Maijan and Mathola are situated on the south bank of the Brahmaputra river. They are 65 km below the confluence of the three tributaries namely Dihang, Dibang and Luhit. The area is covered by tea gardens and lies 4 km east of Dibrugarh (p. 1).

This peneplained area is covered by the recent alluvium at a height of 107.68m. There are two beels. These are filled up by stagnant water. The Brahmaputra plays a significant role in composing the physiography of the area. After the remarkable earthquake of 1950 the area has been subjected to the fury of the flood in each monsoonal season causing acute erosion. The high velocity of water during flood plays one of the major factors for the erosion of the bank which is composed mainly of sand and silt. The bank of the area is most unstable and changes very rapidly even during one flood season. This change has caused migration of the bank line towards south. The natural levees and the sand bars formed in the Brahmaputra river here play an important role in controlling the flow pattern of the river (p. 20-22).

The mighty Brahmaputra flowing from east to west is having a breadth between 10 and 15 km around Maijan and
Mathola. This braided river is encroaching a considerable portion of the area and is carrying heavy sediment load. This has caused wide and shallow drenched bed with sand bars. A few mid-channel islands play a significant role in controlling the flow pattern of the Brahmaputra river and therefore the bed configuration changes drastically under different flow regimes. The total flood discharge at Maijan and Mathola as revealed from the study of discharge contribution of Luhit, Dibang, Dihang and other small tributaries upstream is 33,960 cumec. The tributaries around the region are of very significant nature in view of the catchment area. Dibrugarh was located by the side of the Dibru river, a notable tributary of the Brahmaputra. It merged with the Brahmaputra after the remarkable earthquake of 1950 (p. 22-24).

The type of climate in Assam is subtropical with humid summer and dry winter. The north-easterly is the most prevalent wind in Assam by which the climate of the Brahmaputra valley is greatly influenced. The Brahmaputra river and the surrounding forest are mainly responsible for the formation of mist. The mean annual temperature is 19.5°C, the maximum is 27°C during summer and the minimum is 14°C during winter. The notable evaporation also prevents the temperature to rise abnormally (p. 25-26). The Brahmaputra valley receives an average annual rainfall amounting to 2150 mm. The hilly tracts of the Arunachal Pradesh which
form the catchment of the Brahmaputra river receive very heavy rainfall from the south-west monsoon. This has got much impact on the considerable river discharges of the Brahmaputra (Goswami, 1982, p. 13). The temperature around Maijan and Mathola ranges from 16.6°C to 27.8°C with much humidity. The presence of vast water of the Brahmaputra makes the climatic condition of the area moderate. Maijan and Mathola along with Dibrugarh record an average rainfall of 2442.9 mm annually. An average downpour of 156.36 days annually was recorded during the period from 1953 to 1982 (p. 26-28).

The alluvium covered foreland shelf zone of Upper Assam Valley, a part of Assam-Arakan basin, is bounded by the eastern Himalayas on the north, the Mishimi Hills on the south and south-east, and the Mikir Hills on the south-east. In the Upper Assam Valley, the Himalayas have joined the hill ranges of Assam at an acute angle, forming a syntaxis. The valley where the two ranges meet, the Naga thrust has met with the Himalayan front and overridden by it. The basement block below the Upper Assam Valley appears to be a shattered belt-sondergleichen, but it is a tilted block of basement with a peneplained surface rising as an untroubled monocline from the low level of the Brahmaputra Valley on the north to form the famous Shillong Plateau, and on the north-east, the Mikir Hills. There is a rigid basement block
underlies the north-eastern sector of the Brahmaputra alluvial valley. The Naga Hills are bounded by the alluvium plain consisting of series of thrust-fault anticlines. The imbric structure of Upper Assam is young and composed of relatively soft strata. The pattern at depth is repeated fault-slices, or faulted isoclinal synclines of the crystalline basement (p. 28-30) (Lee, 1952, p. 23-25; Sale and Evans, 1949, p. 357).

The Tertiary succession in Upper Assam shows an excellent development. The Disang series represents a part of the Upper Cretaceous and the Eocene. The succeeding Barail Series is of Upper Eocene and Oligocene age. There is a wide spread unconformity between the Barail and the succeeding Surma series. There is also a minor unconformity between the Tipam and the Dupitila Series. The Surma series belongs to Upper Oligocene and the Tipam series belongs to Miocene, while the Dupitila series is of Miopliocene age. The succeeding Dihing series is separated by a minor unconformity, belongs to Pliocene age (p. 30-33) (Krishnan, 1960, p. 496; Handique and Borgohain, 1983).

At Maijan and Mathola, the shelf facies occurs as a thin veneer of sediments beneath the vast alluvial deposit of Upper Assam. The thickness of the geosynclinal facies in Naga hills and adjoining hilly ranges is 8000m. The dividing line i.e., the belt of Schuppen lies between the two facies (p. 33).
The huge thickness of alluvial deposits of Pliocene in Assam is of synclinal nature formed concomitantly with the elevation of the Himalayas to its north (Krishnan, 1960, p. 573). The post-Barail upliftment raised the central zone between Disang and Zungki faults into a low relief landmass. Following the deposition of Girujans, there were three major periods of folding and upliftments in the regions. The first two were responsible for the deposition of Namsang and Dihing. The third movement tilted Dihing at a quite high angle. Subsequent to the above movements, also small scale movements continuing even today, are responsible for the formation of raised terraces. Thus the Zone of Schuppen developed with the pre-Namsang upliftment and accentuated later on with the post-Namsang and post-Dihing movements (p. 33-35) (Das Gupta, 1977, p. 43-45).

The catchment of the Brahmaputra is one of the most unstable regions in the world. It is comprising of the youthful Himalayan ranges in a region of marked tectonic activities. Though the severe earthquake tremors in Assam can be traced back to 1696 A.D., yet the scientific records are available from the middle of the 19th century. The severe earthquakes of 1865, 1869, 1897, 1908, 1937 and 1950 are notable and these were 6 and 8 in the magnitude scale of Richter (p. 37).
In the north-eastern corner of India, the Himalayas make a syntaxial bend. The mountains rise very rapidly from the plain of the Brahmaputra Valley which along with the knee bend are attributed to the tectonic forces acting from the north gave rise to folds and thrust (Murthy, 1970, p. 93-94). On the south side of the Brahmaputra Valley, the Naga hills, the North Cachar Hills and the hills comprising the Shillong Plateau are terminating abruptly to the west. Thus the Brahmaputra Valley is bounded on the three sides by the U-shaped steep hills. Along the northern margin of these hill ranges, the beds are overthrust. Owing to the thrusts and the faults on the three directions, the region is geologically unstable and bears high seismicity. This makes the north-eastern India as the most active seismic region in the country. The reasons for high seismicity can be attributed to the continuous upliftment even at geologically recent time resulting in the formation of hills and mountains. The related development of plains and valleys has taken place by the down-sinking (p. 37-39).

The earthquakes of 1897 and 1950 had a good impact on a considerable numbers of buildings, railway lines, roads and bridges. Sliding hill sides, blocking and changing of river courses, complication of flood problem and distinct changes in topography, were other notable features caused by these two earthquakes. After the earthquake of 1950 the
rivers namely Dihang, Dibong, Tiding and Subansiri were blocked for some days and then burst causing widespread havoc. Since 1920, 3 earthquakes of magnitudes 8 and above, 15 of 7 to 8, 161 of 6 to 7 and 237 of 5 to 6 had occurred. During the earthquake of 1897 having a magnitude of 8.7, a large tract of land along the Brahmaputra got depressed (p. 39-40).

The great earthquake of August, 1950, with a magnitude of 8.5 and its epicentre in the Mishimi Hill of Arunachal Pradesh created serious flood problem. The extensive hill slides in the catchment of the Brahmaputra and its north-eastern tributaries elevated the bed level of the river. This was accentuated by the huge quantity of bed materials brought down from its upper catchments. This phenomenal silting of large rivers was resulted by the clayey soil and not by the original bed material of coarse sand. In addition to this, the innumerable timber logs embedded therein making the deposit difficult to wash away for which the rivers formed new channels, either by abandoning the old course completely or by-passing them making new course. The new courses caused destruction along their ways. But the Luhit, the Noa-Dihing and the Brahmaputra did not change their courses. However, the silting of the river beds reduced the capacity of the channel and thereby increased the flood spill (p. 40-41).
The earthquake data indicate that the intense earthquake of 1897 were followed by earthquakes of lower magnitude till 1937, and then the magnitude gradually increased and reached its peak in 1950. The 1950 earthquake were again followed by earthquakes with diminishing magnitude till 1968. Then after 1968 the earthquakes had shown a gradual increase in their magnitude (p. 41-42).

The excessive silt load makes the bed shallower and creates erosional problems at Maijan and Mathola. The average low water level of the Brahmaputra here went up from 98m to 101.07m after the 1950 earthquake. This sudden rise of about 3m in comparing to the previous record shows an average rise of 0.027m per year (p. 42-43).

The effect of the earthquake on the upstream tributaries have direct or indirect relations with the flood and erosional problem of the area. Some of these tributaries had changed their courses permanently and some temporarily. Luhit had been silted up and the flood surface extended to a considerable distance. Dibang also had been considerably silted up and the outfall of its tributaries were blocked. The silting up of Dihang caused heavy erosion. The river Suku pushed Dihing to the right bank. The outfalls of Poba and Dholajan were completely blocked (p. 43-45).

The effect of 1950 earthquake also played havoc on the north bank channels opposite to Maijan, Mathola and
Dibrugarh. Buri Suti, Batum and Tongani channels were silted up by 1.5 to 2m. Kanduli Jan was completely silted up. Sissi channel was practically blocked. The Subansiri was shifted to the left and right, and bifurcated into two channels. It was silted up by 3 to 4m and as a result the low water level was recorded at only 0.3m below its bank level. Ranga Nadi also was silted up by 1 to 1.5m (p. 45-47).

From the available records it is observed that during the period from 1914 to 1975 almost every earthquake occurring in the North Eastern India and its neighbourhood was followed by the change in river stage of the Brahmaputra at Maijan and Mathola. The earthquakes of 1927 and 1928 of magnitude 6.25 and 6, made the high water level of the Brahmaputra river to rise to 0.79m. Between 1914 and 1950, the earthquake tremors brought change in the high water level in a span of about 3 years, but between 1950 and 1973, the time logs were reduced. The rise in high water level of the Brahmaputra was recorded within 1 year of 1950 earthquake. During 1977, the flood level of the Brahmaputra crossed the elevation of Maijan and Mathola and also Dibrugarh by 0.3m, took place after 2 years of occurrence of an earthquake of 6.7 magnitude in 1975. The effect of the earthquake of 1950 on the high water level of the Brahmaputra not felt appreciably till 1953 as the river course of Dihang, Dibang and Luhit were blocked by landslide debris. The landslide also made
an appreciable contribution towards the rise in the bed level of the Brahmaputra. The landslide caused by the 1950 earthquake multilated about 75 per cent of the hills in the catchment of the Brahmaputra and its tributaries. The landslides were not confined to the soil cover with vegetation only but also to rock formations. A considerable portion of the debris from the landslides fell directly in the rivers and thereby filling their gorges and blocking their courses. Most of these blocks got burst causing sudden and extensive floods in the rivers. Thus these rivers brought down huge quantities of sand, silt and snag, much more than their carrying capacities. It is observed that an average annual silting rate of the Brahmaputra at Maijan and Mathola was 3 cm but after the 1950 earthquake it was aggraded by about 3m within a few years (p. 47-48).

The tectonic history of the region is related to the upliftment of the Himalayas on the north, and Patkai-Naga-Sirohi-Luchai Hills on the east and south east (p. 48).

The north-eastern region is physiographically subdivided into three: (1) the high younger mountain ranges on the north, east and south; (2) the shield areas of the Assam-Meghalaya Plateau and (3) the alluvium valley of the Brahmaputra and Barak (p. 48).

The Assam-Meghalaya Plateau, separated from other tectonic divisions by fractures, was stable till marine
transgression took place along the southern and the western margins during Upper Cretaceous. The Mishimi massif being tectonically unstable is the seat of frequent earthquakes. The plateau and the massif constitute the craton (p. 48).

The platform (p. 49), lies between the Naga thrust on the south and the Dawki fault on the north, extends from the Mishimi massif to Haflong, is of Precambrian age. The belt of Schuppen has two major faults, viz, the Naga thrust on the north western limit and the Disang thrust on the south eastern limit. The faults now concealed on the eastern, northern and western margins of the craton are supposed to be associated with the epeirogenic movement of the craton itself which might be a horst limited by the Assam valley graben on its north and east, and by the Bengal graben on its west (p. 49)(Mathur and Evans, 1964). The foredeeps were developed between Miocene and Pliocene. The thrust movement from north and east must have proceeded simultaneously (p. 49-50)(Bhattacharjee, 1984).

The eastern Himalayan mountain ranges are composed of thrust sheets piled over the North Eastern Indian landmass along the northern margin of the platform (p. 50). The advance edge of the Tethys along the eastern margin of the Indian shield which was either incorporated in the Himalayas or subsided became the platform of the Assam valley. The subsidence of a geosynclinal basin started during the Permian,
increased in the Jurassic and continued throughout the Cretaceous. The basin experienced first episode of Organic movement during the late Cretaceous or the early Eocene, when the Arakan-Chin Hill geanticline emerged. Continuation of the deep marine environment owing to the formation of geanticline resulted in deepening of the basin, marginal to the anticline for the lateral sag. It is noted that the sedimentary environment initiated during the Jurassic period, continued and covered a reduced area of the basin. The tectonic activity in the basin, producing local depressions and elevations not only were noted in the basin but also on the platform. This flysch stage continued through Eocene to middle Oligocene, when upliftment of the Barail range took place (p. 50-52)(Mathur and Evan, 1964; Bhattacharjee, 1984). The widespread unconformity between Barail and Surma Group marked the initiation of the next molasse stage which continued from upper Oligocene to middle Pliocene. A foredeep developed in Upper Assam indicates the formation of thrust blocks. During middle Miocene, a major upliftment in the whole north eastern part of the region took place, and a foredeep was developed along the southern margin of the Himalayas, which got rapidly filled up by sediments derived from the young mountain ranges. Sedimentation in the foredeep region is still continuing (p. 52-53).
The shelf zone of Assam Valley covered by the alluvium also acted as a tectonic hinge and to some extent controlled the pattern of Tertiary deposition. The Cretaceous-Eocene sediments of the South Shillong Plateau and the Mikir Hills are exposed on ground as they were uplifted along the Dauki and other fault systems. In Upper Assam, these sediments underlie the alluvium along a long linear belt trending ESE-WSW (p. 53).

Three Quaternary geological and geomorphological units of Dibrugarh district were set by neotectonic activity on the Quaternary sediments by the Assam earthquakes of 1897 and 1950. The three geological units in chronological order are Saikhowa formation, Dangori formation and Doom Dooma formation. The geomorphological units in order are Saikhowa surface, Dangori surface and Doom Dooma surface (p. 53-54).

The Guijan-Oakland fault scrap which was developed as a result of 1950 earthquake is the youngest Saikhowa formation in the north. It is a downthrow relative to the older Doom Dooma formation in the south. The difference in elevation between these two formations increased by about 4m in 1950. Several lenticular beels and swamps occur in the Saikhowa formation towards the north of these scrap. When followed from south to north the highly oxidized clay and sand sequence of the Doom Dooma formation terminate abruptly in this fault scrap against the unoxidized grey sand and silt sequence of
the Saikhowa formation. The area towards the north of this scrap is tilted towards the south, as a result small streams flow southward. This is one of the principal causes that the Brahmaputra is finding it easy to move towards south in this area by process of erosion. The Dibru river follows the alignment of this scrap (p. 54-55).

The Saikhowa-Guijan fault scrap runs in a NE-SW direction, where the Saikhowa formation is downthrown towards NW relative to the older Doom Dooma formation in the SE. Prior to the 1950 earthquake, there was no difference in elevation between the Saikhowa and the Doom Dooma formation, but after 1950 and elevation difference of 3 to 6m took place (p. 55).

On account of subsidence of large area on the south bank of the Brahmaputra after the 1950 earthquake, a large scale change in physiography is taking place. The southward migration of the Brahmaputra for about 6km is responsible for the extensive erosion of Maijan and Mathola. Another movement along the Guijan-Oakland fault scrap may endanger Maijan and Mathola along with Dibrugarh by the westerly extension of this fault scrap (p. 55-56).

The Brahmaputra is having a length of 2,897 km from its origin in Tibet to its outfall in Bay of Bengal. It is draining an area of 580,000 Sq.km. In Tibet it is known as Tsangpo. On entering India after girdling round
Namcha Barua, the river is known as Siang in the upper portion and Dihang in the lower portion. Near Sadiya it has joined with Dibang and Luhit. From this juncture, the river is known as the Brahmaputra. It is one of the most remarkable navigable waterways of the world. The river plunges down from an altitude of 3000 m at Pe to 150 m at Pashighat in a series of cascades through narrow gorges without a single fall more than 50 m (p. 57-58) (Kedia, 1978, p. 17).

The Brahmaputra originates from Konggyu Tsho lake in the Kailash range of the Himalayas, 63 km south east of Manas Sarowar lake. Two big Indian rivers, the Brahmaputra and the Indus having their source almost at the same place, traverse in opposite directions towards the east and the west of the sub-continent (p. 58-59).

The course of the Brahmaputra can be divided into three reaches viz. upper reach, middle reach and lower reach (p. 59).

In the upper reach the river is known as Tsangpo. It flows through southern Tibet for about 1100 km eastward. The first notable tributary Raga Tsangpo joins the main stream near Shigaste. The river is then replenished by the water of Kyi Cho. The next important tributary Nyang Chu meets it near Gyantse. From Lhatse Dzong, the Tsangpo has a wide navigable channel for about 640 km. At Tsela Dzong, the river joins Giam da Chu. After Pe, the river abruptly
turns to the north east and north and then traverses in a succession of rapids between high mountains of Gyala Peri and Namcha Barwa. It then turns to the south and south east to emerge from the foot hills and enters the Indian territory as Siang (p. 59-63).

With the name Siang or Dehang the middle reach of the river commences. It traverses Arunachal Pradesh in a more or less southern direction for 226 km. Near Sadriya it is joined by Luhit and Dibang. From this juncture, the river is known as the Brahmaputra. This mighty river then rolls down the Assam valley south west initially for some distance. Thereafter it rolls from east to west for a length of 640 km upto Dhubri, in an oscillating and variable channel. In this oscillating channel, innumerable sand islands form of which most of them are temporary. Majuli is one of the biggest and perhaps the oldest riverine islands in the world, is subjected to rapid erosion since 1950 (p. 63-65). During its course the river receives about 40 tributaries on its north bank and 20 on its south bank (p. 65-66).

The lower reach of the river starts at the point round the Garo Hills and enters Bangladesh. Then it flows southward for a distance of about 250 km across the alluvium plains of Bangladesh as Jumuna before joining the Ganges at Goalando for its final journey to Bay of Bengal (p. 66-67).
The Brahmaputra is the longest river in India. Though its catchment area is lower than the Indus and the Ganges, yet it has the highest maximum discharge of 72670 cumec which is second only to Mahanadi (p. 67-68). Amongst the big rivers of the world, in respect of an average discharge, the Brahmaputra's position is fourth with Huang Ho (Table 5). The average annual load of the Brahmaputra is of very high order. It is second only to Huang Ho (Table 6). The specific yield of the Brahmaputra is highest in the world (Table 7) and hence the acute flood congestion in the valley (p. 68-69).

The Brahmaputra valley is 800 km in length lying almost east to west, is bounded by the Eastern Himalayas on the north, the Patkai range of hills on the east and the Assam range of hills on the south. The width of the Brahmaputra valley is only 80 to 90 km of which the river itself has a width of 6 to 10 km in most places (p. 69-70). Although the valley is monotonously plain, there are some distinct mounds and hills emerging out of the alluvium. In addition there are also some mounds and raised grounds of older alluvium on the southern side of the valley. They enclaves many of the hills of granitic and gneissic rocks as inselberg, which are the extension of Shillong Plateau. It is believed that these areas were raised in block by the vertical movement of the basement complex (p. 70-71).
The valley with the surrounding hills on three sides vary in their formations as well as geohydrologic and meteorologic environments. The north of the valley consists of soft sandstone and weathered disturbed overburden. These are the perennial source of silt, sand and debris which are washed off by the streams during heavy rain. This causes the large sandy deposits on the northern bank. On the east of the Subansiri, the rocks are hard but susceptible to weathering. The rivers of these regions carry boulders, pebbles, sands and silts. The land formations of this part of the valley are composed of these materials. The Patkai and the Naga hills on the east of the valley have soft sedimentary rocks. Rivers from these regions bring down heavy load of fine sand and clayey sediments which gradually build up deep undulating and low lying portions on the south of the Brahmaputra valley. Near the foot hill of the area, some springs emerge out as the flow of ground water being obstructed owing to the permeable layers interfered by layers of less permeable finer deposits below a shallow overburden (p. 71-73).

The Brahmaputra plains are monotonously flat with a very low gradient of 0.15m per kilometre. Due to this low gradient the river does not have any strength to cut its channel deep. It cuts sideways and the erosion of the banks become a very common feature (p. 74).
The alluviation of foreland depression between the Himalayan orogenic belt and the crystalline massif of the Shillong Plateau during Quaternary period was responsible for the evolvement of the Brahmaputra valley. The process of upliftment, both due to vertical and lateral movements, resulted in formation of hills and mountains of the region. Concurrently the Brahmaputra valley got sunk, which seems to be greater in the Upper Assam region (p. 74-75). To the west of Numaligarh, the inselbergs are seen at several places close to the Brahmaputra, but towards east of Numaligarh, such inselbergs are totally absent, indicating the slope of the basement complex towards the eastern side (p. 75).

In the northern side of the Brahmaputra, the inselberg zone gradually gives way to the alluvial plain, abutting against the Siwalik ridges of the Himalayan front. The Siwaliks are followed by a highly tectonised zone of Palaeozoic sediments on which the gneiss and the schists are overthrust. The basement of the entire Brahmaputra valley is made up of the Shillong Plateau Mikir Hills type of metamorphites (p. 76).

The Tertiary sedimentation is the most important part of the geological history of the Brahmaputra Basin. The Upper Assam behaved as a platform giving way to the Upper Cretaceous-Palaeocene-Oligocene geosyncline, now transformed into Naga Patkai ranges. South of the Shillong Plateau, the Palaeocene-Eocene formations extend towards the westward...
fringe. The formations on the shelf and the platform with regional paleo-slope took place during Paleocene-Oligocene period towards south-east (p. 77-78). Owing to the upliftment of the Barails, a large part of the region became landmass towards the end of Oligocene period. Tectonic activities and upliftment in the post-Oligocene period resulted in the sinking of southern margin of the Himalayan front to give rise to the Himalayan foredeep the site of Siwalik sedimentation. The present westerly flow direction of the Brahmaputra occurred during Pleistocene period for the intense south-westerly direct force from Luhit Himalaya. In the Brahmaputra valley the formative process is still active. The foreland depression is experiencing neotectonic movements. Disastrous earthquakes make the valley geologically extremely unstable (p. 78-80).

The north bank tributaries and the south bank tributaries of the Brahmaputra possess quite different characteristics. The north bank tributaries have very steep slopes, shallow braided channels and coarse sandy beds with heavy silt charges. They usually bring flash floods. On the contrary the south bank tributaries have low gradient, deep meanders and comparatively low sediment charges (Barthakur, 1978, p. 8). The Brahmaputra has 40 tributaries on the north bank and 20 on the south bank. The principal north bank tributaries are Dehang, Debang, Subansiri, Ranganadi, Jia-
Bharali, Dhansiri, Barnadi, Pagladia, Manas, Aie, Champamati and Gangadhar. Among the north bank tributaries, Subansiri is the longest having a length of 442 km. It has a recorded highest average annual discharge of 11377 cumec. The Manas is having the largest catchment area of 37500 Sq. km. The major south bank tributaries are Luhit, Noa-Dihing, Buri-Dihing, Disang, Dikhow, Jhaji, Dhansiri, Kapili and Jinjiram. Among the south bank tributaries Luhit is having the largest catchment area of 19432 Sq. km and the highest average annual discharge of 5736 cumec. The longest south bank tributary viz. Buri-Dihing is 362 km in length (p. 80-90).

The meteorological situations responsible for heavy rainfall in the Brahmaputra valley are 'break monsoon', low pressure areas of Bay of Bengal, land lows and upper air cyclonic circulation. If any of these synchronises with the westerly wave then it moves across the Eastern Himalayas causing heavy rain over Assam and its neighbourhood. The break monsoon is responsible for causing heavy rainfall and 50 per cent of major floods in the Brahmaputra, since 1950. With the north-westward movement of the low pressure in the Bay of Bengal, the monsoon activity increases in the North East India. In the Brahmaputra, 25 per cent flood is caused by the passage of stroms from the head Bay. During the monsoon season, the land lows moves from the Gangetic belt strengthening the monsoon over North East India and thereby
causing heavy rain and flood. The heavy rains on some occasions by the upper air cyclonic circulations at lower levels cause a few major floods in Assam (p. 91-94).

From 1956 to 1963, altogether 22 major flood situations were studied, out of which 10 due to break monsoon, 6 due to depression, 3 due to land depression and 3 due to upper air cyclonic circulation occurred. It is seen that August is the principal month during which floods are mainly caused by break monsoon conditions. The flood due to the monsoon depressions from the Bay of Bengal generally occurs in the month of June. In Assam, 95 per cent of the major floods take place in the months of June, July and August. Among these, August is the principal flood month, during which 45 per cent of the major floods occur (I.M.O., 1977).

The floods in the Brahmaputra are generally caused by the concentrated spells of heavy rain in the upper reaches during the monsoon months. Floods in this valley do not occur due to the melting of snows in the Himalayan basin although snow and glacier melts form an important source of contribution to the river during the summer months.

The flood lift of the Brahmaputra was greater prior to the 1950 earthquake, compared to those after 1950. Excepting at Gauhati and Goalpara, flood lift has reduced in all the places after 1950, with a maximum reduction of more than 2m at Dibrugarh, closely followed by Tezpur with
1.95 m. The reduction is more pronounced in the reaches from Dibrugarh to Tezpur than in the lower reaches. The average flood lift is maximum at Gauhati and minimum at Dibrugarh (p. 95).

At Dibrugarh the average rise of L.W.L. was 0.025 m/year between 1913 and 1950. A sudden rise of about 4 m was seen during 1951. This can be attributed to the sudden rise of bed level after the earthquake of 1950. After 1951 a slight downward trend is noticed. The trend of sudden rise of L.W.L. is visible at Tezpur from 1955 onwards. This shows that excess sand required 5 years to reach Tezpur from Dibrugarh, a distance of 245 Km. The sudden rise was seen at Gauhati between 1957 and 1961, the rise was about 2.43 m. However, immediately after 1962, the L.W.L. came down by 2 m that continued upto 1965. At Dhubri a rising trend of 0.033 m/year was noticed between 1931 and 1964 with a maximum rise of 1.2 m between 1940 and 1961 (p. 96-98).

The highest recorded flood at Dibrugarh was 105.98 m on 16.8.77, the danger level is 104.24 m. Before 1950, the danger level exceeded thrice in 1938, 1942 and 1946 but after 1954 it has become an annual phenomenon. At Gauhati the danger level is 49.68 m and the highest level recorded was 51.05 m during 1962. At Goalpara the danger level is 36.28 m. The flood exceeded there for 14 times. The highest flood level of 37.20 m was recorded 4 times during second decade.
of this century, and 1954 and 1962. The danger level at Dhubri is 28.65m and the highest level of 29.97m was recorded in 1974 (p. 99-101).

The time lag of flood peaks from Pasighat to Dibrugarh is 12 hours, whereas from Dibrugarh to Neamati, Neamati to Tezpur, Tezpur to Gauhati and Gauhati to Goalpara is 24 hours and from Goalpara to Dhubri is 15 hours (p. 101).

In Tibet, the discharge observations since 1955 to 1958 at Shigatse, Chughul Dzong and Tsela Dzong are available for monsoon season only. At Shigatse the maximum average discharge of 1726.84 cumec, and the maximum monthly discharge of 2463.23 cumec were in August and the minimum of 414.00 cumec in June. Like Shigatse also, at Chughul Dzong, the maximum average and maximum monthly discharges were in August with 3010.19 and 3912.33 cumec. The minimum discharge of 616.22 cumec was recorded in June. At Tsela Dzong also the trend of maximum average and minimum monthly discharges were in August with 5324.69 and 6165.16 cumec. But unlike the above two stations, the minimum average and minimum monthly discharges of 2410.56 and 2669.44 cumec were recorded in the month of October (p. 102-105).

In India the discharge observations were recorded at Pasighat, Besamara, Pandu and Jogighopa. At Pasighat the yearly mean discharge for the period of 31 years from 1952
to 1982 was 5628.54 cumec, with a maximum monthly average discharge of 12238.81 cumec during August, and a minimum of 1605.00 cumec during February. A total discharge of 69.97 per cent was in the monsoon season. While the maximum annual mean and the maximum monthly mean discharges were noted during 1954, the minimum annual mean discharge and the minimum monthly discharges were recorded during 1953 and 1982. The instantaneous maximum discharge of 29643.10 cumec was on 18.08.62 and the minimum of 795.07 cumec was on 31.12.82. The average annual yield for this period of 31 years was 17.73m Ha.m (p. 105-107).

The yearly mean discharge for the period from 1975 to 1983 at Besamara was 8350.69 cumec with a maximum monthly discharge of 17450.77 cumec in July and a minimum of 2070.44 cumec in February. A discharge of 68.11 per cent was in the monsoon period. The maximum and the minimum annual mean discharges were in 1980 and 1976. The maximum and the minimum monthly mean discharges were recorded in August, 1980 and January, 1981. A maximum of 29450 cumec was recorded on 30.07.79 and a minimum instantaneous discharge of 1001.28 cumec was recorded on 3.1.81. The average annual yield for the period of 1976 to 1983 was 27.07m Ha.m (p. 107-108).

The yearly mean discharge at Pandu for the period between 1955 and 1983 was 15361.35 cumec, with a maximum
monthly discharge of 34215.42 cumec in July and a minimum of 3397.64 cumec in January. Out of a total discharge, 72.71 per cent was in the monsoon season. The maximum and the minimum annual mean discharges were in 1959 and 1977. On 23.8.62, 71900 cumec and on 31.10.76, 1500 cumec were the maximum and minimum instantaneous discharges. The average annual yield was 48.39m. Ha.m (p. 108-110).

The discharge observation at Jogighopa was observed from 1956 to 1957, and it was again started in 1971 and continued until 1979. The yearly mean discharge for 1956 and 1957 was 15723.29 cumec, with a maximum discharge of 36871.36 cumec in July and a minimum of 6260.92 cumec in January. The discharge during monsoon was 69.45 per cent. The maximum annual mean, the maximum and the minimum monthly mean discharges were in 1956, while the maximum instantaneous discharge of 54364.30 cumec was on 24.6.57, the minimum of 4174.70 cumec was on 11.4.56. For these two years the average annual yield was 49.51m Ha.m. For the period of 1971 to 1979, the yearly mean discharge was 16324.54 cumec, with a maximum monthly discharge of 36152.15 cumec in August and a minimum of 4498.06 cumec in February. During this period, 70.95 per cent discharge was in monsoon season. The maximum and the minimum annual mean discharges were in 1974 and 1979. The maximum and the minimum monthly mean discharges were in August, 1977 and February, 1978. On 20.8.77, 70934.80 cumec
was the maximum and on 10.2.77, 2014.50 cumec was the minimum instantaneous discharges. For this period, the average annual yield was 51.44 m Ha.m (p. 110-112).

From the confluence of Dehang, Dibang and Luhit upto the Indo-Bangladesh border, the Brahmaputra has a catchment area of 2,02,100 Sq. km and it carries 6,23,000 cumec of flood water. The river with multiple interlacing channels, separated by shoals, has a width over 10 km. The shifting of these channels and shoals are owing to constant silt movement, also brought in by various tributaries at different points. The braiding characteristics and the preliminary bed load of the river are due to its inability to carry the incoming bed load (p. 112-113).

The catchment of the Brahmaputra in Assam region consists of (1) the north bank tributaries; (2) the south bank tributaries; and (3) the smaller streams on both the banks. The north bank tributaries are having a catchment area of 75,650 Sq. km. The Subansiri, Bharali and Manas contribute more than 90 per cent water of this catchment area. The main south bank tributaries are having a catchment area of 52,600 Sq. km. This is roughly 50 per cent less than the north bank tributaries. Hence the discharge contribution of the north bank tributaries is much higher than that of the south bank tributaries. In respect of silt yield, the south bank tributaries contribution is only about 1/6th comparing to the north bank tributaries (p. 113-114).
The sediment discharge at Pasighat is 6502.59 Hm. At Pandu the maximum sediment load for monsoon and non-monsoon period is 63,677 Hm and 5,778 Hm. The minimum sediment load for monsoon period is 7,852 Hm and non-monsoon period is 0.868 Hm. These data show that the ratio of maximum and minimum sediment load during monsoon is about 1:8, but for non-monsoon period it is high as 1:6000. The maximum and the minimum annual sediment loads are 545 and 70.74 Hm, the ratio being 1:7. The fine sediment predominants during monsoon (P. 114-116).

The profile of the Brahmaputra river is divided into four sections (1) Origin to Indo-China border with an average slope of 1 in 385; (2) Indo-China border to Kobo having an average slope of 1 in 515; (3) Kobo to Indo-Bangladesh border, the average slope is 1 in 6990; and (4) Indo-Bangladesh border to its outfall, the average slope is 1 in 22150 (p. 116-117).

In Assam, the valley slopes of the Brahmaputra between Dibrugarh and Neamati is 1 in 5595, Neamati and Tezpur 1 in 6425, Tezpur and Gauhati 1 in 6750, Gauhati and Goalpara 1 in 8875, and Goalpara and Dhubri 1 in 14650 as calculated from the low water level (p. 117-118).

The cross-section study of the three reaches of the Brahmaputra shows that the maximum width between the banks is 15,585m and the minimum is 1,750m. Out of the cross-
sections 11 show the width between 0 and 5,000m, 33 between 5,000 and 10,000m, 15 between 10,000 and 15,000m, and 2 above 15,000m. The average width of the upper, middle and lower reaches are 8189, 8139 and 7935m. There are average 6 channels in the upper and the middle reaches and 5 in the lower reach (p. 118-120).

**Assam** is having 27 per cent of riverine area, 73 per cent of hilly area and heavy rainfall during monsoon months. With these features, Assam is a flood-prone state. The alluvial rivers of Assam cannot carry the maximum flood discharge during the monsoon months within their formed banks and hence spilling of bank by the Brahmaputra and most of its tributaries is a normal phenomenon (p. 121).

In the Lakhimpur and Dibrugarh districts during 18th century, the north bank was more exposed to flood than the south bank. There were two heavy floods throughout Assam in 1570 and 1642, which caused extensive damage. Embankments were constructed by the Ahom ruler along the Brahmaputra and in some of its tributaries in Sibsagar and Jorhat districts. The Darrang and the Sonitpur districts were also subjected to severe floods in the past, resulting in change of course of almost all the tributaries, there. In the Nowgong district the devastating flood took place in 1825 followed by another 1842. Another great flood appeared in 1937. After the earthquake of 1897 the topography of Kamrup and Barpeta
districts was changed and severe devastating floods appeared frequently. In Goalpara, Kokrajhar and Dhubri districts, the floods were annual phenomenon, with very high floods during 1960 and 1970 (p. 122-126).

The flood problem was very intensive from the beginning of this century, and the flood protection measures on the rivers were started after 1940. The earthquakes of 1897 and 1950 have got much impact on the flood problem of Assam. The 1897 earthquake changed the topographical feature and drainage system of lower Assam. This was felt over 4.54 million sq. km and a large tract of the Brahmaputra specially at Barpeta and Chaygaon area got depressed. The earthquake of 1950 had great impact in changing the topographical features of the Upper Assam. The Brahmaputra upto Neamati, and its tributaries got extensively silted (p. 126-127).

The large scale seismic disturbances from time to time upset the rivers of the entire region. The drainage system is in a state of perpetual flux, where the topographical features and the meteorological situations are enough to create flood in normal conditions. In addition, the frequent seismic disturbances of low magnitude do not allow to re-establish the drainage system upset by the large scale earthquakes. The extensive silt load reduces the channel capacity creating inundation and forces the river to change their course (p. 127-128).
Though the flood problem in this valley existed for two to three centuries, yet, it has become more pronounced after the earthquake of 1950 (p. 128-129).

Prior to 1950 the south bank of the Brahmaputra was high in the Dibrugarh district. However, after the 1950 earthquake heavy silting in the bed drastically reduced the channel capacity. The shifting of the outfall of Dibang to the east also aggravated the condition. The unprecedented flood at Maijan, Mathola and Dibrugarh during 1955 was not resulted only because of the rise of the river bed but also resulted from the high velocity of flow with heavy discharge in a comparatively smaller depth of the river bed. The low-lying Moriahola of the Jorhat district was heavily affected by the fury of flood. There is a 24 km wide depression in the Nowgong district, where the main channel of the Brahmaputra is away in this reach. But in the south bank, opposite Tezpur, an extensive erosion occurred after the 1950 earthquake. From Palasbari to Mornoi in Kamrup district, there is extensive spilling and erosion during the floods. In Goalpara district, between Goalpara and Pancharatna, and between Kharmauza and South Salmara, the flood spill of the Brahmaputra caused very extensive damage. In the reach between South Salmara and Mancachar, the effect of the flood spills of the Brahmaputra is very damaging (p. 129-132).
Towards north bank of the Brahmaputra in the low lying area of Lakhimpur district, copious spilling after the 1950 earthquake is further aggravated. The flooding extends from Dijmur to Gamirihat on the west. Beyond this, the Brahmaputra bank is high. This high land extends like a plateau up to Bishanath in Sonitpur and Darrang districts, but between Bishanath and Tezpur, the bank gets inundated by the spill of the Brahmaputra. In Kamrup district there is an extensive spilling between Rangamati and North Gauhati, and the area from Sualkuchi to the border of Goalpara district. In Goalpara and Dhubri districts, the bank is interspersed with hillocks and only the area west of Dhubri is flood prone (p. 132-134).

The unstable nature of the Brahmaputra coupled with silt and sand strata of its bank causes the considerable bank erosion. The main factors responsible for this instability are excessive sediment, its age old tendency to shift southward and traversing its valley in a series of deep and narrow throats followed by broad shallow aggrading reaches (Ahmed and Maswood, 1984, p. 83). Just after subsidence of flood, the erosion is maximum and the change in river migration takes place (Sen, 1968, p. 211). The excessive sediment load is due to the frequent seismic disturbances of both low and high magnitude. The shifting of the mouth of the numerous south bank tributaries of the Brahmaputra to
the east, and parallel flowing of these tributaries with the Brahmaputra before joining it, indicates southward shifting of the Brahmaputra (Ahmed, et al. 1983, p. 36). Another notable cause of its southward shifting is the numerous north bank tributaries with excessive silt load joining the Brahmaputra form subaqueous deltas. The southward shifting is more pronounced in the upper reach. In the lower reach from Gauhati to Goalpara, the river is confined in between rock of basement complex, and northerly migration is noticed. But beyond Goalpara it is again shifting towards south causing erosion (p. 135-136)(Ahmed and Maswood, 1984, p. 87).

The river scour depth is not constant along the entire length of the valley, as the width of the Brahmaputra is constricted at number of places (p. 136-137).

The bank of the Brahmaputra is predominantly composed of sand and silt with traces of clay, as such it is susceptible to erosion at the slight increase of velocity of water owing to sudden changes in the cross channels by the formation of shoals. No reach of the Brahmaputra bank except where rock outcrops are visible can be considered as firm bank (p. 137)(Ahmed and Maswood, 1984, p. 86-87).

Some of the major factors which control the bank line movement in the Brahmaputra are: (1) the rate of rise and fall of the river, (2) the number and position of major
channels active during the floods, (3) the formation and position of large bed forms, (4) the cohesion and the composition of bank materials and (5) the intensity of bank slumping. In addition to these, the shifting cultivation in the hills of Assam is indirectly helping to a certain extent the erosion (p. 137-138).

Acute erosion of the river bank around Maijan and Mathola including Dibrugarh town, after the earthquake of 1950, resulted in encroachment of large area by the Brahmaputra. The protection measures taken at Dibrugarh resulted in extensive erosion at Maijan and Mathola by deflected current. The Dibru Island situated 9.5 km upstream of Maijan spur is responsible for directing the flow from central channel of the Brahmaputra to the southern bank which hugs the bank of Maijan and Mathola upto Dibrugarh. Prior to 1969, the main channel of the Brahmaputra was on the south of the Dibru Island and now it is on the north. The change of channel configuration has shifted the attack on the bank from downstream of Maijan spur to about 1200m upstream of Maijan spur. The shoal formed upstream of Maijan spur after 1968 flood was gradually washed away, subjecting the south bank to severe river action (Ahmed, et al., 1983, p. 31)(p. 138-139).

The river edge was only 1m from the D.R.T. road. The river water spills over the road and enters the Maijan and Mathola Beels. The annual rate of erosion at Maijan and
Mathola is 33.05 hectare (p. 140).

Since the earthquake of 1950, the southward shifting of the Brahmaputra is causing severe erosion at number of places (Ahmed and Maswood, 1984, p. 83). Sadiya disappeared in 1953 and Palasbari in 1954. The erosion is still pronounced and severe in 5 reaches in the north bank and 11 reaches in the south bank. The maximum erosion takes place during falling stages of flood and it can carry away about 30m of land per day, thereby 1.5 km width of land disappear in a season. Erosion upto 1982 took place over a length of 395 km and 240 km on the south and north bank, respectively. An average of 8057.36 hectare per year is eroded by the Brahmaputra (p. 140-141).

The standard penetration test indicates that the N-value of the soils around Maijan and Mathola ranges between 1 blow/30 cm and 124 blows/30 cm. In the predominant SP soil, the N-value has very wide variation between 1 blow/30 cm and 124 blows/30 cm. It is generally noticed that in the SP soil, the N-value increases with the depth. Upto a depth of 1.95m in Bore Holes 5 and 10, and upto 4.45m in Bore Hole 4, the SP soil is having N-value below 4 and therefore the relative density of the soil is very loose. The SP soil upto a depth of 6.45m in Bore Hole 1, 3.45m, and 7.5 to 7.95m in Bore Hole 2, and 4.95m in Bore Hole 12, has N-value in the range of 4 to 10 indicates loose relative density of the soil. The
N-value of SP soil found in the range of 10 to 30 between 7 to 12 m in Bore Hole 1, 5 to 10m in Bore Hole 2, 4 to 8m in Bore Hole 3, 7 to 9m in Bore Hole 4, 3.5 to 6m and 11 to 18m in Bore Hole 5, 3.5 to 8m and 12 to 14m in Bore Hole 6, 1.5 to 9m and 13 to 17m in Bore Hole 7, 6 to 16m in Bore Hole 8, 9 to 12m and 14 to 18m in Bore Hole 9, 7.5 to 11m in Bore Hole 10, 4 to 6m and 9 to 16m in Bore Hole 11, 6 to 12m in Bore Hole 12, 6 to 8m and 13 to 16m in Bore Hole 13, and 6 to 9m in Bore Hole 14, indicates medium relative density of the soil of these layers. From 12.5 to 22m in Bore Hole 1, 10.5 to 22m in Bore Hole 2, 8 to 17m in Bore Hole 3, 12 to 25m in Bore Hole 4, 9 to 11m in Bore Hole 5, 8 to 12, 14 to 18m and 20 to 27m in Bore Hole 6, 9 to 13m and 17 to 25m in Bore Hole 7, 16 to 17m in Bore Hole 8, 12 to 14m in Bore Hole 9, 11 to 14m and 16 to 21m in Bore Hole 10, 16 to 20m in Bore Hole 11, 12 to 20 and 22 to 23m in Bore Hole 12, 8.5 to 10m and 11.5 to 13m in Bore Hole 13, and 9 to 15m in Bore Hole 14, the SP soil shows N-value in the range of 30 to 50 which indicates dense relative density of the soil. The SP soil below 26.5m in Bore Hole 2, from 10.5 to 12m and below 21.5m in Bore Hole 4, between 6.5 and 8m in Bore Hole 5, below 18m in Bore Hole 9, from 14 to 16m and below 21m in Bore Hole 10, below 20m in Bore Hole 11, between 20 and 22m in Bore Hole 12, between 10 and 11m in Bore Hole 13 and below 15m in Bore Hole 14 having N-value above 50 indicates
that the relative density of the soil is very dense (p.149-153)(Table 24)(Fig. 3-16).

The other non-cohesive SW soil having N-value in the range of 3 to 44 indicates very loose to dense relative density of the soil. The SW soil layers found upto 2m show very loose relative density. The SW soil of lower depths is having medium to dense relative density (p. 149-150)(Table 24).

Of the cohesive soils, the ML is having N-value generally between 1 and 7, indicates very soft to medium relative consistency. But the ML soil from 6 to 6.45m in Bore Hole 1, having N-value 16 and from 4.5 to 4.95m in Bore Hole 8, having N-value 11, shows very stiff to stiff relative consistency of soil. The CI soil shows N-value between 1 and 8 is having very soft to medium relative consistency. The N-value in the range of 4 to 6 is found in the CL soil, shows medium relative consistency of the soil. The only CH soil has medium relative consistency with N-value of 5 (p. 150-153)(Table 24).

The ground water table for the present area was determined in all the 14 bore holes during summer and also in winter. In another 5 test holes it was measured during rainy days and dry days to know the fluctuation. Based on the ground water table, the area can be divided into four zones, viz., (1) west zone represented by Bore Holes 1, 2
and 3; (2) south zone represented by Bore Holes 4, 5, 6 and 7; (3) north zone represented by Bore Holes 8, 13 and 14; and (4) east zone represented by Bore Holes 9, 10, 11 and 12. The ground water table follows the general slope of the land surface, even though at a smaller inclination (Capper and Cassie, 1956, p. 265). This relation of the ground water with the topography of the area is seen in places.

The western zone includes the area from the western end of the Mathola Beel to the Maijan bridge, along the bank of the river Brahmaputra. The land slope in general is from the west to east, the gradient being 0.5m per km. The highest Reduced Level (R.L) of the ground is 107.684m and the lowest is 107.21m. While the western most portion has the ground water level at a much lower depth of 2.18m during summer, the portion near the Mathola Beel has the water table at a much shallower depth of 0.66 to 0.77m during summer. During the winter, a drawdown of water table between 1.22m and 1.29m is recorded. Though there is fluctuation in the water table yet there is no difference in the drawdown. The water table in summer and in winter is encountered in the sandy soil (p. 153-155)(Table 25).

The south zone is low in topography. The R.L. of the ground is between 105.94m and 106.54m. The slope is 0.5m in 500m, with a south-east gradient. There is difference between the water tables at a less inclination of 0.558 to
1.245m. The water table towards the western end is encountered in the sandy soil, but in the middle and in the eastern side in the cohesive soil during the summer. During the winter a drawdown of water level is practically same amounting 1.33 to 1.46m. The water table during the winter is found in the sandy soil (p. 155)(Table 25).

The north zone lying on the bank line of the Brahmaputra is the low lying portion of the area. The R.L. of the ground varies between 103.53m and 104.8m. The slope of the land is towards east which is 1m in 500m. During summer and winter, the water table is encountered in cohesive soil. The water table towards the eastern side is encountered at a lower depth, but towards the western side at a shallower depth, the variation is negligible. In summer, the depth of the water table varies between 1.549m and 2.69m and during winter between 2m and 3.25m. Though there is variation in the land level, yet there is very little difference in the drawdown of water level during the winter, which is between 0.45m and 0.56m (p. 156-157)(Table 25).

In the east zone where the relief of the land has gradually increased towards the east, a rise in height of 2.7m in 500m is noticed. The R.L. of the ground is in the range of 104.8 to 107.52m. At the western end, near the Mathola Beel, the water table is found at a relatively lower depth. Towards the eastern end also it is encountered at a lower depth. Here the water table during summer is found in
the cohesive soil. At the western end during winter, it is found in the cohesive soil, and in the eastern end in the sandy soil. The water table in summer varies between 1.57m and 2.82m and in winter between 2.65m and 3.76m. There is much less variation in the drawdown of water table, which is noted between 0.92m and 1.14m (p. 156)(Table 25).

The ground water table in the area is raised by 30 to 35 cm during heavy rainy days and it again returns to the original level during the dry days (p. 157).

The soil type met with in the investigated area upto a depth of 30.5m is predominantly composed of sandy soil of SP type. The other sandy soil SW occurs in small strips. The SP soil is composed of 2.5 to 97 per cent of coarse sand and 3 to 93 per cent of fine sand. It is generally seen that the percentage of coarse sand is higher in the lower depths than that of the fine sand. In some SP and SW soils, the pebble is generally present in very small percentage ranging from 0.5 to 8. However, 13 samples show the percentage of pebble above 10 and the maximum up to 33. The higher quantity of pebble is found below 6m. In Bore Hole 12, at a depth of 20.5m, 33 per cent of pebble is encountered in the SP soil. A small quantity of silt is also present in the SP soil in the upper region which generally ranges from 0.5 to 12 per cent (Table 26-39)(Fig. 17-54 and 56-87).
There are bands of fine-grained soil of CL, ML and CI types present from the top to 8m depth. The CL type soil is present in Bore Holes 1, 2, 9, 12, 13 and 14. The top CL type soil towards the western side of the Mathola is represented by Bore Holes 1 and 2, and the eastern side is represented by Bore Hole 12, up to a maximum depth of 1.5m. It is also found from 4.5 to 6m, 0.5 to 2m and 4.5 to 5m depth in Bore Holes 9, 13 and 14. In the CL soil, the silt ranges from 1.5 to 53 per cent and the clay from 2 to 6.5 per cent. The fine sand ranges from 42.5 to 65.5 per cent. The CL and the CI soils deform very slowly (Skempton and Bishop, 1950, p. 90) and considerable volume change is resulted from alternate wetting and drying (p. 164-166, 173-174, 176-179) (Tables 26, 27, 34, 37, 38, 39) (Fig. 17-24, 41-42, 48-54, 56-61, 76-77, 82-87).

Another type of fine-grained soil ML is encountered at different depths of Bore Holes 1, 7, 8, 9, 10, 12, 13 and 14. The top ML soil towards the northern side of the Mathola Beel is represented by Bore Holes 8, 13, and 14 up to a maximum depth of 5m. Some thin strips of ML soil are found from 6 to 6.5m in Bore Hole 1, 0.5 to 1.5m in Bore Hole 7, 1.5 to 4.5m and 6 to 7.5m in Bore Hole 9, 3 to 6m in Bore Hole 10, and 1.5 to 2m in Bore Hole 12. In the ML soil, the silt percentage is ranging from 5.5 to 61.5 and the clay from 1. to 4.5. The quantity of fine sand is between 37 and 82 per cent (p. 164-165, 170-178).
The third type of fine-grained soil is Cl. This type of soil is found in Bore Holes 3, 4, 5, 6, 7, 8, 9, 10, 11 and 14. The Cl is found as top soil on the southern side of the Mathola Beel in Bore Holes 3, 5, 6 and 7, and towards the eastern side of the Beel in Bore Hole 11. Bands of the Cl soil are also encountered at different depths from 6 to 6.5m in Bore Hole 4, 3 to 3.5m in Bore Hole 8, 7.5 to 8m in Bore Hole 9, 6 to 6.5m in Bore Hole 10, and 3 to 3.5m in Bore Hole 14. In Cl soil, the silt ranges from 10 to 64.5 per cent, the clay from 2 to 10 per cent and the fine sand from 21 to 71 per cent (p. 166-176, 178).

Another fine-grained soil CH which shows more detrimental volume change than CL and CI soils (Skempton, 1951, p. 180), is encountered as a thin layer of 0.5m in Bore Hole 11 from 1.5 to 2m. This is the only layer of this type of soil in the area (p. 175)(Table 36)(Fig. 80, HU 136).

All the bed samples are SP soil. It is noticed that the samples near to the bank are composed of 85 to 88 per cent of fine sand, and the shoal sample is composed of 71 per cent of fine sand. But the bed samples farthest away from the bank are dominated by coarse sand (p. 179)(Table 40) (Fig. 55, 88).

It is noticed that the average dia of the soil increases to a certain depth, and then it decreases. The average dia increases upto a minimum depth of 6.5m and a
maximum depth of 26m in different bore holes. Only in Bore Hole 11, an increasing trend is noticed upto a depth of 30.5m. The variation in the average dia of fine grained soils, viz., CL, ML and CI is very little. It ranges between 0.046 mm and 0.106 mm in CL, between 0.019 mm and 0.146 mm in ML, and between 0.013 mm and 0.069 mm in CI. But one CI sample from 0 to 0.5m depth in Bore Hole 6 has shown a high value of average dia for fine-grained soil in the tune of 1.75 mm due to the presence of 29 per cent pebble in its composition. The only CH layer also has low average dia of 0.023 mm. The variation in average dia in the sandy SP and SW soils is quite large. In the SP soil it ranges between 0.101 mm and 1.72 mm. The highest value is found at the depth of 20.5 to 21m in Bore Hole 12 as it contains 33 per cent pebble. The average dia of SW soil ranges from 0.101 to 0.736 mm. The average dia of the bed samples increases with the distance from the bank (p. 179-183)(Table 41-55).

The co-efficient of uniformity, Cu, of the CL soil indicates medium uniformity of the soil as it falls within the range of 5 to 15 (Sehgal, 1974, p. 67). But the CL soil found at the depth of 0.5 to 2m in Bore Hole 13 (p. 187)(Table 53) shows Cu more than 15, which indicates that the soil is very non uniform (Ibid, 1974). The CI soil is also having medium uniformity, except one layer found in Bore Hole 10 from 6 to 6.5m (p. 186)(Table 50), which is having
Cu more than 15 and as such it is also very non uniform soil. Two third of the ML soil is having medium uniformity, while one third is having high uniformity, as the Cu is less than 5 (Ibid, 1974). The only CH soil possessing Cu more than 15 indicates very non uniform soil. The predominant SP soil in general with Cu less than 5 is very uniform soil. Some SP soil layers, from 2 to 3m in Bore Hole 1 (p. 184)(Table 41), 3.5 to 4m in Bore Hole 2 (p. 184)(Table 42), 4.5 to 6m in Bore Hole 4 (p. 185)(Table 44) and 2 to 4.5m in Bore Hole 6 (p. 185)(Table 46), have medium uniformity, as Cu falls in the range of 5 to 15. The SW soil has medium uniformity (p. 184-185)(Table 41-43, 45-47). The Cu of bed samples indicates that it is higher near the bank (p. 187)(Table 55).

The co-efficient of curvature, Cc, of the CL soil ranges between 1.21 and 2.02, the CI soil between 0.53 and 2.65, and the ML soil between 0.97 and 2.34. The ML soil found from 3.5 to 4.5m depth in Bore Hole 14 (p. 187) (Table 54) has shown high value of Cc of 3.13. It is seen that Cc of the prominent fine-grained soils lies between 0.53 and 3.13. The other fine grained CH soil has Cc of 2.72 (p. 186) (Table 51). The predominant SP soil has shown wide variation in Cc which ranges between 0.6 and 2. But the SP soil found at the depth of 8 to 9.5m in Bore Hole 10 shows a high value Cc of 3.92 (p. 186)(Table 50). The other sandy SW soil also has wide variation in Cc which ranges between
1.02 and 4.63. The Cc of the bed soil is higher near the bank (p. 187)(Table 55).

The bed soil near the bank shows lower silt factor than the soil away from the bank. The normal scour depth is high near the bank and gradually decreases in the midst of the river (p. 188)(Table 56).

The sp.gr. of soil in general ranges between 2.55 and 2.77, but in Bore Hole 9 from 7.5 to 8m depth the sp.gr. is low amounting to 2.175 (p. 193). The SP soil is having sp.gr. between 2.59 and 2.77. The SW soil is having sp.gr. between 2.57 and 2.715. The fine-grained soils viz. the CI, the CL and the ML are having sp.gr. from 2.175 to 2.705, from 2.595 to 2.66 and from 2.565 to 2.735. The only CH layer has sp.gr. of 2.66. In CI soil low specific gravity of 2.175 in Bore Hole 9 is owing to the presence of decomposed vegetable matters. In Bore Holes 5 and 6 upto 1m, the sp.gr. of 2.55 and 2.556 (p. 192), also has decomposed vegetable matters. No particular trend of increasing or decreasing of sp.gr. with the depth is established. In bed soil also no definite trend of increasing or decreasing sp.gr. is noticed (p.191-194)(Table 57).

The maximum liquid limit (LL) of the cohesive soil is 80 per cent and the minimum is 26.47 per cent. The plasticity index (PI) is in the range of 12.21 to 31.87 per cent.
In the CL soil the LL is between 33.40 and 47 per cent and the PI between 15.14 and 20.53 per cent indicate low to medium plasticity of soil (Burmister, 1949, p. 402-433; Jumikis, 1967, p. 128-129). For the CI soil the LL ranges between 37.47 and 80 per cent and the PI between 12.21 and 29.25 per cent indicating medium to high plasticity of the soil (Ibid, 1949 and 1967). The LL of the ML soil found between 26.47 and 33.60 per cent shows low to medium elasticity. The only CH soil with LL of 61.60 per cent and PI of 31.87 per cent shows high degree of plasticity (p, 197-199) (Table 58).

The moisture content of the undisturbed soil samples ranges from 5.03 to 73.72 per cent. The lowest value is found in the SP soil, while the highest value is found in the ML soil. There is a wide variation of moisture content in different layers of soil in all the bore holes. A trend of decrease in moisture content with depth is noticed. While the fine-grained soils show higher moisture content, the sandy soils show relatively less moisture content. Amongst the fine grained soils, the moisture content in the CL soil is between 28.39 and 57.90 per cent, and in the ML soil is between 16.38 and 73.72 per cent. The only CH soil has moisture content of 38.04 per cent. Amongst the sandy soils, the range of moisture content in the SP soil is from 5.03 to 46.77 per cent, and in the SW soil from 14.51 to 31.74
The wet density of soil in general ranges between 1.18 and 2.30 gm/cc, and the dry density between 0.74 and 1.88 gm/cc. The CL soil is having dry density in the range of 1.28 to 1.63 gm/cc and wet density 1.94 to 2.28 gm/cc. The CI soil has dry density between 0.74 and 1.71 gm/cc, and wet density between 1.18 and 2.22 gm/cc. The dry density and the wet density of the ML soil range from 1.19 to 1.75 gm/cc and from 1.98 to 2.22 gm/cc. The CH soil has 1.31 gm/cc as dry density and 1.77 gm/cc as wet density. In the SP soil, the dry density ranges between 1.23 and 1.86 gm/cc, and the wet density between 1.62 and 2.30 gm/cc. The density of the SP soil in the Bore Holes 1, 3, 6, 10, 11 and 12 indicates loose mixed grained characteristic of the soil (Sehgal, 1974, p.45). The SP soil of Bore Holes 2, 4 and 7 shows presence of dense mixed grained sand and loose mixed grained sand (Ibid, 1974). But the SP soil of Bore Holes 5 and 8 indicates dense mixed grained sand. The SW soil is having dry density in the range of 1.54 to 1.88 gm/cc and wet density in the range of 2.05 to 2.26 gm/cc indicating dense uniform sand (Ibid, 1974)(p.207-210)(Table 60).

The CL soil has very low co-efficient of permeability between $10^{-5}$ and $10^{-6}$ cm/sec. The ML soil in general is having low to very low co-efficient of permeability between $10^{-4}$ and $10^{-5}$ cm/sec. The CI soil is having co-efficient of
permeability between $10^{-5}$ and $10^{-6}$ cm/sec indicating very low degree of permeability. The co-efficient of permeability of the only CH soil is having $10^{-5}$ cm/sec that indicates very low degree of permeability. Amongst the non-cohesive sandy soils, the SW soil shows medium to low degree of permeability between $10^{-3}$ and $10^{-4}$ cm/sec. The predominant SP soil in general is having medium co-efficient of permeability between $10^{-2}$ and $10^{-3}$ cm/sec, but this soil of upper layers upto 5m in Bore Hole 2, upto 6m in Bore Hole 4, upto 4.5m in Bore Hole 6, upto 1.5m in Bore Hole 9 and upto 5m in Bore Hole 11 and also at lower layer as seen in Bore Hole 10 from 8 to 9m is having low degree of permeability with $10^{-4}$ cm/sec. According to Casagrande and Fadum's (1939-40, Fig. 11, p. 23) chart for co-efficient of permeability the fine grained CL, ML, CI and CH soils of the area have poor drainage property. But the sandy SP and SW soils are indicating good drainage characteristic (p. 213-218)(Table 61).

The triaxial shear test shows that fine-grained ML, CI and CL soils show cohesion (C) in the range 0.064 to 0.89 kg/cm$^2$ and angle of internal friction ($\phi$) between 28 and 33.5°. Breaking up, the ML soil has C between 0.21 and 0.49 kg/cm$^2$, and $\phi$ between 28.5 and 31°; the CI has C between 0.121 and 0.89 kg/cm$^2$, and $\phi$ between 28 and 29.5°; the CL has C between 0.064 and 0.53 kg/cm$^2$, and $\phi$ between 28.7 and 29°. The only thin layer of fine-grained soil CH has 0.405
kg/cm² as C and 28.2° as $\varphi$. The predominant sandy SP and SW soils do not show cohesion, as C is zero. The $\varphi$ of SW soil is 30.5 to 35.5° and SP soil is 28.5 to 44°. A tendency of increase in the $\varphi$ value with the depth is marked, as coarse-grained soil increases with the depth. The $\varphi$ is usually less for uniformly textured fine-grained soil than for the soil with well graded texture, which has greater interlocking properties. The $\varphi$ for SP and SW soils, having coarse particles with permeable characteristic, is almost independent of moisture content. The magnitude of $\varphi$ for clean sand (Krey after Jumikis, 1967, p. 585) is practically the same above and below ground water table and is unaffected by water.

From the $\varphi$ value it is found that the magnitude of active earth pressure on the upper layers of fine-grained soil is larger, as $\varphi$ is less, because active earth pressure is a function of $\varphi$ (Jumikis, 1967, p. 585). The $\varphi$ value of SP soil indicates that with the increase of depth, the diameter of sand increases and compactness of soil becomes dense. The denser the soil, the more is the interlocking and hence the greater value of soil strength (Lambe, 1977, p. 94-95). The C in the cohesive soil increases with depth, as the moisture content decreases with the depth. The shear strength of the cohesive soil is very much affected by the moisture content (p. 220-224)(Table 62).
The CL soil has void ratio between 0.73 and 1.38, and porosity between 0.42 and 0.58, showing the characteristic of soft clay. The CI soil has void ratio between 0.71 and 1.25, and porosity between 0.42 and 0.55, indicating soft clay characteristics. But the CI layer from 0 to 1.5 m, which lies above CH soil is having high value of void ratio and porosity of 1.52 and 0.60 has the characteristic of soft slightly inorganic clay. In the ML soil the range of void ratio is from 0.42 to 1.21 and porosity from 0.29 to 0.55. The ML soil shows either of the following characteristics: (1) loose uniform sand with soft clay, (2) dense uniform sand with soft clay, (3) loose mixed grained sand with soft clay and (4) dense mixed grained sand with soft clay. However, the top ML soil found up to a depth of 3 m in the Bore Hole 14 with high void ratio of 2.02 and high porosity of 0.67 is having soft slightly inorganic clay characteristic. The only CH layer shows inorganic clay characteristic with 1.01 as void ratio and 0.50 as porosity. Amongst the sandy soils, the SW has void ratio between 0.42 and 0.85, and porosity between 0.30 and 0.46. The SW soil is generally having dense uniform sand characteristic but some layers are having either loose mixed grained sand or dense mixed grained sand or loose uniform sand characteristics. Amongst the other sandy soils, the predominant soil SP in general has void ratio between 0.32 and 0.68, and porosity between 0.30 and
The SP soil generally shows either loose mixed grained sand or loose uniform sand characteristics. But some layers show either of the following characteristics: (1) dense to loose mixed grained sand, (2) dense mixed grained sand, and (3) dense uniform sand. The low values of void ratio amounting to 0.13 from 6 to 6.5m, 0.29 from 18.5 to 23.5m in Bore Hole 6, 0.21 from 20.5 to 30.5m in Bore Hole 12, 0.16 from 12 to 13.5m in Bore Hole 13 and 0.17 from 10.5 to 16m in Bore Hole 14 with corresponding low values of porosity of 0.11, 0.22, 0.17, 0.14 and 0.14 indicate low moisture content of soil. On the other hand, the high void ratio of 1.24 from 7.5 to 9m in Bore Hole 2 and 1.17 from 7.5 to 9m in Bore Hole 11 with corresponding high porosity values of 0.55 and 0.54 are due to the high moisture content of the soil (p.224-229)(Table 63).

Spurs and embankments are commonly in use as bank protection measures at Maijan and Mathola including Dibrugarh. For a silt-laden river like the Brahmaputra, permeable spurs are effective and it has been used in combination with other river protection measures at Maijan and Mathola. In a braided river like the Brahmaputra, after the subsidence of flood, large shoals and islands are formed. These shoals and islands which change positions constantly during flood, become stable during ordinary stage as the transporting power is reduced. As a result channel wanders in new directions around the
islands and attack the bank causing erosion. As this direct attack may be in the zone between the two spurs, so it is necessary to supplement these impermeable spurs by intermediate permeable one (Wadekar, 1971, p. 222, 226). This is applicable in case of Maijan and Mathola including Dibrugarh (p. 230-232).

Antierosional and flood control measures at Maijan and Mathola include 7 impermeable spurs, 26 permeable spurs, 10 km embankment and 23 km diversion drain. The main protection work was over by 1955. The river channel configuration is responsible for erosion and onward shifting. Between 1961 and 1966, the river shifted and eroded the down-stream area around Mohanaghat but since 1967 erosion took place upstream of Dibrugarh and the trend is still continuing. At Maijan and Mathola the erosion is acute since 1969. Though the antierosional measures controlled the erosion to a certain extent at Maijan and Mathola yet it is much from the eastern reach of Mathola to further upstream covering a length of 10 km. During the flood of 1954 at Dibrugarh; the bank caved 6 km at a stretch. To arrest this 5 stone spurs, 4 of 60m and 1 of 120m length, each with a crest of 30m width and 1.5m thick was constructed at variable interval of 600 to 1300m. To augment the stone spur protection, 21 timber spurs of 60m length were placed at varying intervals between the spurs and on the upstream and downstream ends.
In addition, bamboo frames with brush suspension and bamboo spurs were placed all along the bank under erosion (p. 233-236).

There are 12 permeable spurs between the upstream of Maijan stone spur and the western boundary of the Mathola beel. There are also one 36.5m long Maijan stone spur and one 206m long land spur. The D.R.T. road running parallel to the Brahmaputra also functions like an embankment at Maijan and Mathola. There was an embankment of 4.5m crest width and 8:1 Hydraulic gradient. This was constructed after the flood of 1955, which was raised and strengthened in 1962 and 1971 (p. 236-237).

Because of the unstable characteristics of the banks, the protection work at one reach of the Brahmaputra forms deep embayments upstream and thereby creates fresh erosion. The longest Kahai spur throughout the monsoon season face the frontal attack and a shoal is formed in front of it, this restricting the flow of flood water. During 1967 flood, the river attack shifted to the upstream of Maijan and heavy erosion took place there and at Mathola. This was the case also in 1968 and 1969. After the flood of 1969 a shoal was formed in front of Maijan spur that gradually washed away and there was severe river action on the south bank. The D.R.T. road was inundated and Maijan beel was flooded. During 1970, heavy erosion at a length of 700m on the upstream of Maijan bridge and the D.R.T. road took place.
Almost all the pile spurs at Maijan and Mathola were destructed from 1970 onwards owing to the severe erosion. The land spur at Mathola, to a certain extent arrest the erosion downstream, but on the upstream, the erosion is taking place at an alarming rate thus threatening the eastern part of Mathola, Nagaghoolie and Oakland areas (p. 237-239).

From the above discussions the following conclusions are put forwarded.

The Brahmaputra has a significant role for composing the physiography of the peneplained area around Maijan and Mathola particularly after the great earthquake of 1950. In each monsoonal season, the high velocity of the water erodes the southern bank considerably as this is composed mainly of sand and silt. This has caused migration of the bank line more towards south. The width of the river here is 10 to 15 km as a result of the erosion. The heavy sediment load causes wide and shallow drenched bed with sand bars. The bed configuration changes drastically during the different flow patterns. The total flood discharge is very high estimating at 33,960 cumec.

The type of climate in Assam is sub-tropical with humid summer and dry winter. The north-easterly wind influences the climate of the Brahmaputra valley. Maijan and Mathola along with Dibrugarh show an average rainfall of 2442.9 mm, annually.
In Upper Assam the tilted faulted basement complex is overlaid by the Tertiary formation. The Tertiary formation shows an excellent development and this is not again stratigraphically continuous. Owing to the thrusts and the faults in the three directions, the region is geologically unstable and seismically most active. This high seismicity is responsible for the continuous upliftment and related down sinking.

After the earthquake of 1950 Dihang, Dibang, Tiding and Subansiri rivers were blocked for sometime and then bursted causing widespread havoc. The extensive hill slides in the catchment of the Brahmaputra elevated the bed level of the river. The innumerable timber logs embedded therein made the deposit difficult to wash away for which the river formed new channels. The sudden new courses caused destruction along their routes. The silting of the river bed increased the flood spill and thereby reduced the capacity of the channel. A sudden rise of about 3m in the low water at Maijan and Mathola was recorded. The flood and the erosional problem became pronounced in the area and to its north bank.

The Guijan-Oakland fault scrap developed in the north is the youngest Saikhowa formation composed of grey sand and silt. The northern side of this scrap was tilted towards the south and this is one of the reasons of the bank
erosion and shifting towards south. As the Brahmaputra plain is having a very low gradient, the river is unable to cut its channel deep and cuts sideways. After the 1950 earthquake the Brahmaputra eroded 6 km of the south bank at Maijan and Mathola.

The Brahmaputra has the highest maximum discharge of 72670 cumec which is second only to Mahanadi. In respect of the average discharge and annual load, the Brahmaputra is occupying the fourth and second position in the world. The acute flood congestion in the valley is due to the very high specific yield of the river which is the topmost in the world.

The major floods occur during June to August. The rainfall associated with the monsoon depression cause major floods in the region. During April and May also the region receives a fairly good amount of rainfall for large scale thunderstrom. The heavy rain in the upper reach during monsoon is also a contributor to the floods in the Brahmaputra.

After the 1950 earthquake the flood lift of the Brahmaputra was reduced in almost all the places and it is maximum at Dibrugarh. The flood lift reduction is more pronounced in the upper portion than the lower portion. This reduction lift in the upper portion has resulted acute erosional problem.
The observations at Pasighat, Besamara, Pandu and Jogighopa show that the discharge of the Brahmaputra show an increase from the upstream to the downstream. The maximum discharge during July and August is between 68.11 and 72.71 per cent. The average annual yield is between 17.73 and 51.44 m. Ha.m.

The Brahmaputra has a catchment area of 2,02,100 Sq. km and discharge of 6,23,000 cumec. The catchment area of the Brahmaputra shows that the north bank tributaries is having an area of 75,650 Sq. km and the south bank tributaries 52,600 sq. km. It is seen that (1) the catchment area of the north bank tributaries is higher than that of the south bank tributaries; (2) the discharge contribution to the parent stream from the north bank tributaries is higher than that of the south bank tributaries; (3) the silt yield to the catchment of the north bank tributaries is approximately 6 times higher than that of the south bank tributaries. Therefore the total brought of the north bank tributaries is about 9 times higher than that of the total brought of the south bank tributaries.

The southward shifting of the Brahmaputra has caused the erosion more pronounced in the upper reach. As the river is confined between the basement complex from Gauhati to Goalpara, northward shifting is resulted but it is again migrated towards southward beyond Goalpara.
After the earthquake of 1950, Maijan and Mathola including Dibrugarh are subjected to acute erosion. The protection measures at Dibrugarh further aggravate the condition at Maijan and Mathola by deflecting current. The formation and vanishing of shoals cause channel shifting. The bank has migrated towards south leaving behind newly formed sandbars with increased erosion and encroachment. The top soil is in a very loose state of compaction. The bearing capacity of the soil upto a maximum depth of 4.5m is very low and cannot withstand the external pressure.

Upto a depth of 30.5m, the sandy soil around Maijan and Mathola dominates the other varieties. The soil is composed of fine granular material with no binder and no cohesion for which cannot withstand the onslaught of the heavy flood and is therefore susceptible to erosion even at low velocity. Erosions even during non-monsoon months are not uncommon though it is much less compared to monsoon while the load of water is very high.

The cohesive soil is found upto a maximum depth of 8m. The soil has liquid limit between 26.47 and 80 percent. In the predominant CI soil, the liquid limit is between 37.47 and 80 percent, indicates that the plasticity is medium to high. The effect of shrinkage produces cracks in the soil. During monsoon the cracks of the soil are filled with water and become saturated, thus increasing
the weight of the earthmass that in turn slides down.

The upper layer soil becomes fully saturated by the heavy rainfall during monsoon and is subjected to erosion. It is noted that the moisture content is higher at the upper layers mainly composed of fine grained soils than at the lower layers composed of coarse grained soil.

The dense sand is generally encountered below 5m is of loose nature. As the area is earthquake prone, when earthquake occurs, the shear stress of the soil temporarily increases with the development of negative pore pressure. Then the loose materials show an opposite tendency by temporary transformation of the granular materials into a thick slurry suspension. The loss of cohesion was attributed to drawing of water into zones of negative pore pressure which effects the top fine grained soils, resulting in fissures, that facilitates the movement of water. The extent of reduction in $\varphi$ is generally greater in more plastic clays. In fine grained soil the strength may drop to the residual value in the vicinity of old slides or more or less continuous zones of slickensides as is noticed around Maijan and Mathola. The residual stress also acts as disturbing force in slides of natural slopes (Ahmed and Maswood, 1984).

The top soil with high void ratio and porosity is less permeable and as such consolidation at the top does
not occur. Hence during the high flood, the top is eroded by the heavy water pressure. The sandy soil, with less void ratio and porosity, medium degree of permeability and onslaught of water pressure, is also subjected to erosion.

The anti-erosional measures, viz. porcupine screen and timber spurs are not at all effective to control erosion as these structures cannot withstand the onslaught velocity of the flood like the Brahmaputra. To tackle the flood problem in a more suitable way, construction of embankments on the Brahmaputra and its tributaries has been employed. Such construction of embankments was also started as short term protection measures and these have shown better results in protecting the banks. Storage reservoirs and detention dams on the tributaries of the Brahmaputra are some of the contemplated long term measures which with the already existing net-work of embankment system would reduce the flood congestion in the valley.

The composition of the bank soil at the north bank is more or less similar to that of the south bank. Hence erosion at the south bank is not only due to the composition of the soil alone. The Brahmaputra plain is monotonously flat with a very low gradient. Owing to the low gradient, the river has hardly any strength to cut its channel deep and cuts sideways. The seismic profiles through the Upper Assam Valley also tend to show swarms of fault.
The Naga Thrust has affected the southern bank of the Brahmaputra river causing sinking of the bank wherein the erosion is remarkable.

The shifting of the mouth of the numerous south bank tributaries to the east is also responsible for the southward shifting of the Brahmaputra.

From Gauhati to Goalpara the river is confined in between the rocks of the basement complex. In this region, baring Palasbari, the river is migrating towards north. At Gauhati, the Kamakhya hill with its granitic outcrops is spreading towards the river and acts as a gigantic natural spur. Because of this, and for the Umananda hill in the midstream of the Brahmaputra at Gauhati, the bank is free from erosion. These two help in diverting the current from the south bank. But the current with renewed vigour hit the south bank at Palasbari, a few kilometre downstream and as a result a major portion of this is vanished. Further, beyond Palasbari, the bank has no rock outcrop. The bank of the Brahmaputra cannot be considered as firm, except where there are rock outcrops.