IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 18, Issue 6 Ser. 2 (June 2024), PP 01-25
www.iosrjournals.org

SUNDARBAN MIGHT BE A HISTORY

Dr. Sujib Kar

M.Sc (Geo) M.Sc (Ecology & Environment) PGDM in Environment Management &ISO 14000/14001, Ph.D. Sc. (Cal)

And

Ishita Karmakar, *M.Sc*, **Ishani Karmakar**, *M.Sc*, **Ipsita Chanda**, *M.Sc. student*, **Monidipa Khatua,** *M.Sc. student*, **Mili Naskar**, *M.Sc. student.*

Date of Submission: 11.06.2024 Date of Acceptance: 13.06.2024

Abstract : Sundarban an important tropical delta of the world, having huge biodiversity and as well as the verities of plants are prevailing over here is the typical representation of complex biodiversity zone of the world. Not only that in various times Sundarban has helped the surrounding area by protecting the areas from tropical cyclone. At present biodiversity is continuously degrading and not only that the terrain characteristics are also changing rapidly due to the human interference. In course of time Bhagirathi -Hooghly River has also reduced its flow, that is why the characteristics variations are remarkable. At present along with climatic change of the world the sea level rise is a bigger threat to the area and the altitude of the surface is declining rapidly as well as the sea level is rising. In our study we have tried to analyse such degradation of the surface and as well as the degradation of the surface character.

CHAPTER: I

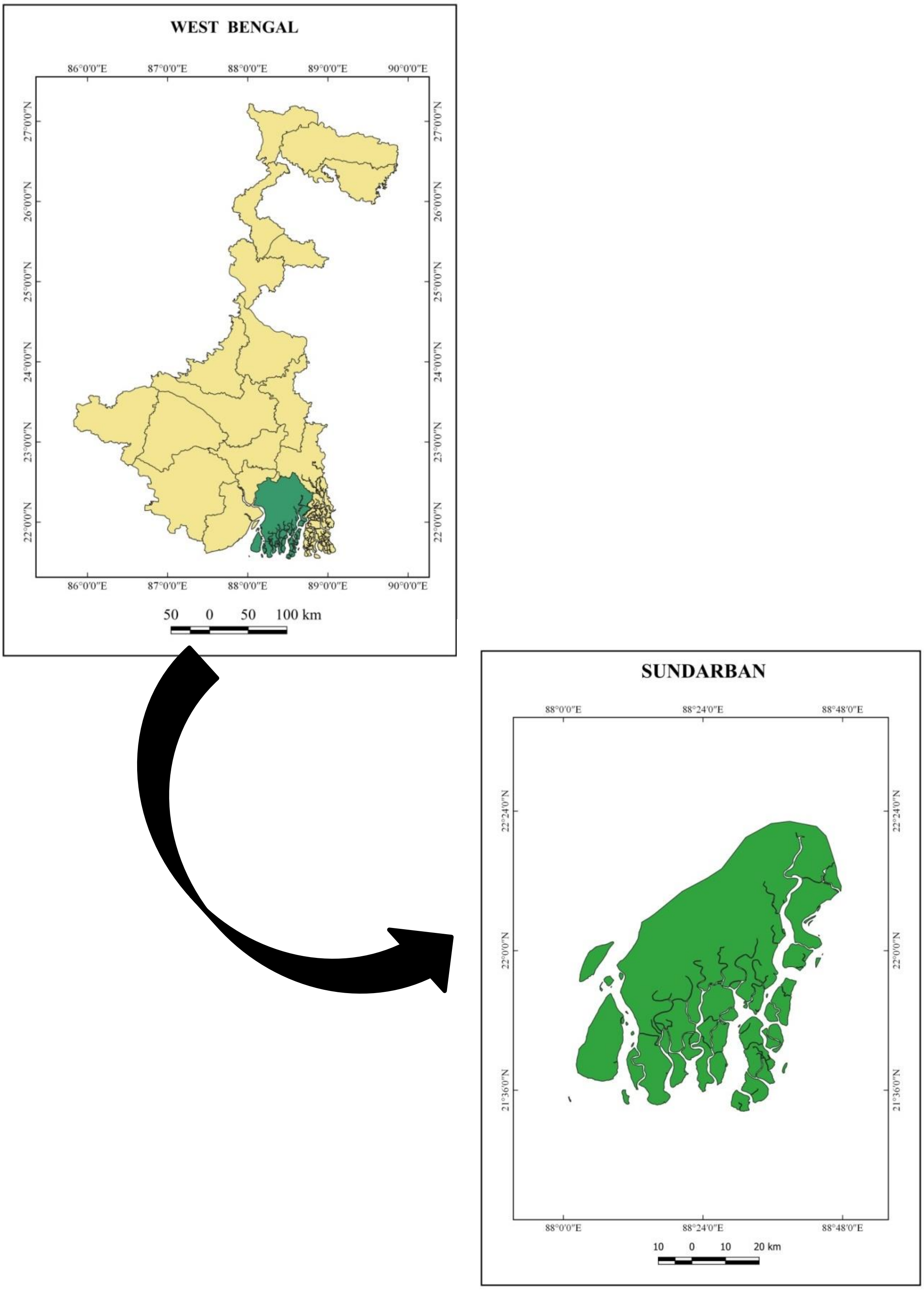
1.1 Introduction: Sundarban the biggest younger delta at the Southern flank of Bhagirathi Hoogly River, which is degrading rapidly. All the tidal channels are becoming absolute day by day due to the changing nature of tide and continuous processes of sedimentation, at the upper reach of these channels. Not only that changing nature of sea wave but also morphogenetic processes at the coastal tracts continuously changing the nature of fore-shore zones. The map drawn by Rennel (1764) is indicating the propagating nature of the delta. And the map of 1925 is indicating that due to the continuous processes of sedimentation the detouched islands are joining together to form an individual landmass. That is why in the year 1925 the distribution of delta has become more well marked and the shape of the delta become much more fixed. But the changes of the delta has started from the year 1970 after the processes of global warming. The river Matla has become extremely thin and its extension has dropped and at present it is in a moribund state. But the coastal tracts are extremely fragmented and the processes of retreation are well marked in the map of 1988. Presently the degradation of the bifurcated channel of Bhagirathi-Hoogly River has started. The satellite photography is clearly indicating this process of degradation. So many bars, sholes and islands are becoming prominent. And on the other hand some islands are completely drowned at the right hand distributary of Bhagirathi-Hoogly River. After the degradation of New moore, Ghoramara and Lohachora, the coastal erosional processes has become much more prominent. And the previous delta is becoming squeezed and retreating back due to the continuous processes of coastal erosion. The rising sea level is indicating major part of the delta is under the level of present sea level that indicates repeated inundation of the area at the time of storm surges and various other hazardous climatic incidents. So to analyse such degrading state of the delta and to get a specific remedy to save the delta we have adopted various techniques to analyse morphodynamics of the area.

1.2 Objective: The main objective of this study is

I. To analyse the present geomorphological condition of the delta.
II. To analyse the impact of global warming and sea level rise on the coastal regions of Sundarban.
III. To analyse the trend of degeneration and predict the future of Sundarban.

1.3 Methodology : To analyse these problems we have adapted three steps methodologies. These are follows:

LOCATION MAP



1) P**re-field Methodology:** Before field excursion we have collected various information on global warming and rising sea-level mainly in the coastal tracts of Sundarban. We have also collected satellite images of different time span from Bhuvan and USGS Earth explorer to analyse the present condition of inundation. After analysing these data we have seen that the area is continuously facing the bad impact of rising sea-level due to the continuous processes of global warming.
2) **Field Methodology:** After analysing the data a field trip has been organised for the verifications of the problems faced by the local people and to collect necessary information. Profile survey also conducted to analyse sedimentation and sea level rise.
3) **Post-field Methodology:** After the completion of field experiment we had adapted the techniques of analysis by applying morphometric techniques and processes. We had also adapted the processes of computation by computer analysis and at the same time we had also prepared mitigation techniques and processes to decrease the impact of sea-level rise and we have adapted some plan proposals for the sustainability of the area.

CHAPTER II

2.1.Geology : Ganges Delta basically emerged its shape and configuration on Bengal fan, basically over the zones of plate shearing, plate evolution, hinge and so many other series of faults. Not only that the Bengal fan is geotectonically changing its nature and characteristics since Eocene period. At that time of geological era, a typical hinge has evolved through the east coast of India starting from south-west Indian ridge and has extended up to the Dawki fault at the north eastern part of India. Prior to the development of this Eocene hinge at the end of Dharwar period basin margin fault has developed in between Bengal fan and Chotanagpur Plateau and Dawki fault line has developed at the northern part of the Bengal fan. Dawki fault was basically tectonically active shear belt at the north eastern part of India which has dissected the Indo-Brahma or Shiwalik river system at the north- eastern part of India by the shearing Shillong Plateau. After the huge plate shearing at the north-eastern part another drainage divide has developed at the north and north-western parts of India known as Potwar plateau. This drainage and this divide has separated the main flow of Indo-Brahma or Shiwalik at the north-western part. After that the various streams such as Alakananda, Mandakini and Bhagirathi etc. has joined the dissected middle part of Indo-Brahma or Shiwalik and after joining with the main flow these streams have created excessive pressure of water flow and simultaneously the upliftment of Himalayas has changed the landscape slope and diverted the stream towards Bengal fan. As the mainstream has diverted, the old stream has been encroached temporarily and spatially. The stream at last has reached Bengal fan just after crossing Rajmahal hills. At the period of Miocene and Kudappa the surface of Bengal fan has repeatedly raptured and has developed various other faults like Pabda or Pabna fault, Ghatal fault, Contai or Bakura fault etc. The phase of Pliocene has just modified the bottom relief of Bengal fan and has created a surface with low bathymetry which indicates the faster rate of sedimentation over this arcuate fan. Depending on these schematic structure as parent rock, successive technical group of formation has occurred over Bengal fan as the lithified layers due to continuous processes of propagating deltaic environment. If we consider the geological cross sections of the area then the sequence will be as follows:

1. The uppermost layer is much softer with fine grained sediment and a balanced textural composition with more or less round shaped granular particles. Its water bearing capacity is maximum because of its textural uniqueness and various fine stratified layers arranged successively within this layer. The depth of the strata is near about 40 to 50 metres with extreme porosity and permeability. That's why these layers normally indicate aquifers of various depths with respect to the topographic variations in this area.
2. A typical layer of extremely fragile grains boulders, pebbles, cobbles and pottery materials which has deposited prior to the formation of Kalighat layer. The extension of the bed is near about 16,000 metres. This layer has no aquifers because the variegated nature of composition does not permit the water to hold in this layer. This layer is not able to carry much more load because of its fragmented texture. Not only that this layer can easily create passage for the biotic elements to penetrate towards the subsurface condition.
3. After this fragile layer two separate beds observed in the subsurface condition. The extensions of these two layers are 150 m to 200m. These layers normally indicate the presence of huge amount of biotic elements which has passed through the porosity and permeability of the upper rock strata. These two layers are much more stable and are able to carry a huge amount of groundwater. At present these layers are found at a depth of more than 180 metress. That’s why the amounts of water prevail in this strata is not easy to pump out for the uses of the common people.

4. After these two layers a thick layer of calcium carbonate prevail in this area and this layer extend up to 4 kilometre. That's why it is clear that the depth of calcium carbonate layer is near about 2 kilometres. This layer is very much sensitive and below this crust layer some fossils are also found. This layer is extremely hard but chemically it is very much sensitive and under this chemically sensitive rock beds schematic platform of Bengal fan extends.

2.2. Geomorphological Setting: The Ganges delta is indicating a complex geomorphic system where features such as channels and inter-channel Islands are present over a wide range of spatial scale. A quantitative description of the morphology of delta is fundamental to assess how they react to the changes in climate forcing the various agents and regulating human activities. In particular it is interesting to analyse how the distributary patterns act over the coastal tracts and perform their activities to develop complex morphogenetic system. On this delta the summation of impact of coastal wave and the action of Bhagirathi -Hooghly river regulate deltaic functions vulnerability and nearest edge distance and resilience. Deltaic distributary network span a wide range of spatial and temporal scales channel widths, for example – range in scale from 100 to 1000 of metress in the main network down to a few metress for drainage distributaries within islands. Channel migration and avulsion occurred in this area in the last thousands of years. While the reworking of channel beds and banks due to flood event can occur within a single year.

The delta is threatened by several factors including anthropogenic activities that are upstream sediment trapping due to dam construction, sediment mining, navigation structures, accelerated subsidence due to water extraction from a natural subsidence and Eustatic sea level rise etc. The response of this delta existence to these forces can be dramatic and results in loss of human lives, economic resources and environmental services. Looking at delta distributary patterns it is natural to quer how the systems morphological activities acting on the delta and how far the distributary patterns are related to deltaic functions, vulnerability and resilience. Among the early quantitative studies of delta networks was that of Smart and Moruzzi (1972) who focused on topology and proposed representing the deltaic networks as a directed graph and analysing various functions of vertex and link number. Among recent efforts Synvitski (2005) and Synvitski and Saito (2007) illustrated empirically the scaling of numbers of the distributary channel with respect to river length and delta gradient.

The recent availability of satellite imagery over major part of the landscape has greatly improved the quantitative analysis of geomorphic features and not only that the satellite imagery has also helped us by supporting photographs to analyse number and size of distributary channels, valley forms, floodplain depressions and oxbow lakes. Here in this context we have tried to analyse the statistical behaviour of the various channels and explore their potential linkages to processes acting on the delta. In particular we are interested in understanding whether the Spatial structure of the deltaic network carries any signature of the processes responsible for delta formation and evolution.

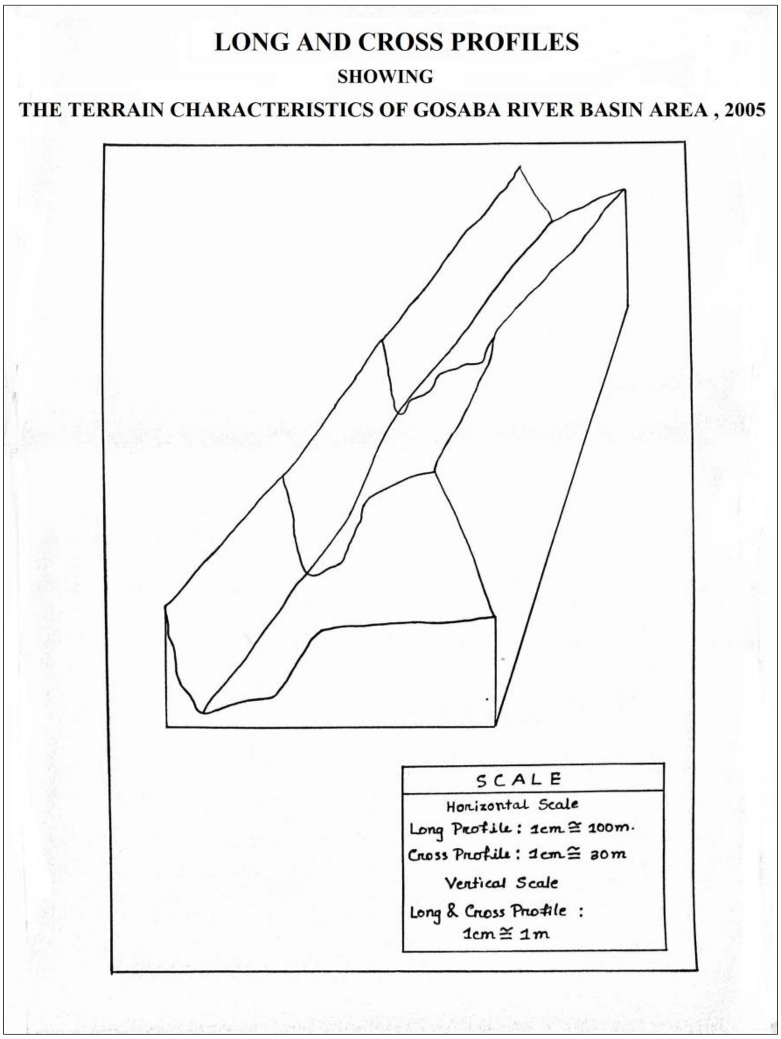
Various geomorphic agents normally perform their variegated activities over the landscape. If we consider the provided climatic data then it will be observed that change in the average condition is negligible. But if we consider the climatic condition of last 10 years then it will be visible that climate is changing rapidly and as a result consequence of climate change are also experienced remarkably and as a result the other side of the river Hooghly mainly at its lower reach is indicating such changes clearly. The increasing climatic temperature has indirectly increased the sea level as a result the water level of Hooghly river and as well as the tidal level are also increasing rapidly and at the same time the increasing cyclonic frequency is changing the nature of morphodynamics over the area. All these aspects normally push saline water through the main channel and as a result salinity of Bhagirathi- Hooghly River is increasing rapidly.

The other most important thing is that the river is going through a tectonically active area. Not only that you've seen hinges passing through the river Hooghly and these hinges tectonically very much active and sensitive, since last two decades due to the steadily rising sea level. The surface is losing its isostatic balance. Since last 2004 the area is experiencing powerful earthquakes and all these quakes are carried by Eocene hinge is degrading the landscape gently. As a result of the rising sea level the vast area of Sundarban is on the verge of submergence. On the other hand as the river Ganga is carrying much more water seasonally the pressure of rising sea level cause excessive riverbank erosion and the vulnerability of the riverbanks are increasing at a faster rate.

2.3. Morphodynamics of the delta: Ganga delta, the typically originated Arcuate delta indicate a complex geodynamics because it reflects huge plate shearing, plate evolution, formational hinge and so many other series of fold over the Bengal fan. Such a typical landscape has originated by the continuous processes of the deposition of river bore materials. Shearing stress over the surface was comparatively greater due to the variation of sea level and at the same time due to the change of nature of works performed by external agents. If we consider the phases of lithification it will be clear that materials originated from the Himalayas and Chotanagpur plateau areas and it will be also clear that the materials originated from these sites are aligned horizontally in the subsurface condition indicating the nature of occurrence of various rock fragment originated in the variable era. The present distribution pattern of streams over Ganges delta reflects the origin of complex geomorphic landscape through the continuous processes of earthquakes, channel shifting and alluviation over the flank of Bengal fan.

Presently such a typical geotechtonic surface has also changed its expansion but basically it is a propagating delta. Due to the various geo-lithological and geo-environmental activities performed by nature and culture gently, the Gangetic delta has transformed into retrograding delta. When a typical nature of stream course joined together with the various streams originated from highlands, they automatically start the processes of landscape degradation and aggradation to maintain the morphodynamics of the surface and as well as to maintain the gradation of the surface. As a result the river course of Ganga was bound to carry huge amount of sediment load produced by fluid dynamics of the river. Not only that to maintain the balance between slope surface of the terrain and sub-aerial lithology the fluid dynamics of the surface try to indicate the intensive activities performed by river and its geotechnical fitting develop along with the Growing nature of the terrain and as well as human activities performed over the specific reach of the stream characteristics. The huge amount of sediment carried by river itself is deposited in a specific area normally try to change the morphogenetic characteristics and at the same time it normally depends on slope degradation and changes of the slope facet within that specific area.

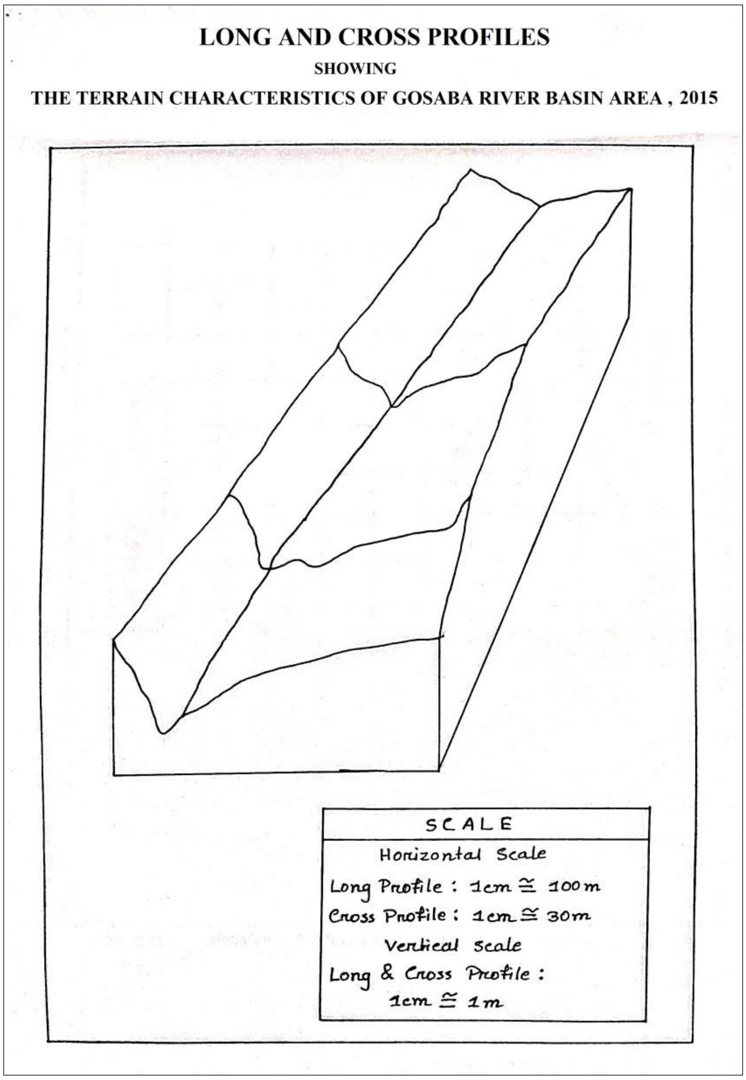
Terrain characteristics of Ganges delta normally indicate the nature of geodynamics performed over these surfaces since geological past. As a result the Benchmarks of the area has successively decline from the Rajmahal hills towards the Bay of Bengal. But the geological cross sections indicate a major part of the surface were saucer shaped and was gently inclined towards the river Bhagirathi-Hooghly and Bay of Bengal. As a result the carrying capacity of the stream is extremely variegated in nature and the mainstream has performed that behaviour of channel course shifting in its various parts and have become the complex genesis of the delta since long time. Not only Basin margin fault at the west of the delta and Dawki fault at the north of the delta, there are so many other faults like Eocene hinge, Padma or Pabna fault, Ghatal fault, Contai fault and various other secondary faults are actively present at the bottom of these surface and these surfaces are also indicating the signs of the repeated processes of rupturing and degradation of the surface nature occurred to maintain the balance of the surface in the geological past. But afterwards the continuous processes of sedimentation have declined the isostatic balance of the surface. As a result geodynamics is continuing over the surface and is changing the characteristics of delta.



2.4.Long and Cross Profile of the Gosaba River with their Successive Changes :

The long and cross profile of Gosaba river has been termed by the dumpy level survey conducted by our group in 2005 and 2015 at an interval of 10 years to analyse the nature of landscape building processes in Sundarban area. The Goasaba river is lying at the middle part of the Sundarban that's why we have selected the river to analyse the landscape building processes and as well as the morphodynamics of the area at greater extent.

The long and cross profile data taken in the year 2005 is indicating comparatively huge rugged terrains with its greater thalweg depth of the confluence zone. And successively the terrain becoming peneplains at the upper reach of the basin. And the data is also indicating comparatively wider river basin at the mouth and successive cross sections taken at an interval of 500 m towards the upper reach.



As we have considered the landscape building processes of Gosaba river by analyzing its terrains characteristics that's why further in the year 2015 we have also conducted another survey in the specific river with typical distance taken by us in the survey of 2005. But it is clear that extension of the surface has been decreased near about 2m. That means decadal rate of sedimentation at the confluence zone of Gosaba river is near about 2m. Such a huge variation of thalweg depth indicate the huge amount of tidal surges within the river and the entry of tidal water within the rivers is taking less time than the river water returning back to the ocean. Such a situation is indicating comparatively gentle and rolling plain topography in the year 2015 caused by huge amount of deposition by the river Gosaba. It is basically a threat of nature that the newly originated alluvial tracts are closing its process of morphogenesis. That means not only Gosaba River the sub-aerial system directly or indirectly indicating the probable inundation of the area.

CHAPTER III

3.1 Temporal Variation of The Delta :

Sundarban delta is a propagating delta in nature but due to excessive human impact the propagating nature has been stopped. The delta is gently developing since last 6000 years to 7000 years and before 2000 years the deltas were also separate and scatterly distributed over the Bengal Fan. But with respect to time it has been observed that all the separate blocks are becoming enclosed as the excessive rate of sedimentation increased to a greater level. The bifurcated flow of various rivers become completely chocked due to the increasing deposition of sediment within the river bed. In some parts like Icchamati, Bidyadhari and Matla thalweg of the rivers have uplifted near about 8-10 metres and that is why at present tidal water is not entering through the smaller rivers and either side of the rivers become joined. And in this way vast delta has developed. If we study properly and compare the area with previous maps then it will be clear that in each and every year the rate of tidal flow is decreasing rapidly and that’s why near about 60% of the river flow area has been completely diminished.

Before independence British government has developed some dykes by the side of Bay of Bengal for the exploitation of Sundarban resources and to make a command over the whole area. But after the formation of dyke delta propagation has been stopped and as a result the changing nature of ocean wave is making erosion prominent at the coastal tracts of Sundarban.

3.2. Spatial Changes :

After the study of the landscape it is clear that Sundarban should be kept separately thinking about its eco – sensitive activities. Since long time that means from the year 1970 no one has thought to save Sundarban and not only that repeated exploitation and deforestation is still continuing. That is why spatially the rate of extension of Sundarban is degrading rapidly. Some parts are becoming inundated by the ocean water due to continuous processes of climatic change and global warming. Some important activities undertake by the common people of the region is also degrading the nature and characteristics of Sundarban. And as a result rate of sea level rise is extremely high and the total delta is receding back and if we consider various maps of the previous time it will be clear that total space of Sundarban has decreased near about 23% to 24% caused by the erosional activities performed by rising sea level. And that is why total area of Sundarban is squeezing rapidly. And a study report of 2017 is indicating that total area of Sundarban has reduced to 1.89 sq.km.

3.3. Increasing Rate of Environmental Hazards :

In the Sundarbans of India hazards and disasters comes in several ways.

A. Cyclonic Hazard: The first and foremost important is the cyclonic hazard along with storm surges. And these types of hazard destroy various parts of Sundarban and the storm surges are increasing the rate of erosion at the coastal tracts and the speedy air easily destroy forest cover. At the time of Amphan total 1660 sq.km. forest area has been completely destroyed. Not only Ampham, Bulbul, Aila and Yash like cyclones has played devastating role over the Sundarban area. Up to the year 2010 from 1970 the area of Sundarban has increased near about 12.52 % due to the extension of settlements and excessive sedimentation in the coastal tracts. But after 2010 the frequency of cyclone is increasing at a faster rate and its causing huge devastation and within this last decade several changes has occurred in this area. And by the cyclonic impact total area of Sundarban has reduced to 20-22%.

B. The second most important hazard of Sundarban is soil salinity and crisis of water for agriculture and fish production because of the continuous increasing of sea level. As per our study it has been clearly observed that in the last 100 years the altitude of Sundarban has decreased near about 0.6-1.3 metres in the coastal tracts and some areas adjacent to the coast has decreased near about 1.3-2.8 metres and beyond that the inner part of Sundarban has reduced to near about 2.8-3.0 metres. Such a huge subsidence level and intensity of human activities increasing in the area since last three decades. As a result major part of the Sundarban has decline down to the sea level. That is why at the time of high tides or storm surges the vast extended area of Sundarban is becoming completely inundated. And in this process the salinity of the soil is increasing rapidly. And in future top failure will occur in several parts. And not only may that huge economic crisis occur. On the other hand the continuous processes of salinization has destroyed the quality of drinking water and fresh water for agriculture in the include areas. And that is why salinity of the area has increased near about 40% to 50% that is before three decades it was near about 18% to 23%. But at present it has increased to 28% to 32%. That means drinking water of the area is not also suitable for drinking of the people and as well as for irrigation of the agricultural fields.

C. Soil erosion is a most important factor of delta degradation. Due to continuous process of sea level rise the wave action has been changed. And that is why tidal surging and storm spilling waves has increased to a greater extend. As a result on shore current asymmetry beach waves are becoming extremely active and by this way soil erosion has increased to a greater extend. At present 24.55% of the coastal tracts are affected by soil erosion. Along with such natural incidence human activities in the coast and as well as in the inner parts of Sundarban has increased the rate if soil erosion to a greater extend. Due to such processes of soil erosion loss of mangrove forests are becoming prominent and lose of land near about 20%- 22 % is noticed at the time of field study.

So, it is clear that various types of hazards are becoming prominent within the Sundarban area and as a result along with the degradation of mangrove biodiversity is also declining at a faster rate.

3.4 Changing Nature of the Ocean Waves:

The study of the coastal tracts of the Sundarbans indicating that, this region is experiencing storm wave environment and swell wave environment as a result chaotic water movement normally occur above the shallow water. The increase in the height of the wave normally decreases in the wavelength which may cause more wave steepness as the wave move towards the coast. The solitary wave processes normally control the rate of deposition which have cause broad, flat traps. No wave is sufficient in itself but it may explain the phenomena of wave breaking. The study of the coastal tracts in the Sundarban indicates it is changing its terrain and that is why it is clear that presence of steep beaches on the flatter powerful ocean wave.

In the coastal tracts of Sundarban, upwelling ocean currents are also becoming sensitive and they are destructing the surface rapidly. Within the geos of the sundarban along with the proceeding of the ocean wave, spell breaker becomes more active but at the time of storm this spell breakers are normally transfer to storms spelling and in such currents oceans wave become much more active and powerful and that's why sometimes ocean waves are becoming much more destructive.

Sinusoidal waves are normally found near Sagar Dwip, Kak Dwip and Namkhana and that's why this wave normally try to destroy the whole impact. Orbital velocity of the Earth is also important for the study of the coastal tracts caused by sinusoidal wave and orbital velocity gains maximum speed at the crest of the waves. When the height and depth ratio of the soils of Sundarban is 0.8 and this data has been received from the unstable coastal tracts of Sundarban area. And by this way the coastline is becoming retro getting and that's why overall coastal areas are experiencing huge amount of sediment load.

3.5 Movement of Tidal Water through the Channels:

At present Sundarban coast is a retro getting coast and that is why the continuous process of swash and backwash may change the coastal landforms easily. At the time of disaster cyclones the height entering into the landscape and inundate in the vast area and this inundated lands at present experience as the mercy land or at the box and these areas are suitable for mangrove environment.

The tidal water enters into the tidal creeks and tidal rivers due to the increasing height of water. They enter into the water very fast, but such water normally take huge time to return back and that is why deposition of sediments are increasing in tidal creeks in the coastal tracts of Sundarban. At present the density of Sundarban has increased and that is why the regulation over the land breeze and sea breeze and as well as the regulation over coastal air pressure has effectively changed, and that is why the thin channels in between the separated deltas are becoming abolished.

CHAPTER IV

4.1 Increasing Sea Level And Its Impact:

Climatic change is a global scenario which is continuously changing since last 5 decades. Continuous processes of urbanization, industrialization and unwise developmental plans have increased the global temperature because of this increasing temperature the sea level is rising very rapidly. But the problem is that majority of Sundarban is located at the sea level and some parts are below the sea level and as the growth of Sundarban is very much restricted by the various activities since the period of Britishers that is why actual morphology of Sundarban has been changed by the human activities and as the growth of Sundarban is restricted that's why the proper morphodynamics of the delta has not taken part. Presently the continuous processes of sedimentation within the tidal channels have joined the deltas but afterwards the formation of several dykes and so many barrier created by human being along the continental margin has restricted the extension of delta towards Bay of Bengal. And because of this situations river bars and soals are now converted into human habitation. And as a result the immature surface of the delta formed by the continuous processes of oceanic action is at the verge of destruction due to the rising sea level. Previously the sea level at the Sundarban was increasing very slowly but at present the rate of increasing sea level has increased to a greater extent and that is why we are calculating its probability of degradation in future. At present the rate of increasing of sea level is 4.44mm. And tentatively within next 8-10 years total Sundarban area will be denudate under the extension of Bay of Bengal.

4.2 Changing Nature of Storm Surges

As the sea level is rising the nature of erosional activities performed by the ocean has also changed and as a result the edge Sundarban previously was in a concave slope surface but at a present due to excessive erosion and deposition at the edge slope profile towards the sea has changed and in major areas it has become oval in shape. As a result the movement of storms normally create excessive friction by pushing water mass through the continental shelf towards the delta. As a result when storms proceed towards the coast they normally create huge water sprouts and sometimes ocean water surge towards the coast in a greater speed and height. Their excessive speed and height create huge devastating energy at the coastal tracts and by this way normally create huge loss of land, human property and various other resources.

4.3 Impact of Human Activities:

The global warming is not the only cause of the degrading nature of Sundarban because since long time man is utilizing the resources for their livelihood. Various types of research have been conducted by the government and NGOs to get the maximum benefits of the resources of Sundarban. As this area enjoy saline soil and saline water in the rivers that's why local people has converted the land at the bank of the rivers as the place for prawn cultivation. As the local people are using these lands their unwisely detouching the land of Sundarban from the natural flow of the rivers. So that they have tried to control the continuously growing population and they have also tried the get the full benefit of such geographical location.

For this reason major parts of Sundarban has lost its balance because of unwise land utilization and the construction of roads, bridges etc. in the various parts of Sundarban. That is why a complete management plan is very much required so that all the unwise activities performed at the coastal tracts should be completely band and at this stage of global warming if we are unable to restrict human activities performed at the various level in Sundarban we are unable to control its degeneration process and we will lose Sundarban in future.

CHAPTER V

5.1 Anthropogenic Impact at The Coastal Tracts:

Since long time Britishers extended their road network in the Sundarban area only to exploit the various resources of Sundarban. Along with extension of roads they had constructed unecofriendly dykes and so many other barriers to separate the land from the Bay of Bengal. Because of this the propagating delta had stopped its nature and the extension of the delta towards Bay of Bengal has been completely restricted. Afterwards various developmental activities like construction of roads, bridges and residents losing its balance. And not only that the soils at the coastal tracts are also sliding towards the sea due to the excessive urbanization caused by the heavy vehicles in the roads, on the other hand since long time various human activities related to prawn cultivation has extended in all the tidal creeks. And that's why the river banks have lost their balance. Not only those unwise human activities have changed the slope surface of the tidal creeks and that's why rate of erosion has been enhanced since last decade.

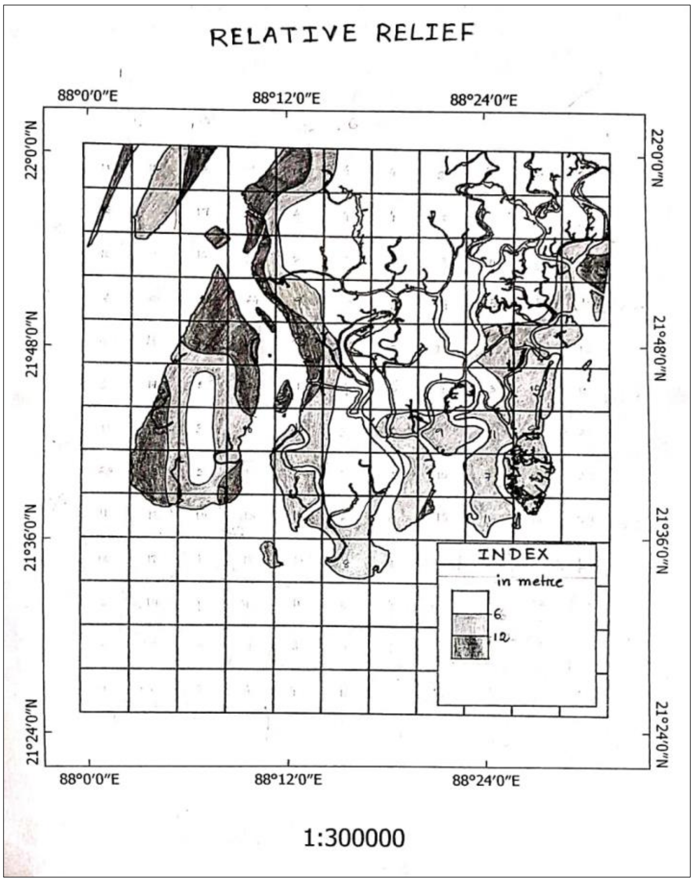
5.2 Rate of Retreation of Sundarban since 1988 :

To analyse the surface characteristics and its nature in the period of climatic change we have studied various maps since 1988. At the time of our study we have also calculated total land area covered by Sundarban. And it is found that in the year 1988 total area of Sundarban is 1831.52 km^2 and in that period there were so many water bodies and thin channels within the delta area. But afterwards delta building processes has gained a momentum. In the year 2001it has found that the area of the delta has been increased in comparison to 1988 and the total area of 2001 was 1921.061 km2. That means the total land surface of the delta has increased near about 90 km^2 in 12 years. And after that we have studied the data of 2011 and it is found that the area of the delta has further increased near about 48 km^2 and total area of the year 2011 was 1969.16 km^2. So it is clear that upto 2011 the mechanism of delta formation was active and delta was propagating and the delta has also increasing in size. Afterwards the size of the delta has started its reduction in shape that means degeneration of the delta has started. In the year 2019 total area of the delta has reduced 103.767 km^2 and the total area of that year was 1865.393 km^2. Such a huge fluctuation of land area has occurred only within 9 years. And the surface became extremely active along with the global climatic change, global warming and various other factors. That means the coast line of Sundarban has started its phase of degeneration. Furthermore we also have considered the map data of 2021. And in that year it has been observed that the total area of Sundarban was 1819.983 km^2. That means within 2 years retreation of the delta has occurred near about 45.41 km^2. That means in the year 2021 the total land of the area was 20.21 km^2. The survey data and various other information are indicating the Sundarban delta is degrading at a faster rate. That is why the total area of Sundarban is decreasing very rapidly.

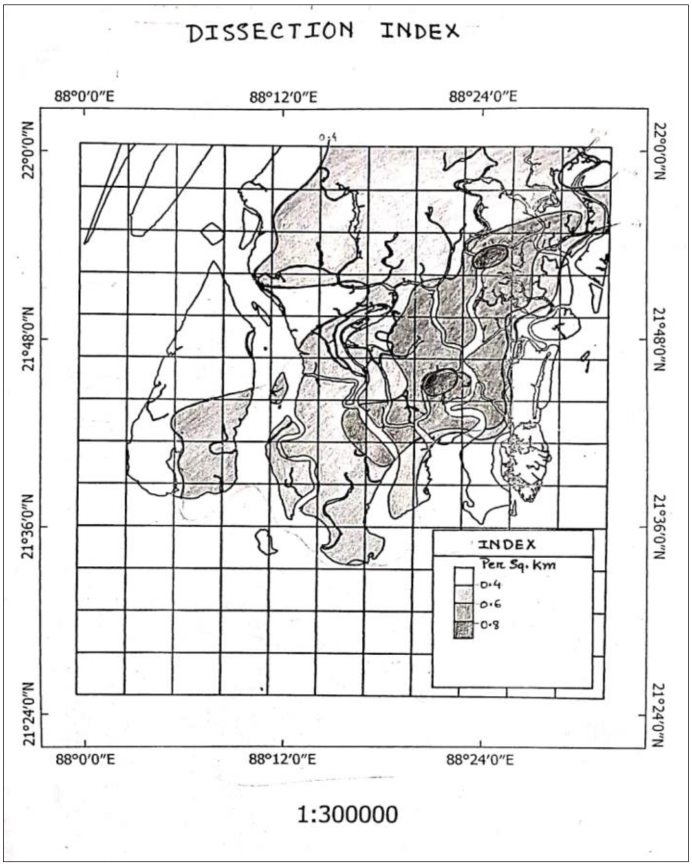
The unwise growth and development along with have caused the retardation of Sundarban till 2011. The delta was propagating and that is why the increase in the delta is growing steadily but after 2011 the delta is reducing.

5.3 Changes in the Morphodynamics :

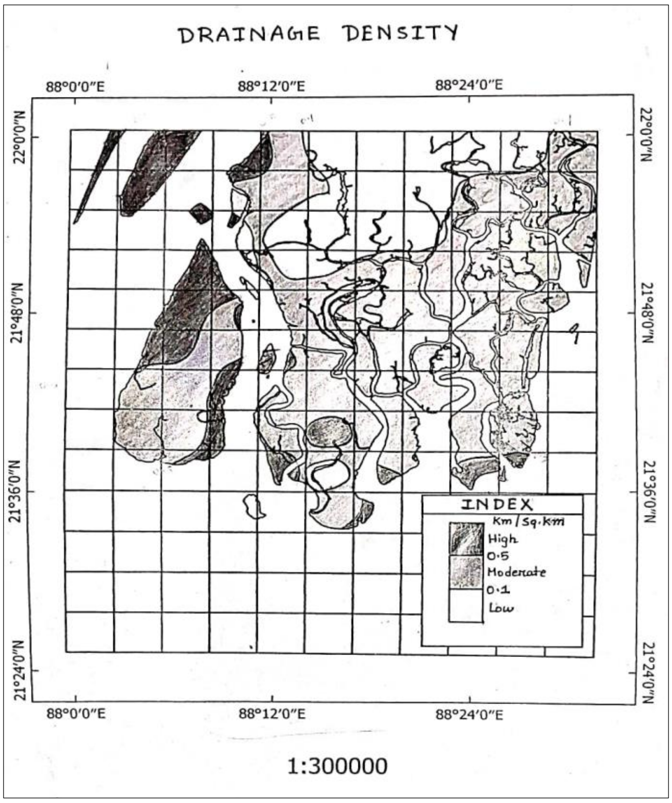
I. **Relief:** To analyse the physical conditions of Sundarrban we have analysed it's morphometric characteristics. And it has been found that relative relief of the area is comparatively greater at the southern part of the delta because landscape building processes are continuing over the area. Relative relief is also greater at the northern and western part of Sagar island and it is also greater on the side of river Ganga. It indicates in these areas river erosion and coastal actions are very much prominent. Not only that the confluence zones of Matla, Hariabhanga and Sqptamukhi river are also indicating comparatively greater relative relief. It is because of the continuous processes of coastal action and tidal activities basically at the northern part of Bay of Bengal. These areas are also covered by mangroves and that's why some parts are experiencing extremely active tidal processes.



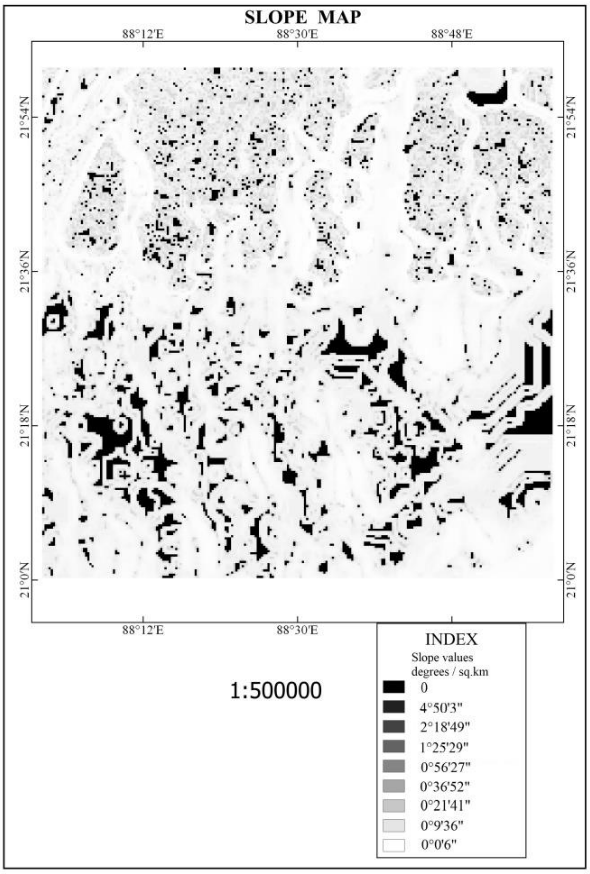
1. **Dissection Index:** Dissection Index is a typical map which normally reflects the intensity of the erosion of the surface. From the drawn map it has been found that some parts of north Hariabhanga and north Saptamukhi basin are experiencing 0.8m/km dssection. That means these two areas are experiencing not only the tidal impact but also some anthropogenic causes have accelerated the rate of erosion in these two areas. Whereas rate of erosion is also prominent at eastern part of Sundarban mainly within the Indian part. Because excessive tidal surges and seasonal inundation caused by excessive rainfall. Not only that the water from Bay of Bengal enter within the river mouth Hariabhanga. Saptamukhi and Gosaba because of excessive tidal surges and such surging impact have caused excessive rate of erosion, but by the side of river Matla, river Ganga and such eastern part of Sagar Island is also experiencing moderate rate of erosion. So it is clear that the southern part of Sundarban is degrading very



rapidly. And because of its degradation some parts of Sundarban are also experiencing high rate of dissection index. So it is clear that the core Sundarban area is degrading very rapidly.

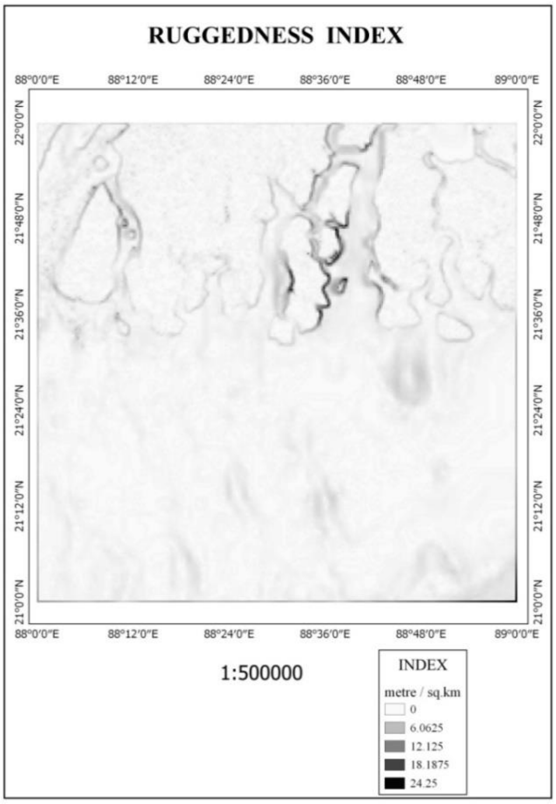


2. **Drainage Density:** To analyse the landscape characteristics it is very important to understand the nature and characteristics of drainage network prevailing over the area. And as the drainage pattern is restricted by the relief of the surface that is why it is found that the zones of greater relative relief are indicating comparatively higher drainage density. At the southern part of the delta all the tributaries of various channels have joined together to for Anastomosing channels. And in such channels there is so many fingertip surface and hampering the growth of Sundarban towards south. Sundarban region by itself bears some evolutionary history performed by river, xoast and anthropogenic activities on the landscape building processes of Sundarban.
3. **Slope:** Landscape slope of a surface normally indicates the intensity of erosion. Here it is clear that slope of the surface is comparatively greater on either side of the tidal creeks but continuity of the slope surface is not prevailing over the area. That is why the distribution of scattered slope surfaces is prominent over the area. It is also found that north-western and southern part of Sagar island surface by the side of the river Ganga, some scattered parts by the side of river Matla and Saptamukhi are experiencing slope surface near about 4° to 5 °. And the other parts of the Sundarban are experiencing comparatively less slope surface. To analyse this situation it is indicated that erosion rate is prominent in the high angle slope surface areas and the rate of erosion has decreased in the other areas. And not only that the surface slope is greater by the sides of the rivers that indicates some anthropogenic impact over the area because artificial dykes, creeks has been formed by the human activity that's why the delta is degrading rapidly.



4. **Ruggedness Index:** Ruggedness index is a typical map which normally indicate the genesis of the surface with respect to its morphological characteristics. In our study area it has found that, as the surface is lying mostly at the sea level. That is why the amount of ruggedness is

comparatively less at the southern flanks of Sundarban. But it is comparatively greater at the north-eastern part of Sagar Island and Saptamukhi. It indicates the landscape building processes are still continuing in these areas but as it is a degrading landscape side that's why the area experiencing higher ruggedness index. That means the zones of higher ruggedness index will be eroded very quickly and will wash out by the tidal activities. And within 2-3 years such ruggedness will be declined at the surface will experience rolling plain topography. Such a change of the surface indicates the landscape building processes of Sundarban is on the verge of its end. That's why high elevated surface and rugged surface are becoming eliminated and destroyed by the sub-aerial denudation.



5.4 Changing Nature of Human Interference and Livelihood :

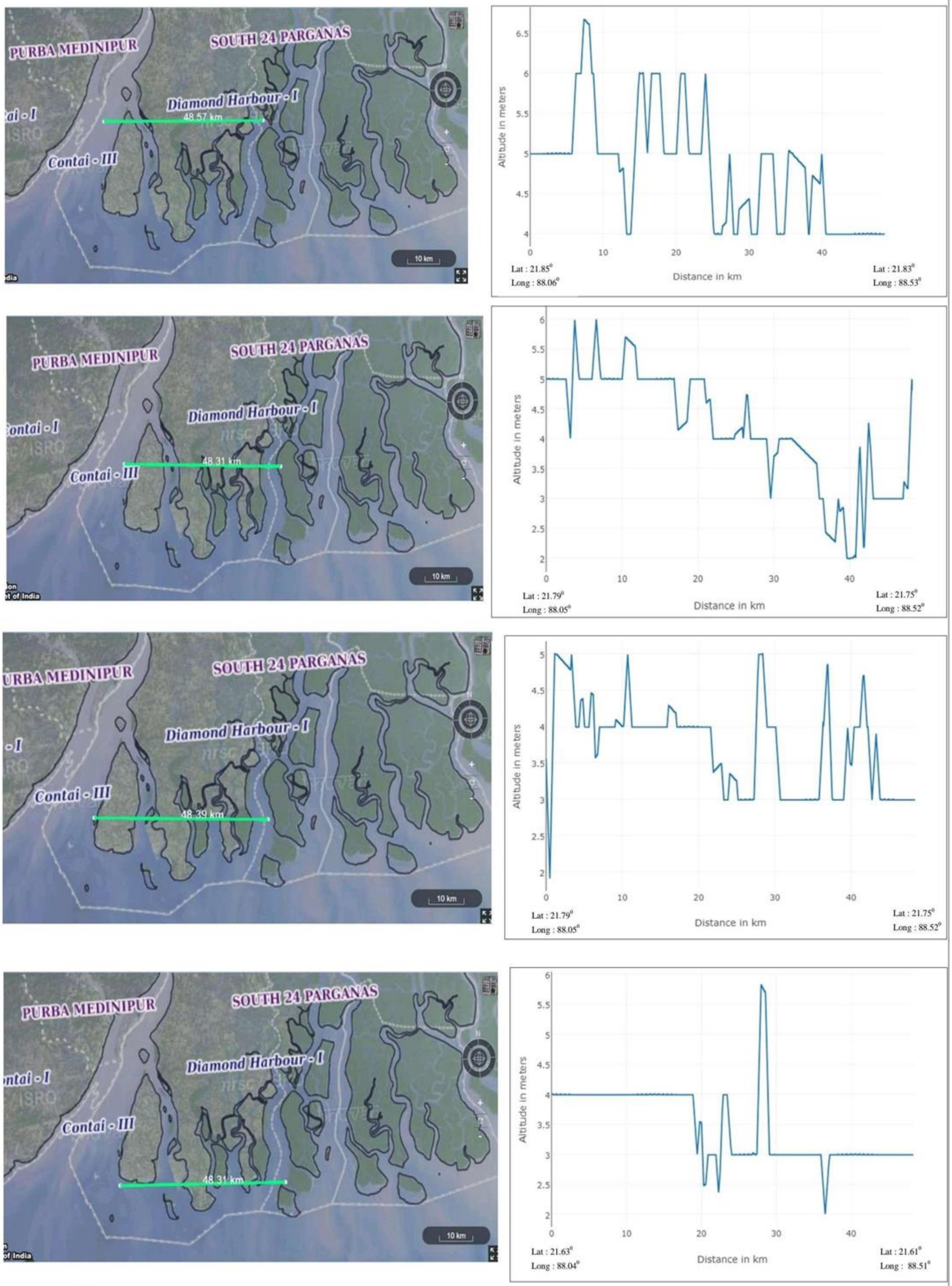
Since a long time human interference over the Sundarban region has been increasing at a faster rate. Previously the surface area in major were only utilized for agricultural processes. But at present along with agriculture some cottage industries has also developed and not only that at this period of global warming and climatic change without any help it is not possible to maintain the agricultural activities because the monsoon is abnormal and inactive too. As a result the people involved in agriculture normally try to utilize the land for at least two crops that are Aman and Boro. And to maintain that they are bound to use the groundwater. Not only that along with the groundwater they are producing their food crops and side by side they are converting the lands from various other service sectors to the rudimentary state of economy. On the other hand the tourism industry is flourishing in this area as a result a good number of people are involved in tourism activities and by this way they are learning to stay there in Sundarban area for a long span of time. Various other pieces of information are also indicating the carrying capacity of the surface is decreasing. And that is why big construction sites are becoming damaged at a faster rate. And not only that at present huge amounts of sediments are moving through the subsurface water towards the Bay of Bengal. And for that reason the surface of Sundarban is also degrading very rapidly. Wise and expected rate of development along with the view of sustainable development we can change ourselves to save the delta. All other impacts are directly or indirectly hampering the balance of the surface. And as a result Sundarban is degrading.

CHAPTER VI

6.1 Hypothesis

Depending on the overall analysis it is clear that Sundarban is degrading at a faster rate. At present to analyse all these aspects we have studied various aspects like its physical condition and as well as the anthropogenic condition over the deltaic area. It is clear that since long time we are exploiting Sundarban without thinking its future, that is why the balance of the landscape surface as well as the ecological balance has been hampered in the various parts of Sundarban. If we consider Sundarban is a Heritage site then it is clear that we should think for its sustainability but without thinking the situation we are continuously using Sundarban for its various resources and at present we are utilising Sundarban as the tourist spot of India. As we continuously destroy it's various aspects only to manage the human urge we have destroyed it's each and every survival condition. So it is clear that day by day we are losing Sundarban.

The cross section over the Sundarban area is indicating that some portion of the land has already gone below the sea level and the majority of the land is lying at the sea level only. But below the tidal level the



G

Source: BHUVAN 3D

increasing frequency of cyclones and as well as the increasing rate of global warming is increasing the water surface over the Bay of Bengal and if the situation continues the total surface of the Sundarban might go below the sea level of Bay of Bengal within next 5 to 6 year. Government is not thinking anything properly to save Sundarban the international organisations are repeatedly giving warning that the sea level will increase to a great extent and in our study it has also found that in the last 10 years sea level has increased near about 0.5 metre. If this rate continue in the next 5 to 6 years then it is clear that 70% of the surface area of Sundarban will be completely inundated within the Bay of Bengal.

CHAPTER VII

7.1 SUGGESTIONS

If we try to solve the problems which Sundarban is facing in recent years we should make some important plans by which we can save Sundarban since long time as we are exploiting Sundarban. At first we have to control our activities and after that we have to aware local people about their future problems because these people are going to destroy their everything at the same time we have to think for the proper settlement planning not only for the Sundarban but also for the adjoining areas. To manage the present situation we have to follow the following steps.

1. We have to restrict the unwise growth and development over the Sundarban area without thinking the carrying capacity of the surface.
2. With the help of proper management plan we have to control the sub surface sediment flow from Sundarban and as well as we have to manage the formation of dykes in the various parts of Sundarban.
3. We have to clear the banks of the river by lifting sediments from the river banks so that they can easily carry the amount of sediment load entering the river at the time of tides.
4. Government should take drastic steps to control prawn cultivation within the river banks show that the normal flow pattern of the rivers should be untouched.

ACKNOWLEDGEMENT

The authors acknowledges Late Professor Dr. Subhas Chandra Mukhopadhyay, Late Professor Dr. Ananda Dev Mukhopadhyay, Professor Dr. Prithwish Roy, Professor Dr. Arunava Mishra for their constructive suggestions and help. The authors further acknowledges their father, mother and family member for their suggestions and help and the author furthermore acknowledge the librarian of GSI and the eminent research work of Dr. D.R. Nandi and the librarian of Central Ground Water Board and various other researchers in this field.

REFERENCES:

[1] M. Ahern, R.S. Kovats, P. Wilkinson, R. Few, F. Matthies Global health impacts of floods : epidemiologic evidence
[2] Epidemiol. Rev., 27 (2005), pp. 36-46
[3] R. Akhtar, A. Dutt, V. Wadhwa Health Planning and the Resurgence of Malaria in Urban India
[4] R. Akhtar (Ed.), Urban Health in the Third World, S.B.Nangia and A.P.H. Publishing Corporation (2002) [5]. S.F. Altekruse, D.L. Swerdlow, N.J. Stern Microbial food borne pathogens
[5] Vet. Clin. North Am. Food Anim. Pract., 14 (1998), pp. 31-40
[6] S. Altizer, R.S. Ostfeld, P.T.J. Johnson, S. Kutz, C.D. Harvell Climate change and infectious diseases: from evidence to a predictive framework
[7] Science, 341 (2013), pp. 514-519
[8] L.M. Beck-Johnson, W.A. Nelson, K.P. Paaijmans, A.F. Read, M.B. Thomas, O.N.Bjørnstad The Effect of Temperature on Anopheles Mosquito Population Dynamics and the Potential for Malaria Transmission
[9] L.M. Beck-Johnson, W.A. Nelson, K.P. Paaijmans, A.F. Read, M.B. Thomas, O.N.BjørnstadThe Effect of Temperature on Anopheles Mosquito Population Dynamics and the Potential for Malaria Transmission
[10] R.A. Bissell Delayed-impact infectious disease after a natural disaster
[11] J. Emerg. Med., 1 (1983), pp. 59-66

[12] M.J. Bouma Methodological problems and amendments to demonstrate effects of temperature on the epidemiology of malaria. A new perspective on the highland epidemics in Madagascar, 1972–1989
[13] Trans. R. Soc. Trop. Med. Hyg., 97 (2003), pp. 133-139
[14] M. Bouzid, F.J. Colón-González, T. Lung, I.R. Lake, P.R. Hunter Climate change and the emergence of vector-borne diseases in Europe: case study of dengue fever
[15] BMC Public Health, 14 (2014), p. 781
[16] C.B. Bridges, M.J. Kuehnert, C.B. Hall Transmission of influenza: implications for control in health care settings Clin. Infect. Dis., 37 (2003), pp. 1094-1101
[17] S. Bunyavanich, C.P. Landrigan, A.J. McMichael, P.R. Epstein The impact of climate change on child health
[18] Ambul. Pediatr., 3 (2003), pp. 44-52 [19]. CDC Waterborne diseases
[19] Climate and Health Program: Centers for Disease Control and Prevention (2010)
[20] J.P. Chretien, A. Anyamba, J. Small, S. Britch, J.L. Sanchez, A.C. Halbach, C. Tucker,K.J. LinthicumGlobal climate anomalies and potential infectious disease risks: 2014–2015
[21] PLoS Curr., 7 (2014)
[22] S.R. ChristophersAedes aegypti (L.) The Yellow Fever Mosquito. Its Life History, Bionomics and Structure
[23] Cambridge University Press, Cambridge (1960)
[24] Dr. Sujib Kar, Impact of Global Warming on Earthquake on The Bengal Basin area with respect to The Global Scenario, International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 2 Issue 7‖ July. 2013 ‖ PP.20-28
[25] Dr. Sujib Kar, Proper Environmental Management is the proper way to poverty Eradication ; A case study of South of West Bengal & Bangladesh, International Journal of Scientific and Research Publications, Volume 3, Issue 9, September 2013 1 ISSN 2250-3153
[26] Dr. Sujib Kar, Don't Let Sundarban to be cry of Bengal, ILEE, Vol. 33(2), December 2010
[27] Dr. Sujib Kar, Apocalypse of Water Born Diseases in Kolkata, IOSR, Vol. 13, Issue 1, Ver. 1, January 2019 PP 57-64, www.iosrjournals.org
[28] Dr. Sujib Kar. Et al., Kolkata The City on The Cradle, IOSR, ISSN: 2319-2399, Vol. No.17, Issue No. 11 Ser. 2 (November), PP 04-08, https://www.iosrjournals.org/
[29] https://bhuvan-app3.nrsc.gov.in/data/download/index.php
[30] https://bhuvan-app1.nrsc.gov.in/globe/3d.php
[31] https://earthexplorer.usgs.gov/
[32] https://www.gebco.net/data_and_products/gridded_bathymetry_data/
[33] https://www.telegraphindia.com/my-kolkata/news/world-meteorological-organization-report-raises-alarm-over-abnormal-rise-in-bay-of-bengal-in-30-years-and-bengal-warming-up-faster-than-most-of-india/cid/2015491

APPENDIX

RELATIVE RELIEF					
GRID NO.	VALUE IN metre	GRID NO.	VALUE IN metre	GRID NO.	VALUE IN metre
1	14	49	13	96	4
2	13	50	15	97	4
3	12	51	7	98	4
4	7	52	7	99	9
5	5	53	4	100	10
6	6	54	18	101	15
7	11	55	4	102	9
8	20	56	5	103	10
9	11	57	9	104	6
10	16	58	27	105	2
11	8	59	18	106	3
12	3	60	10	107	3
13	7	61	6	108	4
14	12	62	10	109	5
15	12	63	14	110	11
16	9	64	11	111	3
17	8	65	4	112	11
18	13	66	4	113	7
19	17	67	4	114	11
20	15	68	4	115	14
21	13	69	3	116	7
22	18	70	2	117	5
23	15	71	4	118	1
24	14	72	4	119	4
25	5	73	3	120	3
26	4	74	2	121	3
27	14	75	2	122	3
28	17	76	8	123	9
29	16	77	8	124	10
30	24	78	4	125	9
31	14	79	1	126	10
32	2	80	4	127	10
33	3	81	4	128	13
34	3	82	3	129	12
35	10	83	3	130	10
36	9	84	3	131	6
37	9	85	3	132	2
38	2	86	6	133	3
39	3	87	3	134	13
40	21	88	8	135	13
41	20	89	7	136	10
42	19	90	4	137	12
43	24	91	6	138	2
44	28	92	3	139	3

45	24	93	3	140	7
46	10	94	3	141	11
47	17	95	3	142	5
				143	2

DISSECTION INDEX					
GRID NO.	VALUE (per sq. km)	GRID NO.	VALUE (per sq.km)	GRID NO.	VALUE (per sq. km)
1	1.750	49	2.5	96	0.667
2	1.625	50	-7	97	0.8
3	2	51	-2.333	98	1.5
4	-7	52	-0.8	99	2
5	-5	53	2	100	2.5
6	-6	54	0.5	101	-
7	-11	55	0.625	102	-10
8	10	56	1.286	103	-2
9	-11	57	3.652	104	-0.5
10	-	58	2.571	105	0.5
11	-	59	2	106	0.5
12	-3	60	1.2	107	0.8
13	-3.5	61	1.667	108	0.714
14	2	62	3.5	109	1.375
15	2.4	63	5.5	110	0.750
16	-	64	-4	111	1.571
17	-	65	-4	112	1.4
18	2.6	66	0.5	113	2.750
19	2.8	67	0.5	114	7.0
20	2.5	68	0.429	115	-1.167
21	2.16	69	0.333	116	-1.250
22	2.25	70	0.571	117	-0.2
23	-	71	0.667	118	0.571
24	14	72	0.6	119	0.6
25	-	73	0.5	120	0.6
26	-4	74	0.5	121	0.6
27	2	75	1.333	122	1.8
28	2.429	76	8.0	123	2
29	2	77	-	124	1.8
30	3.0	78	-	125	2
31	2	79	0.571	126	2.5
32	0.333	80	0.5	127	-13
33	0.5	81	0.429	128	-4
34	0.5	82	0.5	129	-5
35	1.667	83	0.6	130	-3
36	-9	84	0.5	131	0.4
37	-2.25	85	0.75	132	0.6
38	-0.5	86	0.6	133	2.167
39	-1	87	1.333	134	3.250
40	3	88	1.75	135	2.5

DRAINAGE DENSITY					
GRID NO.	VALUE (km/sq.km)	GR ID N O.	VALUE (km/sq.km)	GRID NO.	VALUE (km/sq.km)
1	0.82	49	69	96	0.12
2	0.91	50	0	97	0.12
3	0	51	0	98	0.16
4	0	52	0	99	0.27
5	0	53	0	100	0
6	0	54	0	101	0
7	0	55	0.03	102	0
8	0	57	0.10	103	0
9	0	58	0.47	104	0
10	0	59	0.51	105	0
11	0	60	0.39	106	0.08
12	0	61	0.20	107	0.11
13	0	62	0.58	108	0.26
14	0.5	63	0	109	0.20
15	0.35	64	0	110	0.24
16	0	65	0	111	0.24
17	0	66	0	112	0.26
18	0	67	0.03	113	0.26
19	0.62	68	0.11	114	0
20	0.23	69	0.07	115	0
21	0.06	70	0.10	116	0
22	0	71	0.16	117	0
23	0	72	0.19	118	0
24	0	73	0.20	119	0.04
25	0	74	0.58	120	0.24
26	0	75	0.07	121	0.19
27	0.55	76	0.34	122	0.13
28	0.94	77	0	123	0.23
29	0.85	78	0	124	0.24
30	0	79	0	125	0.42
31	0	80	0	126	0.35
32	0	81	0	127	0.86
33	0	82	0.04	128	0
34	0.02	83	0.14	129	0
35	0	84	0.10	130	0
36	0	85	0.10	131	0
37	0	86	0.26	132	0.12
38	0	87	0.22	133	0.16
39	0	88	0.5	134	0.26
40	0.79	89	0	135	0
41	0.43	90	1	136	0
42	0.52	91	0	137	0
43	0.69	92	-1	138	0

44	0.45	93	0.05	139	0
45	0	94	0.05	140	0
46	0.60	95	0.05	141	0
47	0.69			142	0
				143	0

CROSS PROFILE 1. GOSABA RIVER 2005 (At the Confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
0	-	0.31	3.43	
01	5.3	1.12	2.62	
02	16.3	1.49	2.25	
03	9.2	2.41	1.33	
04	16.3	3.2	0.54	
05	31.1	3.45	0.29	
06	63.2	3.02	0.72	CL=3.44)
07	76.4	2.85	0.89	(BM=3.43m)
08	112.2	1.93	1.81	
09	131.2	1.05	2.69	
10	291.79	0.84	2.9	
11	282.71	0.64	3.1	

CROSS PROFILE 2. GOSABA RIVER 2005 (500mt. North of Confluence)

POINTS	DISTANCE (m)	STEADIA READING in metrte	RL	REMARKS
0	-	0.43	3.43	
01	3.2	0.92	2.94	
02	4.3	1.31	2.53	
03	11.2	1.47	2.39	
04	14.5	2.83	1.03	
05	18.3	3.12	0.74	
06	32.4	3.31	0.55	(CL=3.86)
07	47.3	2.96	0.9	(BM=3.43m)
08	72.4	1.25	2.61	
09	98.4	0.93	2.93	
10	110.3	0.54	3.32	
11	130.7	0.34	3.52	

CROSS PROFILE 3. GOSABA RIVER 2005 (1000mt. North of confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
0	-	0.25	3.43	
01	3.5	0.98	2.7	
02	5.5	1.35	2.33	
03	11.4	2.34	1.34	
04	17.3	2.42	1.26	
05	21.7	2.12	1.56	
06	35.4	1.87	1.31	(CL=3.67)
07	47.6	1.31	2.37	(BM=3.43m)
08	64.2	1.11	2.57	
09	85.6	0.98	2.7	
10	92.7	0.43	3.25	

11	98.5	0.24	3.44	

LONG PROFILE 1. Of GOSABA RIVER 2005 (confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
01	150	3.34	3.43	
02	150	3.13	3.64	
03	150	2.89	3.88	
04	150	2.67	4.1	
05	150	2.32	4.45	
06	150	1.18	5.59	
07	150	0.92	5.85	(CL=6.77)
08	150	0.86	5.91	(BM=3.43m)
09	150	0.43	6.34	
10	150	0.32	6.45	
11	150	0.28	6.49	

LONG PROFILE 1. GOSABA RIVER 2015 (confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
01	150	2.95	0.63	
02	150	2.36	1.22	
03	150	1.89	1.69	
04	150	1.43	2.15	
05	150	1.15	2.43	
06	150	1.00	2.58	
07	150	0.91	2.67	(CL=6.35)
08	150	0.72	2.86	(BM=3.43m)
09	150	0.45	3.13	
10	150	0.23	3.35	
11	150	0.15	3.43	

CROSS PROFILE 1. Of GOSABA RIVER 2015 (At The Confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
0	-	0.12	3.43	
01	4.3	0.63	2.92	
02	5.6	0.86	2.69	
03	8.4	1.15	2.4	
04	11.3	1.62	1.93	
05	16.7	2.61	0.94	
06	21.4	2.27	1.26	(CL=3.64)
07	32.8	1.86	1.69	(BM=3.43m)
08	51.6	1.16	2.39	
09	69.4	0.86	2.69	
10	85.9	0.62	2.93	
11	122.3	0.21	3.34	

CROSS PROFILE 2. Of GOSABA RIVER 2005 (500mt. North of Confluence)

POINTS	DISTANCE (m)	STEADIA READING	RL	REMARKS

		in metre		
0	-	0.26	3.43	
01	4.2	0.35	3.34	
02	5.3	0.64	3.05	
03	8.4	0.67	2.72	
04	13.8	1.22	2.47	
05	24.6	1.93	1.76	
06	31.7	2.14	1.55	(CL=3.66)
07	46.8	1.67	2.02	(BM=3.43m)
08	67.2	1.32	2.37	
09	84.5	1.15	2.54	
10	88.4	0.86	3.53	
11	92.5	0.23	3.46	

CROSS PROFILE 3. Of GOSABA RIVER 2015 (1000mt. North of Confluence)

POINTS	DISTANCE (m)	STEADIA READING in metre	RL	REMARKS
0	-	0.12	3.43	
01	4.2	0.64	2.91	
02	6.8	0.94	2.61	
03	13.2	1.12	1.43	
04	17.4	1.31	1.24	
05	21.2	1.86	1.69	
06	29.4	1.41	2.14	(CL=3.59)
07	41.5	1.13	2.42	(BM=3.43m)
08	51.6	0.97	2.58	
09	61.3	0.52	3.03	
10	69.4	0.27	3.25	
11	72.1	0.16	3.37	