Documentation on past disasters, their impact, Measures taken, vulnerable areas in Assam.

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1. Introduction

Northeastern Region, including Assam is prone to natural disasters like earthquake, floods, landslides, cyclone and occasional draught .The population in the NER of India- particularly Assam is subjected to perennial floods, landslides and environmental degradations. Disasters cause sudden disruption to the normal life of a society and cause enormous damage to property to a great extent. Review of the past major disasters show a very grim picture of the region in regards to potential disasters in future. The lesson learnt from these past events may guide us to take appropriate decisions in time of disasters. A brief account of some of the disasters in Assam is given below:

1.1. Earthquake Occurrences

Wedge between two plate collision boundaries, the Himalayan in the north and the Indburman in the east, the Northeastern region is one of the seismically most active regions of the world (Fig.1). With complex tectonic and geology set up of the region and intense continental convergence of the northward moving Indian plate at the rate of 20+03mm/year can produce earthquakes of magnitudes 8 and above every few hundred years. Consequently it has been under continual threat from major earthquakes and the subject being seriously debated in national and international forums.. The two great earthquakes of magnitudes 8.7 in 1897 and 1950 are memorable events in the annals of earthquake history of the world. These earthquakes have been so intense that the rivers changed their courses, ground elevations immensely affected. Besides as many as twenty destructive earthquakes of magnitudes 6~7 rocked this region during the past century. Some better known damaging earthquakes of NE Region are described below:

Significant earthquakes in assam

Both instrumented and non-instrumented events are listed below. Reported magnitudes are listed for instrumented events while the maximum observed intensities are listed for non-instrumented shocks. Some of the latter might also have magnitudes assigned to them by various authors, in which case the reference is stated.

Earthquakes during Non-Instrumental Period in Assam

- 1548 earthquake during the reign of king Suklenfa of Ahom kingdom
- 1596 earthquake during the reign of king Sukhamfa - do-
- 1601 earthquake during the reign of king Susengfa - do-
- 1642 earthquake during the reign of king Sarufa. - do-
- 1663 earthquake when Mirjumla fled away from Assam
- 1696 earthquake during the reign of king Rudra Singha. - do-
- 1732 earthquake.
- 1759 earthquake during the reign of king Rudra Singha - do-
- 1772 earthquake of relatively severe intensity.
- 1832 earthquake.
- 1848 earthquake.

Earthquake during Instrumental Period In Assam

The following major Earthquakes occurred in the years 1869, 1897, 1923**,** 1930, 1943, 1947, 1950, 1985, 1984 &1988.

1869 - Cachar (Assam), India, M 7.5

Date	10th January 1869
Epicentre:	9.4 kilometers N of Kumbhir (Assam), India
Latitude:	25.00º N
Longitude:	93.00º E
Origin Time:	11:45 UTC / 17:15 IST
Magnitude:	7.5
Max. Intensity:	VIII

Cachar (Assam) India earthquake

The earthquake that struck Cachar, Assam on 10th January 1869 caused heavy damage in the region The epicentre of this earthquake located in the Cachar region of Assam.

The impact of the shock was felt over 6,50,000 square kilometres. There was heavy damage in the towns of Cherrapunji, Silchar, Shillong and Sylhet and also in Manipur. Fissures opened on the banks of the Surma river and sand vents threw up great amounts of sand and water. The epicentral tract was 30 - 45 kilometres long and 5 - 6 kilometres wide lying on the northern border of the Jaintia Hills. The hypocentre had a depth of 50 kilometres.

1897 - Near Rongjoli, Assam, India, Ms 8.7

Date	12th June 1897
Epicentre:	14 kilometres ESE of Sangsik (Meghalaya), India
Latitude:	25.50° N
Longitude:	91.00° E
Origin Time:	11:41 UTC / 17:11 IST
Magnitude:	Ms 8.7

Bent rails at Rangapara,
Tezpur-Balipara Tramway

SAND VENT AT ROWMARI, 12 JUNE, 1897

Ground effect in Shillong Plateau

All Saints' Church, Shillong

This was one of the most powerful earthquake in the Indian sub-continent and probably one of the largest known anywhere. The quake wrecked havoc across south-west of the present states of Assam, Meghalaya and Bangladesh. About1542 people were killed and hundreds more injured. Damage from the earthquake extended into Kolkata where dozens of buildings were badly damaged or partially collapsed. Shaking from the event was felt across India, as far as Ahmedabad and Peshawar. Seiches were also observed in Myanmar.

It had a magnitude estimated variously between Ms 8.7 and Mw 8.. The earliest report of extreme ground acceleration is recorded for this earthquake, where stones on the roads of Shillong as said to have "vibrated like peas on a drum". Recent studies also indicate that this might have been a blind earthquake because there was no surface exposure of the fracture

Previously this earthquake was thought to have been caused by a slip along north dipping fault that forms the plate boundary under the eastern Himalayas. New studies show that it originated on a south-south-west dipping fault, named the Oldham Fault, bounding the north-western section of the Shillong Plateau. During the event, the total slip on this fault, amounted to 16 metres, which is among the greatest for any known earthquake. Geodetic observations indicate that the rupture extended up to 35 kilometres into the crust and might have even cut though its base, which in this region, lies at a depth of 43-46 kilometres. The rupture of the Oldham Fault terminated at a depth of 9 kilometres from the surface of the earth, implying that this event was blind.

Post-earthquake surveys mapped large fault scarps on the western edge of the Shillong Plateau, most notably the Chedrang and Samin fault scarps. The former, which follows the Chedrang River, perhaps suggests an old line of weakness and resulted in numerous sag ponds and waterfalls as the drainage was disrupted. The Cedrang fault extended over 19km. The maximum offset recorded here was 35 feet. These faults were the result of large scale secondary faulting that accompanies blind earthquakes, which is often observed and sometimes misinterpreted as the primary rupture. The high ratio of slip to fault length implies a high static stress drop at the high end of the observed range and this is consistent with the violence of the shock, where observations indicative of accelerations in excess of *1g* were noted.

The earthquake caused great destruction to many towns in Assam and Meghalaya. Most often referred to is Shillong and Guwahati, where most of the structures like the Telegraph House, were demolished.For example, all stone works in the neibourhood of Shillong, including most of the bridges,were absolutely leveled to the ground.The stone houses ,and particularly the Churches, were reduced flat heaps rubles.Two 30-40 ft tall monuments of excellent cut stone work were ruined. Ekra-built buildings also got damaged. Plank buildings of wooden framework and resting unattached on the ground remained intact.

The severity of the effects in this area requires that this entire area is in the near field.Oldham has drawn the contour line encompassing the known cases of severe damage to indicate the "limit of severe damage" resembling a hat (Fig.2). On the basis of Oldham's descriptions another contour was drawn (Seeber & Armbruster, 1981) to show the limit intensity of VII to IX, which extends ~550km in E-W direction. This contour line delimits the intense liquefaction in the alluvial plains. The western extent of the 1897 landslides and intense liquefaction are sharply defined and abut with the 1934 Bihar earthquake landslides and "slump belt" respectively. According to them the 1897 rupture probably did not extend farther than longitude 93*E.

Landslides were reported all across the Garo Hills. The towns of Dhubri, Goalpara, Guwahati and Coach Bihar in Assam and West Bengal were heavily damaged. Earthquake fountains, some 4 feet high, were reported from Dhubri. The Jolboda and Krishnai bridges were also ruined. At Goalpara, a 10-foot wave from the Brahmaputra (possible subsidence), swept into the area, destroying the bazaar and many pukka buildings. Ground waves were reported from Nalbari, where the observer saw rice fields rise and fall as the waves passed under them. At Guwahati, the earth subsided along the Brahmaputra and several sand vents were formed. The Brahmaputra is also reported to have risen by 7.6 metres and even reversed its flow during the shock. Large scale subsidence was also reported from Muktagacha, Bangladesh. This town was constructed on reclaimed ground. . Fissures and sand blows occurred over a wide area of Assam, Meghalaya, West Bengal and northern Bangladesh. Fissures and sand blows were also reported from some parts of Bihar.

The earthquake affected both Dhaka and Kolkata, which are presently the most densely populated cities in the region. At Dhaka, most of the buildings were heavily damaged and many collapsed. Sand vents also occurred at many places in the city. Kolkata, was also badly affected, though to a much lesser extent than Dhaka. Walls and parapets came off many buildings, and the steeples of some churches were broken off. Damage was reported from Bardhwan, Bhagalpur, Behrampur, Comillah, Chittagong, Jamalpur, Jessore, Khulna, Monghyr (Munger), Murshidabad, Naokhali (Maijdi) and Purnea.

Shaking effects of the main shock were experienced over a wide area of the subcontinent as far as Himachal Pradesh, Myanmar and the present-day Indo-Pakistan border. At towns like Lucknow and Allahabad, the shaking was strong enough to displace crockery. At Kathmandu, trees and free standing objects swayed and people ran outdoors. To the south it was felt at Bezwada in Andhra Pradesh and in the west upto Sehore, in Madhya Pradesh. Chandeliers and lamps oscillated at Piploda and Khandwa. It was not felt in Mumbai, though instruments did pick up the disturbance. Long period effects such as water oscillations were also reported. At Ahmedabad, water in a tank was set into motion and it spilled over partitions in the tank. In Myanmar, on the Theingale River, near Tagaung, no tremors were felt but water in an old river course was "lapping along its banks" and at Thayetmyo, water in a tank began to oscillate back and forth for about three minutes, rising 18 inches on the side of the tank. Hot springs at Sitakund became more active following the quake, while those at Rajgir discharged coloured water for three days.

Dozens of aftershocks were felt in the region. At the Bordwar tea estate, a week after the main shock, the surface of a glass of water standing on a table was in a constant state of tremor. At Tura, a hanging lamp was kept constantly on the swing for 3 days. On June 13, at around 01:30 local time (LT) and again at 13:00 LT two severe shocks were felt. The earlier event was strong enough to be felt at Kolkata and as far as Sutna, which lies beyond Allahabad. Two more shocks, were felt at Kolkata, at 22:40 LT on June 13 and at 00:47 LT on June 14. Later, on June 22, at 07:24 LT, June 29, at 22:19 LT and October 2, at 20:58 LT, strong aftershocks were felt as far as Kolkata. The last event felt in Kolkata, occurred at 01:40 LT on October 9, 1897.

1923 – (Meghalaya), India, Ms 7.1

Date	9th September 1923
Epicentre:	South Meghalaya, India
Latitude:	25.25° N
Longitude:	91° E
Origin Time:	22:03:42 IST
Magnitude:	Ms 7.1

A strong earthquake shook parts of south of Meghalaya, Assam, West Bengal and Bangladesh on the morning of 9th September 1923.

The earthquake causes heavy damages at Mymensingh, Cherrapunji, Guwahati. The earthquake was also felt at Barisal, Chittagong, Nagrakata, Midnapore, Srimangal, Sivasagar,Tatung, Salonah, Borjuli, Narayanganj.

1930 - Dhubri (Assam), India, Ms 7.1

Date	2nd July 1930
Epicentre:	3.9 kms NNW of Dabigiri (Meghalaya), India
Latitude:	25.80° N
Longitude:	90.20° E
Origin Time:	21:03:34.4 UTC / 03:23:34.4 IST
Magnitude:	Ms 7.1

A strong earthquake shook parts of western Assam, West Bengal and Bangladesh on the morning of 2nd July 1930. Strong as it was the Dhubri earthquake most surprisingly but thankfully did not cause any fatalities, though a few were injured. This, in spite of the fact that it hit in the early hours of the morning. Most of the buildings in Dhubri and the surrounding areas were destroyed in this shock.

It was felt as far away as Kolkata, Chittagong, Dibrugarh, and Patna. It was felt nearly all over northern-eastern and eastern India. This earthquake was followed by six major aftershocks of magnitude 6. The first three were in the immediate epicentral region south of Dhubri. The next three were in the region southeast of Goalpara, on the Assam-Meghalaya border.

1941 - Near Tezpur, Assam, Ms 6.5

Date	21 January 1941
Epicentre:	Near Tezpur, Assam
Latitude:	26.50 N
Longitude:	92.50 E
Origin Time:	02:30:16.0 UTC
Magnitude:	Ms 6.5

1943 - Near Hojai (Assam), India, Ms 7.2

Date	23rd October 1943
Epicentre:	13.6 kms E of Hojai (Assam), India
Latitude:	26.00° N
Longitude:	93.00° E
Origin Time:	17:23:17 UTC / 22:53:17 IST
Magnitude:	Ms 7.2

At around 11 PM on the 23rd of October 1943, a major earthquake rattled northeast India. The shock had a magnitude of 6.9 (Mw). This would be the first of three powerful earthquakes that would hit the region in the next seven years.

Felt strongly in the region and in neighbouring Manipur. Not much is known about this earthquake as it occurred at the height of World War II when the threat of Japanese aggression on the eastern border of British India was extremely high.
Doug Warr, who was stationed with a medical unit near Dimapur, gives an eyewitness account of the events of that night. "At the time I was with a medical unit stationed on the Manipur road, seven miles from Dimapur. I was awakened in the night by violent shaking - so violent that I found myself clinging desperately to the charpoy to avoid being shaken off. There was a rumbling noise. I don't know how long it lasted - perhaps a few minutes - and then it subsided to occasional slight tremors. In the morning we discovered that there were fissures and great unevenness in what had previously been level ground, trees had fallen and buildings had been damaged. There was some damage to the Manipur road, I think to the bridges on either side of my unit, but for security reasons a complete ban was imposed on the mention of any consequences of the quake so we never heard precise details. Of course, rumour was rife and we heard lurid accounts of fissures that had opened and swallowed men and vehicles but these were never substantiated and may have been figments of somebody's imagination. We shall never know”. – Dong Warr.

Dimapur was 74.5 kilometres SSW of the epicentre. Based on this account it is possible that the MM intensity near Dimapur was VIII to IX.

1947 - Arunachal Pradesh, India, Ms 7.7

Date	29th July 1947
Epicentre:	Arunachal Pradesh, India
Latitude:	28.80° N
Longitude:	93.70° E
Origin Time:	13:43:20 IST
Magnitude:	Ms 7.7

The earthquake of 29th July, 1947, had a magnitude of 7.7 This earthquake is felt over larger region – Assam, Bengal (upto Kolkata) & Bihar (upto Purnea).

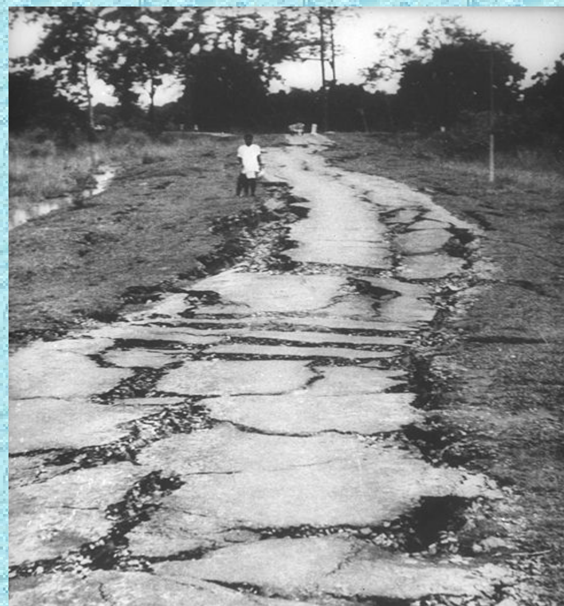
At Jorhat in Assam water overflowed riverbanks. At Dibrugarh, Jorhat & Tezpur crack in walls & failure of electricity at Guwahati. The earthquake is also felt at Silchar, Kathmandu, Rajsahi, Krishnagar, Lasha, Cooch-Bihar, Mymensingh, Dhubri, Rangpur, Tezpur, Srimangal, Bogra, Kalimpong, Comilla, Darjeeling, Guwahati, Purnea.

1950 - Arunachal Pradesh, India, Mw 8.7

Date	15th August 1950
Epicentre:	20.7 kilometers NW of Tajobum (Arunachal Pradesh), India
Latitude:	28.50° N
Longitude:	96.50° E
Origin Time:	14:09:28.5 UTC / 19:39:28.5 IST
Magnitude:	Ms 8.7,

North Lakhimpur, Assam Bridge on Ranganadi

Saikoaghat, Assam.



Cracks and fissures in Upper Assam Trunk Road
15TH AUGUST, 1950

This "Independence Day" earthquake was the 6th largest earthquake of the 20th century. Though it hit in a mountainous region along India's international border with China, 1500 people was killed and the drainage of the region was greatly affected. The resultant floods were the cause of most of the fatalities aftermath of this earthquake. The initial shock was followed by thousands of aftershocks, some of which were big earthquakes enough to be reckoned.

It had a magnitude of 8.7 and struck a relatively sparsely populated region along the Indo-China border. This earthquake is often referred to as the "Assam Earthquake of 1950".

The earthquake occurred at 19:39 PM on August 15, 1950. It was felt throughout north-eastern India and in many parts of eastern India. It was also felt throughout Bangladesh, Bhutan and Myanmar. Damage occurred in the entire region as far as Kolkata. It was felt across a wide area of the subcontinent, over an area totaling 4.5 million square miles.

There was widespread devastation in Upper Assam, the Abor Hills and the Mishmi Hills. The region that suffered the most damage to life and property was 15,000 square miles. This included the districts of Jorhat, Lahkimpur, Sibsagar and Sadiya, in Assam. Dibrugarh and Saikoaghat were among the worst affected areas. Railway communications were disrupted due to damage to tracks and bridges. However, the area that suffered damage and encompassed by the isoseist VIII was nearly 75,000 square miles. There were fissures in the earth, from which water and sand was emitted. These are called sand vents and represent liquefaction due to intense ground shaking. Vast areas of land either were elevated or subsided, altering the drainage of the region.

There were huge landslides in the mountains and these dammed tributaries of the Bramaputra River, like the Dihang, Dihing and Subansiri. The latter was dammed by landslides for several days and some worst liquefaction damage was reported from the area where the river enters the plains.These were breached a few days later and resulted in serious flooding. Most of the loss of life was as a result of the flooding and not directly from the earthquake. Pilots flying over the meizoseismal area reported great changes in topography; this was largely due to enormous slides, some of which were photographed. Alterations of relief were brought about by many rockfalls in the Mishmi Hills and destruction of forest areas. 1,526 deaths were recorded, out of which 600 were from Lakhimpur and Sibsagar districts alone. In the Arbor Hills 70 villages were destroyed with 156 casualties due to landslides. Dykes blocked the tributaries of the Brahmaputra; that in the Dibang valley broke without causing damage, but that at Subansiri opened after an interval of 8 days and the wave, 7 metres high, submerged several villages and killed 532 persons.Mathur concluded that at least $5x10^{10}$ cubic metres of material was involved in the sliding.This is about 30 times of the average load of detritus carried by the river Brahmaputra annually (Fig.3).

F. Kingdon-Ward, a botanical explorer at Rima, very near to the epicentre, heard heavy explosive sounds. These sounds were also heard at many places in India and Myanmar, at distances of over 750 miles. Though his primary concern was getting back to India, he did confirm violent shaking at Rima as well as extensive landslides. Anders Kvale coined the term seismic seiche in 1955 to describe oscillations of lake levels in Norway and England caused by the earthquake.

This earthquake was caused due to a slip on the Jiali and Po Chu Faults in southern Xizang, along the border with northeast India. The fault plane mechanisms for this event indicates strike-slip faulting (Ben-Menahem et al. 1974) with one of the planes striking NW. Surface faulting is thought to have also occurred as a result of the quake. A recent fault plane solution by Chen & Molnar (1977) suggested a plane dipping NW with a slip in the dip direction of the plane. According to this model the source of all known great earthquakes, that is, the Himalayan detachment extends further east than the surface termination of the Himalaya, and also the locus of the 1950 event. The earthquake was followed by a large number of aftershocks, most of which were of magnitude 6.0 or greater. These were very frequent following the earthquake and continued for many years after the main shock. Their frequency however kept on decreasing with the passage of time. The aftershock zone extended from 94 degrees east longitude to 97 degree east longitude. The aftershocks Chen and Molnar, 1977) are located primarily in the central portion of themeizoseismal area, and extended considerably beyond the limit of the landslides to the north and to the southeast (Fig.3).

The most dramatic feature of the 1950 event was landslides. The landslides covered15,000 sq. km (Mathur,1953).According to him at least $5x10^{10}$ m^3 of material was The occurrence of landslides in the mountains and extensive liquefaction in the alluvial plains correspond closely to severe damage to buildings, roads and rails, etc involved in the sliding. This is about 30 times the average yearly amount of detritus carried by the Brahmaputra river.

The Subansiri river was dammed by landslides for four days (Poddar, 1953) and worst liquefaction damage was reported from this area where this river enters the plains. The areas of most severe landslides correspond to the deepest gorges of the meizoseismal area along the Dihang, the Dibang and the Luhit rivers.

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1954 - Arunachal Pradesh, India, Ms 7.7

Date	21st March 1954
Epicentre:	Manipur-Burma border
Latitude:	24.2^{o} N
Longitude:	95.1^{o} E
Origin Time:	23:42:17 IST
Magnitude:	Ms 7.7

The shock has a magnitude of 7.7 and originating from Manipur-Burma border. The shock was felt widely over whole of Assam, Bengal & parts of Bihar & Orissa. Minor damages reported from parts of Assam.

1957 - Arunachal Pradesh, India, Ms 7

Date	1st July 1957
Epicentre:	Near Indo-Burma border
Latitude:	25^{o} N
Longitude:	94^{o} E
Origin Time:	19:30:20 IST
Magnitude:	Ms 7

This earthquake of 1st July, 1957 had the magnitude of 7.0 and it has the epicenter near Indo-Burma border. This earthquake is widely felt over Assam, Manipur, Tripura, East Pakistan and parts of West Bengal & Bihar. No report form Burma is available. According to the press, only Silchar (Cachar) reported minor property damage. The shock was felt at Tezpur, Halflong, Guwahati, Kailasahar, Silchar, North Lokhimpur, Rowriha, Kumbhirgram, Kohima, Dhubri, Lumding, Pasighat, Imphal, Bindukuri, Shillong, Mazbat, Goalpara, Agartala.

1984 – Silchar (Assam), India, Mw 6.0

Date	31st December 1984
Epicentre:	SSE of Silchar (Assam), India
Latitude:	24.64^{o} N
Longitude:	92.89^{o} E
Origin Time:	23:33:37 UTC
Magnitude:	Mw 6.0

20 people were killed in Cachar District and a 100 were injured. This quake was "forecast" on the basis of a seismic swarm, which was followed by a period of quiescence.

This earthquake affected an area of about 250sq km. Damage seem to be of moderate nature except around Sonaimukh Bazar area.The Sonaimukh bridge over the Sonai river, afew school buildings got severely damaged.The Sonaimukh bridge was dislodged from the abutment towards SE direction as a result the bridge was closed to traffic. Two furlongs away from the said bridge , the Nitya Gopal High School and the Sonai Senior Madrassa were severely damaged. These schools are housed in traditional Assam type buildings having walls made of ikra or bamboo strips being cement plastered. Unfortunately the half brick walls were resting on the floor rather than to the foundation.The wall fell towards north. The entire desk –bench were thrown haphazardly over the floor, the ceiling fans got twisted, heavy almirah also tilted. The boundary walls of both the schools were raged to ground. A few furlong away two mosques were also affected and in one the bell tower was thrown to a distance of about 20ft. Numerous cracks developed on the floor and walls. The affect on the bridge over the Rukmini river was there.

1985 – Tipi (Arunachal), India, M 5.3

Date	12^{th} October 1985
Epicentre:	Assam –Arunachal Boundary, India
Latitude:	27.1 N
Longitude:	92.5 E
Origin Time:	
Magnitude:	M 5.3

The zone confining to MBF near Tipi experienced an earthquake of magnitude 5.3 on October 12^{th}, 1985 at a depth of 9 km. Later, numerous events of magnitudes $3.0 < Md < 4.5$ occurred in this zone at depths 10-30 km. Kameng fault is also passing vertically and meeting MBF though this point. This is one of the zone where the the Himalayas change trend from E-W to ENE- WSWand gradually assume NE-SW trend.

This earthquake caused extensive damage in and around Tipi .The orchid farm at Tipi and its housing colony suffered damage. There was no casualty. The earthquake was followed by a large number of aftershocks of moderate strength.

1988 - India, Ms 7.3

Date	6th August 1988
Epicentre:	Indo-Myanmar
Latitude:	24.149^{o} N
Longitude:	95.127^{o} E
Origin Time:	05:03 IST
Magnitude:	Ms 7.3

This was a significant earthquake, which occurred on the Indo –Burma border. Its hypocentre was at a depth of 91km. Widespread damage was there at Jorhat, Golaghat, Dirugarh and Manipur. However, because of its occurrence at a considerable depth the effect was comparatively low.

1.2 Need of Earthquake Disaster Mitigation Measures

Based on the intensity geotectectonic features and potential hazards from earthquakes the entire northeastern region has been included in the severe seismic Zone V of BIS code.. The construction of high rise buildings in Guwahati and other cities of this region have been continually flouting the rules of BIS codes. This has become a serious concern of the government and public at large. Invariably, we ourselves have created such conditions which make people vulnerable by permitting excessive urbanization in a region of heightened danger. We have allowed multiple constructions which hitherto should have been rejected considering high seismic risk in the region. Identical conditions prevail in all towns of Assam not to speak of other States capitals of the region. The earthquakes of 1897 and 1950 when occurred , Assam and present NE States were sparsely populated. Urbanisation was totally absent, therefore death toll was very low, a mere 1500 odd people were killed. If the region, which is now densely populated, is to be struck by earthquakes of the same size, the results would be unmanageable. The aspect of the height of buildings has not been adhered to inspite of high seismic risk. Another aspect which afflicts the city like Guwahati, is the hill belt having a fragile ecosystem landslides in the hill belt sends a danger signal for a catastrophe. To add to these the dangerous areas, the cities are plagued by dense settlements, limited vacant space and narrow streets.

Furthermore, it may be noted that in 1950 a single oil refinery was in operation at Digboi. During these years three more refineries have been added. Nonetheless, about thousand km petroleum crude transporting pipeline from Naharkatia to Barauni has been laid only last decades. Continuous transportation of highly inflamable products across the entire length of the narrow valley having large concentration of thickly populated villages and towns is a matter of concern. Recent damages caused by the so-called militant bomb blast are an eye opener. Surprisingly this pipeline crosses most of the railway bridges, culverts and pools. Obviously, in any disastrous events the communication link will be destroyed and paralyzed. These developments, therefore, call for a much better standard of preparedness than was necessary in the past. Therefore, a high degree of societal activation would be required to implement hazard mitigation measures. This kind of awakening is necessary if we are to move beyond taking action only as reaction to disaster rather than anticipation.

Earthquakes are natural hazards, but the disasters are man-made. As has been qouted, "earthquakes don't kill, unsafe buildings do". It is the high vulnerability of our buildings that turns hazards into disasters. Ensuring structural and operational safety of the buildings would require adequate attention to not only the structural design, but also the form and configuration of the building. Present constraints are that knowledge about earthquake resistant design and construction in the form of Codes of practices and guidelines is available in the country. The Bureau of Indian Standards (BIS) has laid down the national standards for construction in seismically vulnerable areas However, in our States /cities, these codes have not been made mandatory. Even if these byelaws exists, due to lack of awareness, education and poor enforcement, these are not being followed. This leads to a tendency of using inferior materials and neglect of municipal byelaws. As a result seismically unsafe constructions are being coming up , thus increasing vulnerabilities.

Thus the building damage potentiality to earthquake motions is ever increasing. Assam and all the Northeastern States, therefore, tend to depict a grim scenario with respect to seismic hazard. Because a major earthquake adversely affects practically all facets of human activity and paralyses the total functioning of society, besides becoming a big economic burden on the country reducing the pace of sustained economic development and often lead to a heavy drain of available resources meant for pursuing development activities.

A World Bank Report on "catastrophes and Development" noted that such a situation results because catastrophe is not incorporated into economic projections. Firstly, if disaster impacts are not anticipated, the diversion of scarce financial resources to relief and reconstruction efforts, inhibits continuation of development plans. Second, the continuing and significant reallocation of resources post-disaster wrecks havoc on the budgetary planning process. Third, poorer countries rely on international assistance to pay for a substantial portion of these losses. But the resources available to international community are also limited.

Centre for Natural Disaster Management at Assam Administrative Staff College, since its inception started Disaster Management training programmes. The Centre undertakes training programmes at all levels, viz. village, panchayat, block ,district and state levels aiming at bringing awareness amongst the government officials and communities about disasters and possible mitigation measures. These training programmes have been able to generate interest and receive constant demand to conduct training at respective districts.

2. Flood Occurrences:

Nowhere in our country flood problem is more acute than in the flood plains of the river Brahmaputra and Barak basins and other smaller river sub-basins in the flood plains of Assam. Historical records reveal that the valley faced flood hazards since primeval times. It is said that a great flood in 1570 nearly reduced the region into famine. Also there are innumerable references to floods which occurred during the reigns of the Ahom dynasty.

2.1 Causes of Flood

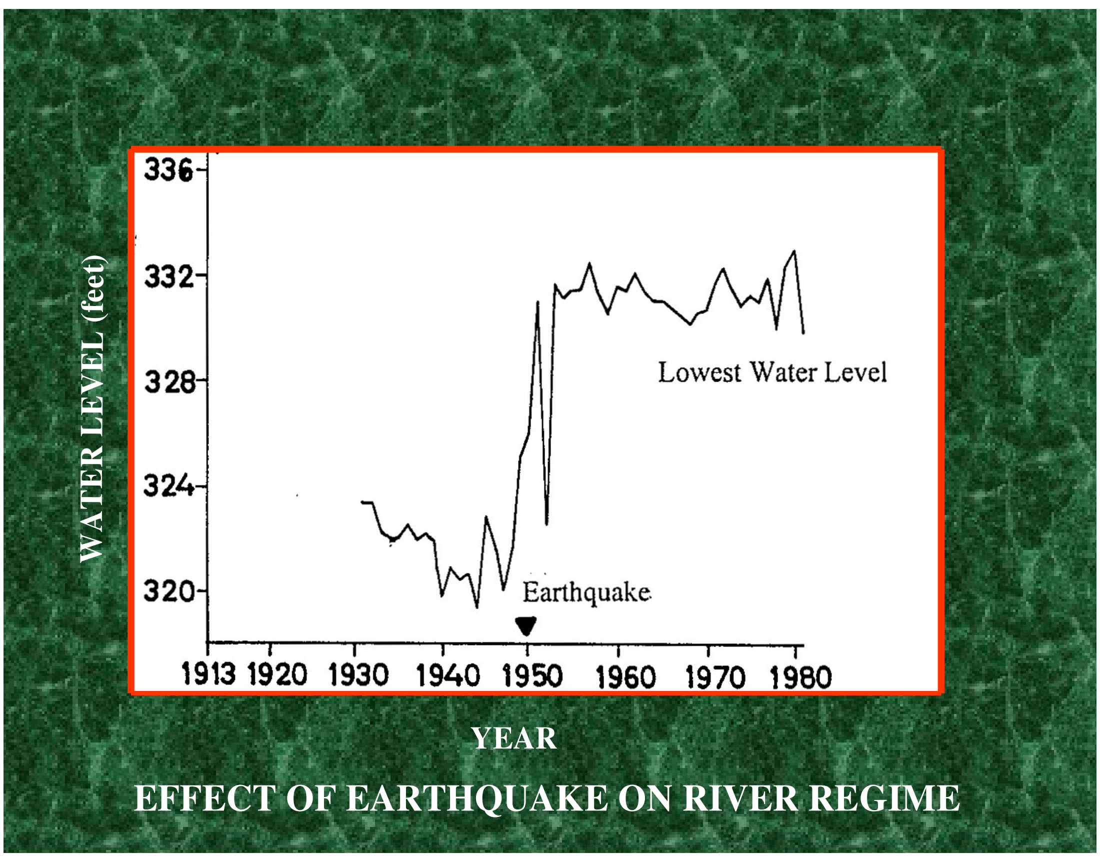
Why Assam's flood problem is getting worse day by day? The simple answer is that surplus water is no longer draining away via the earth's natural channels. Because of Assam's unique geographical location in a vast tropical region ,it can hardly avoid being at risk; where all the prime casual agents of floods are writ large ,for instance, the giant sediment carrying rivers, heavy torrential rainfall ranging from 248cm to 635cm in a short spell of 4 to 5 months and many other contributing factors.In other words, the Brahmaputra basin is not only huge ,it embraces other important rivers that can all awash simultaneously and in a short period during June to September.

Experts view the problem of flood as a combination of several natural and anthropogenic factors. Precisely the unique geographic setting of the region, high potent monsoon rainfall regime, easily erodable geological formations in the upper catchments , seismic activity, accelerated rate of basin erosion, rapid channel aggradation, massive deforestation, intense land use pressure, explosive population growth especially in the flood prone belt and adhoc type of temporary measures of flood control are some of the dominant factors that cause /or intensify floods in Assam. The extremely dynamic monsoon regime visa-vis the unique physiographic setting of the basin has been considered as the single most important cause for frequent occurrence of flood in this region.

It has been observed that the water yield of the basin is one of the highest in the world. For example, at Pandu the maximum discharge recorded was 72,794 cubic metre per sec. in 1962. Its annual average sediment load during flood at Pandu is 400million ton.High rates of yield together with the limited width of the valley (50--80km) and greatly flattened gradient lead to tremendous drainage congestion and resultant flooding. It is more damaging than the excessive rainfall in the catchments Principal sources of water borne sediment load are soil erosion in the catchments and flood plains of a river and bed and bank erosion. Mass movement of soil such as landslides, slumps and soil creep may add to sediment load. The river itself occupies a width of 6 to 10 km at most places. The impact of earthquakes on the regime of the river, especially on the morphology of the channel, has considerable influence on the flood potential of the Brahmaputra. The vivid example has come after the 1950 Assam earthquake. After the 1950 event the erosive power of the river has increased along its banks. Sadiya town at the confluence of the Dibong and Lohit disappeared in 1953.A major chank of the

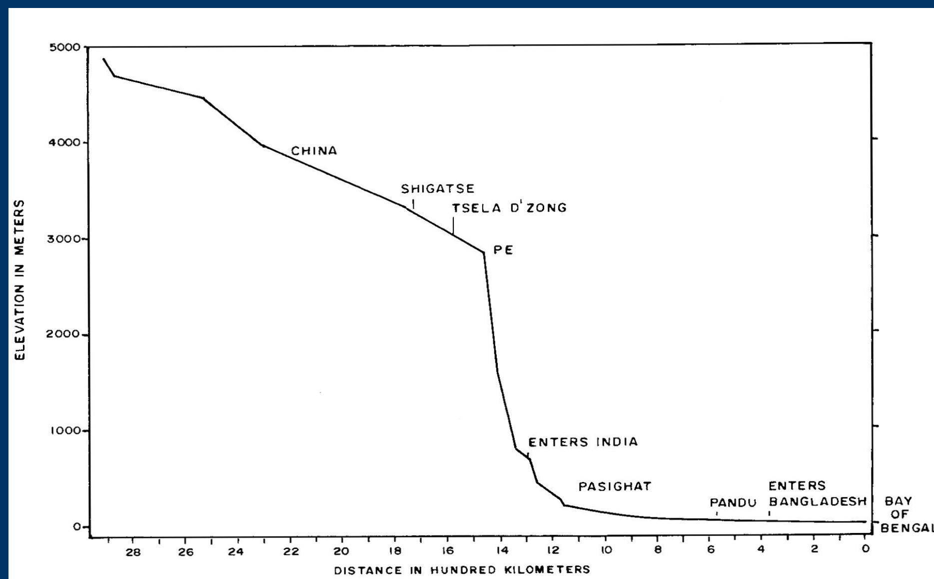
Dibrugarh and Palashbari towns were destroyed in 1954.As a result of the earthquake extensive landslides occurred in the hills temporarily blocking the courses of the Subansiri, Dibang ans Dihang. Bursting of these temporary bunds created by landslides after a few days released enormous amount of impounded water, producing devastating floods downstream The heavy load of sediments both suspended and bed loads of the Brahmaputra and some of its tributaries gets deposited on the river beds resulting in rapid rise of river beds. Obviously a considerable reduction of the carrying capacity of the channel results causing them to spill over the banks during summer high flows and inundate the surrounding lowlands .The intensity of floods before and after the 1950 earthquakes can be visualized from the following account. It has become a perennial feature since then. Prior to 1950, the Brahmaputra river would rarely exceed the danger level in the upper reaches of the valley. But since 1954,the river goes above danger mark every year more than once.

- Before 1950 floods occurred in Assam in 1897,1910, 1911, 1915, 1916, 1931, mainly in the north bank of river Brahmaputra
- After 1950, floods occurred in Assam in ’54, ’62, ’66, ’72, ’74, ’77, ’78, ’ 84, ’86, ’87, '88, '89, '90, '91, '92, '93, '94, '95, '96, '97, '98, '99, '2000, and is still continuing. (Table-I)



(SOURCE: D. C. Goswami, Gauhati University)

2.2. The Basin Configuration:



LONGITUDINAL PROFILE OF THE BRAHMAPUTRA RIVER

***(SOURCE: D. C. Goswami, Gauhati University*)**

The Brahmaputra basin covers an area of 5,80,000 sq. km out of which 70,634 sq km falls within Assam. It is bounded on the north by the Himalayas, on the east by the Patkai range of hills along Assam-Myanmar border, on the south by Assam Meghalaya range of hills and on west by the Ganga basin. The Assam basin has a length of about 1540km in EW direction and maximum width of 682 km in NS direction. The State of Assam lies in the middle reach of the river Brahmaputra and Barak.The river Brahmaputra have braided platform multiple channels. The valley width in the Brahmaputra and Barak basins is very limited with substantial areas covered by hills, railways, and national highways. The adverse geographical features coupled with the heavy rainfall ranging from 248cm to 635c.m. and largely concentrated during 4 to 5 monsoon months is responsible for frequent and damaging flood.

The Barak basin has its drainage area in India, Myanmar and Banagladesh. The drainage area of the basin in India is 26,123sq. km. The basin spans the states of Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Assam and forms a part of the main Brahmaputra basin.

Due to rise of the river bed the Brahmaputra has displayed a tendency to grow wide every year. Perhaps, in the primordial past, the depth of the Brahmaputra was much greater. But centuries of silt deposits have made it far shallower today. After the 1950 earthquake, there was a general rise of the low water level by 3metres of the Brahmaputra river at Dibrugarh. The Dihang river silted up by 6 metres near Sadiya. The extreme braided nature of the river coupled with silt and sand strata of the banks is the main cause of erosion. The excessive sediment load of the Brahmaputra and its tendency for lateral shift, towards south in many stretches for geological reasons appear to contribute for instability.

The tributaries of the Brahmaputra have widely divergent characteristics. Not to speak of the Brahmaputra valley and Barak valley itself is criss- crossed with an incredible number of rivers, big and small, as well as streams and rivulets. Not less than 57 tributaries on its north bank and 33 on its south feed the Brahmaputra on its course through the valley. Some of these are huge rivers by themselves and carry more water than , say, many of the famous rivers in Europe. The tributaries have their own tributaries, some are inordinately large, which in turn fed by numerous rivulets and streams. Added to all these are wide and divergent braids of the Brahmaputra and meanders which issue from it. Thus Assam has an intricate maze of water bodies spread not merely across the valley, but also hills enclosing it.

The extreme braided nature of the river coupled with silt and sand strata of the banks is the main cause of erosion. The excessive sediment load of the Brahmaputra and its tendency for lateral shift, towards south in many stretches for geological reasons appear to contribute for instability.

2.3 The Characteristics of the North Bank Rivers:

- Most of the rivers coming down from the Himalayas and joining the Brahmaputra have vast catchment areas ; receiving annual rainfall ranging from

- The rivers characterised by very steep gradients in the mountains and flow rapidly carrying heavy load of silt ; while descending on the plains they flatten with sharp sagging of gradients, resulting in heavy siltation of river beds in the aftermath of the floods.

- The Brahmaputra river has a mean gradient of only about 1,5m per km over a distance of around 650km between Kobo where the confluence is, and Dhubri where it leaves Assam and enters Bangladesh. he gradients:

  1) Between Kobo and Dibrugarh- the bed slopes 0.62m/km

  2) Between Dibrugarh and Neamati ,, ,, ,, 0.17m/km

  3) Between Neamati and Guwahati ,, 0.13m/km

  4) Between Guwahati and Dhubri ,, ,, ,, 094m/km

Flowing over such a flat terrain, the river loses the velocity attained in the mountains, consequently its capacity to carry the silt , ie the sediments garnered by the Dihang-Dibang-Luhit combine is deposited on the river bed. The process being continuous the river bed has become shallower and shallower every passing year.

- Bring flash floods because of short distance between their source in the hills and the confluence,
- rivers characterised by very steep slope and shallow braided channels,
- have coarse sandy beds and carry heavy silt

2.4. The Characteristics of the Rivers of the South Bank:

* rivers have comparatively flatter grades and deep channels right from the foothills,
* the beds and banks are composed of more clayey component, hence more stable,
* carry comparatively low silt charge.

2.5 There are Natural Constrictions at Various Locations along the Brahmaputra. The Constrictions are at

Murkonselek	- 4.8 km
Disangmukh	- 5.1 km
Dhanshirimukh	- 4.4 km
Tezpur	- 3.6 km
Pandu	- 1.2 km
Soalkuchi	- 2.4 km
Pancharatna	- 2.4 km

Constricting or choking the water ways result in higher floods. The continuous migration of both banks on large scale in between these constrictions has affected a number of villages , towns and embankments.

2.6. Human Intervention

Effect of Embankments:

The short term ad hoc type of flood protection measures so far adopted in the case of the Brahmaputra, especially the extensive network of earthen embankments around 5000k.m., has deleterious impact on the regime of river, more specially its aggradations ,thus contributing to further intensification of flood hazard potential of the valley. The 1986 Assam Flood Expert Committee has aptly brought out the problems .It has been observed that the embankments have changed the behviour of the rivers towards worst. And therefore, suggested that no more embankments should be constructed to avoid a deterioration of the situation *The Rastriya Barh Ayog has grimly warned that a stage may come when it may no longer be possible to contain the river by embankment*. Former Chief Secretary H.N. Das while venting his opinion in The Economic Times 29th Nov'1998 wrote "Build a Dam and be Damned". Possibly this is the main reason for the present predicament Apart from river embankments, railway and road embankments have also seriously hampered and changed the drainage pattern in the state. Openings in roads and railway culverts are often inadequate. The 1986 report points out that river, road and rail embankments have together created serious drainage congestion in Nagaon district.

Ill effects can be seen from the accompanying illustration. The embankment leads to high flood level within the embanked area, resulting in rise of river beds with consequent reduction of fertility of land behind the embankment. In case of a breach, the flood water submerges the surroundings sometimes with devastating potential. Drainage congestion is a major problem due to construction of embankment even after the flood water has receded. Water in the surrounding areas does not have an outlet. The sluices provided become non-operational for various reasons. This results in rising of river beds and narrowing of the channel. The water logging is another problem in embankment construction. It aids in aggrading the river beds, silt which used to be deposited in the plains, now drops inside the river channels. The land drainage pattern gets changed drastically because all streams are now guarded by marginal embankments.

3. Performance of Embankment Measures

Construction of embankment widely adopted as structural measures of flood management though has provided reasonable degree of protection. There are 31.5 lakh ha. of chronically flood prone areas in the state. Some 50% of this area i. e. 16.3 lakh ha. are protected by constructing 4450 km. of embankments. The efficacy of embankment has also become a controversial and debatable topic on the ground of:

- loss of land for construction and resettlement
- risk and effects of sudden embankment failure
- disruption of fish breeding cycle between rivers and flood plain
- increased flooding in unprotected areas
- loss of sediment for nutrient and land building.
- Reduced passage for flow of flood water and consequent rise of the level of flood waters,
- Drainage congestion behind the embankment
- Gradual rise of river beds due to silting.

Usually construction of embankment and associated flood mitigation methods results in general increase of water levels unless suitable long term measure like storage reservoir or channel improvements are provided. Till now the embankment have been adopted as an alternative to long term solution in the Brahmaputra valley. This sometimes leads to disastrous situation due to breaches of embankments. I fact, the popular feeling in Assam today is that embankment themselves have become a major factor for causing floods and people would be much better off without them. The 1986 Assam Flood Expert Committee strongly felt" ***that the embankments have changed the behavour of Assam rivers towards worst .No more embankment should be constructed to avoid a deterioration of situation."***

Inspite of the large number of embankments as shown below (table-X) adverse affect of embankments is obvious from the Dhemaji District Flood Control schemes. Dhemaji suffers from severe floods every year.

TABLE-X

Name of embankments	Length (in km)	Year of construction
Dhakuakhana-Korha bund	19.00	1952-53
Tenga-am-Ghilamara bund on L/B of Sampara	13.50	1952-53
Deorighat-Sissikalghar bund of Brahmaputra	27.15	1954-55
Rly. Line Gohaingaon bund on North bank of Kumotiya	7.59	1954-55
Rly line bund from L/S of Jiyadhal embkt to Tinigharia	6.23	1954-55
Sissikalghar bund from Moridhal to Charikaria	29.29	1954-55
Dizmore-Sonarigaon bund from Brahmaputra embkt.	23.18	1955-56
Sissikalghar-Tekeliphuta bund from Brahmaputra embkt.	27.15	1955-56
Boginadi-Gogamukh bund from Subansiri embkt.	2.50	1957-58
Subansiri-Samparaghat-Jengraimukh bund	10.00	1962-63
Gainadi upstream bund	3.30	1963-64
Gogamukh-Samparaghat bund from subansiri	32.50	1965-66
Jengraimukh-Selamukh bund from Subansiri	6.75	1967-68
Baan Pratirodh Jiyadhal bund	5.12	1975-76
Baruati bund from upstream of Gainadi	6.60	1975-76
Rly bund from upstream of Gainadi	7.00	1975-76
Gurorthali bund on the North Bank of Kumotiya.	3.00	1978-79
Sampara PWD road bund	3.65	1978-79
Rly line Nilakh bund from upstream of Gainadi	3.00	1978-79
Bahir Silley bund (Part-I) from Leku CPWD bridge.	5.05	1984-85
Tinigharia bund (Part-I) from Jiyadhal embkt	5.00	1984-85
Bahir Silley bund (Part-II) from Leku CPWD bridge.	3.05	1987-88

[Reference: ASSAM IN CLUTCHES OF FLOODS: REVIEW: DHEMAJI **by** Bhupen Gogoi **in** ***The*** *Dainik Agradoot* **(Sunday Supplementary) 23rd July 2000**]

The Expert Committee lamented the fact the Brahaputra has not been studied adequately but extensive flood control measures like embankments have been undertaken. At present, the flood control measures taken up by the state govt. annually are only connected with the repairing of the breaches in the embankments.

3.1 The Problems of the Embankments Failure are, such as:

- Failure due to piping
- Cutting of embankment by antisocial elements for quick relief,
- Cutting of toe by cultivators leading to exposure of the hydraulic gradient,
- Erosion of embankment river current,
- Improper maintenance,
- Use of substandard construction materials,
- Use for temporary shelter when villages are inundated,
- Accumulation of rain water due absence or inadequate cross drainage facility.

3.1.1 Deforestation

Human intervention and depredation in the watersheds also aggravate the problem.. The most serious environmental problem now facing on earth is deforestation. This part of world is not lagging behind either. The size of the problem can only be understood from an historical perspective. Few decades ago the entire region has been unrecognizably densely wooded with most human activities seemingly conducted within interminable forestland. Today that scenario is no longer existing. What is so alarming is the rate of tree felling in the hill States. It is so rapid that doubt has been raised whether we will ever be able to make amends for the harm that has been done. Its effects, if unchecked, are most certain to bring about permanent ecological harm with dramatic increase in flooding problem. According to a report "the State of India's Environment,1987" by an NGO, it is understood that from Kashmir to Assam the story is the same. Below 2000metres there is literally no forest left. In the middle Himalayan belt which rises to an average height of 3000metres, the forest area, originally estimated at being a third of the total areas , has reduced to a mere 6.8%. We are seeing the serious consequences arising when the trees, termed as natures' own flood barriers are felled. Because of denudation of forest cover the surface runoff has considerably increased leading to devastating floods in recent days..

3.1.2 Road Building

Impact of development activities in the Himalayan States like Arunachal, Sikkim, Bhutan have greatly jeopardized the stability of the Himalayan slopes. Several experts believed that road building activities have been the worst form human interventions in the Himalayan mountains in terms of promoting soil erosion and landslides. Prior to 1962, the Himalayan mountains were, for the most part, accessible only on foot. The 1962 Chinese aggression, however, prompted a massive road construction programme.

As a result large volumes of debris are removed to build even a km of road. With the construction of roads large landslides are produced in the Himalayan roads. Landslides are major contributor of debris and soil to the rivers

3.1.3 Encroachment

Encroachment of large number of wetlands that serve as natural reservoirs like *beels*, swamps and marshes has also reduced the retention capacity of the drainage system causing flood level to rise .Another aspect that is causing serious concern ,is the occupation of the *chars*- island formed by shifting sand bars by migrants from Bangladesh. As these sand bars are seasonal in nature , and are generally being flooded during high floods do aggravate the flood situation by way of number of population affected and property damaged.

4. Past Measures of Mitigation and Achievements

4.1 Structural Measures

The basic premise is that flood needs to be abated by identifying the cause of inundation and implementing the most obvious solution. In that context

The **B**rahmaputra Board was created to prepare flood control master plans for the entire northeast. The Board's master plans envisage the setting up of water flow ,meteorological and earthquake recording stations, modernization of flood forecasting equipments , anti-erosion schemes, jhum control , new drainage networks and multipurpose dams.

The unprecedented disastrous flood of Assam in 1954 and the tragedy and suffering that followed the event, highlighted the need for tackling the flood problem on an emergent basis. The remedial measures were undertaken in three phases:

a) immediate
b) short term
c) long term

The immediate phase extending over a period of two years was for investigation and collection of data to cover construction of some embankments in the most vulnerable reaches and immediate remedial measures to protect towns and other vital installations. The short term measures envisaged flood control measures, such as construction of embankments, channel improvement, protection of towns and realigning of villages, etc. In the long term phase further works which included creation of storage reservoir were contemplated.It is observed that five tributaries of the Brahmaputra, namaely the Jia Bharali, Debang, luhit,and the Subansiri taken together constitute about 70% of the annual yield of the Brahmaputra at Pandu.Construction of storage on the above tributaries will be able generate huge hydropower besides moderation of floods, etc. The Dihang Dam Projects envisaged the construction of a 296-m.high-rock fill dam and the Subansiri Dam Project envisages the construction of 257-m. high rock fill dam near Gerukamukh.The studies on mathematical model have confirmed that with the construction of the Subansiri Dam, the reduction in the flood height of the Brahmaputra would be about 0.25-m. at Neamatighat. Similarly, as confirmed by the same studies more than I-m. reduction of flood height could be achieved in the entire reach between Kobo and Guwahati with the construction of Dihang Dam. The construction of embankments along the banks of the Brahmaputra was started in 1954, based on the limited hydrological and other data. The Government had built total of about 4,448 km of embankments on the rivers of Assam till 1988.Out of this 3647 km is in Brahmaputra valley, which consists of embankment along the Brahamaputra and various tributaries.

Storage reservoirs have been suggested on these rivers, namely the Subansisri, Dibang, Luhit and Dihang with the aim of flood moderation These rivers together contribute about 50 percent of average annual flow into the Brahmaputra. The Dihang dam will reduce the flood height at Pandu by 0. 6m to 1.75m. The Subansisri dam would bring further reductions of 0.4to 0.15m. The Brahmaputra Board's Master Plans so far could not be executed because of various reasons .

Dredging of the Brahmaputra river was suggested by a number of experts, during the 1950s and early 1960s.The Govt after much ado, decided to undertake the effort to dredge the Brahmaputra on an experimental basis in 1966.The first operation was made in 1974 at Chimna in Kamrup district. A seven killometres stretch was dredged with a width of 30metre. A second attempt was made at Alikash to reduce erosion. The dredging prevented bank erosion but failed to serve as good measure because the dredged portions got immediately filled up with silts. It was understood that for a successful implementation of dredging civil work has to be undertaken to train the river to flow through the dredged area and to remove the earth. The effect on environment has also been indicated. As it a repetitive process involving huge expenditures, the dredging was not recommended for further continuation.

4.1.1 Erosion Problem and Control

The bank line of the Brahmaputra is extremely unstable consisting mostly of fine sandsand silts.Large scale slumping of river banks takes place when the levl falls after a flood. Erosion, therefore, has become a serious problem as it eats away the valuable land. The braided nature of the Brahmaputra adds unpredictability to the erosion problem making it more serious. In spite of good amount of anti-erosion measures executed to contain the attack of the river banks or embankments, the erosion problem has increased in recent years.At some places, a few kilometres of bank along with villages fertile lands ,and roads are being eroded every year. The extent of loss to erosion varies from year to year depending on the severity of floods. Government of Assam had taken up bank protection works for the last three decades. Th important works are at Dibrugarh, Jorhat, Majuli, Tezpur, Guwahati, Soalkuchi, Palasbari ,and Dhubri.

Majuli the largest River Island of the world is seriously affected by erosion of the Bramaputra and the Subansiri rivers. The Sumoi Mari channel cuts across the island which is gadually widening rapidly; for that matter , a mere 10 metre wide channel has become almost 50 m now.Prior to 1950 earthquake, erosion inthis area was not acute. The erosion became acive thereafter and attained serious dimension after the 1954 flood.Since then erosion has been continuing unabated on both the banks.In 1987 Majuli suffered the severest flood having lost 50,000 cattle and crop To address the problem Brahmaputra Board suggested some action both short- , medium and long term actions. However these are in planning stage.

Adverse effect of anti- erosion measures may occur in the upstream or to the down stream of the location or to the opposite bank. A detailed analysis may be required to assess the effect of such measures.

4.2 Non- Structural measures

Non- Structural measures are devised to dissuade people to keep away from water on the plea that flood plains belong to the river.

Of various attempts at flood control an effective management of the upstream watershed areas has been emphasized, either preventing erosion or by diverting excess water into tributaries. Reforestation is an obvious example, as is the creation of catchments basins reservoirs to trap sediments and debris.

Watershed Management, flood plain zoning, and regulation of land use have not been rigorously followed. For scientific management of watershed/ catchment area, a comprehensive and integrated plan is warranted. It requires dialogue between the State governments of Arunachal Pradesh , Nagaland , Assam and, in particular with Central Government intervention because the major part of the watershed / catchment area lies within these hill states. *Assam government has little to do unless the matter is brought as inter-state subject*. Dialogue with China, Bhutan and Bangladesh would be essential to implement the scheme.

To regulate, land use in flood prone zones, identification of priorities is a must to stop the menace, however which has not been emphasized or enforced. There is no legislation for flood plain zoning in northeastern states, except Manipur. Regulation of land use for different flood prone zones with different priorities has to be initiated forthwith.

Unless some strong awareness programme is initiated urgently, unplanned and extensive use of the flood plain would continue. As such uncontrolled and indiscriminate development of flood plains has leads to ever increasing flood damages inspite of substantial investment in flood management sector during the last decades.

5. Government Action Plans

The Assam Govt has a well laid plan to deal with the problem arising out of floods.To effectively coordinate the efforts of various authorities in the State and District level definite work elements have been identified. Firstly, the Divisional Commissioners will coordinate the work of the concerned heads of departments. Whereas, the Deputy Commissioner will coordinate the activities at district level subject to the general supervision of the Divisional Commissioner.

The DC will plan his programme of action and ensure that all preparations as per scheme has been made so that they are able to deal with any situation arising out of floods; covering the periods -- before, during and after floods. This is elaborated in Assam Relief Manual.

6. Recent Status of Disaster Management in Assam during the year 2003 (Source: Revenue Deptt., Govt. of Assam)

- A State Control Room has already been established with Computers, Wireless set, GPS and telephone (No. 0361-2230493)
- The existing Control Rooms on relief established in all districts are being strengthened as Disaster Management Information Centre.
- A District Control Room has already been set up in Kamrup district for disaster management with telephone No. 0361-2605959.
- Commissioner & Secretary, Revenue Department has been declared as the Relief Commissioner of the State.
- State Steering Committee under GOI-UNDP Disaster Risk Management Programme has been constituted with Chief Secretary of the State as its Chairman. The first meeting of the committee has already been held.
- An agreement with UNDP signed for implementation of Disaster Risk Management Programme in the State from 2003 to 2007 as per instruction of Ministry of Home Affairs.
- District Project Officers in 6 districts (Kamrup, Dhubri, Lakhimpur, Dhemaji, Karimganj, Cachar) have already been posted on fresh recruitment and currently engaged in preparation of District Disaster Management Plan in collaboration with District administration.
- Interview for the post of State Project Officer to help Relief Commissioner has already held and posting is being offered very soon.
- A website on Disaster Management in Assam is being initiated. The URL : http://sdmassam.nic.in
- Disaster (Earthquake) Management Plan for the state of Assam has been prepared.
- A draft Earthquake Mitigation Plan for Guwahati city has been prepared.
- Do's & Don'ts for Earthquake and other leaflets, handouts are prepared and sent to field level for distribution.

- A civil engineer has also been appointed under GOI-UNDP programme for taking initiative in motivating people for construction of disaster resistant structures.
- Core committee constituted by GMDA for vulnerability assessment of building in Guwahati City.
- Disaster Management Bill for the State of Assam is drafted and sent for vetting to the State Legislative Department.
- An Apartment Bill also prepared which will be placed in the next session of the State Legislative Assembly.
- For creating a momentum in disaster management activities in the apex level, three national level workshops already been organised in the State. Further to rise consciousness of electing representatives, a workshop was held for them on 30-03-2003.
- Training programme for trainers, namely, Circle Officers, Block Development Officers, Police Officers, Civil Defence Personnel ,etc. has already started by the Centre for Natural Disaster Management at the Assam Administrative Staff College, Khanapara. For this purpose, a faculty is already appointed in AASC with assistance from Govt. of India.
- Education Department is being moved for inclusion of basic disaster related material in the textbooks for classes VIII, IX and X of SEBA course as already done by CBSE.

6.1 Action under Consideration:

- Pattern of Orissa State Disaster Management Authority and Gujrat State Disaster Management Authority are under examination and the matter is processed in the Revenue Department for constitution of an authority to suit the need of the State.
- It has already approved by the Chief Minister for merging Relief & Rehabilitation Department in the Department of Revenue. Since Revenue Department is the nodal Department to look after all disaster management activities, it is proposed to rename the Department as Revenue and Disaster Management Department. The matter is now under examination of the Administrative Relief Department.

7. Landslide Occurrences:

The whole of northeastern region is located in an earthquake prone and heavy rainfall zone. As stated above it has a history of facing probably the worst earthquake impact in 1897 and 1950.These earthquakes were accompanied by extensive landslides in hills which latter upset the regime of the Brahmaputra basin.

Landslides and urban floods are two most pervasive natural hazards that undermine the urban development of the Guwahati as well as other towns in NE region. In the recent past Guwahati has witnessed a number of devastating landslides in its hilly belt. Fragile eco-system of the hilly areas due to poor communication, bad road, indiscriminate, gross misuse of land and forest, economic conditions of the inhabitants create serious administrative problems. The loss of life and property has become a matter of concern. The hill slope failure and soil erosion associated with siltation, flashfloods and water logging in the low lying areas also create immense problems in the city drainage and sewerage system. Heavy and continuous rainfall during monsoon aggravates the process of slope failure.

Barring a few isolated studies no serious and coordinated approach have been taken to tackle the landslide problem here.

8. Cyclonic Storm

Occasional cyclones do occur in the region, particularly in western Assam their severity is more during monsoon. At times these cyclones are devastating bringing colossal loss of human lives and damage to property.

In developing strategy for disaster mitigation arising out of cyclone target oriented message should be designed and communicated so as to alert the vulnerable group. Moreover, general public should be made exposed to the right kind of education beside s information oriented programmes on disaster management. Infrastructure like housing, communication networks compatible with disaster conditions needs encouragement.

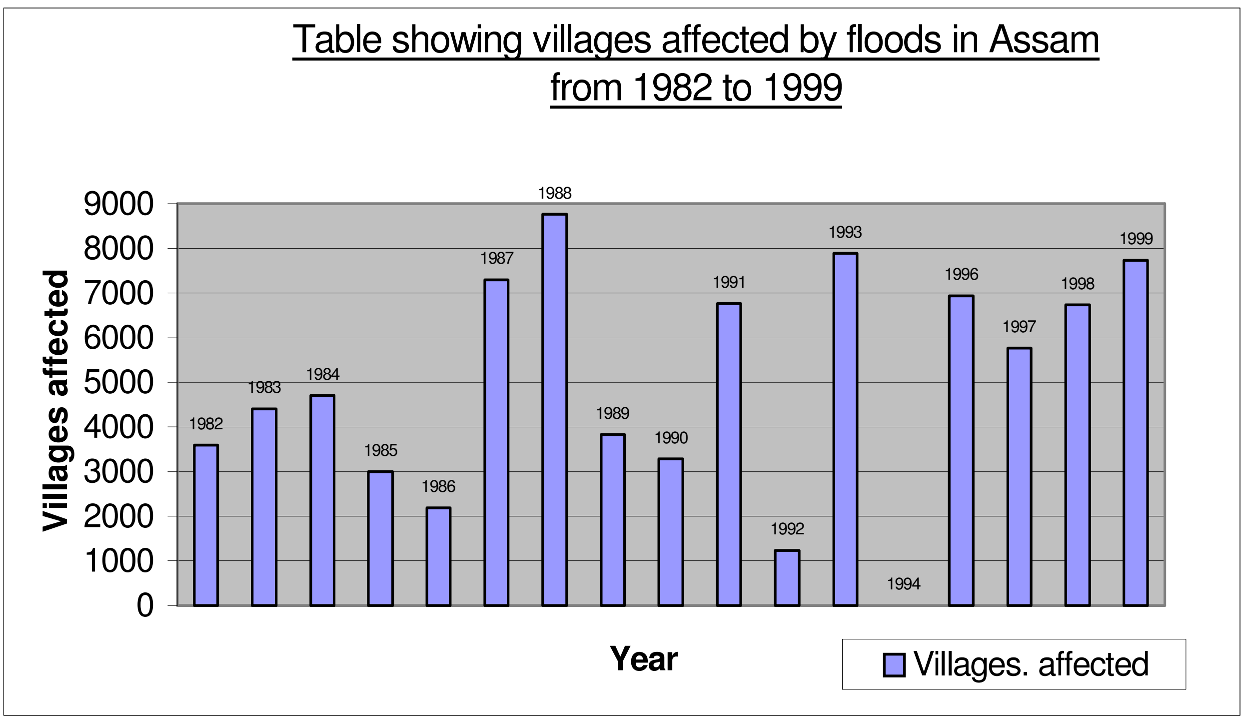
9. Impact

Agriculture and allied activities have overriding importance as a source of livelihood to the people of Assam. As 92.6 percent of cultivated land or 3.15 m ha (million hector) is flood prone, and recurring floods in the Brahmaputra and Barak valleys cause serious erosions, loss of life and livestock and heavy damage to infrstucture property retarding agricultural productivity. The flood damage to crops, cattle, houses and utilities between 1953 and 1995 is estimated at Rs. 4400 crore with a peak of 664 crore in a single year (Shukla Commission, 1997). Even in half of the assessed flood prone areas do not have any flood management structures. The limited flood management structures that exist are not properly maintained.

Floods have impeded the technological transformation of agriculture in Assam. For farmers do not apply costly inputs such as fertilizers and high yielding variety (HYV) seeds for fear of being washed away by floods. Moderation of floods by maintaining the forests and arresting deforestation in catchment areas though possible, could not be done because the solution to moderation of flood primarily rests outside Assam.

It was a majestic waterway one of the most powerful on earth, influencing the lives and livelihoods of tens of millions of people. It has fallen into disuse as a major navigational and transport system especially over the past 50 years. The Brahmaputra was, in earlier days, a deeper river capable of carrying large transport vessels and it was navigable from Calcutta to Sadiya (Assam). This cheapest mode of transport in inland waterways served Assam for a long period of about 100 years till late fifties. Calcutta port was reached from Dibrugarh in 8-10 days, but now the same route takes 40 days. As mentioned earlier the earthquake of 1950 led to changes in river's hydrography as well as silt loaded capacity. The earthquake was followed by severe floods in mid 1950s bringing untold devastations and miseries in their trail. The once easily navigable river became shallower, especially in dry months.

The construction of embankments as flood control measures failed to serve the purpose for which it was meant .As mentioned above it has most deleterious effects. In that context the Planning Commission, Government of India took a strong view as under: *"The government must ban further construction of embankments by unthinking engineers, supported by politicians and officials, who do not understand the hydrology of rivers.It should also include social scientists, environmentalists and geographers in developing strategies to deal with the situation* .Otherwise both flood relief and fund meant for embankments are likely to go to corrupt and well-connected, and death and devastation in Assam will continue."



(Source: Flood Control Department of Assam, Ghy.)

Year after year the same tragic scene is replayed but no long term solutions thought of except bounding the river. The report emphasized that it would be far more practical to encourage an investment in boat building then ensure that every village prone to floods and displacement has at least two well equipped boats to move people to higher ground and also get relief supplies to them and then generate employment.

More serious than the superficial evidences of the havoc caused by floods in terms of increasing loss of life and property are the micro-level irreversible and untold repercussions on the poorer and weaker sections; of course, comprising the majority, of the community. Such endemic victims of flood suffer from morbidity arising out of malnourishment as their scarce resources of livelihood, the tiny patch of land, becomes unproductive due to rising water table and the katcha houses collapse to ravages of floods.

The constant dampness of floors and walls in these houses not only damage their scanty belongings – grains, clothes, and the like and also expose them to the risk of fatal diseases such as malaria, and the most dreaded encephalitis,; besides gastro-enteritis, dysentery, diarrhea, typhoid, and influenza. Contamination of drinking water is the basic cause of a host of diseases. This most important factor affecting the pattern and intensity of water-borne diseases is the abundance of surface water. This, together with the high water table gives an ideal environment for propagation and dissemination of water –borne pathogens.

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