3rd Year Field Report

On

Geomorphological and Environmental Characteristics of Sonadia and Maheshkhali Islands of Bangladesh

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I also take this opportunity to express a deep sense of gratitude to Dr. Asib Ahmed sir, Al Artat Bin Ali sir and Raisa Sultana mam for their cordial support, valuable information and guidance, which helped me in completing this task through various stages.

I am also thankful to my classmates and group members who helped me to complete the tasks within due time.

Abstract

Geography & Environment is the discipline that studies man and environment relationship on the spatial and temporal context. Physical environment and human environment both are the main streams of this multi-disciplinary subject. To study the spatial patterns of any particular area having some specific objectives, every year this department arranges field trip for the students as a part of its regular curriculum.

In continuation with this process, we, the students of 3rd year, have made our field trip to Sonadia and Moheshkhali Islands of Cox's Bazar from 2nd November to 5th November. This field work was entirely based on Physical geographic aspect. So the prime purpose was doing Geomorphological Mapping, Sand Dune Study, Profile Study, Borehole Sediment Collection of Sonadia Island and Slope and Vegetation Study of Moheshkhali Island as well as Sediment Dynamics and Hydrological Survey in The Bay of Bengal.

As very few scientific research works have been done on Sonadia Island and Moheshkhali simultaneously, this south-eastern part of Bangladesh was chosen as our study area to identify the geomorphic features and other physical information. We tried to bring out unknown information with the help of different scientific experiments.

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Chapter 1

Introduction

1.1 General background

Research comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications. It is used to establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. A research project may also be an expansion on past work in the field. To test the validity of instruments, procedures, or experiments, research may replicate elements of prior projects or the project as a whole. The primary purposes of basic research which is opposed to research are documentation, discovery, interpretation, or the research and development of methods and systems for the advancement of human knowledge. Approaches to research depend on epistemologies, which vary considerably both within and between humanities and sciences.

For acquiring knowledge through practical observation there is no other way without observing different physical and socio-economic conditions of various region of a country. Geographers use spatial analysis to define a particular region that process is based on practical analysis rather than descriptive method. Usually as a student of Geography and Environment we get a yearly tour trip somewhere around in Bangladesh. We try to learn many important aspects through it.

Therefore, we, the students of 2018-19 Honors third year, went to Sonadia and Moheshkhali Island of Cox's Bazar district. The trip that was conducted consisted of Geomorphological Mapping, Sand Dune Study, Profile Study, Borehole Sediment Collection of Sonadia Island and Slope and Vegetation Study of Moheshkhali Island as well as Sediment Dynamics and Hydrological Survey in The Bay of Bengal. Although the time span of the trip was limited to a few days, the physical geographic aspects of the study area were surveyed throughout the trip. The focus of the research report would be give an idea about these various existing physical geographic aspects of the study areas.

1.2 Selection of the study area

The study area was selected by our honorable course teacher Professor Dr. M. Shahidul Islam. We performed our surveys and observations in Sonadia and Moheshkhali Islands. These are the remote islands under Cox's Bazar district. As very few scientific studies have been done on these islands simultaneously, this south-eastern part of Bangladesh was chosen as our study area to identify the geomorphic features and other physical information. We tried to bring out unknown information with the help of different scientific methods and experiments to get a better knowledge about these areas.

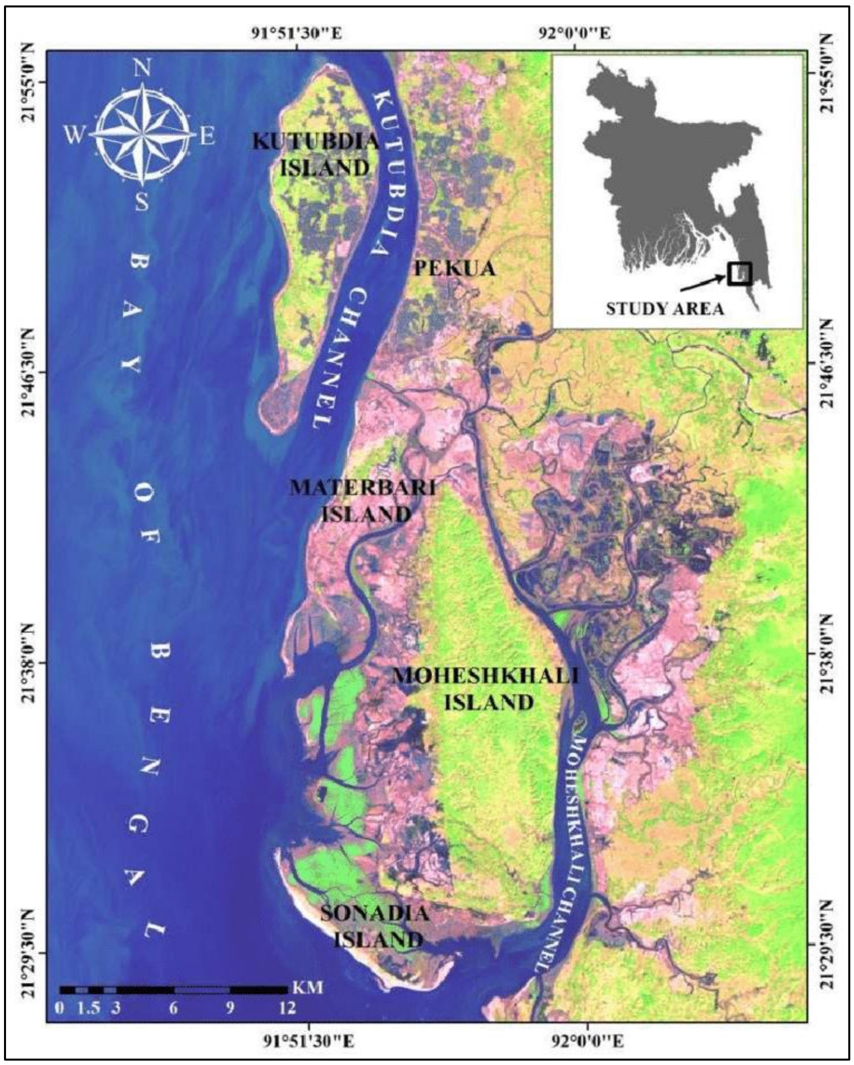


Fig 1.1: Geographical location of Sonadia and Moheshkhali Islands

1.3 Objectives of study

The main objectives of this field trip was

- Preparation of Geomorphological and land-use map of Sonadia Island
- Dune Morphological survey of Sonadia Island
- Lithological survey of Sonadia Island.
- Slope and vegetation study of Moheshkhali Island.
- Perform hydrological survey and know the sediment dynamics of The Bay of Bengal.

1.4 Techniques used

1. Geomorphological and land-use mapping:

Geomorphological mapping is the fundamental technique in physical geography to depict micro scale landform and landscape. In our fieldwork we had to do the geomorphological and land-use map of entire Sonadia Island. For this we divided the Island into 16 square grid (2km*2 km).There were 7 groups consisting 30 students in total for this survey. Students had to collect information from direct observation from the field and make sketches for any feature.

2. Dune morphological Survey:

- **Slope measurement of sand dunes:** There are few techniques to measure the slope. But in our fieldwork we used slope meter to measure the slope of dunes.
- **Height measurement:** We measured the height using ranging rod or using trigonometrical method.
- **Profiling of dune:** We had to do profiling to see the stratification within the dune.
- **DCP:** It is a method that is used to see the compactness of soil. This method was used to measure the compactness of dune.
- **Dune sample collection:** The sediments were collected from different places of dune for lab test.

3. Lithological survey:

Boring Data collection: There are many methods to collect subsurface sediment sample. But the most extensively used in Department of Geography and Environment is Gauge Sampler.

Profiling: Profiling of soil is conducted to know the layer formation within the soil. Match- stick technique is used so that all the boundary of the layer can be easily recognized and can be plotted on a graph paper.

Monolith is used to collect sediment from this profile so that the sequence of the sediment layer can be further used for lab test.

DCP Survey: Dynamic Cone Penetration is a test to measure in- situ resistance of subsurface sediment layers. The test is performed by pushing a rod into the soil repeated hammering at a fixed force. Several DCP test were conducted in our fieldwork at various location to measure the compactness of soil.

4. Ocean Survey:

Bathymetric survey of the ocean: It includes the measurement of underwater depth of ocean floors. It was done for mapping the underwater topography.

Sediment sample collection from Ocean floor: Grab sampler were used to collect bottom sediment. After collecting these sediment in this process we had to keep this in a sampling bag for further analysis.

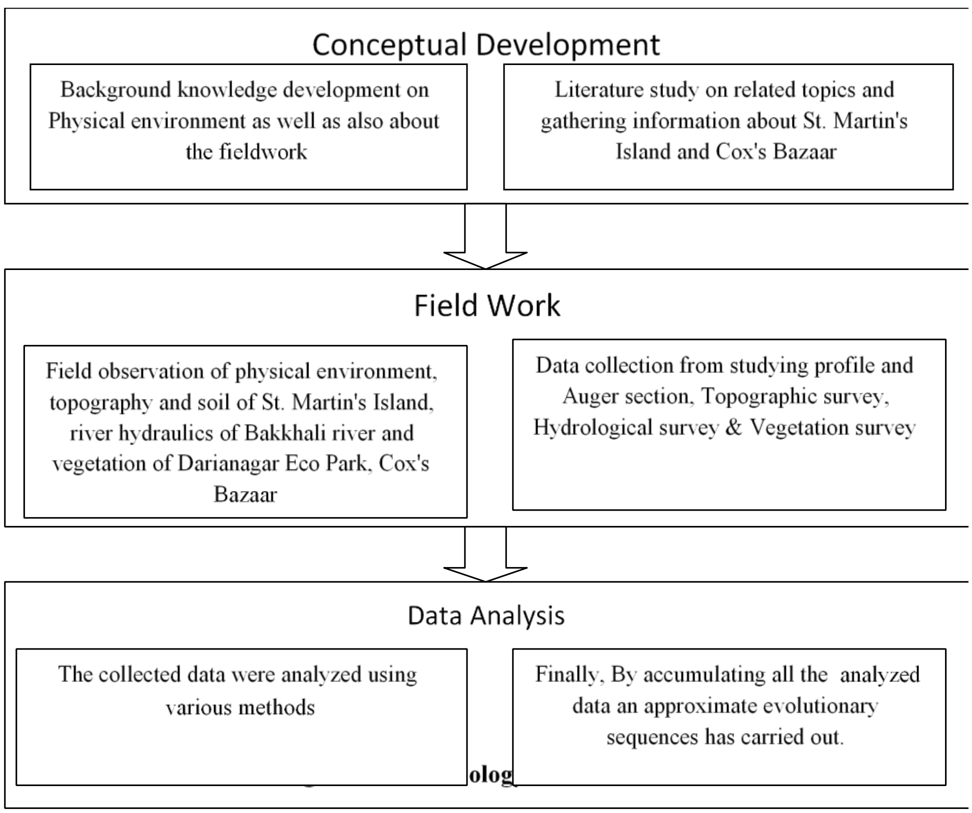
Ocean water quality study: Water sample from any desire depth of ocean, river or other water bodies can be collected using water sampling bottle. In our department the most widely used is Van Dorn water sampler that is modified by Professor Dr. M. Shahidul Islam.

5. Vegetation Survey:

Vegetation survey was conducted to introduce us with various plant species of Moheshkhali Island. This survey included both qualitative and quantitative approaches. Quadrate method was used. In this method the surveyed area was divided into 25 equal square blocks and each block has its own ID number. In a sampling method the block was selected for complete vegetation survey.

1.5 Field Plan

For our study we have used the Inductive approach that can be described under three categories



Before Fieldwork

These activities include all preparatory activities before going to the field. The following tasks were made within the department-

- Acquiring knowledge about field work in Geography and other issues related to field study and physical environment

- Preparing and repairing of important instruments for the field like Gauge sampler, water sampler, monolith and most importantly the newly invented Sediment Graber instrument for collecting sediment from the bottom of the river.
- Making an effective field plan to distribute the field activities properly
- From this transportation, accommodation and facilities were made ensured before leaving for Cox's Bazar.

At the Field

During the field work list of activities were done sequentially. These doings were completed according to the following sequence.

Day-1:

- Observing the geomorphic features of Sonadia Island (sand dune, sandy beach, mud field etc.)
- Measuring topography and sand dune and collecting sediments sample for lithostratigraphic survey and identifying the sediment of Sonadia Island.
- Collecting data and sample of the Bay of Bengal for hydrological survey.

Day-2:

- Slope measurement and vegetation data collection of Moheshkhali Island.

After Fieldwork

After returning from trip the lithological data, vegetation data and collected samples were analyzed to construct major output of the study.

1.6 Limitations of the research

Like every field work there were also some limitations in our fieldwork. Some of the major limitations are-

- Time limitation
- Instrument limitation
- Less experience
- Human technical error
- Defect in techniques
- Natural hazards

Chapter 2

Geomorphological study of Sonadia Island

2.1 Introduction

Geomorphology is the science of landforms, with an emphasis on their origin, evolution, form, and distribution across the physical landscape. Understanding geomorphology is therefore essential to understanding one of the most popular divisions of geography. Studying geomorphological processes provides significant insight into the formation of the various structures and features in landscapes worldwide, which can then be used as a background for studying many other aspects of physical geography.

Today, the study of geomorphology is broken down into the study of various geomorphological processes. Most of these processes are considered to be interconnected and are easily observed and measured with modern technology. The individual processes are considered to be either erosional, depositional, or both.

- An erosional process involves the wearing down of the earth’s surface by wind, water, and/or ice.
- A depositional process is the laying down of material that has been eroded by wind, water, and/or ice.

The main aim of the course is understanding of natural processes which act on the earth' s surface and the landforms. The course also considers some of the practical aspects of reading a geomorphological, map, recognizing the landforms and understanding the natural processes.

The importance of geomorphology for physical geographers is not only important in understanding Earth’s physical changes but also in preparing for hazards. For instance, understanding issues of deforestation, soil properties, and seasonal precipitation can better assess frequencies of flooding events and their potential danger.

2.2 Geographical account of Sonadia Island

Sonadia Island at Moheshkhali of Cox's Bazar is situated in the southern-eastern coastal region of Bangladesh at 21°N and 91°E. The island covers an area of 10,298 hectares. It lies a few kilometers north of Teknaf Peninsula, north-west of Cox's Bazar town and is bounded by the Bay of Bengal on the West and East. The Island is separated from the mainland by the Moheshkhali channel and from Moheshkhali Island by the Boro Canal.

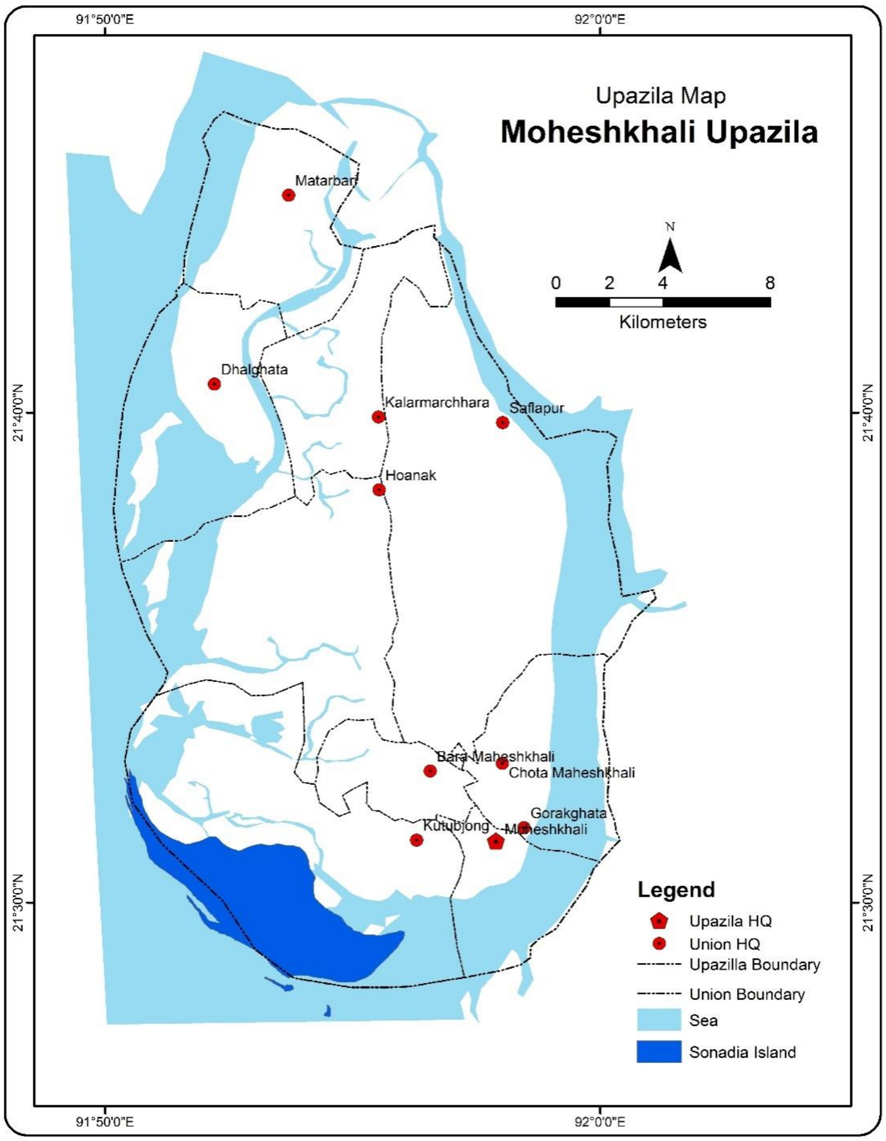


Fig 2.1: Geographical location of Sonadia Island

2.3 Geomorphological classification of Sonadia Island

Though Moheshkhali Island is little far from the active delta formation region, it still receives a lot of sediment and undergoes coastal process which helps reshape the morphology of the island's coast, especially the south and south-eastern part including Sonadia Island. Changes are apparent in the south-eastern coastline of Sonadia Island, which thus gets the characteristics of a sandbar. In Sonadia Island, Sandy beach and Shoals units may seen.

Fig 2.2: Geomorphological mapping team

The island presents a variety of geomorphological classifications:

- ***Intertidal Zone:*** The intertidal zone is the area of the marine shoreline that is exposed to air at low tide, and covered with seawater when the tide is high. In Sonadia, it comprises 0.97% area.

- ***Fore Dune***: Fore dunes are continuously disturbed by the wave action. These are the newly developing dunes, initiated by windblown sand being trapped by vegetation.

- ***Medium Dune:*** This semi-stable transition zone between the dynamic fore dune zone and the stable landward zone is dominated by a limited number of low-growing, or hardy, wind-tolerant native plants.
- ***High Dune:*** High-dunes are those dunes that are typically more stable and covered with intermediate woody and herbaceous species. They are still subject to sand accretion and erosion processes but to a lesser extent. Eventually these dunes will be succeeded and covered with woody shrub and tree species forming coastal forest.
- ***Wetland:*** Wetland covers about 2.55 square km area of the island which is about 9.26% of the total area.
- ***Swamp:*** Swamps are defined by their ability to support woody plants and trees. The mangroves are distributed at the sheltered inland part of Sonadia and a very narrow intertidal area on the edge of the estuary, covering an area of 560 ha, and at northern Ghtivanga, covering an area of 1162 ha and Amabashyakhali 809 ha giving a total mangrove area of 2622 ha (41.9% of total area).
- ***Mud Flat:*** Mudflat areas are rich in intertidal grassy vegetation and mangrove growth .The total mudflat area was estimated at 785.2 ha in 2010.The largest undisturbed salt marsh area is in south Sonadia Island; Other areas are along the mangrove formations north of sonadia .The mud flats constitute important habitats for migratory and resident birds and numerous of invertebrates.
- ***Plain Land:*** It covers 4.43% of the total area occupying local settlements, agricultural area and roads in the island.
- ***Undulating Land:*** Undulating topography simply means having a wave-like topography. This part of the land. It contains the Jhaw trees and comprises an area of about 2.93 Square kilometers.
- ***Waterbody:*** Various streams and canals have crisscrossed the island which covers about 4.40% of the total area.
- ***Beach:*** The length of beach is very long here in this zone. The soils mainly consisted of sand coming from sea through high tidal action. Some organic matters with the parts of sea animals and plant parts are associated with the sand. The sand dune habitat is unstable due wind action. Sand always moves from embryo dune to towards land.

Table 2.1: Geomorphological classification of Sonadia Island

Landform	Area (sq. km)	Area (Acres)	Area (%)
Intertidal zone	0.267	66.06	0.97
Fore Dune	0.0495	12.246	0.18
Medium Dune	0.167	41.475	0.61
High Dune	0.26	64.373	0.94
Wetland	2.55	631.345	9.26
Swamp	14.55	3593.332	52.68
Mudflat	3.0077	743.235	10.9
Plain Land	1.221	301.826	4.43
Undulating Land	2.929	723.989	10.61
Beach	1.384	342.034	5.02
Stream	1.22	300.194	4.40
Total	**27.6**	**6820.109**	**100%**

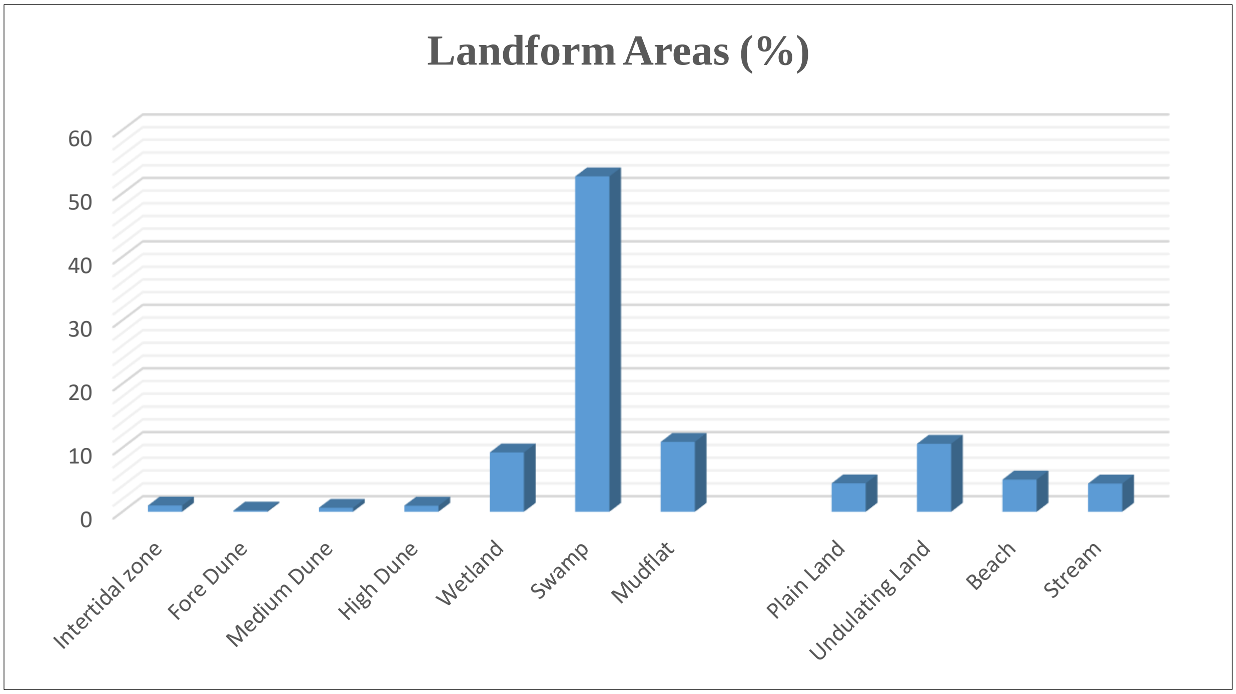


Fig 2.3: Landform areas of Sonadia Island

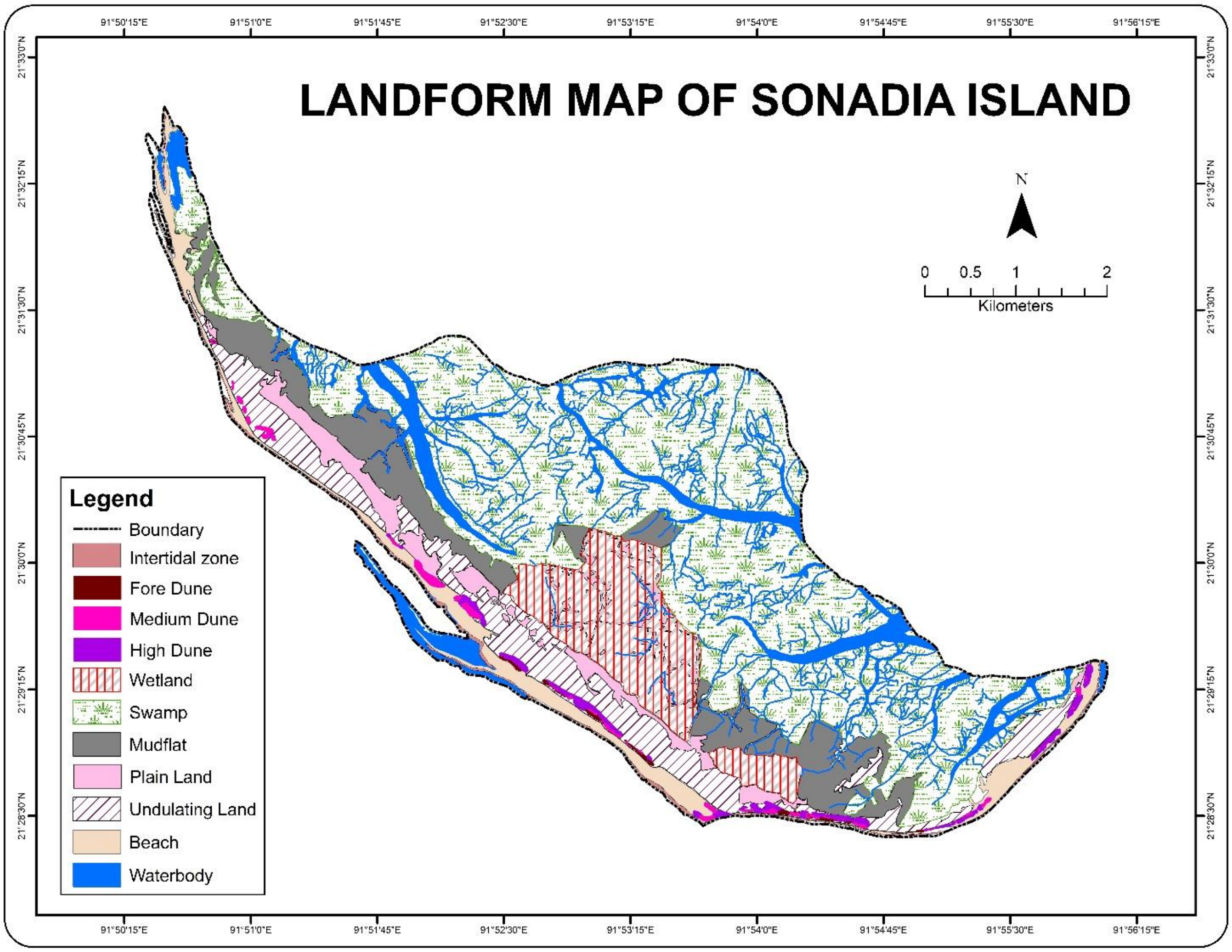


Fig 2.4: Landform map of Sonadia Island

2.4 Lithostratigraphy of Sonadia Island

Lithostratigraphy refers to the element of stratigraphy that deals with the description and nomenclature of the rocks of the Earth based on their lithology and their stratigraphic relations. The boring method is used for exploration of the lithology at greater depths of a particular area.

Here we used the Auger Boring method to know the lithostratigraphy of the Sonadia Island. This method is fast and economical, using simple, light, flexible and inexpensive instruments for large to small holes. The examination of the sub-soil conditions for simple buildings to be erected in clayey or sandy soil can be best performed by a post hole auger. The auger is held vertically and is driven into the ground by rotating its handle by applying leverage. The auger is pressed down during the process of rotation.

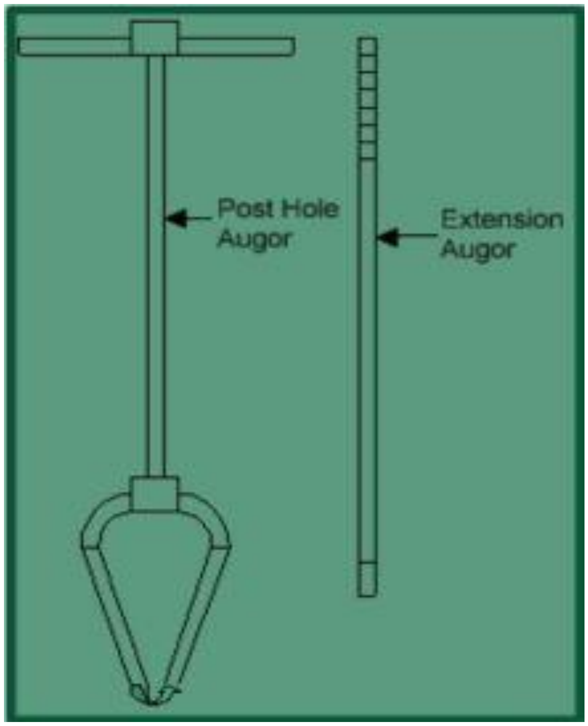


Fig 2.5: Auger Boring

Besides this, gauge sampler, measuring tape, hexa blade, PVC pipe etc were used to get the task done properly.

The boring location or sample site was a mudflat area which is situated in a spot having the GPS value of 21°30'32.15" North and 91°53'10.36" East. It was also rich in intertidal grassy vegetation and mangrove growth. The total mudflat area was estimated at 785.2 ha in 2010. The largest undisturbed salt marsh area is in south Sonadia Island; Other areas are along the mangrove formations north of sonadia .The mud flats constitute important habitats for migratory and resident birds and numerous of invertebrates.

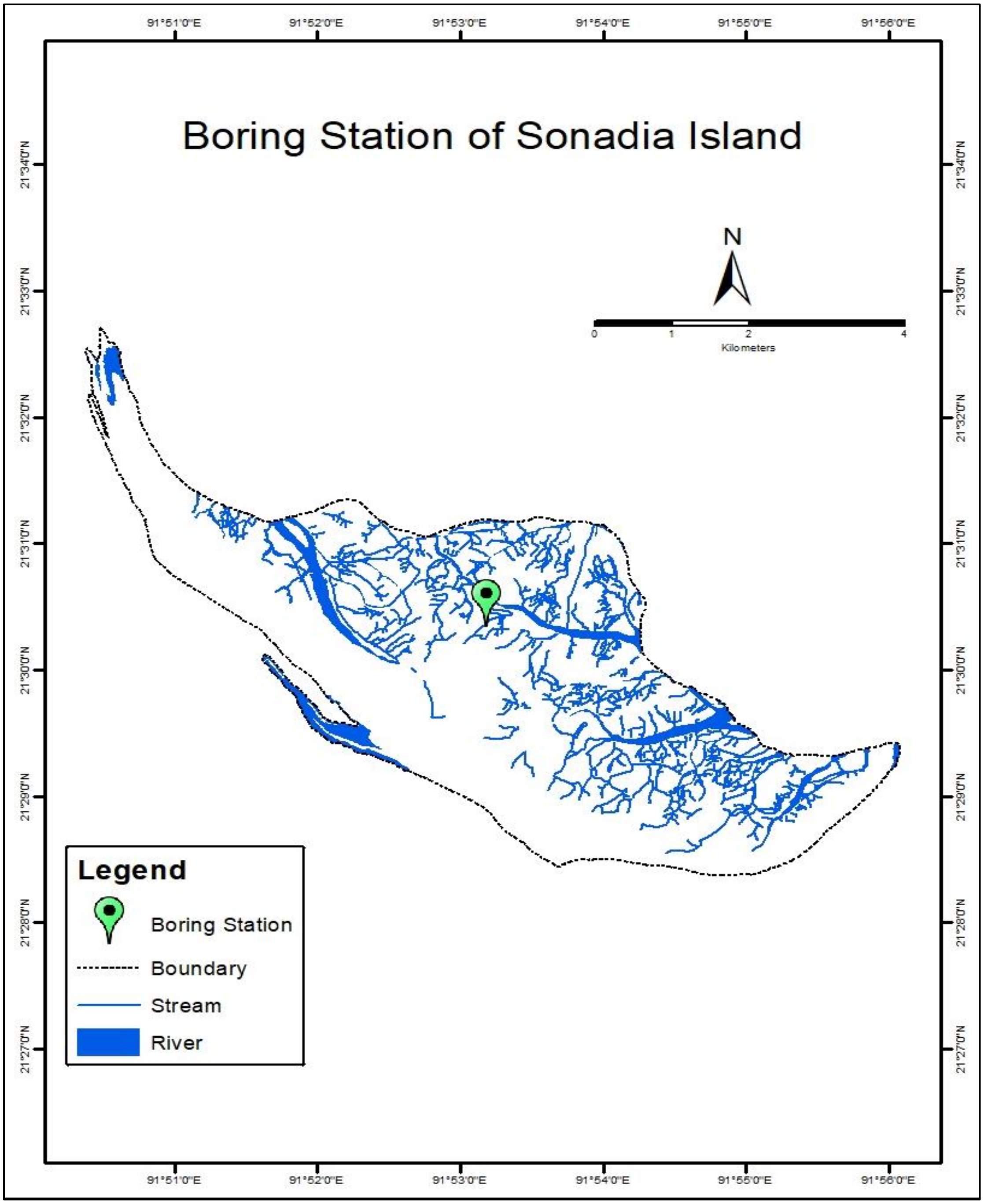


Fig 2.6: Boring Station of Sonadia Island

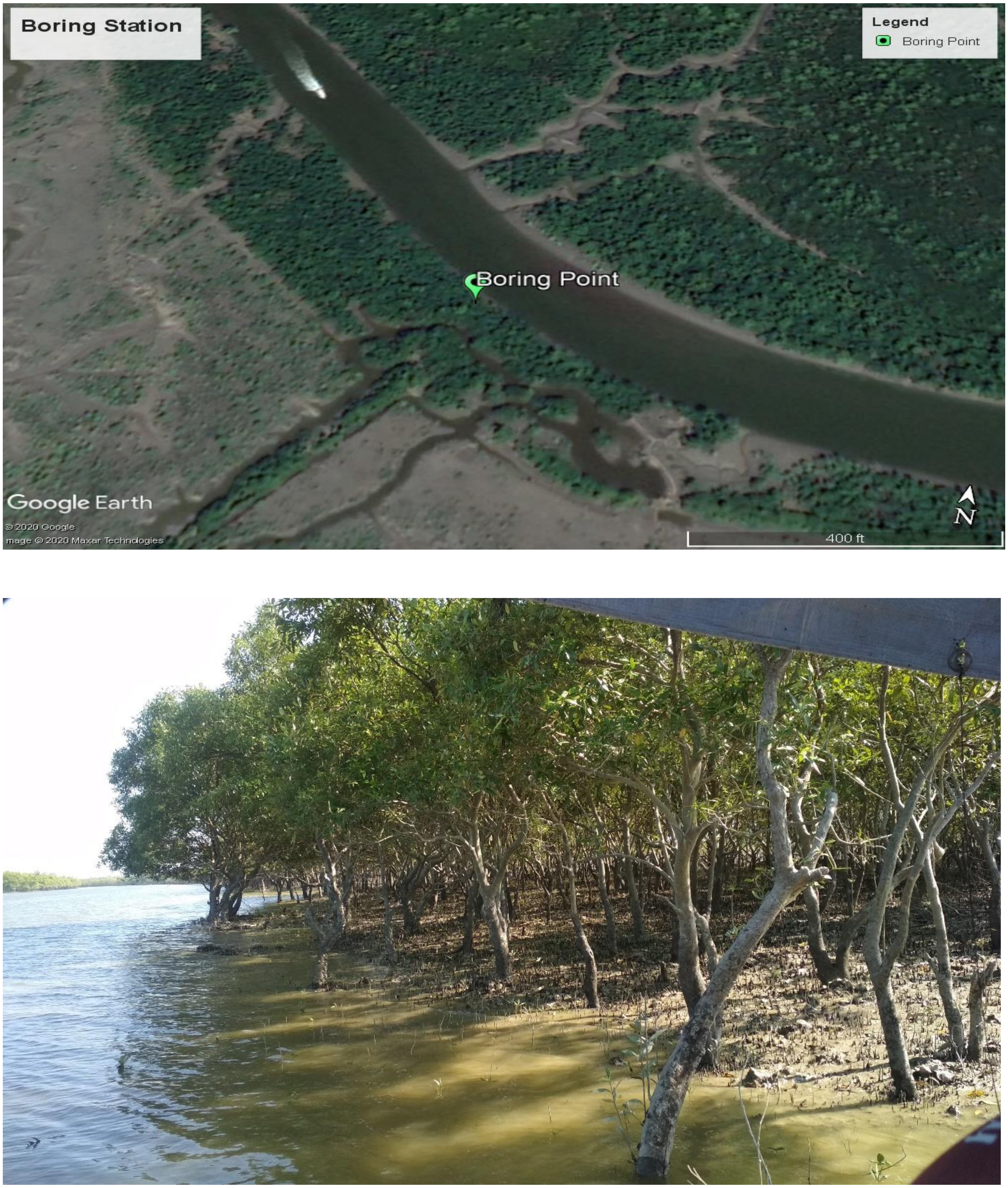


Fig 2.7: Boring sampling site

Fig 2.8: Collecting samples at the boring station

Table 2.2: Boring data from the sampling site

Depth (cm)	Symbolic Description	Description
0-10	As3 Ag1 Ga+ Th++ Nig3 Sic3 Straf0 Elas0	Very dark grey, silty clay, fresh, rootless, neometaphor
10-38	As3 Ag1 Ga+ Th+ Nig3 Sic3 Straf0 Elas0 Ls0	Dark grey, organic, silty clay,molted
38-50	As4 Ag+ Nig3 Sic3 Straf0 Elas0 Ls0	Sticky clay, medium grey, organic, low porosity
50-90	No data	No data
90-102	As4 Ag+ Nig3 Sic3 Straf0 Elas0 Ls0	Sticky clay, medium grey, organic,low porosity
102-112	Ga3 As1 Ag+ Nig2 sic2 Straf0 Elas0 Ls3	Sandy clay, medium grey, organic, medium porosity, upper boundary clear
112-120	Ga2 As2 Nig2 Sic3 Straf0 Elas0 Ls+	Sandy clay, medium grey, organic, low porosity
120-160	Ga3 As1 Nig2 Sic3 Straf0 Elas0 Ls+	Sandy clay, medium grey,

	Sh++	organic, medium porosity
160-210	Ga4 Sh++++	Sand, organic
210-257	As3 Ag1 Ga+ Nig2 Sic2 Straf0 Elas0 Ls1	Sticky, silty medium clay, medium porosity
257-290	As2 Ga1 Ag1 Nig2 Sic2 Straf0 Elas0 Ls1	Sticky, Silty clay, molted, medium porosity

For a description of component elements of biogenic sediments a system devised by Troels-Smith

(1955) is used. There are five main sediment categories:

- Turfa ('peat', coarse fraction)
- Detritus (median fraction)
- Limnus (fine fraction)
- Argilla (clay and silt)
- Grana (sand and gravel)

Relative abundance is recorded on a five-point scale:

- ⇨ 0 = absent
- ⇨ 1 = minor presence (1/4)
- ⇨ 2 = medium presence (2/4)
- ⇨ 3 = major presence (3/4)
- ⇨ 4 = sole presence (4/4)

A trace can be represented by '+'.

Moreover, the physical properties are as follows:

- Nig = Darkness;
- Sicc = Dryness;
- Strf = Stratification;
- Elas = Elasticity;
- Ls = Upper boundary etc.

Each is subdived into elements, as described in the following figure:

Class	Code	Element	Description
	Sh	Substantia humosa	Humous substance, homogeneous microscopic structure.
I Turfa	Tb $^{0-4}$	T. bryophytica	Mosses +/- humous substance.
	Tl $^{0-4}$	T. lignosa	Stumps, roots, intertwined rootlets, of ligneous plants +/- trunks, stems, branches, etc., connected with these, +/- humous substance.
	Th $^{0-4}$	T. herbacea	Roots, intertwined rootlets, rhizomes, of herbaceous plants +/- stems, leaves, etc., connected with these, +/- humous substance.
II Detritus	Dl	D. lignosus	Fragments of ligneous plants >2 mm.
	Dh	D. herbosus	Fragments of herbaceous plants > 2 mm.
	Dg	D. granosus	Fragments of ligneous and herbaceous plants, and, sometimes, of animal fossils (except molluscs) < 2mm > c. 0.1 mm.
III Limus	Ld $^{0-4}$	L. detrituosus	Plants and animals (except diatoms, needles of spongi, siliceous skeletons, etc., of organic origin), or fragments of these. Particles < c. 0.1 mm, +/- humous substance.
	Lso	L. siliceus organogenes	Diatoms, needles of spongi, siliceous skeletons, etc., of organic origin, or parts of these. Particles of < c. 0.1 mm.
	Lc	L. calcareus	Marl, not hardened like calcareous tufa; lime and the like. Particles < c. 0.1 mm.
	Lf	L. ferrugineus	Rust, non-hardened. Particles < c. 0.1 mm.
IV Argilla	As	A. steatodes	Particles of clay < 0.002 mm.
	Ag	A. granosa	Particles of clay 0.06 to 0.002 mm.
V Grana	Ga	G. arenosa	Mineral particles 0.6 to 0.2 mm.
	Gs	G. saburralia	Mineral particles 2.0 to 0.6 mm.
	Gg (min.)	G. glareosa minora	Mineral particles 6.0 to 2.0 mm
	Gg (maj.)	G. glareosa majora	Mineral particles 20.0 to 6.0 mm

Fig 2.9: Scheme for the description of the composition of biogenic sediments (from Troels-Smith, 1955).

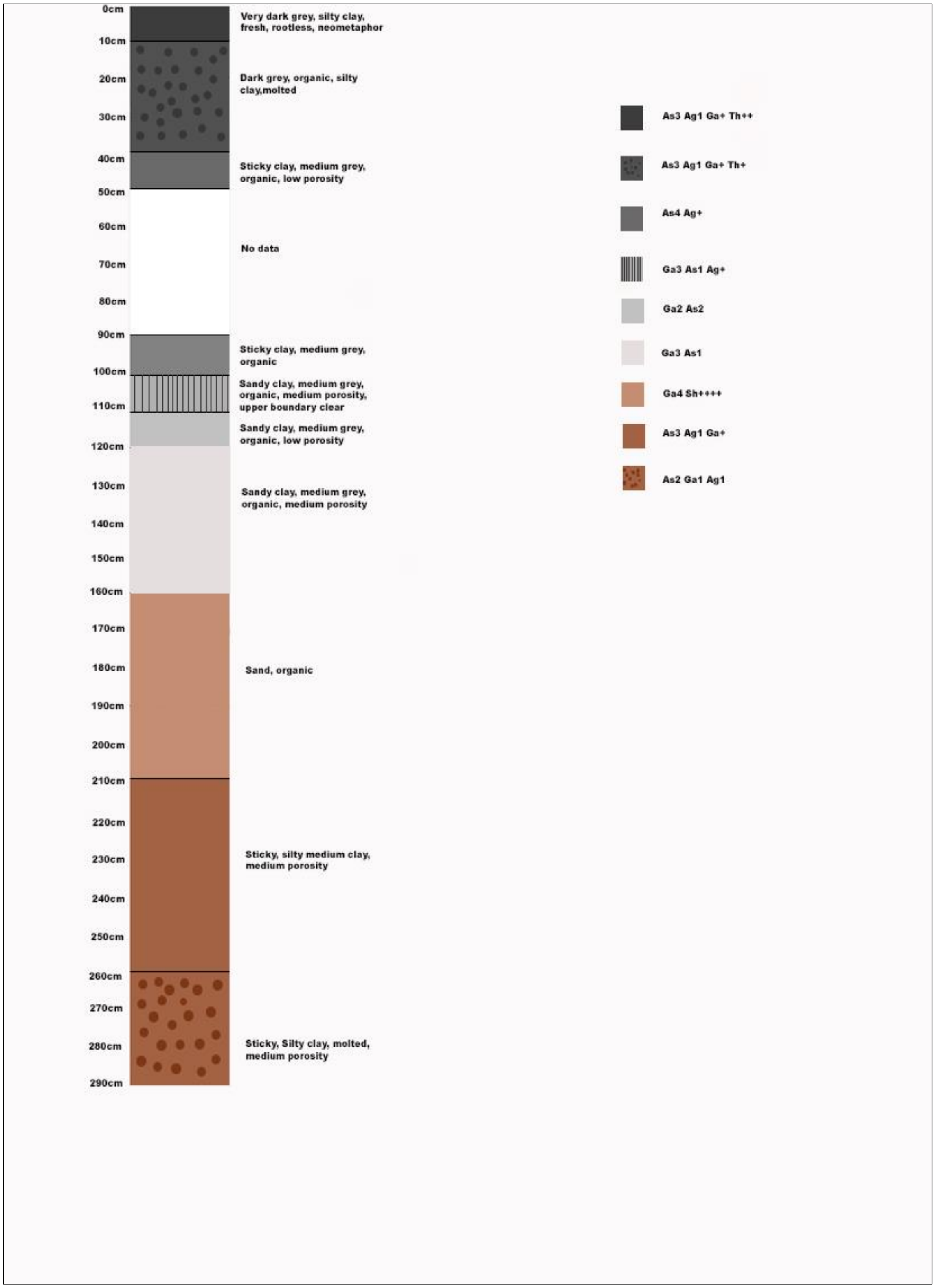


Fig 2.10: Profile of the sampling site

2.5 Land stability of Sonadia Island

Land or soil stability is an index of soil degradation (Cerdà, 2000) and is a measure of the capability of the aggregates to maintain their bonds under stresses that might cause their disintegration. It is generally measured by the DCP survey.

Dynamic Cone Penetration (DCP) is a test to measure in- situ resistance of subsurface sediment layers. The test is performed by pushing a rod into the soil repeated hammering at a fixed force. Several DCP test were conducted in our fieldwork at various location to measure the compactness of soil.

The DCP apparatus uses an 8kg weight dropping through a height of 575 mm and a 60º cone having a diameter of 20mm. It has the following parts:

a) Handle

b) Top Rod

c) Hammer (8kg)

d) Anvil

e) Handguard Cursor

f) Bottom Rod

g) 1 Meter rule

h) 60˚Cone

The DCP is designed for the rapid in-situ measurement of the structural properties. It is also used for determining the compacted soil sub-grade beneath the surface. Continuous measurements can be made down to a depth of 800 mm or, when an extension rod is fitted, to a depth of 1200 mm. Thus the soil layers can be identified and the thickness of the layers can be determined.

We performed DCP survey in total three stations in Sonadia Island and collected the soil samples which later were examined thoroughly in our physical lab. The sampling sites and derived data from the collected samples is given below.

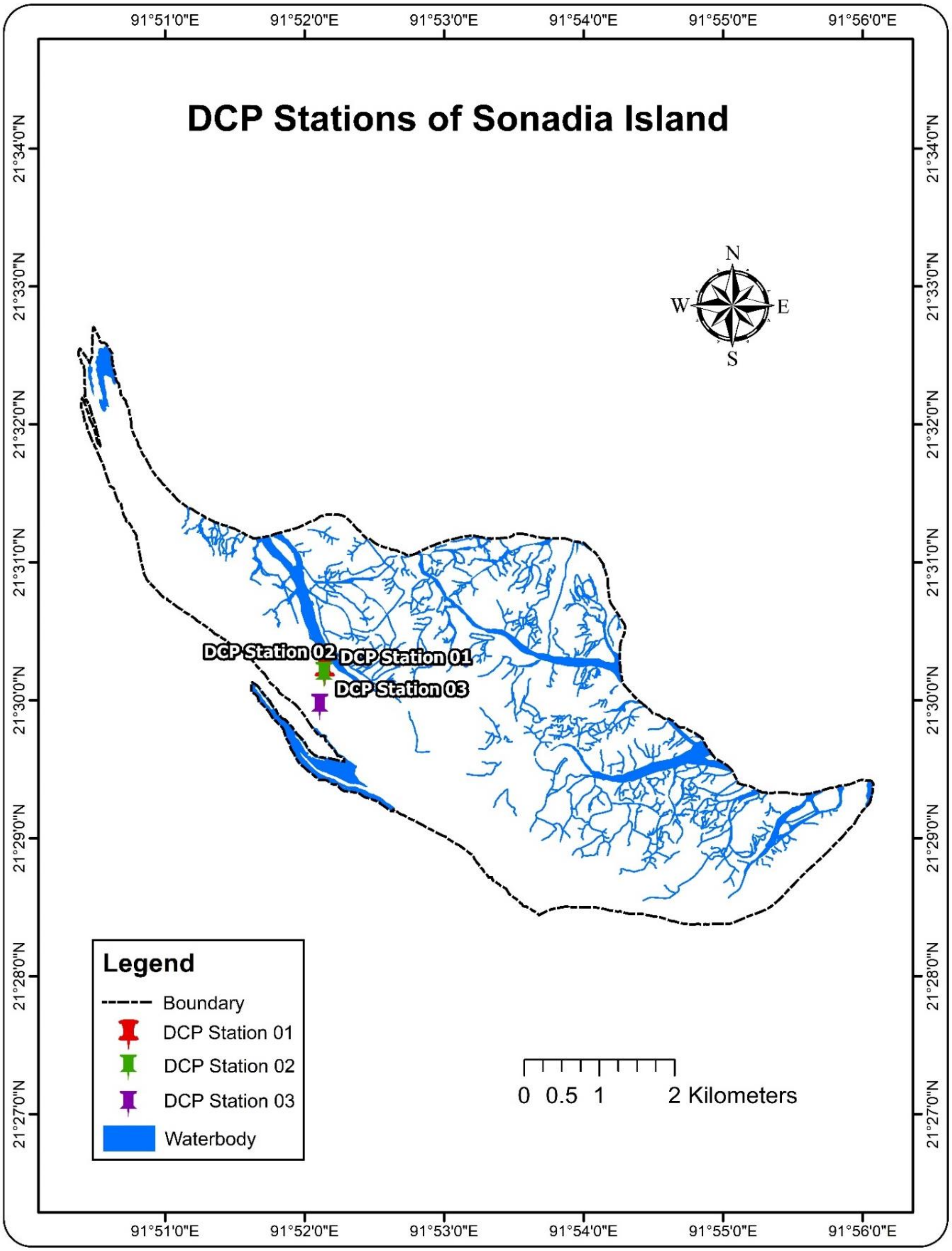


Fig 2.11: DCP stations of Sonadia Island

Fig 2.12: Team performing DCP at the station-1

Table 2.3: Penetration of DCP Data (Station 1: Upper land)

Hit No.	Cumulative Penetration (cm)	Penetration (cm)
0	0	0
1	5.6	5.6
2	9.6	4
3	12.1	2.5
4	15.1	3
5	17.6	2.5
6	20.6	3
7	23.1	2.5
8	26.1	3
9	29.1	3
10	32.1	3
11	35.1	3
12	38.1	3
13	42.1	4
14	47.6	5.5
15	53.1	5.5
16	59.1	6
17	63.1	4
18	68.1	5
19	73.1	5
20	78.1	5
21	82.1	4
22	85.1	3
23	89.6	4.5

24	93.1	3.5
25	95.6	2.5
26	98.1	2.5
27	99.1	1
28	102.6	3.5
29	106.1	3.5
30	111.1	5
31	116.1	5
32	121.1	5
33	124.1	3
34	126.6	2.5
35	129.1	2.5
36	132.1	3
37	136.1	4
38	141.1	5
39	144.1	3
40	148.1	4
41	153.1	5
42	156.6	3.5
43	158.6	2
44	160.6	2
45	162.1	1.5
46	164.1	2
47	165.6	1.5
48	167.1	1.5
49	168.1	1
50	169.1	1
51	170.1	1

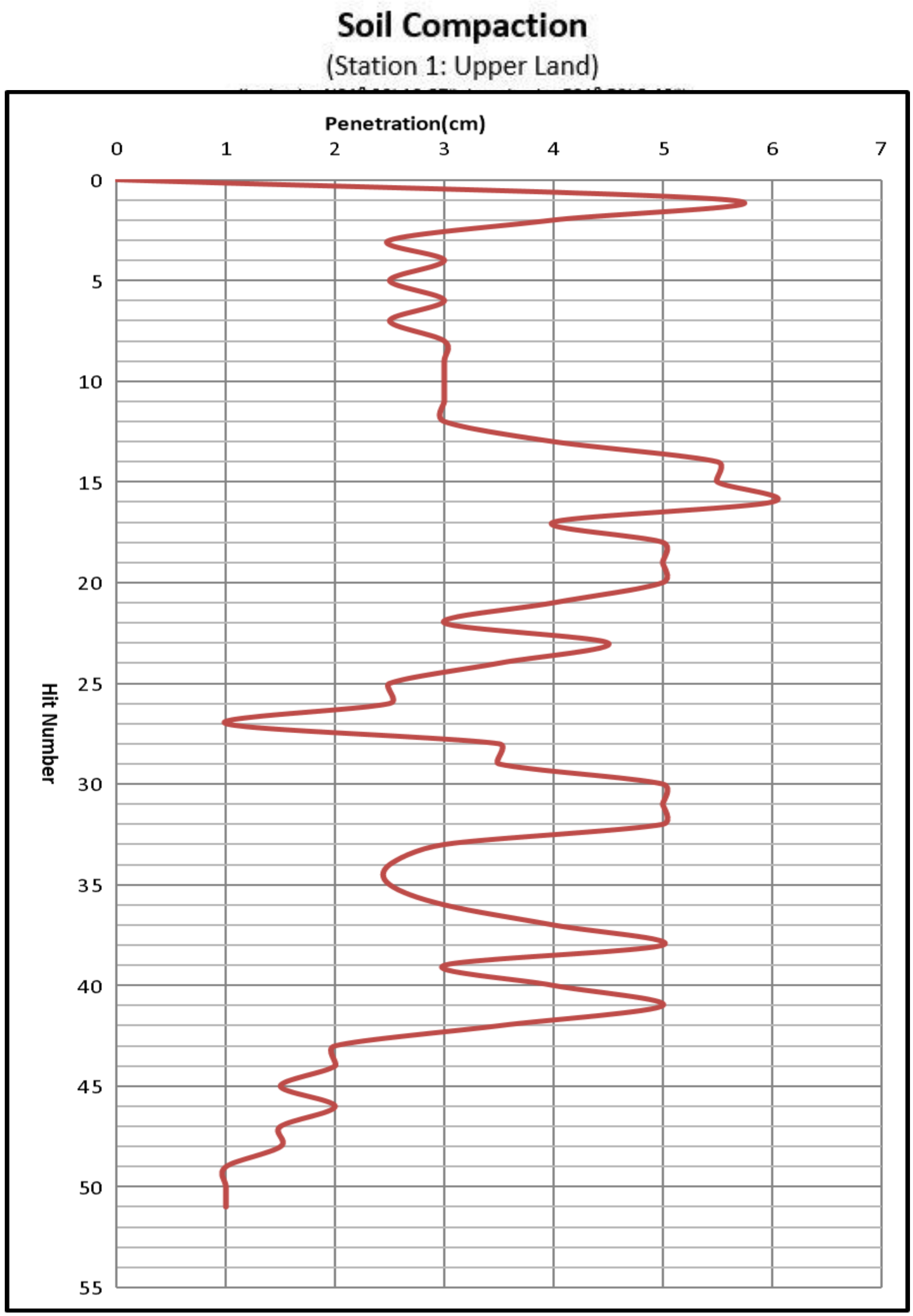


Fig 2.13: Soil compaction- Upper land (Station-1)

Table 2.4: Penetration of DCP Data (Station 2: Low land)

Hit No.	**Penetration (cm)**	**Cumulative Penetration (cm)**
0	0	0
1	6	6
2	4.5	10.5
3	2.5	13
4	3.5	16.5
5	3	19.5
6	4	23.5
7	4.5	28
8	3	31
9	3	34
10	4	38
11	3	41
12	4	45
13	4	49
14	5	54
15	7.5	61.5
16	8.5	70
17	11.5	81.5
18	6	87.5
19	2.5	90
20	3	93
21	2	95
22	2.5	97.5
23	2	99.5
24	3	102.5
25	2	104.5
26	1.5	106
27	2	108
28	2.5	110.5
29	4	114.5
30	4	118.5
31	2	120.5
32	4	124.5
33	4	128.5
34	14	142.5
35	2	144.5
36	2	146.5
37	2	148.5
38	2	150.5

Hit No.	Penetration (cm)	Cumulative Penetration (cm)
39	2	152.5
40	2	154.5
41	3	157.5
42	10	167.5
43	4	171.5
44	2.5	174
45	2.5	176.5
46	2	178.5
47	2	180.5
48	3	183.5
49	9	192.5
50	4	196.5
51	72	268.5
52	5	273.5
53	6	279.5
54	5	284.5
55	5	289.5
56	5	294.5
57	3	297.5
58	3.5	301
59	3.5	304.5
60	3	307.5
61	3	310.5
62	3	313.5
63	3	316.5
64	2.5	319
65	2.5	321.5
66	3	324.5
67	2.5	327
68	3.5	330.5
69	2	332.5
70	3	335.5
71	3	338.5
72	2	340.5
73	3	343.5
74	2	345.5
75	2	347.5
76	1	348.5
77	2	350.5
78	3	353.5
79	3	356.5

Hit No.	Penetration (cm)	Cumulative Penetration (cm)
80	2	358.5
81	2.5	361
82	2	363
83	2	365
84	1.5	366.5
85	2	368.5
86	1	369.5
87	1	370.5
88	1	371.5

Fig 2.14: Team performing DCP at the station-2

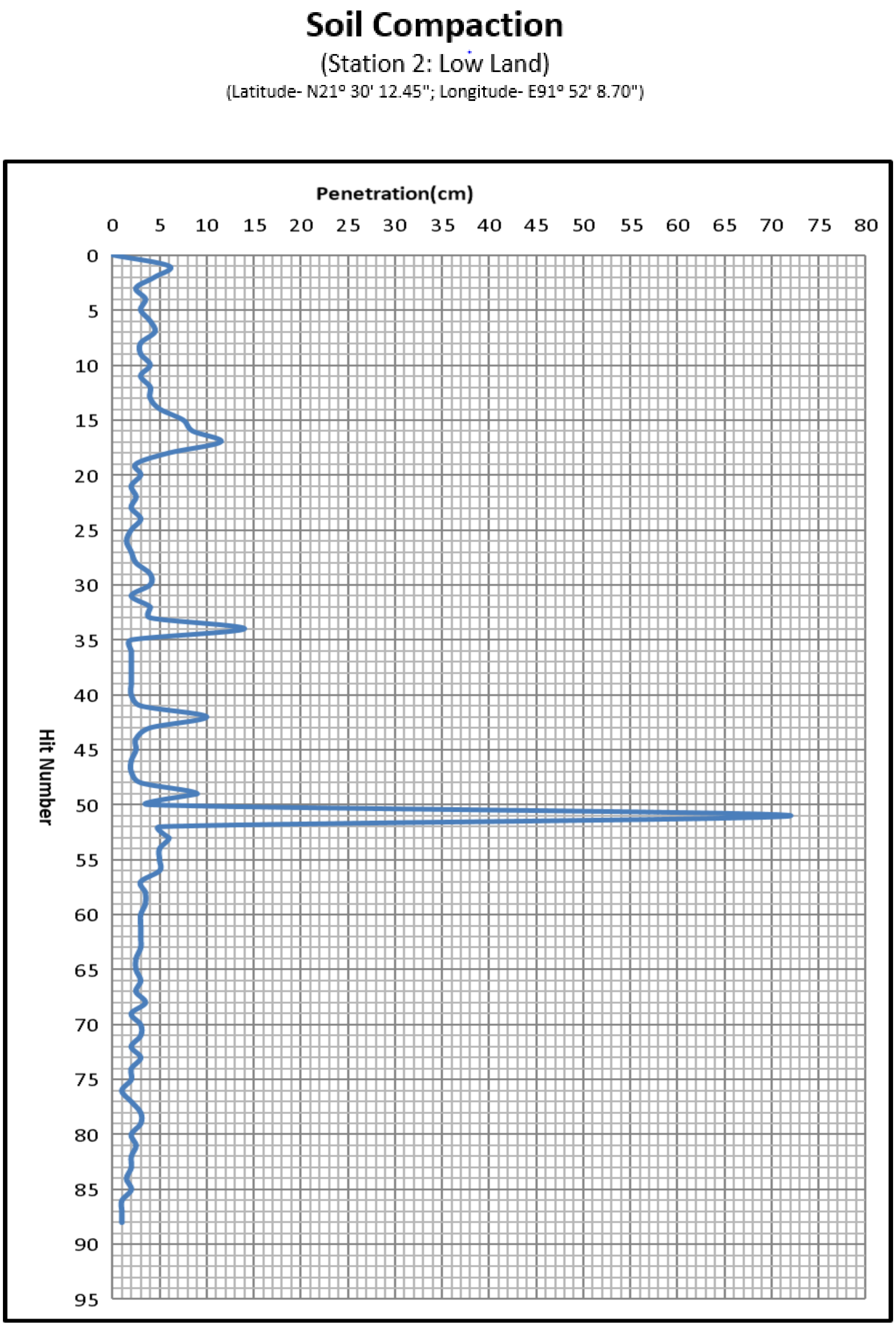


Fig 2.15: Soil compaction- Low land (Station-2)

Table 2.5: Penetration of DCP Data (Station 3: Sand dune)

Hit No.	**Cumulative Penetration (cm)**	**Penetration (cm)**
0	0	0
1	23	23
2	34	11
3	43	9
4	52	9
5	60	8
6	66	6
7	73	7
8	79	6
9	84	5
10	89	5
11	95	6
12	102	7
13	108	6
14	112	4
15	115	3
16	118	3
17	121	3
18	123	2
19	126	3
20	129	3
21	133	4
22	135	2
23	138	3
24	141	3
25	143	2
26	145	2
27	146	1
28	149	3
29	151	2
30	152	1
31	154	2
32	155.5	1.5
33	157	1.5
34	159	2
35	160	1

Hit No.	Cumulative Penetration (cm)	Penetration (cm)
36	162	2
37	163	1
38	164.5	1.5
39	166	1.5
40	168	2
41	169	1
42	171	2
43	172	1
44	173.5	1.5
45	175	1.5
46	177	2
47	178	1
48	180	2
49	181.5	1.5
50	183	1.5
51	185	2
52	186	1
53	187.5	1.5
54	189	1.5
55	190.5	1.5
56	192	1.5
57	193	1

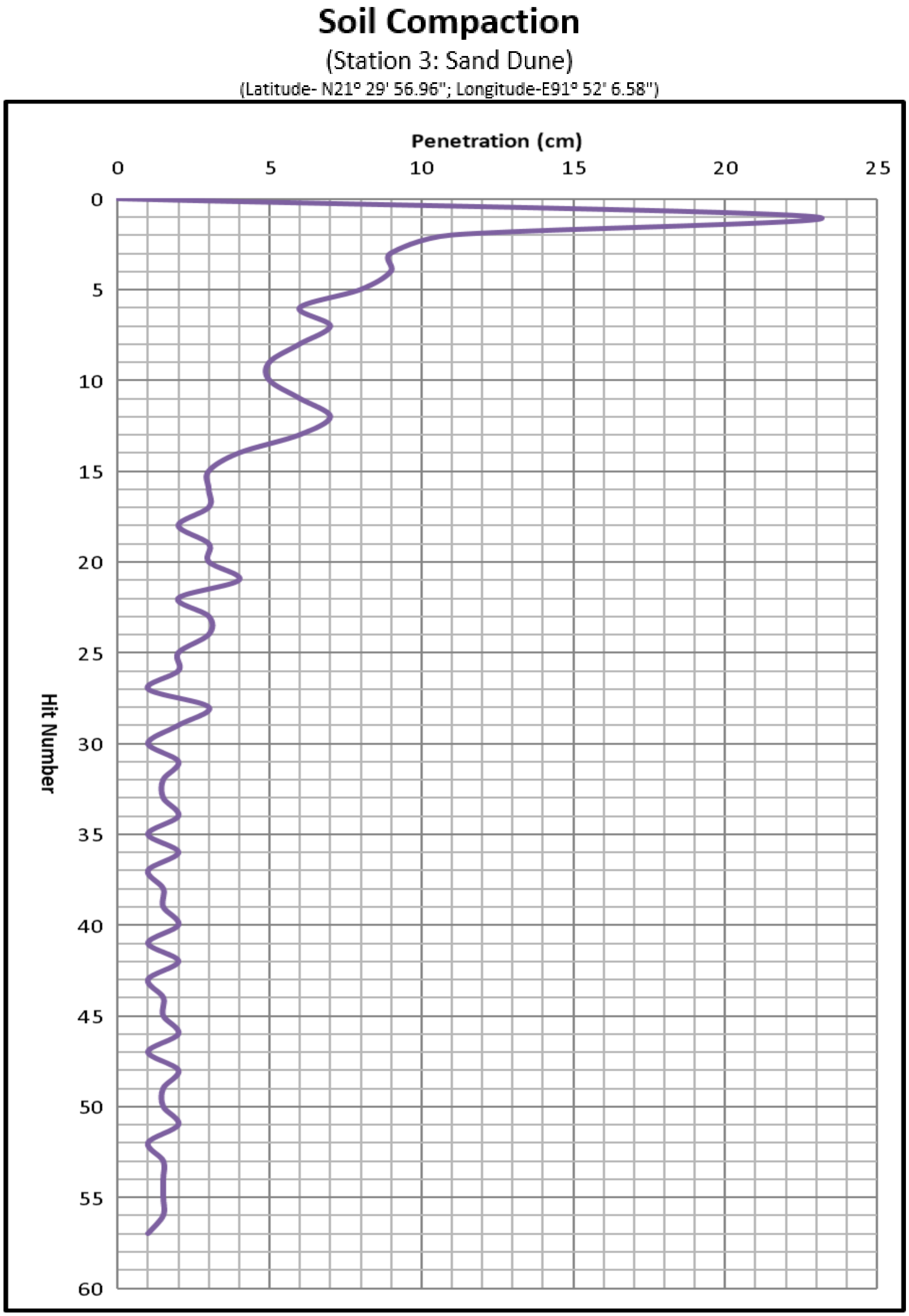


Fig 2.16: Soil compaction- Sand dune (Station-3)

Soil Compaction

(Station 1,2,3)

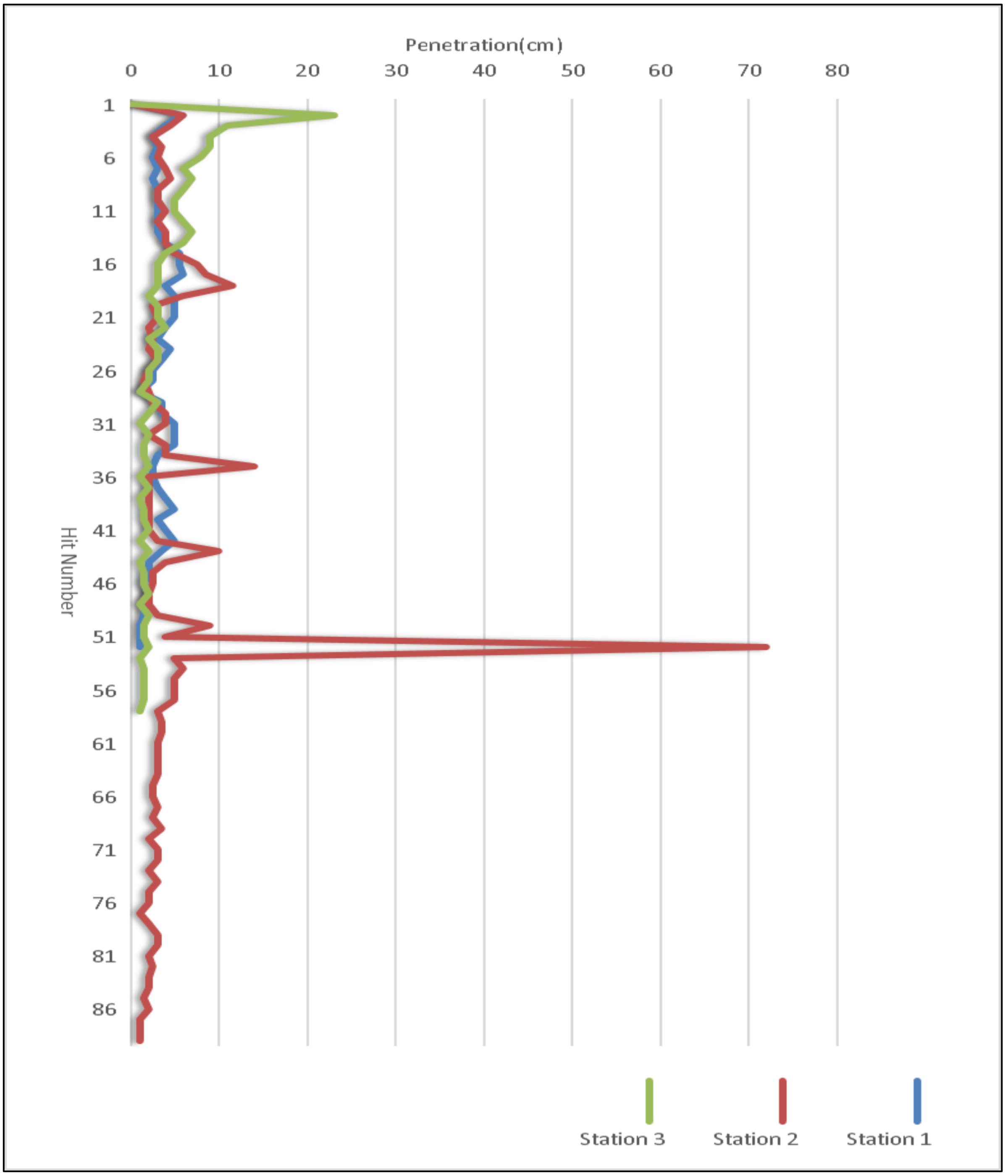


Fig 2.17: Soil compaction- Upper land (Station-1,2,3)

2.6 Land cover map of Sonadia Island

Land cover refers to the physical material at the surface of the earth. Land covers include grass, asphalt, trees, bare ground, water, etc. Sonadia island all over covers about 27.6 square kilometres area which exhibits various physical features including jhaw forest, mangrove, shrimp farming, dune vegetation, bridge, waterbody, settlements, roads, grazing land etc.

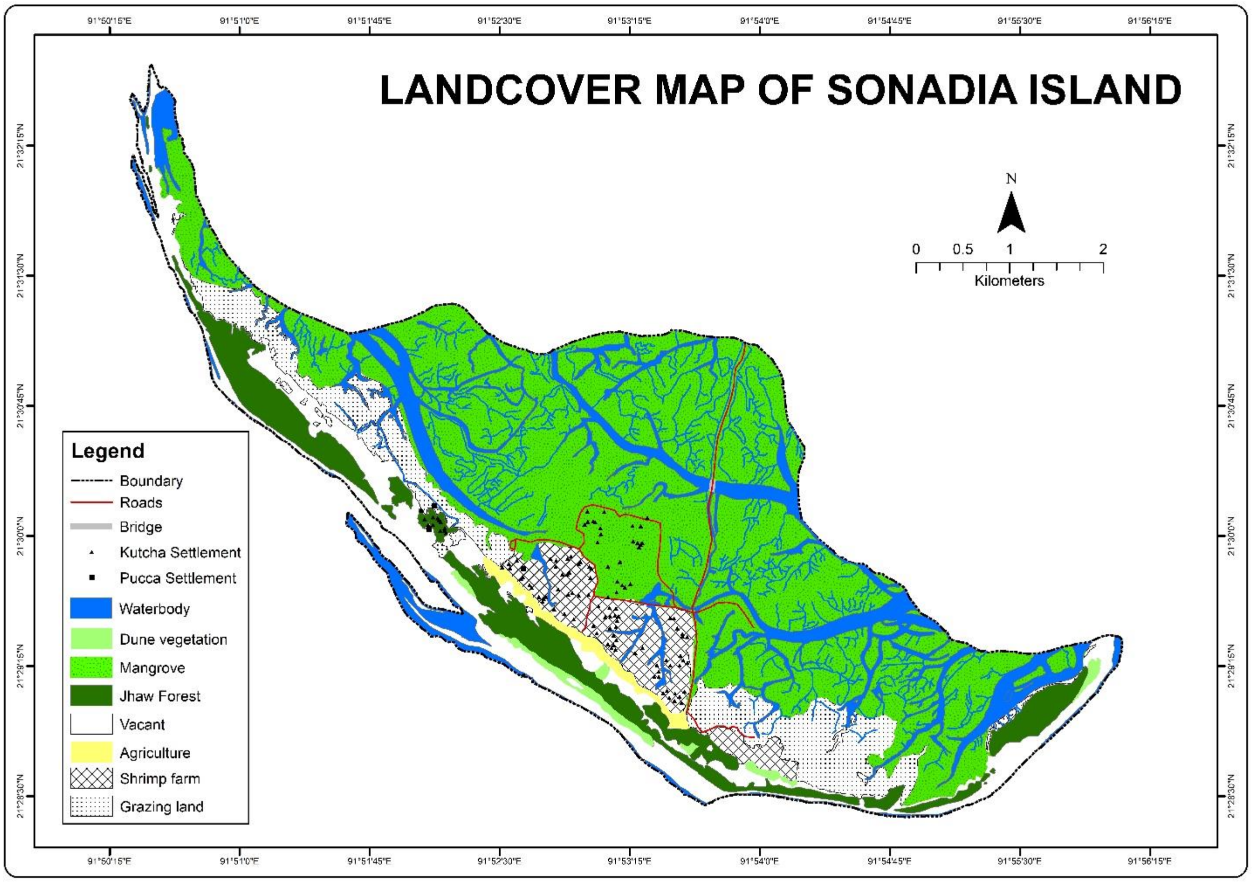


Fig 2.18: Land cover map of Sonadia island

Table 2.6: Land cover of Sonadia Island

Land cover	Area (sq. km)	Area (Acres)	Area (%)
Shrimp farm	2.045	505.231	7.41
Mangroves	15.58	3850.883	56.46
Jhaw forest	2.25	555.736	8.15
Grazing land	3.011	744.088	10.91
Dune vegetation	0.26	63.452	0.93
Agriculture	0.26	65.225	0.96
Waterbody	3.59	886.109	12.99
Vacant	0.60	149.385	2.19
Total	27.6	6820.109	100%

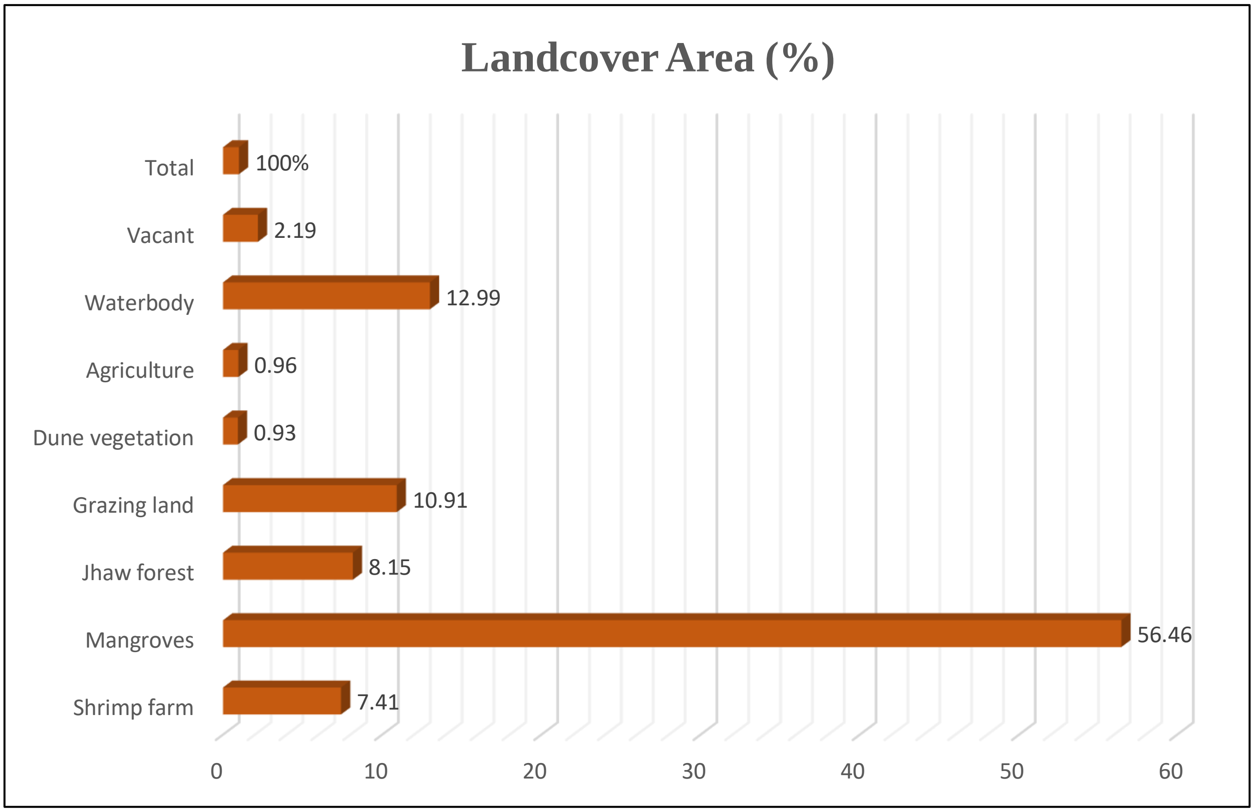


Fig 2.19: Land cover of Sonadia Island

Shrimp farm

Mangroves

Jhaw forest

Grazing land

Vacant

Agriculture

Dune vegetation

Waterbody

Bridge

Settlement

2.7 Conclusion

Sonadia Island is one of the biodiversity hotspot of Bangladesh. Sonadia is considered ecologically important by the government and in 1999 was declared as an ECA under Environmental Act of 1995. The island is unique for wintering shorebirds specially the globally critically endangered Spoon-bill sandpiper, one of the rarest migratory birds in the world, with a population of just 300-350 pairs left in the wild (Zöckler, 2006). Lying within the East Asian-Australasian Flyway, Sonadia is used by migratory birds as a stopover during their long migration further south.

The island provides breeding areas for four globally threatened species of marine turtles, and serves as a significant bird refuge for over 80 migratory species. Sand dunes are home for many plants and animals. They act as a natural barrier to the destructive forces of wind and waves, sand dunes serve as are our first line of defense against coastal storms and beach erosion. They absorb the impact of storm surge and high waves, preventing or delaying flooding of inland areas and damage to inland structures.

They are often severely degraded due to excessive exploitation, chaotic urban growth, trampling, invasion of species, sea level rise and climate change. When structures are built so close to a beach as to prevent this natural fluctuation, overall erosion of the beach and loss of dunes can occur. This leaves a shoreline much more vulnerable to damage from storms.

Chapter 3

Sand Dunes of Sonadia Island

3.1 Introduction

The sand dunes are a vital part of the natural character of the Sonadia Island. The continued health of the sand dunes and beach is very important for the protection of local people from predicted sea level rises (which are likely to have a major impact on the Island). The beach is the breeding habitat

for globally threatened turtles. The dunes act as a filter for rainwater as it recharges the groundwater. They also prevent sand being blown inland by winds.

Winter winds and tidal forces accelerate the erosion of dunes that have had vegetation removed. Keeping the above importance of sand dunes into consideration, the following objectives were set out for the field work:

- ⇨ Understanding the current topography of the dunes at Sonadia Island
- ⇨ Slope measurement of sand dunes
- ⇨ Height measurement of sand dunes
- ⇨ Profiling of dune to see the stratification within the dune.
- ⇨ Dune sample collection from different places of dune for lab test.

3.2 Coastal Sand Dunes

Sand dunes are dynamic elements of the landscape. A coastal sand dune is a hill of sand built by wind action and an extension of the beach into the land. While a beach is closely linked to the sea and controlled by waves and tides, the dunes are linked to land and are controlled by winds. Sand dunes are common features of shoreline and desert environments.

Sand dunes form in intertidal zones of coastal beaches, where there is enough sand and adequate wind. Sand dunes range in size from ridges less than 1m in height and width, to massive dune fi elds that extend inland for many kilometres (Hesp, 2000). They are found worldwide but are less developed in tropical and subtropical zones (where wind velocities are lower and the soil is damper)

Some examples of well-developed dune systems in the world are found along the Great Lakes, the Pacific and Atlantic coasts of USA and Mexico, the Gulf of Mexico, central America, Brazil, Europe (Great Britain, Ireland, western France, southern Spain, Denmark, The Netherlands and Poland), the Mediterranean, southeastern Australia, South Africa and even Sri Lanka where nearly 300 km of low dune coasts have been described.

Many coastal sand dunes first appeared in association with stable beaches. That is, when sediment supply was adequate along the margin of some water body that was not transgressing rapidly. There are geomorphologic features which are considered as coastal sand dunes in the geologic record from the early Tertiary period (65 million years ago), although some authors suggest that coastal dunes existed back in the Cambrian period (500 millions years ago). However, present-day coastal dune systems are confined to the geological time when the ocean level was at its present position to allow dunes to form, and sediment supply was sufficient. According to this, most present coastal dunes are relatively young because the shoreline system is relatively young. For example, most of the dunes in northern Europe, USA and Canada formed from shelf debris moved onshore as glaciers retreated and sea level stabilized during the Late Pleistocene and Early Holocene (ca. 10 000 years ago). The earliest dunes in the British Isles are around 5000 to 6000 years old, while the Dutch dunes date from about 4000 to 5000 years before present. A similar chronology has been suggested for the dunes in North America (e.g. Oregon). The Australians claim that the sea level around their continent has been stable for the last 5000 to 6000 years and that the oldest coastal landforms are of that age. The modern shoreline at the Gulf of Mexico is of the order of 3000 ± 500 years.

Formation of dunes is through sand accretion. Sand that is brought in by the winds gets trapped by the shrubs, creepers, trees and other obstacles that are found on the coast. This accumulated sand forms mounds of sand that keep growing over time to form large dunes (McHarg, 1972).

Dunes form typically on large flat beach profiles with a large sediment supply to the backshore. Dunes develop in a different way to other depositional features because they are the result of the interaction between marine processes and the atmosphere. In brief, dunes begin to form beyond the strandline of the beach where dry sediment is transported by wind through saltation and suspension. Beach litter and debris that collects on the storm beach acts as an obstacle to saltation and sediment begins to build up. Over time, an embryo dune develops, which may become vegetated by marram grasses.

Dunes have a typical form, the windward side is gentle sloping and shaped my wind movement. The leeward side faces away from the shore and is steeper and unstable. Dunes increase in size inland. As vegetation stabilizes the dunes, fore dunes and yellow dunes develop. Within dune profiles there is clear crest and trough pattern. The troughs are called slacks and result form a positive feedback of continued removal of sediment out of the trough with its transfer by wind up the windward side of the next dune. It is common for the slack to be eroded so much that it reaches the water table where salt rich ponds are found.

One beach can vary quite substantially with the seasons. During the winter, stronger waves pick up more sand (but leave behind larger sediment), causing the beach to be steeper and coarser. In summer, gentle waves transport sand onshore and the beach takes on a shallower slope with finer sand.

Sand dunes are highly variable in terms of their size, longevity and mobility. They range from small and ephemeral to massive and persistent sand accumulations. They may extend inland for up to 10 km although their width may also be only a few meters. In terms of substrate mobility, dunes may be considered as mobile, semi-mobile or stabilized. When they are mobile, they may be either gaining or losing sand. Semi-mobile dunes are partially covered by vegetation and the stabilized ones are totally covered. The more plant cover the dunes have, the less mobile becomes the substrate.

The shape and size of dunes formed depends on the shape of the beach. On a shallow-sloped beach, the energy of waves is dissipated and the suspended grains of sand are deposited, resulting in greater dune potential. Steeper beaches do not dissipate this energy as well, and sand is more frequently washed back out to sea. Consequently, dunes on steeper beaches are smaller.

Once sand has been deposited on a beach, it is transported by the wind. When the prevailing wind direction is onshore, the sand gradually migrates landward from the water's edge. Shallow slopes of sand form, grains move up the slope and are dropped on the steeper lee ("protected") side of the pile, where the wind velocity is lower. When plants colonize dunes, their roots and stems help to anchor the shifting sand. The structure of plant stems and leaves create small pockets of protection from the wind, causing more sand to accumulate. It is important to note that sand dunes undergo a continual cycle of erosion (breaking down) and accretion (building up) with the wind and waves.

3.3 Sand dunes of Bangladesh

In our country sand dunes can be found in the south-eastern coastal areas including Sonadia and Saint Martin's island. The topography of the sand dune here is very undulating in nature.

- The average height of sand dunes is about 5m.
- The sand dunes direction are south to north and in some cases the direction are west to east.
- The dunes are interrupted by valleys of different meter wide.
- The sand dune habitat is unstable due to wind action.
- Sand always moves from embryo dune to towards land.
- The part of sand dune habitat particularly north of forest beat office has been changed because of Jhaw Plantation. Due to monoculture plantation of Jhaw, sand movement is inhibited from embryo dune to towards land. That is why, topography of this sand area is uniform. Undulation in sand dune is rare in this area.
- The beach length is very short here.
- Beach erosion is very severe in this site.

Climate change and sea-level rising are the current issue in all over the world, especially in Bangladesh which is the worst affected and is facing early impacts of climate change (Sikder 2010). The physiography of coastal area of Bangladesh is more diverse and dynamic than is generally recognized. Failure to recognize this could lead to serious misconceptions about the potential impacts of a rising sea-level on Bangladesh due to global warming (Brammer 2014).

The accurate shoreline change extraction and change detection analysis is an important task that has applications in different fields such as development of setback planning, hazard zoning, erosion-accretion studies, regional sediment budgets, adopting different conservation measures e.g. protection of human life, protection of biodiversity, poverty, natural environment and conceptual or predictive modeling of coastal morphodynamics (Aedla and Reddy 2015).

3.4 Classification of Sand dunes of Sonadia Island

Coastal dunes are widespread immediately above the beach and along the shorelines. This dune system is particularly well developed around with the shoreline in the Sonadia island. The dunes of Sonadia are of mainly three types:

a) ***Fore Dune***: Fore dunes are continuously disturbed by the wave action. These are the newly developing dunes, initiated by wind-blown sand being trapped by vegetation. This is the area where sand-binders thrive as they are well adapted to this highly variable environment. Incipient fore dunes are not necessarily permanent features that develop into established fore dunes, and their fate will be decided by the factors such as wave action.

The development and morphology of fore dunes will depend on a variety of factors that include:

i. Sand supply
ii. Degree of vegetation cover
iii. Plant species present
iv. Rate of windblown sand accretion and erosion
v. Frequency and magnitude of wave and wind forces and erosion
vi. Dune scarping and over wash processes

vii. Extent of human interference and use

Fig 3.1: Fore dunes in Soandia Island

a) ***Medium Dune:*** This semi-stable transition zone between the dynamic fore dune zone and the stable landward zone is dominated by a limited number of low-growing, or hardy, wind-tolerant native plants.

Fig 3.2: Medium dune in Sonadia Island

b) ***High Dune:*** Back-dunes are those dunes located beyond the established fore-dunes and are typically more stable and covered with intermediate woody and herbaceous species. They are still subject to sand accretion and erosion processes but to a lesser extent.

3.5 Sand dune characteristics of Sonadia Island

Two successive sand dunes, positioned along the shorelines of the island, were selected for profiling. Both dunes were located at the western side of Sonadia island. They are showed below:

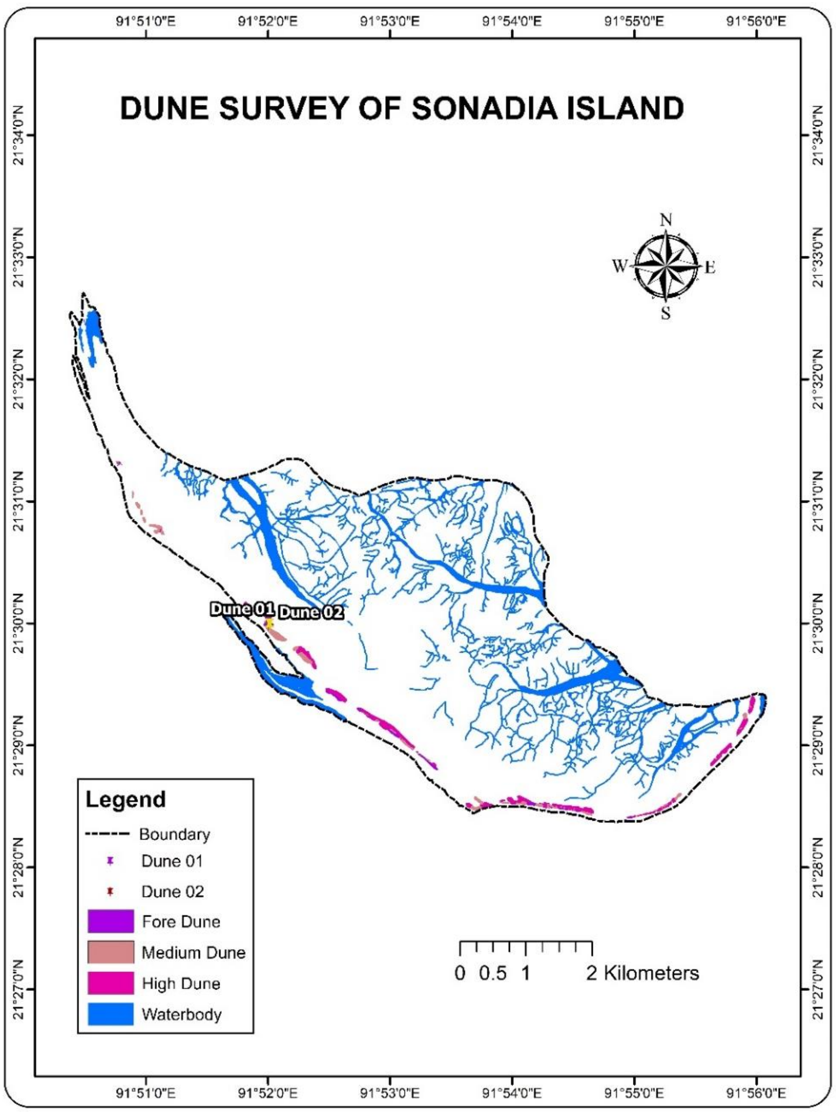


Fig 3.3: Sand dune stations in Sonadia Island

Fig 3.4: Sand dune stations in Sonadia Island

3.5.1 Case 1

Table 3.1: Sand Dune-1

Station point	Latitude	Longitude	Distance (m)	Base Distance	Bearing
A	21°30'.19"N	91°52'.28"E	18.63 m	18.41	132° SE
B	21°30'.29"N	91°52'.13"E	18.75 m	18.35	0° N
C	21°30'.33"N	91°52'.27"E	10.8 m	10.41	290° SW
D	21°30'.25"N	91°52'.11"E	19.52 m	19.31	78° NE
E	21°30'.38"N	91°52'.27"E	19.67 m	19.46	250° SW

Here, height of the Top point of the dune was 2.85 m.

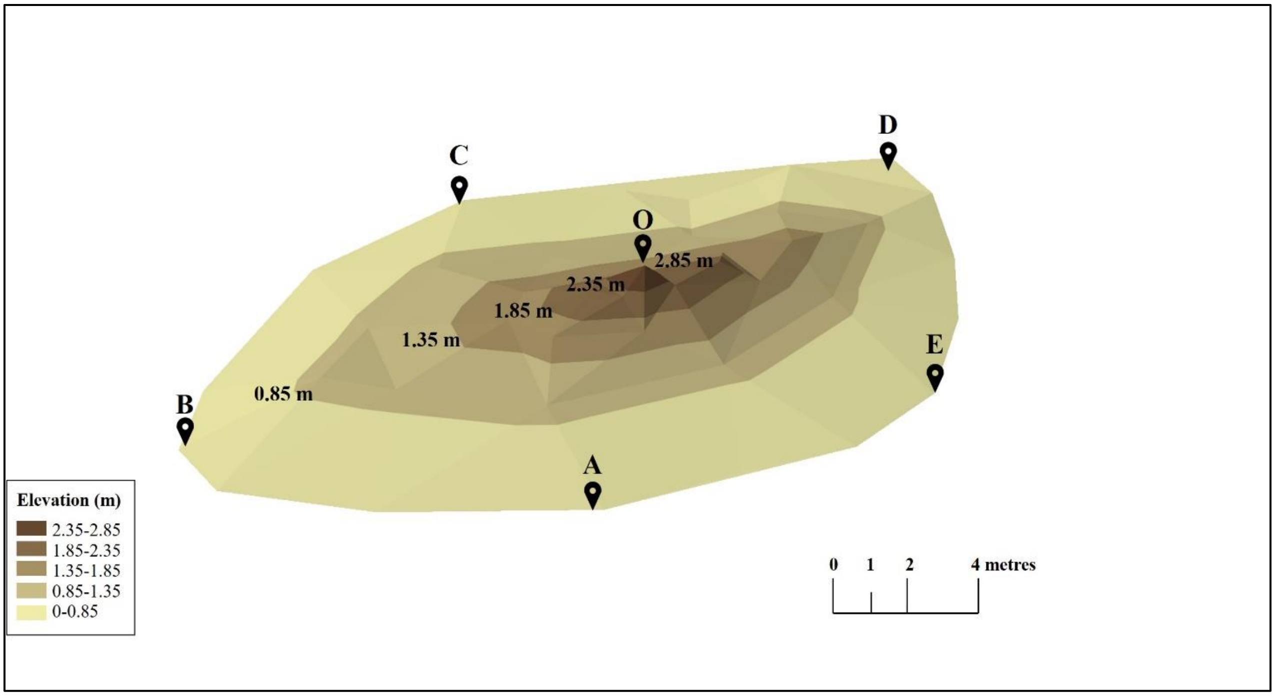


Fig 3.5: Sand Dune-1

3.5.2 Case 2

Table 3.2: Sand Dune-2

Station point	Latitude	Longitude	Distance (m)	Base Distance	Bearing
A	21°29'.9.5"N	91°52'.99"E	21.35 m	21.1	144° SE
B	21°29'.89"N	91°52'.97"E	18.3 m	18.02	99° NE
C	21°29'.90"N	91°52'.95"E	22.5 m	22.27	181° SE
D	21°29'.92"N	91°52'.93"E	24.5 m	24.29	321° NW
E	21°29'.94"N	91°52'.91"E	23.2 m	22.98	64° NE

Here, the height of the top point was 3.21m

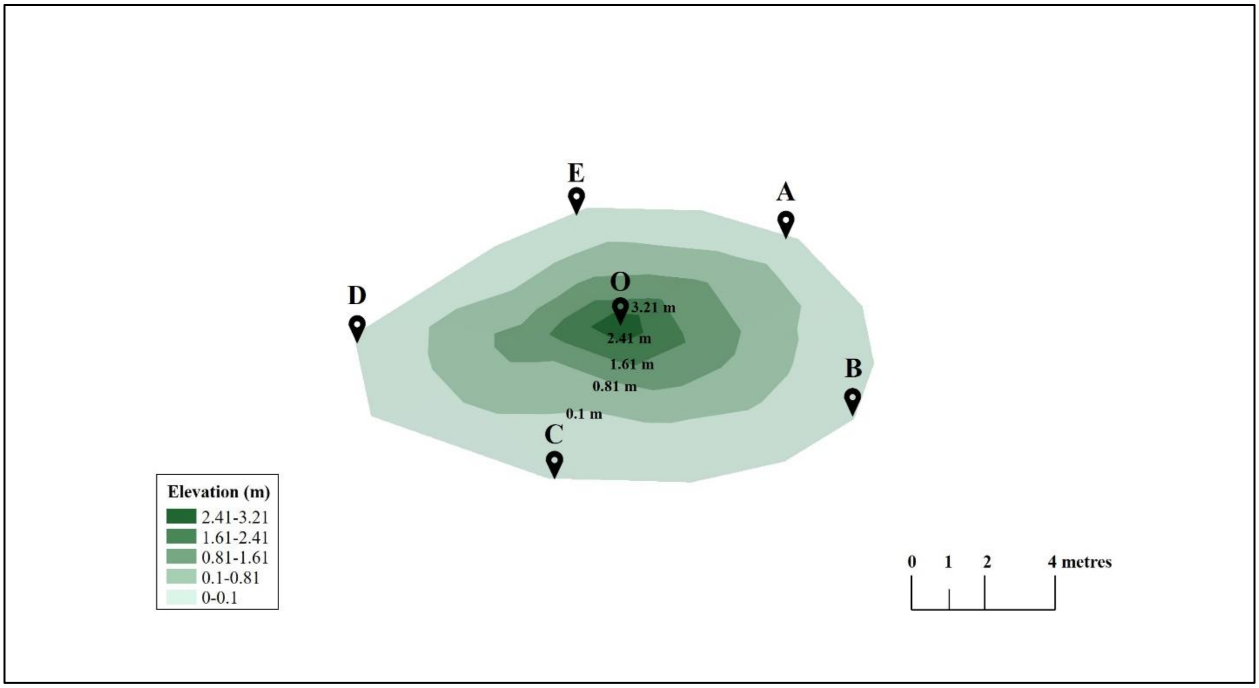


Fig 3.6: Sand Dune-2

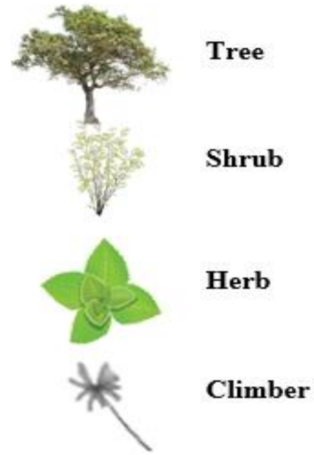
3.6 Sand dune vegetation

Vegetation stabilizes the dunes in two ways-

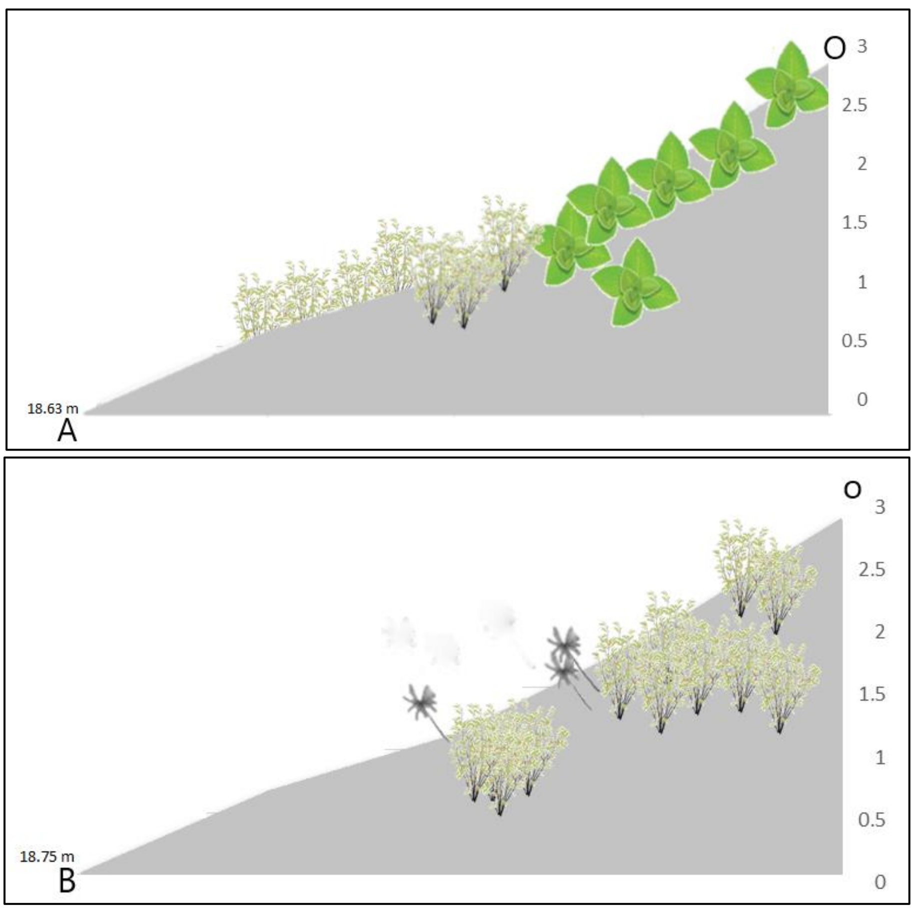
- Firstly, the roots bind the sand together
- Secondly, the above ground vegetation traps particles of sand as they are blown over the surface.

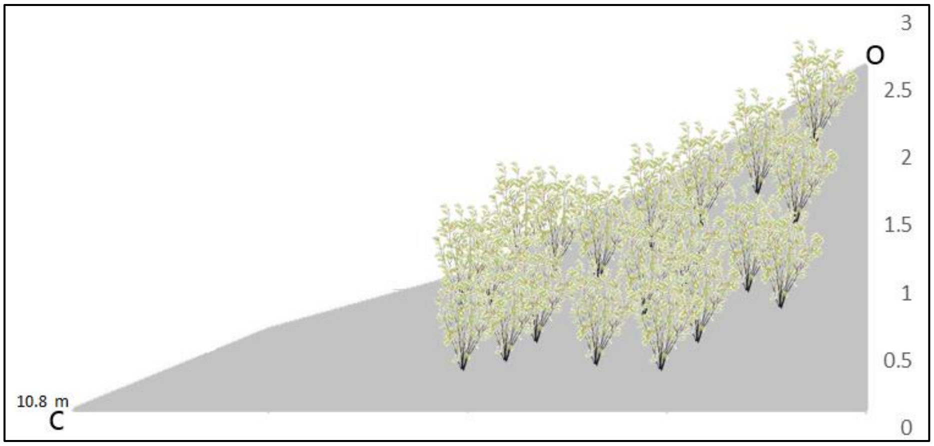
Dunes provide habitat for highly specialized plants and animals, including rare and endangered species. They can protect beaches from erosion and recruit sand to eroded beaches. Formation of dunes is through sand accretion. Sand that is brought in by the winds gets trapped by the shrubs, creepers, trees and other obstacles that are found on the coast. This accumulated sand forms mounds of sand that keep growing over time to form large dunes (McHarg, 1972). When dunes are less vegetated they remain unstable and so they migrate.

Here,

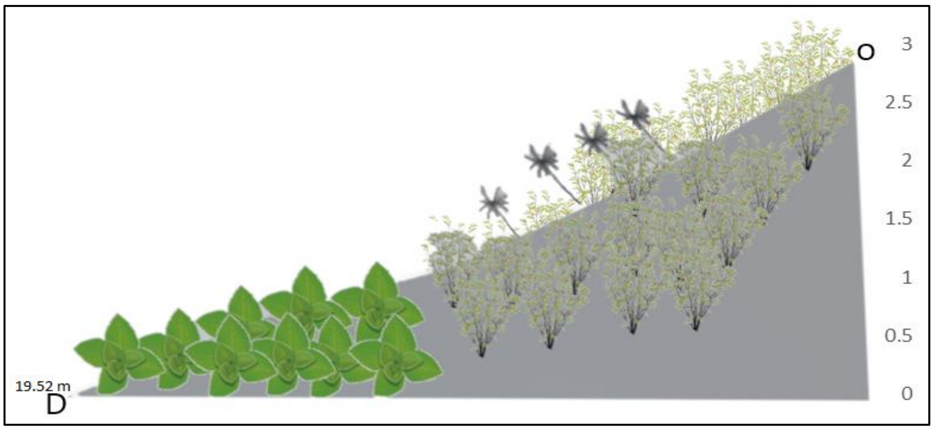


Dune-1 vegetation

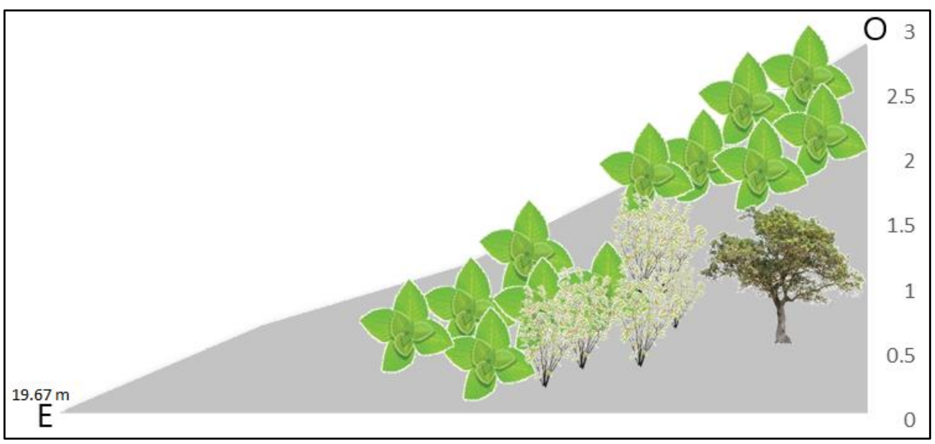




3
O
2.5
2
1.5
1
0.5
10.8 m
C
0

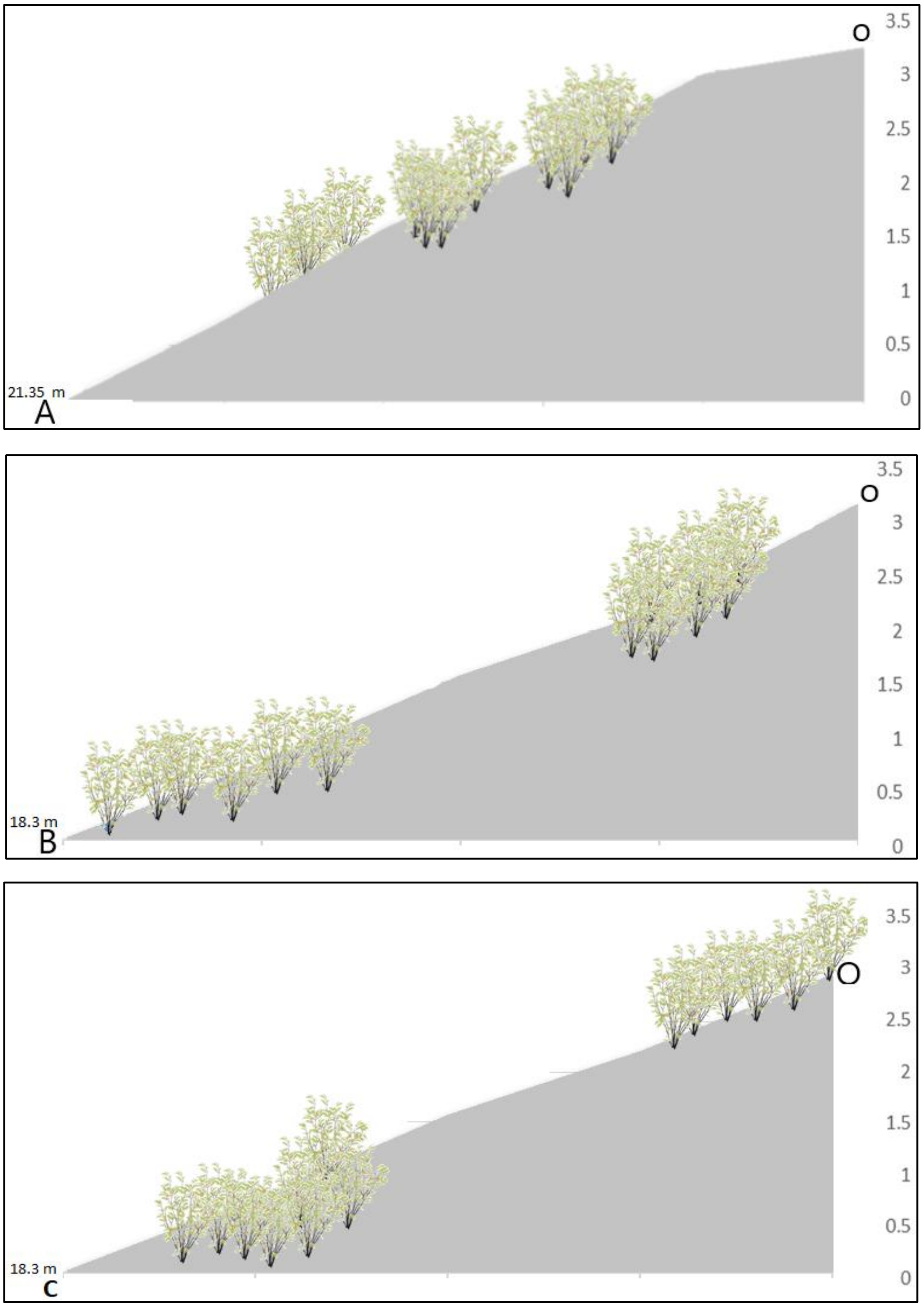


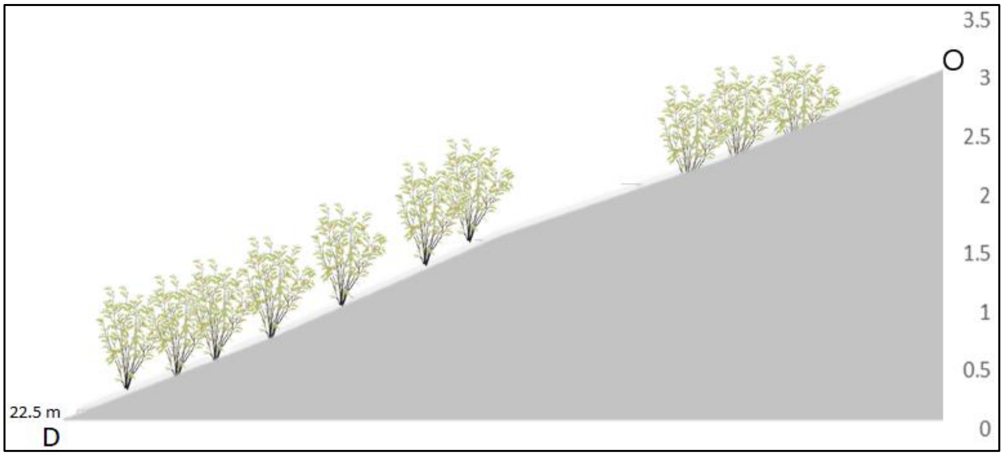
O
3
2.5
2
1.5
1
0.5
19.52 m
D
0



O
3
2.5
2
1.5
1
0.5
19.67 m
E
0

Dune-2 vegetation





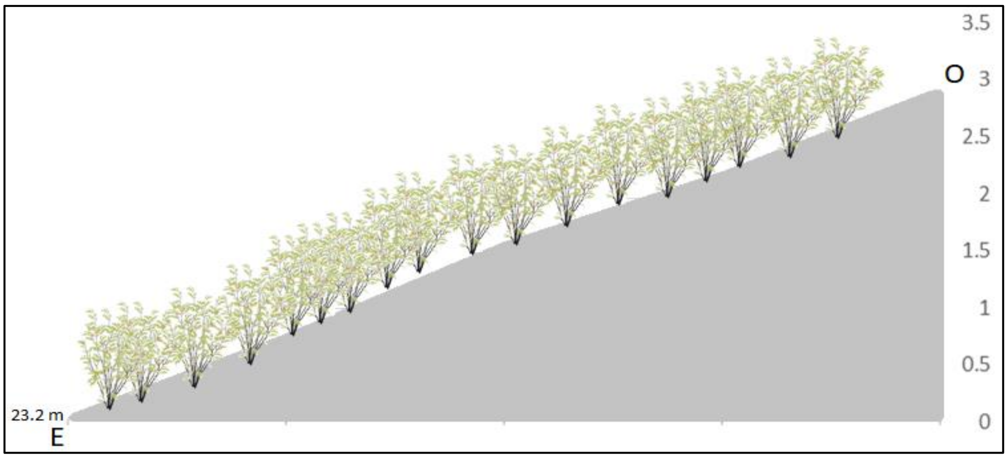
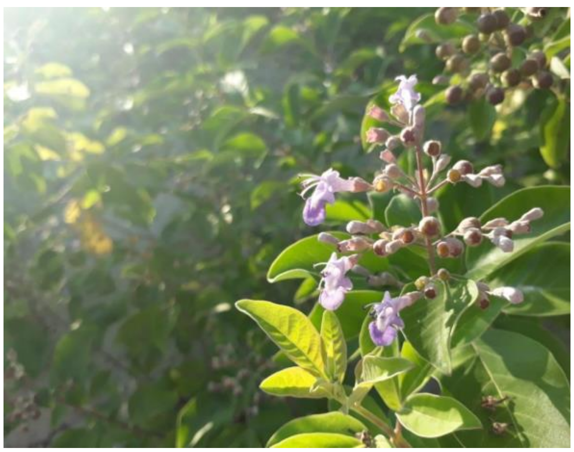


Table 3.3: Sand dune vegetation

Type of Plants	**Local Name**	**Scientific Name**	**Habit**	**Habitat**
A	Bon-neel	Tephrosia purpurea (L.) Pers.	H	Cultivated
B	Berela	Sida cordifolia L.	H	Homestead
C	Nishinda	Vitex trifolia L. f	S	Sandy beach, roadside
D	Jao	Casuarina litoralis	T	Homestead
E	Moggula	Lantana camara L.	S	Homestead, Roadside
F	Churilla kanta	Dalbergia spinosa Roxb.	C	Mangrove
H = Herb, S = Shrub, C= Climber, T= Tree				

Type A

Type B



Type C

Type D

Type E

Type F

Fig 3.7: Sand dune vegetation

3.7 Sand dune and its ecology

Our beautiful Planet-Earth nurture several kinds of ecosystem among which sand dune is less studied when compared to coral, mangrove, lagoon and estuary. One of the most important things to realize about the coastal and dune environment is that it is dynamic, like the forces that shape it, and is always changing. Accepting change can be difficult for humans but it is important to note that the change is a natural and health part of this ecosystem and helps maintain the biodiversity.

Despite geographical differences, sand dunes have been considered as a specific ecosystem due to several common environmental features. Coastal sand dunes constitute a variety of microenvironments due to substrate mobility and physical processes. Plants establishing on the coastal sand dunes are subjected to several environmental fluctuations which affect their growth, survival and community structure. The most important factors include temperature, desiccation, low moisture retention, soil erosion, sand accretion, soil salinity, salt spray, changes in organic matter and pH.

Dunes provide habitat for highly specialized plants and animals, including rare and endangered species. These plants and animals live in a harsh environment of salt spray, shifting and infertile sand, bright sunlight and storms. Some of the animals which depend on sand dunes include snakes, ghost crabs, nesting sea turtles. Biodiversity increases inland as more and more plants colonies the dune system.

Plant species that initially settle on dunes have deep roots which reach for the water table, root nodules that produce nitrogen compounds and fleshy stem and leaves that assist in retaining water

The deep roots hold the sand in place, and the dune grows into a fore dune as more sand is blown over. Grasses nitrify the soil, thereby allowing less hardy plants to colonies the dunes. These too are adapted to low soil water content and have small, prickly leaves which reduce transpiration. Leaching occurs on the dunes, washing humus into slacks, and the slacks may support a wider array of flora and fauna than the exposed tops of dunes. It is usually in the slacks that rarer species are found; sometimes the soil of the dune slacks gets waterlogged and only marsh plants can survive in this condition.

Chapter 4

Slope and Vegetation of Moheshkhali Island

4.1 Introduction

Maheshkhali is the only hilly island in Bangladesh. It covers an area of approximately two hundred and sixty-eight square kilometers, and is blanketed in breathtaking mangrove jungles, spectacular ranges of hills and striking landscapes, with some hills standing at just over three hundred meters.

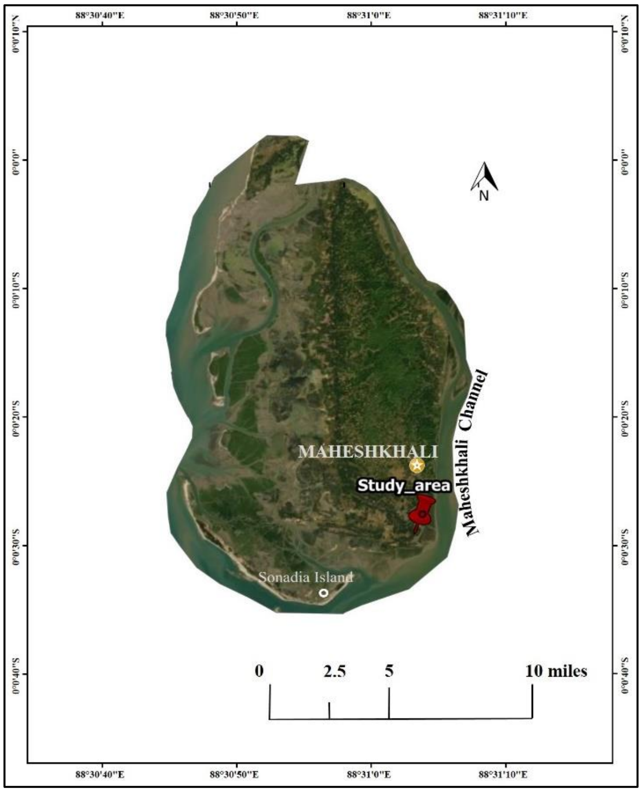


Fig 4.1: Map of Moheshkhali Island

Some of the main attractions on Moheshkhali are the picturesque and peaceful beaches. The Shrine of Adinath, which is dedicated to Shiva, the quaint Buddhist temple and the pagoda are also stunning attractions to visit on the island. The recent completion of the Shaheed Ziaur Rahman Bir Uttam Bridge has connected the island to the mainland.

Fig 4.2: Moheshkhali Island

4.2 Slope analysis

We performed our slope analysis task at the Adinath temple hills by using a clinometer. A clinometer (also known as a declinometer or inclinometer) is used to measure the steepness of a slope, and can be used to work out the heights of tall things, such as buildings or trees. To measure a slope using a clinometer, first we need to find something up a slope that is at about eye height, and then we need to look along the sight (the straw along the straight side of the protractor) at this object. Then, we waited until the weighted line had stopped swinging, and then carefully hold it against the protractor. Finally, Read the angle off the protractor (if the numbers are above 90, subtract 90 to get the correct value).

Clinometers can also be used to measure the heights of things such as trees. And to do so, we have to find an area of flat ground with a tall tree, and plenty of room to walk away from the tree. Then we have to look through the clinometer to find the top of the tree, and walk away from the tree in a straight line until the angle on the clinometer reads 45 degrees. The distance between us and the tree is the same as the distance from the trunk of the tree at eye level to the top of the tree. We then have to measure the distance from the clinometer to the tree – this gives the height of the tree from eye level to the top. Finally, we have to add the height from the ground to the clinometer (eye level) to total an estimate of the height of the tree. Thus, we can get the height from it

Fig 4.3: Slopes at Adinath temple

4.3 Slope measurements of a hill

We measured the slope of a hill at the Adinath temple of Moheshkhali island. The data that we collected from the survey is given below:

Table 4.1: Slope measurement data of Adinath hill

Input Serial	**Segment Distance (m)**	**Distance from 0 (m)**	**Slope (°)**	**Descend from the top (m)**	**Horizontal Distance from 0 (m)**
1	5.6	5.6	5	0.488	5.579
2	1.54	7.14	25.67	1.155	6.967
3	2.79	9.93	5.3	1.412	9.745
4	6.83	16.76	16.67	3.37	16.288
5	1.66	18.42	37	4.369	17.614
6	2.36	20.78	20.5	5.195	19.825
7	3.27	24.05	26.33	6.645	22.756
8	11.2	35.25	19.5	10.382	33.314
9	6.4	41.65	30.5	13.628	38.83
10	8.4	50.05	20	16.5	46.724
			Average= 20.647 °		

Here, the column ‘Distance from 0 (m)’ is the cumulative of the column ‘Segment Distance (m)’. Thus, the total distance traversed while measuring the slope is 50.05 m.

Total Vertical Displacement= 16.5 m

Total Horizontal Displacement= 46.724 m

Fig 4.4: Slope measurement data of Adinath hill

Fig 4.5: Slope measurement at Moheshkhali Island

4.4 Vegetation study

Vegetation survey was conducted to introduce us with various plant species in Moheshkhali island. This survey included both qualitative and quantitative approaches. Quadrate method was used to get the task done.

A quadrat is a frame that is laid down to mark out a specific area of the community to be sampled. Within the quadrat frame, the occurrence of plants is recorded using an appropriate measure of abundance. Quadrats may be square, rectangular or circular and they may be of any appropriate size. The quadrat method can be used in virtually any vegetation type to quantify the plant community. Because a single quadrat cannot be expected to sample a community adequately, repeated quadrat samples are taken.

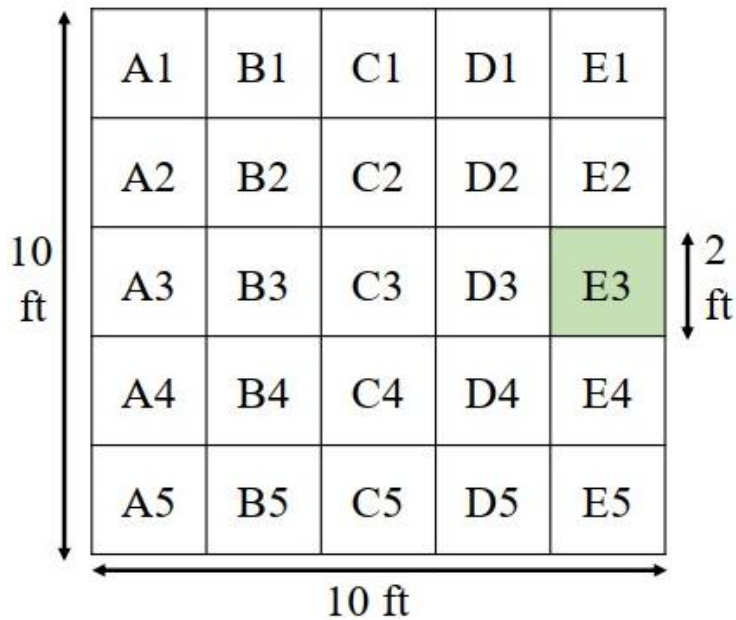


Fig 4.6: Quadrat method

When sampling vegetation using quadrats, different measures of abundance can be quantified to assess the influence or "importance" of each species in that quadrat. For example:

- *Counts* – a simple tally of the number of individuals of a species
- *Cover* – the percent (%) area of the quadrat occupied by a plant species.
- *Density* – estimated by quantifying the number of individuals of a species per unit area.
- *Frequency* – the proportion of quadrats sampled in which the species is represented.

In this method, the survey area was divided into 25 square blocks and each block had its own ID number. In a sampling method random blocks were selected in a lottery to complete vegetation survey. Overall cover, density and frequency estimates were then calculated for each species from the entire data set by combining all of the quadrats together.

4.5 Vegetation survey

The vegetation survey was conducted into two groups in the Moheshkhali island. The data and samples collected by the groups are given below:

4.5.1 Group 1

Table 4.2: Group-1 vegetation survey

Block	Latitude	Longitude	Tree	Shrub	Herb	Grass	Moss	Fern
D2	21º31'38.19"	91º58'20.96"	1	9	12	133	×	×
B3	21º31'38.27"	91º58'21.06"	1	7	41	93	A few	×
A4	21º31'38.26"	91º58'21.17"	1	16	29	133	A lot	18

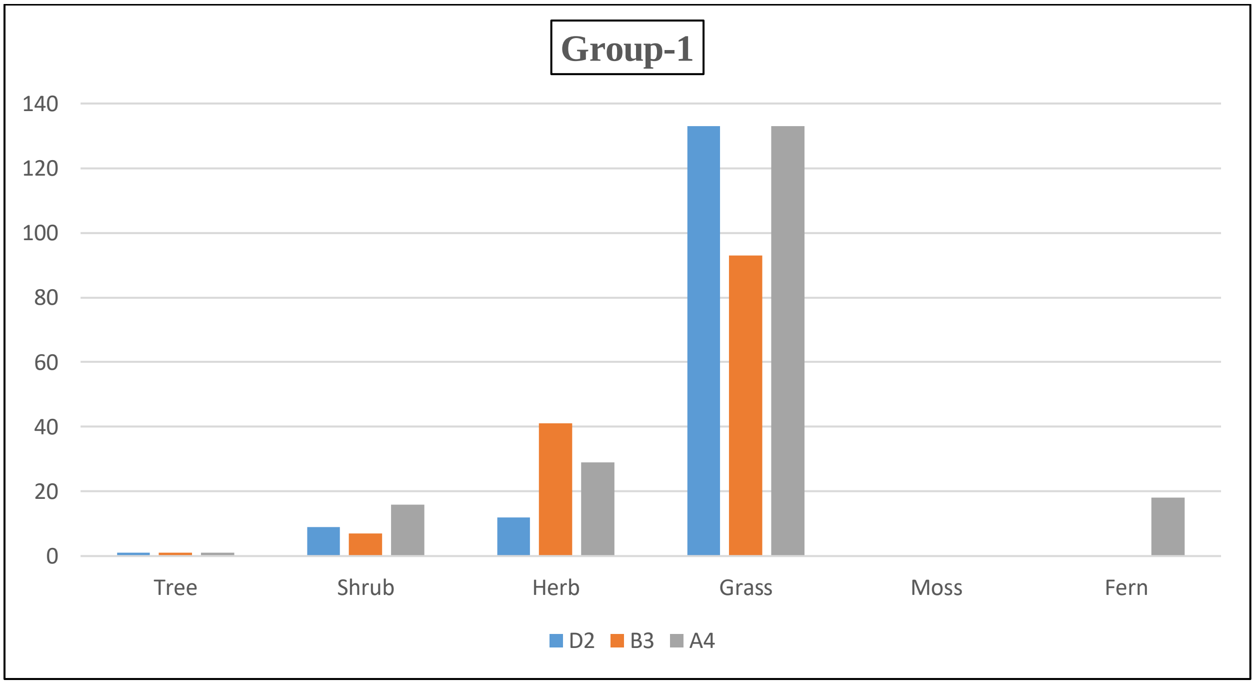


Fig 4.7: Group-1 vegetation survey

Shorea robusta (Sal)

Clerodendrum viscosum (Bhat)

Ficus palmate (Wild fig)

Azadirachta siamensis

Eupatorium odoratum

Dicranella heteromalla (Moss)

Desmodium triflorum

Axonopus compressus (Grass species)

Cyperus pangorei (Sedge)

Fig 4.8: Group-1 vegetation identifications

4.5.2 Group 2

Table 4.3: Group-2 vegetation survey

Block	Latitude	Longitude	Tree	Shrub	Herb	Grass
A5	21º31'38.22"	91º58'21.39"	1	4	50	20
B2	21º31'37.67"	91º58'37.75"	5	9	40	5
C1	21º31'37.71"	91º58'21.64"	1	×	8	37

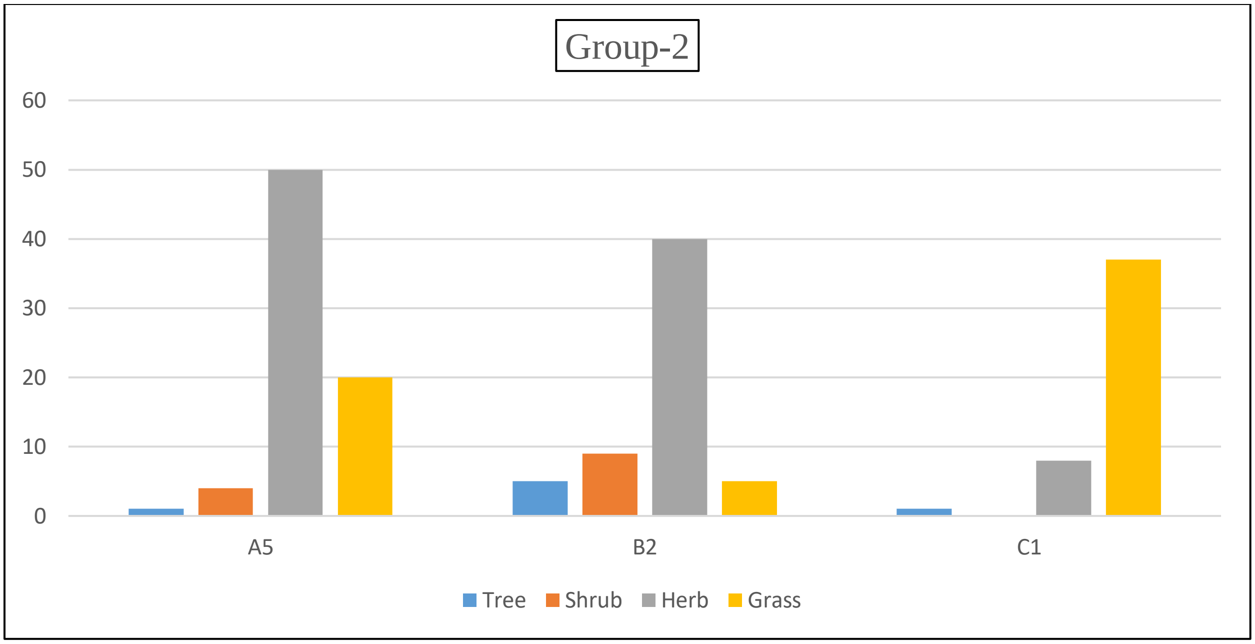


Fig 4.9: Group-2 vegetation survey

Borreria hispida(Landrina)

Clerodendrum viscosum(Bhat)

Cyperus pangorei (Sedge)

Adiantum capillus-veneris

Fig 4.10: Group-2 vegetation identifications

Table 4.4: Total vegetation found from both groups

Tree	10
Shrub	45
Herb	180
Grass	421

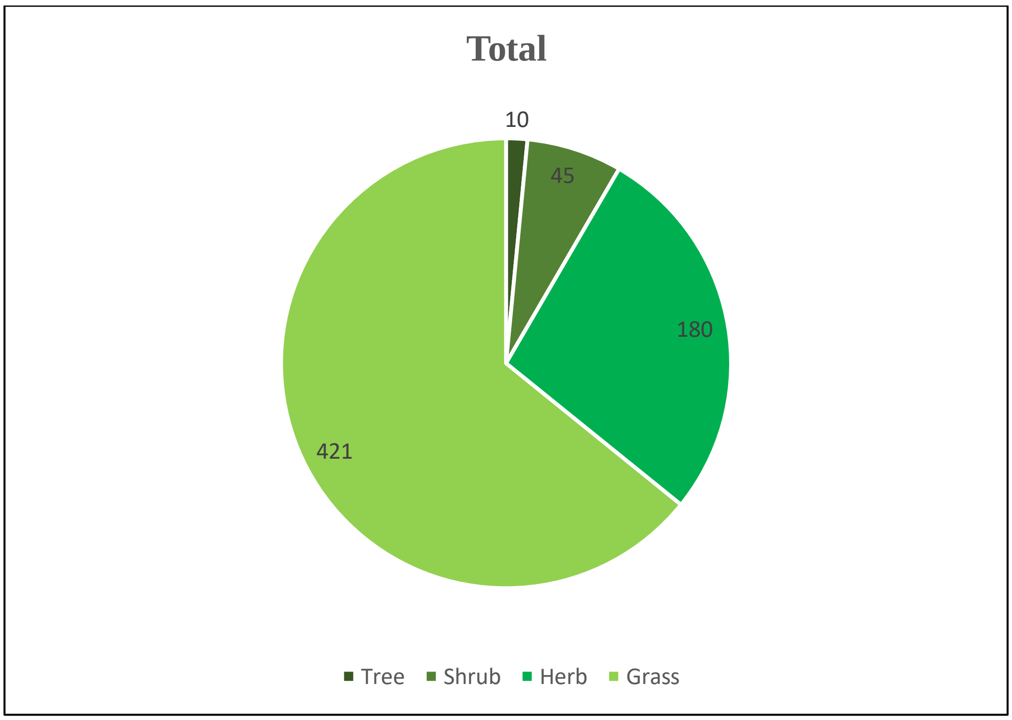


Fig 4.11: Total vegetation found from both groups

4.6 Slope-vegetation relationship

Distribution of vegetation in the total survey in the observed slope is as given in the legend in the profile:

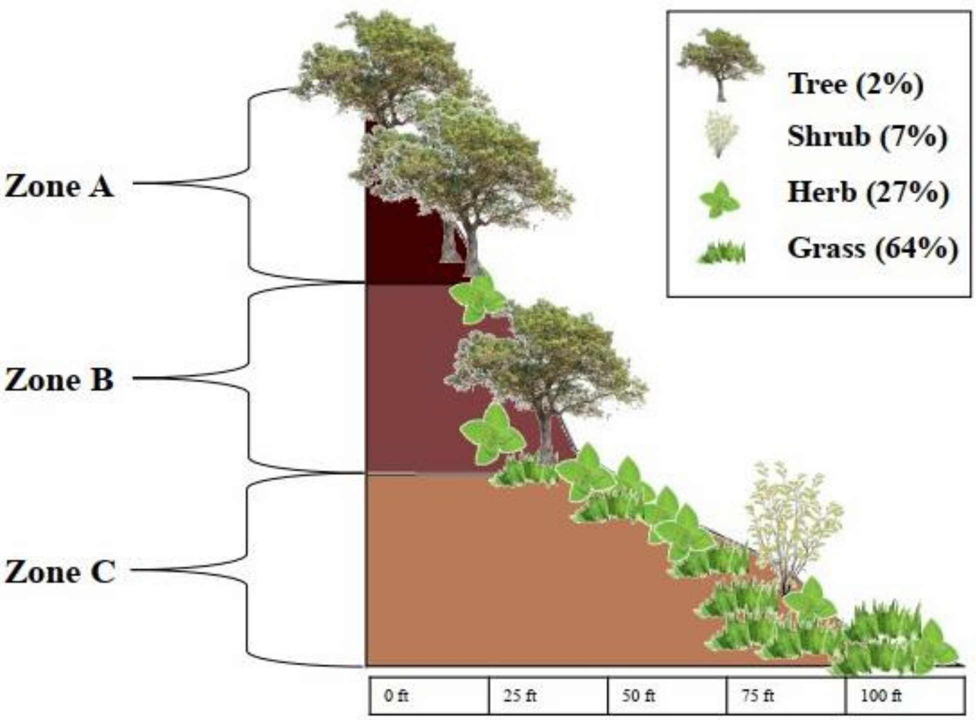


Figure 4.12: Profile with Vegetation Distribution

Here, Dominant plant type in

i. Zone A = Trees
ii. Zone B-C = Herbs
iii. Zone C = Grass (few Shrubs)

4.7 Conclusion

Moheshkhali islands exhibits rather complex geological system on the eastern cliff coast of Bangladesh characterized by hilly topography surrounded by coastal plain exhibiting unique geologic, tectonics and as well as geomorphologic peculiarities. Significant changes in Land use/Land cover have been occurring since recent past. Anthropogenic activities are to blame the most for physical as well as the environmental changes of this area.

Chapter 5

Sediment Dynamics in the Bay of Bengal

5.1 Introduction

Bay of Bengal, large but relatively shallow embayment of the north-eastern Indian Ocean, occupying an area of about 839,000 square miles (2,173,000 square km). It lies roughly between latitudes 5° and 22° N and longitudes 80° and 90° E. It is bordered by Sri Lanka and India to the west, Bangladesh to the north, and Myanmar (Burma) and the northern part of the Malay Peninsula to the east.

The bay is about 1,000 miles (1,600 km) wide, with an average depth of more than 8,500 feet (2,600 metres). The maximum depth is 15,400 feet (4,694 metres). A number of large rivers—the Mahanadi, Godavari, Krishna, and Kaveri (Cauvery) on the west and the Ganges (Ganga) and Brahmaputra on the north—flow into the Bay of Bengal. The Andaman and Nicobar groups, which are the only islands, separate the bay from the Andaman Sea.

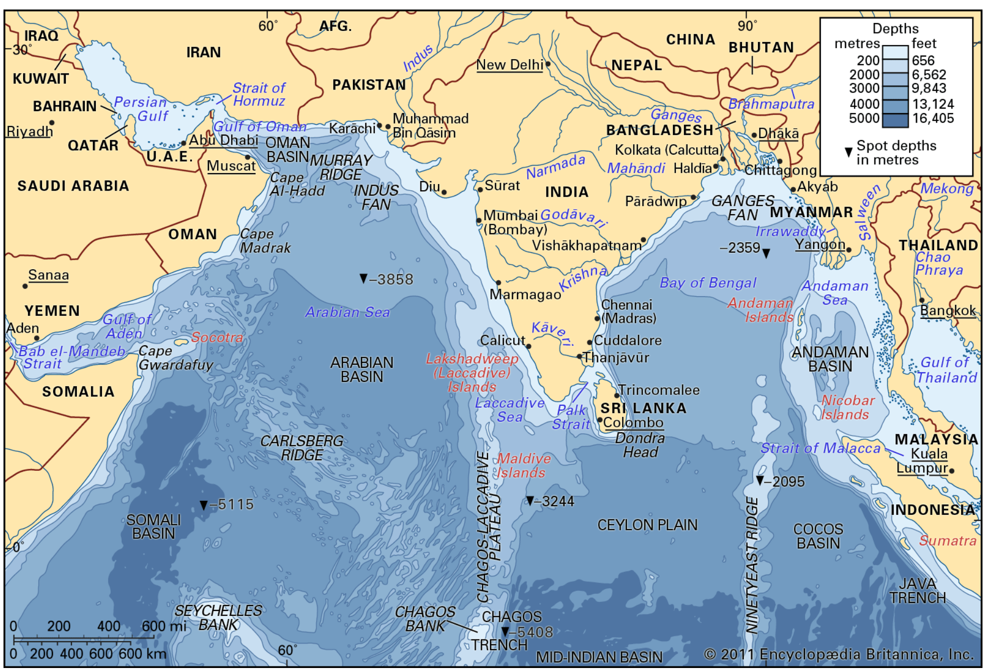


Fig 5.1: The Bay of Bengal

5.2 Techniques applied

The following techniques were applied in our hydrological survey-

- **Bathymetric survey of the ocean**: It includes the measurement of underwater depth of ocean floors. It was done for mapping the underwater topography.
- **Sediment sample collection from Ocean floor**: Grab sampler were used to collect bottom sediment. After collecting these sediment in this process we had to keep this in a sampling bag for further analysis.
- **Ocean water quality study**: Water sample from any desire depth of ocean, river or other water bodies can be collected using water sampling bottle. In our department the most widely used is Van Dorn water sampler that is modified by Professor Dr. M. Shahidul Islam.

The instruments that were used to do the mentioned tasks are-

- GPS device, Anchor, pH meter, Turbidity meter, Water sampler, Secchi disk, Thermometer, Grabber

5.3 Sampling locations

Samples were taken from 9 stations by two surveyor groups using two different boats. They're-

Table 5.1: Sampling locations of hydrological survey

Stations	X (N)	Y (E)
1	21.47208	91.9231
2	21.4675	91.91936
3	21.45134	91.90268
4	21.4679	91.88565
5	21.46712	91.88595
6	21.45116	91.88461
7	21.43553	91.86916
8	21.43552	91.88465
9	21.45026	91.90014

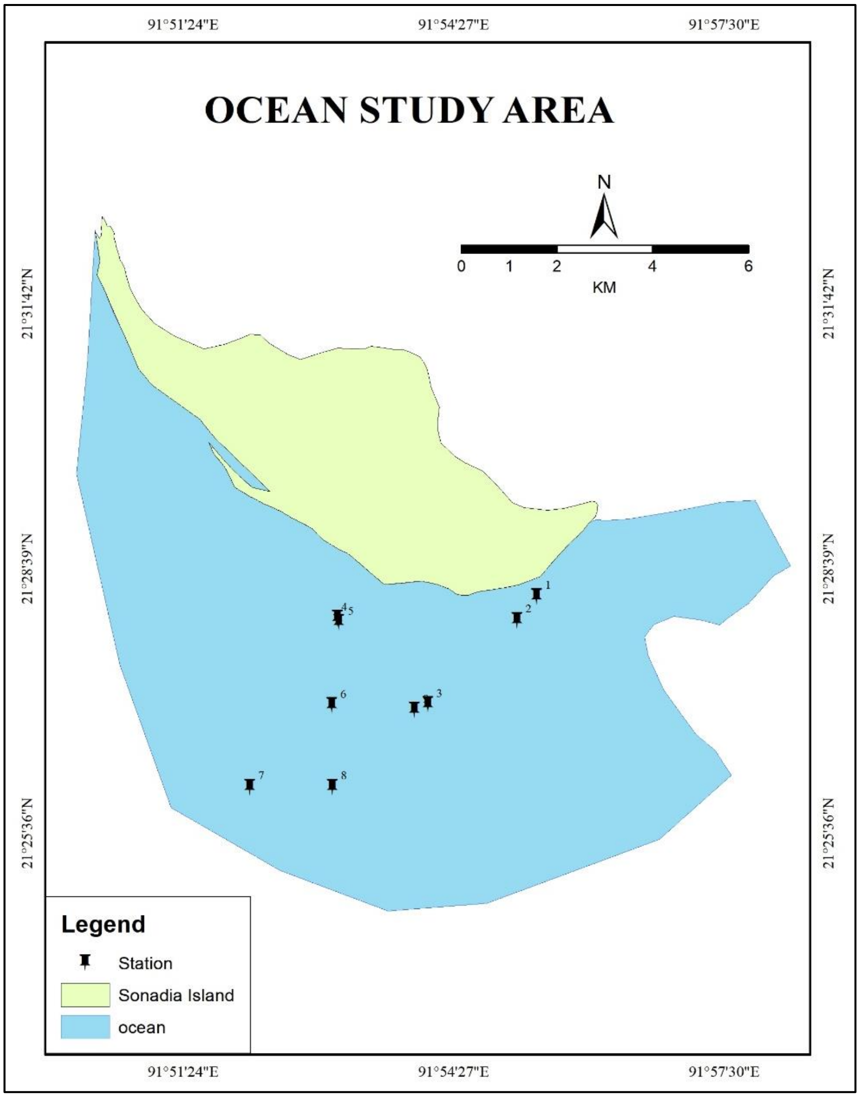


Fig 5.2: Sampling locations of hydrological survey

5.4 Visibility study

Visibility is generally considered to be the distance at which an object underwater can be readily identified. Underwater visibility is measured two ways:

1. ***Horizontal visibility*** — how far you can see looking straight ahead and
2. ***Vertical visibility*** — how far you can see looking up or down.

Horizontal visibility is usually more important, since it affects our ability to view the underwater environment and keep track of our dive.

Three factors primarily affect underwater visibility:

- light penetration
- biological species and
- particulates.

Not surprisingly, these factors are often related to one another, as well as to other environmental factors. Oceanographers and other marine researchers are very interested in measuring underwater visibility primarily since the availability of light plays such an important role in biological productivity and the absorption of heat energy. One method of making such a measurement is with a device called a Secchi Disk.

The Secchi Disk is a white disk, 4 inches/10 cm in diameter, which is lowered into the water to a depth at which it just disappears from sight. From this depth measurement, researchers can determine the extinction coefficient — a measure of how quickly illumination decreases with depth. This in turn can be related to other important physical and biological measurements.

The water visibility readings that we have got from our sampling locations are given below:

Table 5.2: Water visibility of the sampling locations

Stations	**Water Visibility(cm)**
1	130
2	95
3	120
4	94
5	110
6	90
7	107
8	75
9	85

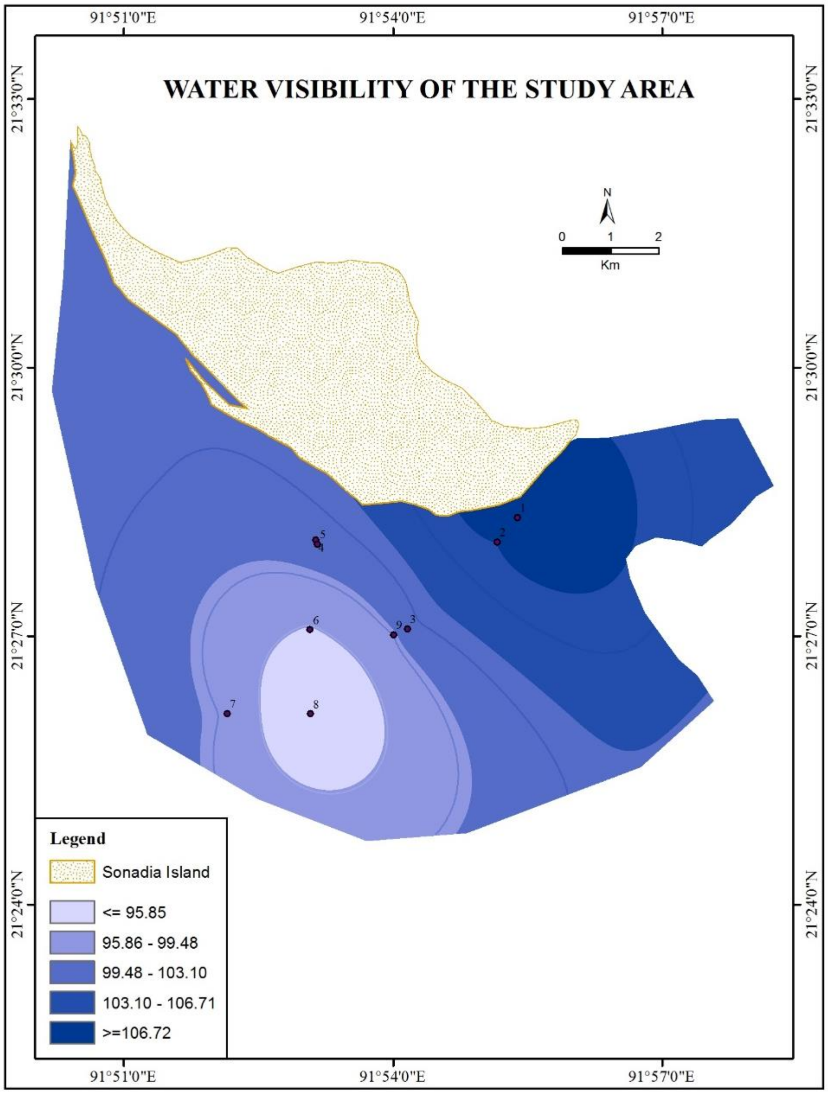


Fig 5.3: Water visibility of the study area

5.5 Characteristics of bottom sediments

Sediments in the Bay of Bengal are dominated by terrigenous deposits from the rivers, derived mainly from the Indian subcontinent and from the Himalayas. Calcareous clays and oozes are found near the Andaman and Nicobar Islands and atop the Ninety-east Ridge. The amount of organic matter present in the continental-shelf sediment of the northern part of the east coast is poor compared with the world's average for nearshore sediments.

Table 5.3: Characteristics of bottom sediments

Stations	Ocean Depth (m)	Sediment Type
1	5.8	Silty Clay
2	5	Silty
3	7	Sandy
4	3	Sandy
5	4.3	Silty Clay
6	8.7	Sandy
7	13	Sandy
8	10	Sandy
9	10	Silty Clay

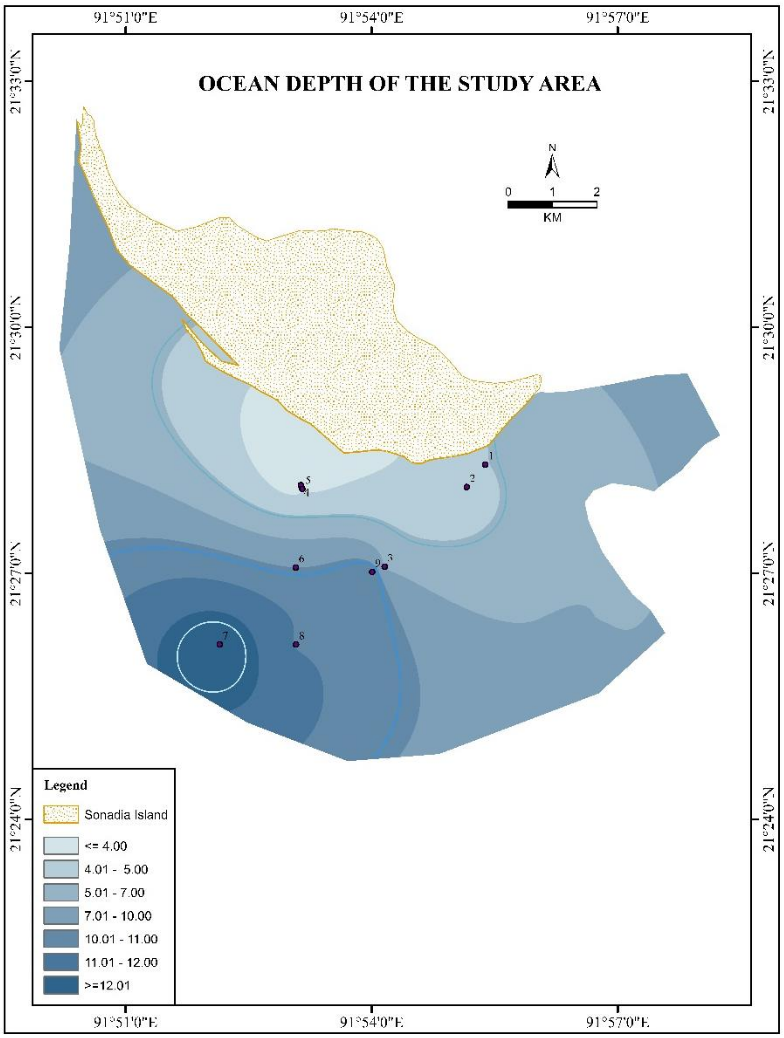


Fig 5.4: Ocean depths of the study area

A large area of the Bay of Bengal is covered by clay. Sand, silt and silty clay are confined to a narrow margin along the coast. Regionally foraminifera and unidentifiable calcareous fragments increase towards the central and southeastern parts of the Bay, which explains the high $CaCO_3$ (over 50%) in the sediments of this area; the percentage of terrigenous material and insoluble matter decreases in the same direction.

The light fraction (<2.7) of the acid treated sediments consists of quartz, felspar, rock fragments and radiolaria. The heavy minerals consist of feldpar, hornblende, mica, pyroxene, epidote, garnet, opaques, sillimanite, tourmaline, zircon, tremolite-actinolite, etc. The distribution patterns of different minerals in these sediments define a number of terrigenous mineralogical provinces. Illite, kaolinite and montmorillonite are the prominent clay minerals with minor amounts of mixedlayered minerals and chlorite.

5.6 Characteristics of water quality

A wide range of water quality parameters are monitored within the ocean with key parameters reported herein being temperature, pH, salinity, turbidity etc. A brief description of these parameters are provided below:

- ***Temperature:*** The mean annual temperature of the surface water is about 28°C. The maximum temperature is observed in May (30°C) and the minimum (25°C) in January-February. But the annual variation in temperature is not great, about 2°C in the south and 5°C in the north.

Table 5.4: Water Temperature (°C)

Stations	**Water Temperature(°C)**
1	30.5
2	32.2
3	31.5
4	31.9
5	32.5
6	31.2
7	31.9
8	31.6
9	30.9

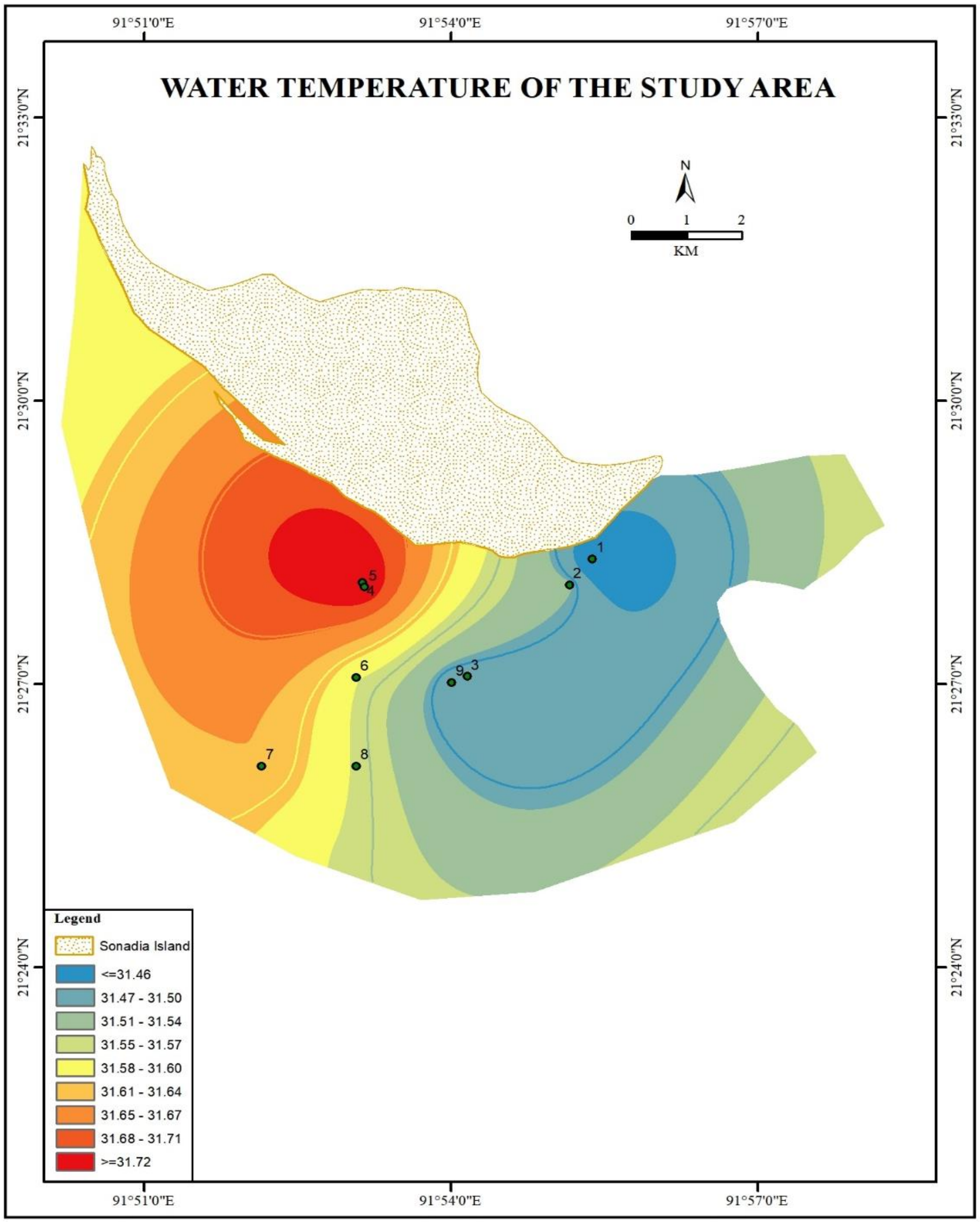


Fig 5.5: Water Temperature (°C)

- ***Turbidity*** is a measure of the cloudiness or haziness in water caused by suspended solids (eg sediment, algae). Turbidity is expressed in Nephelometric Turbidity Units (NTU) and is measured using a relationship of light reflected from a given sample. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water.

Table 5.5: Turbidity of Surface Water (FTU)

Stations	Turbidity of Surface Water(FTU)
1	7.28
2	9.53
3	15.68
4	15.42
5	4.73
6	15.04
7	12.33
8	17.7
9	15.99

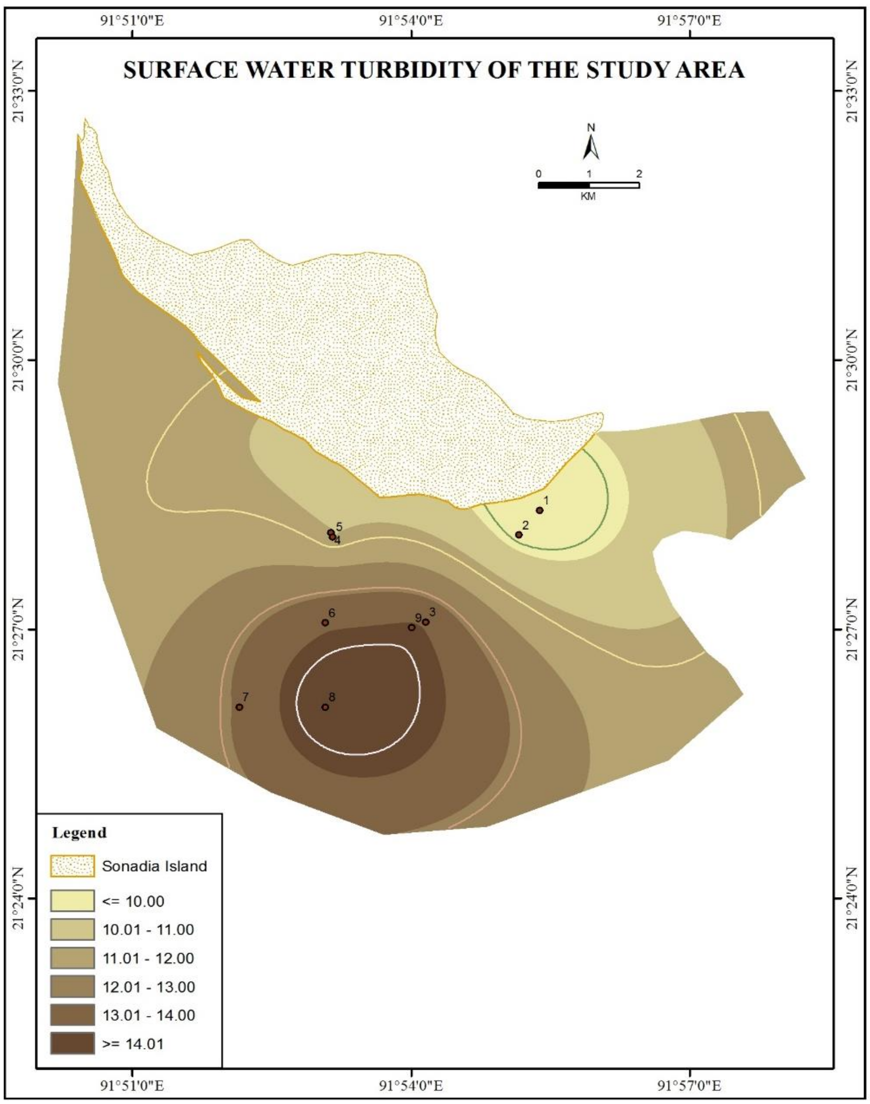


Fig 5.6: Turbidity of Surface Water (FTU)

- ❑ ***pH*** is an indicator of acidity or alkalinity. pH is a logarithmic scale and an increase or decrease of one pH unit is a 10 fold change. Neutral water has a pH of 7, acidic solutions have values between 0-6 and alkaline solutions have values between 8-14.

Table 5.6: pH of Surface Water and 5 Meter Deep Water

Stations	pH of Surface Water	pH of 5 Meter Deep Water
1	7.4	7.4
2	7.7	7.6
3	7.8	7.7
4	7.8	7.8
5	7.8	8.2
6	8	7.8
7	7.8	7.9
8	7.9	7.8
9	7.8	8

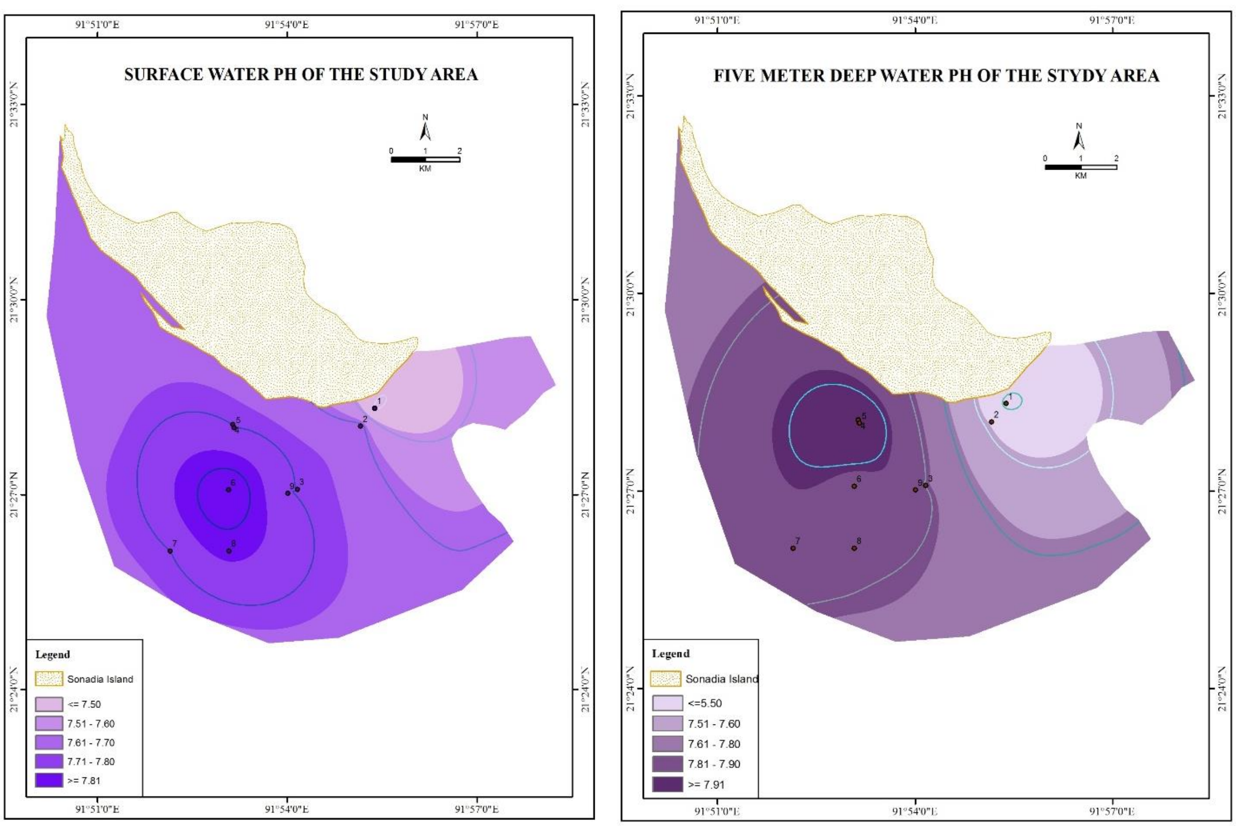


Fig 5.7: pH of Surface Water and 5 Meter Deep Water

- ***Salinity*** is a measure of the amount of dissolved salts in the water. Saline water conducts electricity more readily than freshwater, so electrical conductivity (EC) is routinely used to measure salinity. As salinity increases, it may become toxic to native freshwater organisms.

Table 5.7: Salinity of Surface Water and 5 Meter Deep Water

Stations	Salinity of Surface Water (ppt)	Salinity of 5 Meter Deep Water (ppt)
1	0	30
2	30	30
3	31	30
4	28	28
5	32	30
6	32	34
7	37	38
8	38	37
9	36	38

The surface salinity in the open part of the Bay oscillates from 32% to 34.5% (parts per thousand, ie grams per kilogram of sea water) and in the coastal region varies from 10% to 25%. But at the river mouths, the surface salinity decreases to 5% or even less. Salinity gradually increases from the coast towards the open part of the Bay.

The coastal water is significantly diluted throughout the year, although the river water is greatly reduced during winter. Along the coast of the Ganges-Brahmaputra Delta, salinity decreases to 1% during summer and increases up to 15% to 20% in winter. The surface salinity at the mouths of some large rivers like the Ganges, Brahmaputra and some Indian rivers like the Krishna, Godavari and Mahanadi varies widely from one day to another, especially in summer. Salinity of water also changes vertically. The influence of the fresh water is experienced up to depths of 200-300m. From the surface, the salinity gradually increases downward and at about 200-300m it reaches 35% and at about 500m the salinity is more than 35.10%, but at 1,000m it decreases slightly and attains 34.95%. With further increase of depth salinity decreases and at 4,500m it is close to 34.7%.

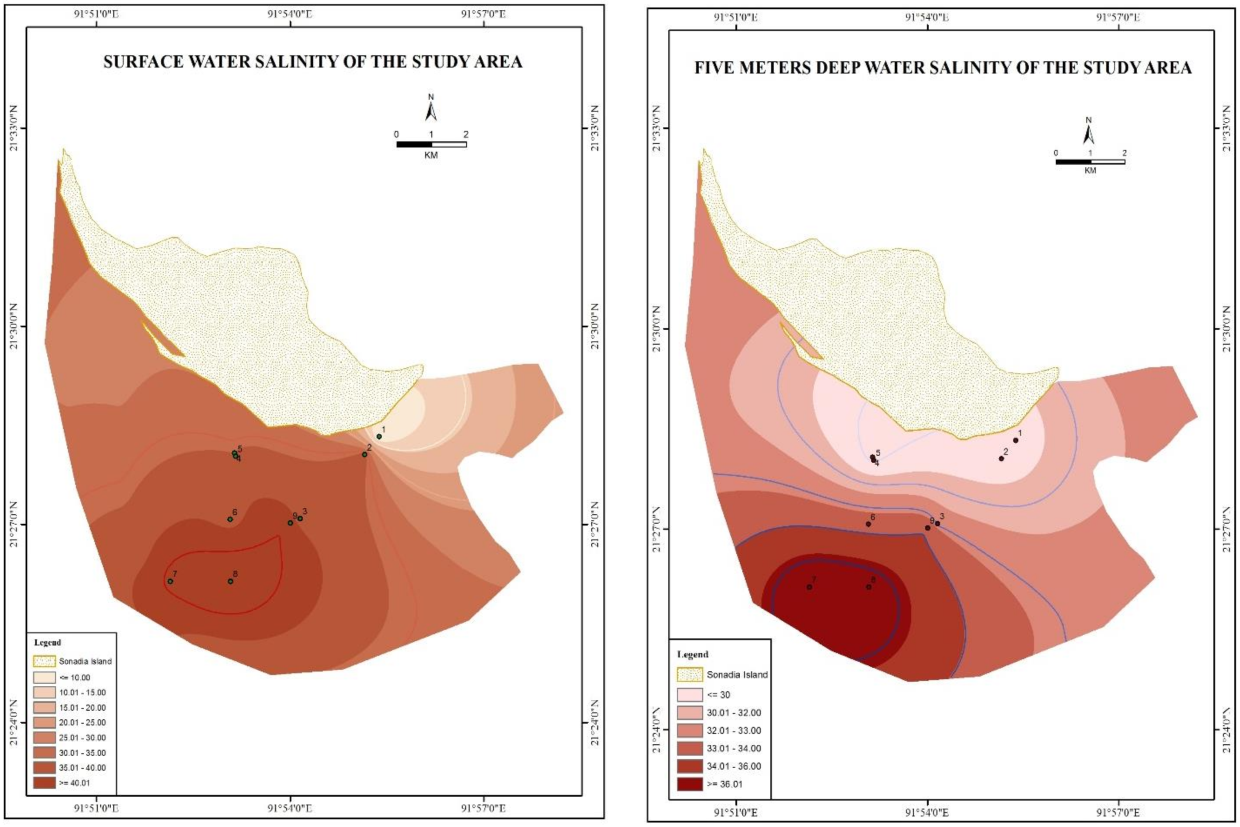


Fig 5.8: Salinity of Surface Water and 5 Meter Deep Water

5.7 Sediment Dynamics in the Bay of Bengal

The Bay of Bengal is one of the largest fresh water and sediment input sites of the world ocean. The annual fresh water discharge into the Bay exceeds 1.5x1012 m3 reducing the mean salinity by about 7% in the northern most part. Fluxes of water are closely connected to the transport of sediment and dissolved constituents through river systems.

The Bay receives about 2000 million tons of sediments annually contributed mainly through the Himalayan rivers-the Ganga and the Brahmaputra; Indian Peninsular rivers-the Mahanadi, the Godavari, the Krishna and the Kaveri, and the Irrawady and the Salween from the Myanmar

According to Tarafder (1975) cited in Islam (2001), 2.4 billion tons of sediment from the combined GBM river system is flowing to the Bay of Bengal annually through the Meghna River mouth. Nearly 6 million m^3s^{-1} of water carrying an estimated 2,179 million tons of sediment is carried down to the sea each year by the Ganges-Brahmaputra river system (Curay and Moore, 1971). Whatever the statistic is this huge volume of sediment is not uniformly distributed over the continental shelf. Rather, different climatic, fluvial and oceanographic factors act as driving forces in their spatial distribution.

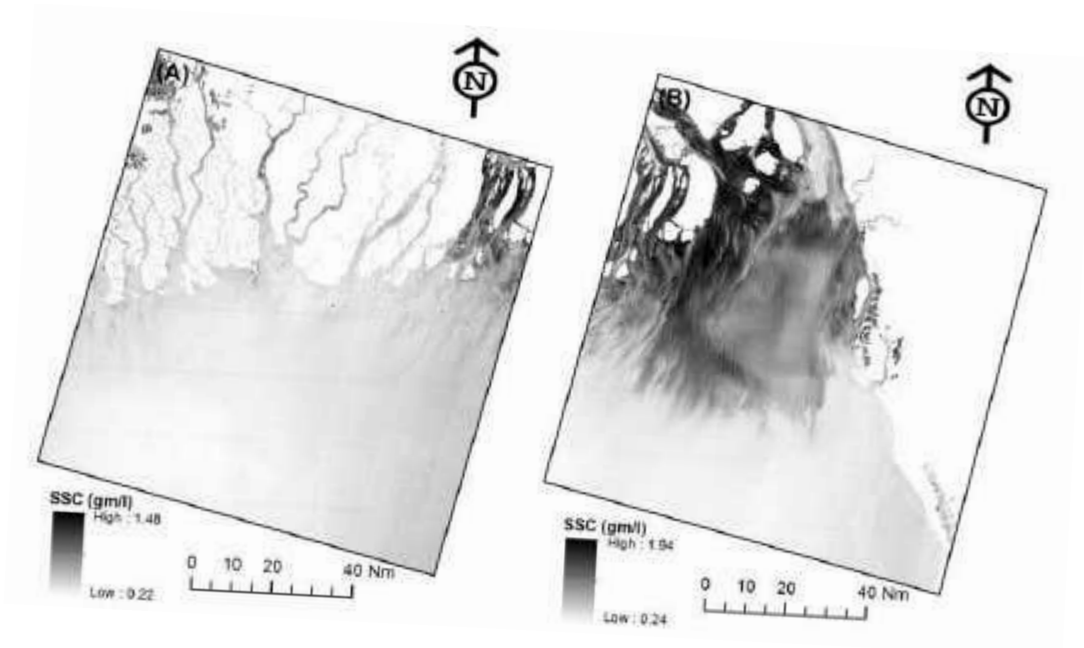


Fig 5.9: Spatial Distribution of Suspended Sediment Concentration (SSC) in the Bangladesh Coast of The Bay of Bengal (A-West and B-East Coast) During the Month of April.

Among these, freshwater discharge from rivers and from their numerous distributaries, velocity of fresh water input, seasonal pattern of ocean current, salinity fluctuation in the coastal sea, daily and monthly fluctuation of tide, wave and atmospheric disturbances like cyclone, tsunami, etc. are notable. During the period of high water discharge (June to September) the concentration of Suspended Sediment Concentration (SSC) remains high in coastal water and found unevenly distributed throughout the coastal sea up to a certain distance.

Maximum suspended sediment is concentrated within the 5 meter water depth contour line and decreases significantly beyond to the 5 meter water depth contour line but continues up to the 10 meter water depth contour line.

After 10 meter water depth contour line it drastically decreases and during this low discharge period is found in minimum concentration up to the 40 meter water depth contour line (80 km southward from the shore) to the south of the Meghna estuary.

The distance how far the suspended sediment will be found in the bay largely depends on the velocity of the freshwater input and the salinity in water. During the high discharge period 90% of the suspended sediment and 80% of the fresh water of GBM System discharge into the Bay of Bengal

5.8 Conclusion

The circulation and hydrography of the Bay of Bengal is complex due to the interplay of semi-annually reversing monsoonal winds and the associated heat and freshwater fluxes. Apart from this, the inflow of warm high saline waters of the Arabian Sea, the Persian Gulf and the Red Sea origin and a number of synoptic disturbances (cyclones) originating during both pre-monsoon (May) and post-monsoon (October) period also affects the dispersal pattern in the Bay of Bengal. Suspended sediments play a major role in the coastal ocean turbidity, water quality, estuarine, tidal inlet, coral reef and mangrove ecosystem. The impacts of the enormous discharge of riverine fresh water and sediments are least understood. However, the consequences could be severe, like changes in coastal morphology and the ecosystem since these rivers carry disposed sewage, industrial effluents, agricultural residues, etc. into the Bay of Bengal which contains higher concentration of Biochemical Oxygen Demand (BOD) and faecal coliform.

Therefore, coastal sediment transport and dynamics are central to the analysis and prediction of environmental quality, habitat stability, public-health risks, marine hazards such as ship-grounding, access to ports, seabed scouring, siltation of harbours and coastal protection.

Chapter 6

Conclusion and Recommendation

6.1 Conclusion

From the above discussion we have come to know about the unique geomorphological settings and environmental characteristics of Sonadia and Moheshkhali island. They are both playing a great role in maintaining coastal ecological balance as well as in saving the lives of the inhabitants.

Sonadia Island is one of the biodiversity hotspot of Bangladesh. Sonadia is considered ecologically important by the government and in 1999 was declared as an ECA under Environmental Act of 1995. The island is unique for wintering shorebirds specially the globally critically endangered Spoon-bill sandpiper, one of the rarest migratory birds in the world, with a population of just 300-350 pairs left in the wild (Zöckler, 2006). Lying within the East Asian-Australasian Flyway, Sonadia is used by migratory birds as a stopover during their long migrationfurthersouth.

The island provides breeding areas for four globally threatened species of marine turtles, and serves as a significant bird refuge for over 80 migratory species. In addition, its inshore waters are feeding grounds for a number of globally threatened marine mammals, such as the Irrawaddy and Bottlenose dolphins. Sonadia Island supports the last remnants of special mangrove forests, which once stretched along most of the coastline of Chittagong and Cox's Bazar. These mangrove species are different from those found in the Sundarbans and can tolerate higher levels of salinity. Besides-

- Sand dunes are home for many plants and animals. These plants and animals live in a harsh environment of salt spray, shifting and infertile sand, bright sunlight, and storms. Some of the animals which depend on sand dunes include snakes, ghost crabs, nesting sea turtles.

- Coastal sand dunes act as water filters, enhancing and maintaining coastal water quality.

- Maintain the natural character including the natural vegetation and morphology.

- They act as a natural barrier to the destructive forces of wind and waves, sand dunes serve as are our first line of defense against coastal storms and beach erosion. They absorb the impact of storm surge and high waves, preventing or delaying flooding of inland areas and damage to inland structures.

- They are also sand storage areas that supply sand to eroded beaches during storms and buffer windblown sand and salt spray. As mentioned above, coastal dunes give protection to the land.

- They can protect beaches from erosion and recruit sand to eroded beaches. Formation of dunes is through sand accretion. Sand that is brought in by the winds gets trapped by the shrubs, creepers, trees and other obstacles that are found on the coast. This accumulated sand forms mounds of sand that keep growing over time to form large dunes. (McHarg, 1972).

Their complex and changing topography generates a high environmental heterogeneity. The flora and fauna found in coastal dunes and barrier islands are greatly affected by the substrate mobility, extremely high temperatures, drought, flooding, salinity and a scarcity of nutrients. They show morphological, physiological and behavioral responses to these limiting conditions.

They are often severely degraded due to excessive exploitation, chaotic urban growth, trampling, invasion of species, sea level rise and climate change. When structures are built so close to a beach as to prevent this natural fluctuation, overall erosion of the beach and loss of dunes can occur. This leaves a shoreline much more vulnerable to damage from storms.

6.2 Recommendation

In spite of the legal protection enjoyed by the coastal sand dunes, they are still being exploited and are under serious anthropogenic pressure. The need for management and conservation policies that consider the natural dynamics of these systems is evident. Several strategies are described:

- Legal protection of the existing sand dunes from further losses due to anthropogenic factors, whether caused directly or indirectly.
- Restoration of sand dune vegetation.
- Development and promotion of planning policies and procedures to prevent or minimize further losses of sand dune habitats to development.
- Official and legal recognition and involvement of local initiatives for sand dune protection and restoration
- Reviving of traditional sand dune restoration and management practices that have proven success.
- Continuous monitoring and surveying of sand dunes
- Restoration of sand dune habitats lost to forestry, agriculture or other human uses.
- Raising public awareness and the essential mobility of coasts and the value of maintaining unrestricted coastal processes.
- Engagement and support (monetary and technical) to local communities for the restoration and protection of sand dunes and associated ecosystems.

References

- M. Shahidul Islam and Md. Khalequzzaman *Coastal and Marine Environment of Bangladesh.* Dhaka: BAPA-BEN, 2016 .
- Alcántara-Ayala, Irasema. 2002. "Geomorphology, Natural Hazards, Vulnerability and Prevention of Natural Disasters in Developing Countries." Geomorphology 47 (2-4): 107–24.
- Briney, Amanda. "The Process and Definition of Geomorphology." ThoughtCo, Feb. 11, 2020, thoughtco.com/overview-of-geomorphology-1435326.
- Arulmoorthy, M.P. (2015). Coastal sand dunes.
- Hodgson, J.M. (1997) Soil Survey Field Handbook. Soil Survey Technical Monograph No. 5. Silsoe.
- Burton, R.G.O. (1983). 'How to Complete the New Recoding Forms.' Soil Survey and Land Research Centre. May 6, 1983.
- Cerdà, Artemi. (2000). Aggregate Stability Against Water Forces under Different Climates on Agricultural Land and Scrubland in Southern Bolivia. Soil & Tillage Research - SOIL TILL RES. 57. 10.1016/S0167-1987(00)00155-0.
- Miththapala, S (2008). Seagrasses and Sand Dunes. Coastal Ecosystems Series (Vol 3) pp 1-36 + iii. Colombo, Sri Lanka: Ecosystems and Livelihoods Group Asia, IUCN.
- M. L. Martínez and G. Vázquez. 'Coastal Sand Dunes and Barrier Islands.' México: Encyclopedia of Life Support Systems (EOLSS).
- Brammer, H. 2014. Bangladesh's dynamic coastal regions and sea-level rise. Climate Risk Management. 1: 51-62.
- Sidker, T. 2010. September. The impacts of climate change on the coastal belt of Bangladesh: An investigation of risks & adaptations on agricultural sector. In Proceedings of international conference on environmental aspects of Bangladesh (ICEAB10)
- Aedla, R., G. S. Dwarakish and D. V. Reddy. 2015. Automatic shoreline detection and change detection analysis of netravati-gurpurrivermouth using histogram equalization and adaptive thresholding techniques. Aquatic Procedia, 4: 563-570.

- McHarg, I., 1972. Civil Engg., 42, 66–71.
- Baxter, J. (2014). “Vegetation Sampling Using the Quadrat Method,” *Methods in EEC (BIO 221B)*, Spring 2014.
- Verlaan Philomene A., Joseph R., Balakrishna M. Suri, (2009). ‘Bay of Bengal,’ *Encyclopædia Britannica*, Encyclopædia Britannica, inc., September 24, 2009.
- Rossier Robert N., “What is visibility? Illuminating facts about an unclear situation,” *DiveTraining*
- Siddiquie H.N. (1967). “Recent sediments of the Bay of Bengal,” *Elsevier*, Marine Geology, August 1967.
- Mohanty, Pratap & Pradhan, Yaswant & Nayak, Shailesh & Panda, Uma Sankar & MOHAPATRA, G N. (2008). Sediment Dispersion in the Bay of Bengal. 10.1007/978-1-4020-6646-7_5.
- Mahmud Sourav, (2017). ‘ Save Sonadia, save Sundarbans,’ *The Daily Star*, 12 April, 2017.
- Islam, Md & Maitra, Mrinmoy & Khan Majlis, Abdul & Murshed, Sanzida & Rahman, Sunbeam. (2011). Spatial Changes of Land Use/Land Cover of Moheshkhali Island, Bangladesh: A Fact Finding Approach by Remote Sensing Analysis. 2. 43-54.