Annual Report 2021

Bangladesh Oceanographic Research Institute

Ministry of Science and Technology

Government of the People's Republic of Bangladesh

Bangladesh Oceanographic Research Institute

BORI

Explore the Ocean, Serve the Nation

বাংলাদেশ ওশানোগ্রাফিক রিসার্চ ইনস্টিটিউট

Annual Report

of

Bangladesh Oceanographic Research Institute

September
2021

Bangladesh Oceanographic Research Institute

Ministry of Science and Technology

Government of the People's Republic of Bangladesh

Published By
Bangladesh Oceanographic Research Institute

Annual Report
2020-2021 Fiscal Year

Time of Publication
September, 2021

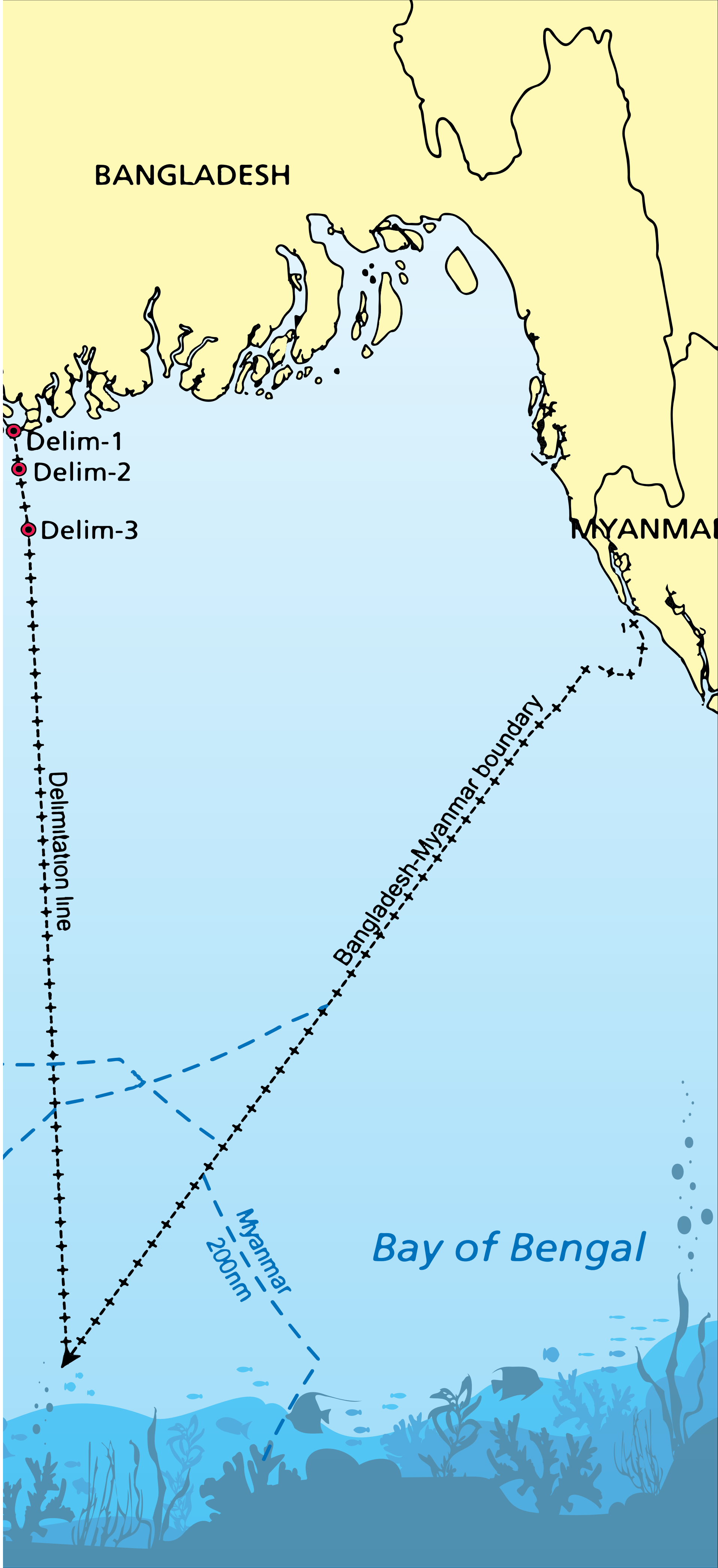
Concept
Sayeed Mahmood Belal Haider
Director General, BORI

Design & Development
Abu Sharif Md. Mahbub-E-Kibria
Executive Editor
Senior Scientific Officer (SSO), BORI

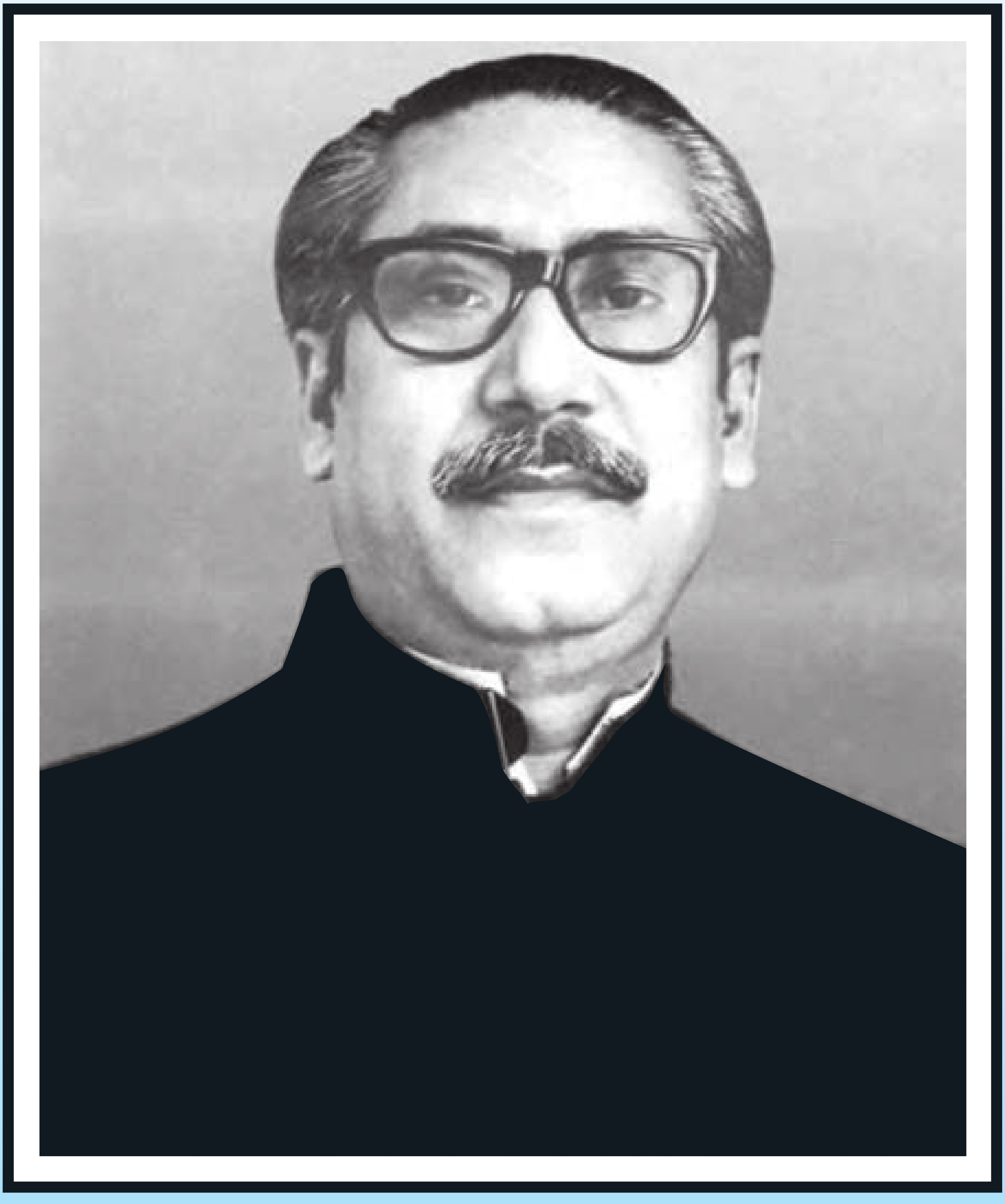
Disclaimer

All the Information in this 'Annual Report-2021' is true and complete to the best of our knowledge. Liability of each chapter goes to respective division. Executive editor disclaim any liability regarding to the provided information.

Printing
Raiyan Printers
Shahjalal Akash
337, Dhaka University Market, Katabon, Dhaka.
Contact: 01712-204207, 01678-670582



BANGLADESH
Delim-1
Delim-2
Delim-3
Delimitation line
Bangladesh-Myanmar boundary
Myanmar 200nm
Bay of Bengal



Father of the Nation Bangabandhu Sheikh Mujibur Rahman

Bangabandhu established the legal entitlements of Bangladesh maritime areas and marine resources by passing the "Territorial Waters and Maritime Zones Act-1974"

Honorable Prime Minister Sheikh Hasina at Inani Sea Beach, Cox's Bazar (6 May, 2017)

(Photo : PID)

"*There is a link between the development of human civilization and ocean. The nearer a society is to the ocean; the better the life is of its members* (14th HACGAM, 2018)"

- Sheikh Hasina

Arch. Yeafesh Osman
Minister
Ministry of Science and Technology
Government of the People's Republic of Bangladesh

Message

It gives me an immense pleasure knowing that Bangladesh Oceanographic Research Institute is going to publish Annual Report 2021. I hope this report will reflect all research activities and other development works completed by BORI last year.

Father of the nation Bangabandhu Sheikh Mujibur Rahman had a vision of prosperous and developed 'Sonar Bangla' and as part of that to implement Bangabandhu's dream, Honorable Prime Minister Sheikh Hasina declared national strategic plan 'Vision 2041' and emphasized on Blue Economy for further social advancement.

Blue Economy is an essential matter for best use of marine resources and for sustainable financial and social development. Ocean supplies food and energy that are needed for human being. Bangladesh government has adopted measures to secure sustainable use the marine resources for achieving comprehensive development.

I expect Bangladesh Oceanographic Research Institute will keep up its progress in ocean research and will materialize Bangabandhu's dream of building 'Sonar Bangla'.

Joy Bangla,
Joy Bangabandhu.

(Architect Yeafesh Osman)

Ziaul Hasan ndc
Secretary
Ministry of Science and Technology
Government of the People's Republic of Bangladesh

Message

I am glad to know that Bangladesh Oceanographic Research Institute (BORI) is going to publish Annual Report-2021 which represents the brief compilation of oceanographic research activities performed by BORI.

Bangladesh is blessed with valuable living and non-living marine resources in the demarcated maritime boundary in the Bay of Bengal. Bangladesh has a 12 nautical miles Territorial Sea, 200 nautical miles Exclusive Economic Zone (EEZ) and 354 nautical miles Continental Shelf. We have a 710 km long coastline in the Bay of Bengal. Marine fisheries, local-international sea tourism, coastal aquaculture etc. are contributing a remarkable role toward its overall socio-economic growth in Bangladesh.

Bangladesh has already been qualified for graduating from Least Development Countries (LDCs) category being guided by the competent leadership of Honorable Prime Minister Sheikh Hasina. Her Excellency rightly understood the importance of Bay of Bengal and its resources exploration and to exploitation to boost up national economy. Accordingly, the present government has formulated necessary plans and policies and involved relevant government agencies for proper action.

As one of the government agencies mandated to conduct research on oceanic resources and sustainable harvest thereof BORI gets grants from the Ministry of Science and Technology (MoST). It has young scientists working in the laboratories with modern equipment to explore resources of ocean in order to strengthening national economy. BORI has been trying to level best to make substantial contribution of flourishing Blue Economy of Bangladesh with the support of MoST and being in line with the direction of Honorable Prime Minister.

I strongly believe that this annual report will benefit related sectoral personnel, researchers and key stakeholders. I would like to thank all who took part in preparing this annual report.

(Ziaul Hasan ndc**)**

Sayeed Mahmood Belal Haider
Director General
Bangladesh Oceanographic Research Institute
Ministry of Science and Technology

PREFACE

The birth centenary of Father of the Nation Bangabandhu Sheikh Mujibur Rahman is observed as "Mujib Borsho" from March 2020 to December 2021 across the country. Bangladesh Oceanographic Research Institute (BORI) also celebrated "Mujib Borsho" through different activities. The only national institute for ocean research, BORI, has been working relentlessly to fulfill the dream of Bangabandhu's 'Sonar Bangla' by exploring and exploiting marine resources.

Bangabandhu establishes the legal entitlements of Bangladesh maritime areas and marine resources by passing 'Territorial Waters and Maritime Zones Act' in 1974. After a long period of time, Bangladesh settled the maritime boundary dispute with the neighboring countries by the efficacious leadership of Honorable Prime Minister Sheikh Hasina. Now BORI is moving forward with a motto of "Explore the Ocean, Serve the Nation".

BORI is conducting its research activities according to government roadmap to satisfy the guidelines of Election Manifesto-2018 (Chapter 3.22), BORI Blue Economy Implementation Plans, Blue Economy Implementation Plan by MoFA and the Perspective Plan 2021-2041. BORI enunciated research plans as short-term, mid-term and long-term to implement SDG-14 and BORI has taken it as a national obligatory task.

In 2020-2021 fiscal year, BORI scientists completed 7 research projects funded by BORI. Scientists from different divisions performed a variety of research activities; such as- identification of marine debris by RS & GIS technology, beach profiling along Cox's Bazar coast, Sedimentological and mineralogical composition of south-eastern coast, phytoplankton assemblage in the south patches fishing ground, extraction of Phycocolloids from sea weed and taxonomic classification of seaweed in the Saint Martin's Island coast, macro-meso-micro plastic identification in the south-eastern coast, water quality assessment in the Cox's Bazar coast and Statistical analysis and future prospecting of non-conventional marine fisheries. Besides BORI's regular R&D projects, scientists also got special allocation for 4 projects from the Ministry of Science and Technology.

BORI has a stronghold on administrative, financial, engineering, ICT and medical services to support the scientists for their best research works. BORI celebrates national days with proper honor and respect. BORI has already taken proper steps to maintain a hygienic working environment in laboratories and campus arena.

Like every year, BORI is going to publish Annual Report-2021 that reflects its performance on ocean research as well as other related works throughout the year. I am thanking to all who have developed this report successfully.

(Sayeed Mahmood Belal Haider)

CONTENTS

Acknowledgement

It is my great pleasure to work in this Annual Report-2021. I would like to thank Mr. Sayeed Mahmood Belal Haider, DG, BORI for his innovative inputs to enrich this report. I am grateful to all divisional heads & scientists for their resourceful contribution. Special thanks to Board of Editors for their timely support. I also thank each and every person who has helped me directly or indirectly to complete this report successfully.

Abu Sharif Md. Mahbub-E-Kibria
Executive Editor
Senior Scientific Officer & Head
Environmental Oceanography and Climate
Bangladesh Oceanographic Research Institute

BORI

Name	: Bangladesh Oceanographic Research Institute
Status	: Statutory Autonomous Body
Ministry	: Science & Techonology Ministry
Location	: Marine Drive Road, Cox's Bazar
Campus Area	: 40.62 Acres
Website	: www.bori.gov.bd

Photo Credit @ Shafiqul Islam Shafiq, BORI

Future Planning

- Acquisition of a modern oceanographic Research Vessel.
- Establishment of Marine Aquarium at BORI campus.
- Set up of a modern Oceanographic Data Center.
- Establishment of a modern Training Center cum International Hostel for oceanographer, ocean engineers and related professionals.
- Procurement of modern equipment for good research.
- Implementation of planning for Blue Economy.

CHAPTER 1

Bangladesh Oceanographic Research Institute (BORI)

Background of BORI

Bangladesh Oceanographic Research Institute (BORI) is the first and only national research institution on marine science in Bangladesh, which will be able to play an important role in ensuring the development of Blue Economy.

Photo Credit @ Shafiqul Islam Shafiq, BORI

After winning the maritime boundary settlement case with Myanmar on March 14, 2012 andIndia on July 7, 2014, Bangladesh achieved sovereign rights to a total of 1,81,813 square kilometers of sea area, 200 nautical miles of exclusive economic zone, and all types of living and non-living ocean resources. If Bangladesh can ensure the sustainable use of the ocean resources, then the economy of Bangladesh will progress faster. The potential for setting up an international level ocean research institution, development of integrated coastal zone management, mining of mineral resources, and proper utilization of ocean resources including development of tourism and mariculture have increased the interest of the international community towards the Blue Economy in Bangladesh. The prospect of this newly developed sector is unlimited. For this reason, BORI will be able to play an important role in oceanographic research and create skilled manpower. The organization will work to conduct all the activities as a focal point of Bangladesh at national and international levels in the field of oceanography. Besides conducting its own research, BORI will assist in the research work of other local or foreign organizations, colleges and universities as well.

Photo Credit @ Shafiqul Islam Shafiq, BORI

The Father of the Nation Bangabandhu Sheikh Mujibur Rahman initiated the establishment of ocean research institute in 1973 with the aim to enrich the country's economy and reducing poverty through exploring, exploiting and conserving valuable resources of the Bay of Bengal. But after the brutal and tragic killing of Bangabandhu in 1975, that initiative totally stops. In 1996, Honorable Prime Minister Sheikh Hasina constituted a Review Committee for the establishment of National Institute of Ocean Science.

After receiving the recommendation of the review committee, the decision of establishing the National Oceanographic Research Institute was acceptedin 2000. In order to ensure proper utilization of marine resources, a project under the Ministry of Science and Technology was adopted in the period from June 2000 to July 2005 for the establishment of National Oceanographic Research Institute (1st Phase). After a long time in 2009, the visible progress of the establishment of National Oceanographic Research Institute (NORI) was achieved through the intensive initiative of Honorable Prime Minister Sheikh Hasina. When presenting the proposal for establishing the institute on 4 acres of land in the ECNEC meeting on 02/07/2009, Honorable Prime Minister extended the amount of land to 40 acres instead of 4 acres. She also ordered to redesign and represent the project including laboratory, residential building, club building, playground, school buildingand marine aquarium with international quality. Acquisition of 40 acresof land in Jungle Goalia Palang Mouza of Khunia Palang Union of Ramu Upazila of Cox's Bazar district was completed in 2010. The establishment project was implemented at a cost of Taka 102.80 crore. Under the heading of "National Oceanographic Research Institute Establishment Project (NORIP) (1st phase) (2nd Revised)" has been constructedwith 13 buildings including 3-storey Institute building with laboratory, 5-storey 3 officer quarters & 2 staff quarters, 1 Director General's Bungalow, 2-storey 1 Officer Dormitory & 1 staff Dormitory, 3-storey 1 Club Building & 1 Rest House, 5-storey 1 security personnel building, and 2-storey 1 school-cum- Medical Centre. Initially BORI has been purchased about 1096 nos. of scientific instruments for oceanographic research. For the implementation of the overall function of the project, 14 officials were working including 1 senior scientific officer, 3 scientific officers, 1 administrative officer and other employees. In addition, under the project, there was 1 platoon Ansar & VDP members for the safety of the Institute and 8 daily-basis manpower to keep the Institute premises neat and clean.

On 5 March 2015, "Bangladesh Oceanographic Research Institute Act, 2015" was passed in the national parliament for the keen endeavor of the present Honorable Minister Architect Yeafesh Osman of the Ministry of Science and Technology. It was a great achievement for oceanographic research. The institute has been established on 08/09/2015 with the powers given in sub-section (1) of 3 of "Bangladesh Oceanographic Research Institute Act, 2015" (Act 07 of 2015). On 19/05/2017, for the appointment of officer and staff the 'employment regulatory of Bangladesh Oceanographic Research Institute, 2017' was issued. A total of 223 posts have been created for the institute. The first meeting of the Board of Governors of BORI was held on 25/05/2017. The organogram of BORI comprises 2 wings. Among them one is research wing (6 research divisions) and the other is administrative wing including engineering sector, medical centre, ICT and library cell. Considering the seer thoughts of Honorable Prime Minister Sheikh Hasina, initiatives have already been taken to establish a Marine Aquarium of international quality in the institute premises for ocean research & tourism.

BORI at a Glance

The Bangladesh Oceanographic Research Institute (BORI) has emerged as an independent organization. It is the first and only national institution in the field of marine science. This institution will be able to play an important role in the exploration and development of country's marine resources and play a leading role in revenue earnings. Multiple research and development programs will be conducted in each of the research departments. Successful implementation of the current action plan will be possible through the development of sustainable technology in the country, achieving poverty alleviation programs and various development targets of the United Nations. Future research activities will be expanded more widely. If this institute effectively handles the management of the sea related research activities, application of research results and management of all the related activities, Bangladesh will emerge as a prosperous and developed country by using marine resources. We have won the sea under the dynamic and visionary leadership of the daughter of Bangabandhu, Prime Minister Sheikh Hasina, and there is no doubt that we will soon emerge as a developed nation using the sea resources. There are two wings of BORI. One is Research wing and another is Admin, Planning & Finance wing.

Research Wing	Admin, Planning & Finance Wing
1. Physical and Space Oceanography	1. Administrative Division
2. Geological Oceanography	2. Accounts & Finance Division
3. Chemical Oceanography	3. Engineering Division
4. Biological Oceanography	4. Information Management Division • ICT Cell • Library Cell
5. Environmental Oceanography and Climate	
6. Oceanographic Data Center	5. Medical Center

Vision of BORI

> *"To contribute in the economic development of the country by adopting maritime research activities, applying research results, operating, managing and controlling all related activities"*

Mission of BORI

Development of mineral, agriculture, fisheries, environment and industrial sectors through utilization of sea resources and the development of environmentally friendly and sustainable technology and research activities to increase productivity for the benefits of mankind.

To improve knowledge related to maritime education, research, training and development of knowledge related to the research and use of sea resources and to take action to protect the environment.

To search all living creatures of the sea and to expedite sustainable production of those resources for economic welfare.

Identity and research the presence of offshore island, coastal areas and ocean bottom minerals, placer deposits, coal, oil and other minerals including gas.

Study of hydrography, sedimentation, astrology, meteorology, navigation & communication system and the development of commercial communications.

Encourage public and private organizations to invest in the trade and trade related to the marine and marine environment and to serve as consulting organizations.

Providing assistance in respect of the country's maritime strategies and policies and proposals for planning including maritime law.

Identify various environmental issues (coastal, deep sea circulation, delta formation, water flow, etc.) and environmental natural disaster and climate issues.

Undertake coordinated approach to improve international relations and linking the oceanography with the local and international organizations.

POTENTIAL AREAS OF MARINE RESOURCES IN BANGLADESH

- Experts are speculating that there is one of the world's largest fuel (oil or gas) reserves in the Bay of Bengal which can control the energy-politics and economy of the day.
- In the Bay of Bengal, Heavy Mineral, such as Ilmenite, Titanium oxide, Rootail, Zircon, Garnet, Magnetite, Monazite, cobalt etc. have been found, which can be a huge source of foreign currency.
- There are about 475 species of fishes in the Exclusive Economic Zone (EEZ) of the Bay of Bengal. Fishing capacity can be increased to the desired level by reviving modem fishing trawlers and training.
- Salt can be exported abroad by using advanced technology in salt cultivation.
- Construction of deep sea ports with modern facilities will increase the activities of feeders of international commercial vessels.
- Marine shellfish and finfish farming can bring foreign currencies. There are already many opportunities of commercially produced PUFA's (Poly Unsaturated Fatty Acids) such as omega-3 and omega-6 antioxidants from different seaweed species.
- Development of existing fish resources can be done through the use of marine biotechnology. Organic technology also can play a role in preventing oil spillage.
- Use of adequate research and advanced technology is necessary to prevent marine and coastal environmental pollution in ship breaking industry.
- Because of the high wind speed in the offshore areas of the sea, renewable energy can be generated by establishing windmills. Electricity can be produced using the wave and tide as well as by applying the Ocean Thermal Energy Conversion (OTEC) technology.
- According to various sources, by the year 2030, 10% of the output the world's cobalt, copper, zinc and Rare Earth Element (REE) will be produced from the sea.
- Construction of marine aquarium, travelling system by cruise ship & by ensuring adequate safety in the coastal area can become one of the main sources of national revenue.

Photo Credit @ Md. Tarikul Islam, SO, BORI

MAJOR ACHIEVEMENTS OF BORI

- It has managed and financed for 8 R&D projects in FY 2019-20, 6 R&D projects in FY 2018-19 and 5 R&D projects in FY 2017-18.
- It has taken a Comprehensive Blue Economy Plan and implementing successfully.
- It has taken a Complete & Comprehensive Safety Plan for its employees for the ongoing Pandemic COVID-19 response.
- BORI has recently assisted technical support with RT-PCR as a COVID-19 response to Cox's Bazar Medical College to detect SARS-CoV-2 virus in nasal swab sample.
- A Development Project Proposal (DPP) has been proposed for establishment of marine aquarium on 10 acres of land in Institute area.
- A Development Project Proposal (DPP) has been proposed for establishment of Bangladesh Oceanographic Research Institute (Phase-II).
- 19 scientists, engineers and other officials have attended at a training program at National Institute of Oceanography (NIO), Dona Paula, Goa, India.
- In the recent meeting of JSTC with India possibility of mutual co-operation was discussed.
- A delegation of China's Third Institute of Oceanography recently visited the Institute campus in Cox's Bazar and discussed about joint activities.
- Already 104 persons against 223 posts in the revenue sector has been recruited/posted and recruitment process for the remaining posts is in progress.
- Construction works including construction of building, residential building, quarters, dormitory, guest house, DG bungalow on 40 acres of land is already completed.
- Eight modern laboratories equipped with latest equipment have been established.
- The Bangladesh Ocean Research Institute Act-2015 is passed by the Jatiya Sangsad in the year 2017. The rules of the Institute were formulated.

Institutional Structure

Board of Governors

Director General
Total Personnel: 223

1 X PA/Satlipikar
1 X Driver
1 X Office Sohayak

Director (Admin, Planning & Finance)
Total Personnel: 93

1 X PA/ Satlipikar
1 X Driver
1 X Office Sohayak

Physical & Space Oceanography
(Total Personnel-24)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
3 X Laboratory Attendant
2 X Office Sohayak

Geological Oceanography
(Total Personnel-23)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Laboratory Attendant
2 X Office Sohayak

Environmental Oceanography & Climate
(Total Personnel-18)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
3 X Senior Scientific Officer
6 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Office Sohayak

Chemical Oceanography
(Total Personnel-23)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Laboratory Attendant
2 X Office Sohayak

Biological Oceanography
(Total Personnel-27)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
5 X Senior Scientific Officer
10 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
3 X Laboratory Attendant
2 X Office Sohayak

Oceanographic Data Center
(Total Personnel-13)
1 X Senior Scientific Officer
3 X Scientific Officer
1 X GIS Analyst
2 X Data Analyst
1 X Computer Operator
3 X Date Entry/Control Operator
2 X Office Sohayak

Administrative Division
(Total Personnel-49)
1 X Deputy Director (Admin)
1 X Assistant Director (Admin)
1 X Administrative Officer
1 X Store Officer
2 X Computer Operator
1 X Store keeper
1 X Office Assistant cum Computer Typist
3 X Office Sohayak
6 X Cleaner
2 X Mali

a) Security
1 X Security Supervisor
9 X Security Guard

b) Transport
1 X Transport Supervisor
7 X Driver
5 X Boat Man/Diver/Speed Boat Driver
2 X Office Sohayak

c) Dormitory & Rest House
1 X Care Taker
2 X Cook
2 X Assistant Cook

Accounts & Finance Division
(Total Personnel-08)
1 X Accounts Officer
1 X Assistant Accounts Officer
1 X Accountant
1 X Auditor
1 X Computer Operator
1 X Office Assistant cum Computer Typist
2 X Office Sohayak

Medical Center
(Total Personnel-07)
1 X Medical Officer
1 X Nurse
1 X Medical Technician
1 X Office Assistant cum Computer Typist
1 X Medical Attendant
2 X Office Sohayak

Engineering Division
(Total Personnel-15)
3 X Assistant Engineer (Civil, Electrical, Marine)
3 X Sub-assistant Engineer
2 X Work Assistant
3 X Machine Operator
2 X Office Assistant cum Computer Typist
2 X Office Sohayak

Information Management Division
(Total Personnel-10)

ICT Cell
1 X Programmer
1 X Assistant Programmer
2 X Data Analyst
1 X Computer Operator
2 X Office Sohayak

Library Cell
1 X Librarian
1 X Library Attendant
1 X Office Sohayak

Summary of Manpower

SL No	Name of Post	Number
1.	Director General (DG)	1
2.	Director	1
3.	Chief Scientific Officer (CSO)	5
4.	Principal Scientific Officer (PSO)	10
5.	Deputy Director	1
6.	Senior Scientific Officer (SSO)	20
7.	Programmer	1
8.	Scientific Officer (SO)	42
9.	Other Officers Equivalent to Scientific Officer	09
10.	GRADE: 1 to 9	90
11.	GRADE: 10	10
12.	GRADE: 11	10
13.	GRADE: 13	25
14.	GRADE: 14	18
15.	GRADE: 16	5
16.	GRADE: 19	19
17.	GRADE: 20	45
	TOTAL	**223**

Transport and Major office equipments

	Number
1. Transport	
a) Jeep	2
b) Pick up	2
c) Microbus	2
d) Minibus	1
c) Truck	1
f) Motorcycle	5
g) Speed Boat	3
h) Fishing Boat	2
2. Office Equipment	
a) Generator	03
b) Computer & Accessories (with UPS)	115
c) Printer	15
d) Multimedia Projector	5
e) Photocopy Machine	5
f) Scanner	5
g) Fax	3

CHAPTER 2

Research Summary

Photo Credit @ Physical and Space Oceanography Division, BORI

Project Theme:
Determination of spatial and temporal variations in sea surface chlorophyll and nutrients.

Duration:
February 2018 to June 2020

Implementation area:
Coastal marine area of St. Martin's Island, Cox's Bazar and Kutubdia.

Summary of project work:
Determined spatial and temporal quantification of sea surface chlorophyll and nutrients (NO_2, NO_3, NH_4, SiO_2, PO_4). Besides, baseline data of physico-chemical parameters (SST, Salinity, TSS, TDS, pH, Secchi depth) of seawater have been collected in the Cox's Bazar and Kutubdia coastal marine area. Extension of this study is going on.

Roles in Public Welfare:
It will be possible to determine the potential fishing zone by adopting integrated projects in the future using the status of chlorophyll and nutrients in the sea surface. This project will play an important role in marine fishing. The baseline data obtained through this project will play an important role in regulating any project at the government/private level in the coastal area. The level of conservation and exploitation of aquatic animals are determined by knowing the feeding and migration habits of aquatic animals in coastal areas.

Project Theme:
Beach profiling along the coast of Cox's Bazar.

Duration:
July 2019 to June 2021

Implementation area:
Coastal area of Cox's Bazar

Summary of project work:
Geographical survey is done in the beach area. 10 benchmarks have already been set up for profiling work and work is underway to set up 10 more benchmarks. Beach profiles of most areas are being prepared using comparative use of satellite data, benchmark data and survey data. Work is underway to create beach profiles in the rest of the area.

Roles in Public Welfare:
Once the complete beach profile of the coastal area of Cox's Bazar is completed, the coastal erosion trend can be identified. This section analysis will enable long-term planning of coastal areas. Currently the government has various mega projects on the coast of Cox's Bazar so that beach profile will play a vital role in the projects. Moreover, beach profile will also play an important role in creating tourist facilities.

Photo Credit @ Physical and Space Oceanography Division, BORI

Photo Credit @ Geological Oceanography Division, BORI

GEOLOGICAL OCEANOGRAPHY DIVISION

Project Theme:
Sedimentological and Mineralogical Distribution in the Nearshore marine Area and Determination of Sediment Source.

Duration:
February 2018 to June 2020

Implementation area:
St. Martin's Island, Cox's Bazar-Teknaf, Maheshkhali-Kutubdia (3100 sq. km area).

Summary of project work:
Important heavy minerals such as zircon, rutile, magnetite, ilmenite and some Rare Earth Elements (REE) such as uranium, thorium and selenium are found in the bottom sediment of the Nearshore marine area. Significant amount of these minerals are found in some areas. Extension of this study is going on.

Roles in Public Welfare:
Heavy Mineral is very important in blue economy. Significant quantities of precious minerals such as zircon, rutile, magnetite, ilmenite, etc. and elements such as uranium, thorium and selenium can be collected from the bottom sediment of the area that will bring economic benefits to the country.

Project Theme:
Determination of the effect of tectonic activity on the relative rise of sea level fluctuation based on the rate of subsidence and upliftment in the eastern coastal belt of Bangladesh.

Duration:
July 2019 to June 2020

Implementation area:
Eastern coastal area of Bangladesh.

Summary of project work:
The tidal trend is identified from the historical tidal data of 8 tidal gauges in the eastern part of Bangladesh. Data is collected from GNSS stations in Khulna and Chittagong for tectonic movement calculations. Relative tectonic maps have been prepared through bathymetric maps of Cox's Bazar coast, surface geological maps and topography analysis. Work is underway to identify the effects of the relative fluctuation of sea level.

Roles in Public Welfare:
Earthquakes, geological changes, tidal surges, etc. are predicted in the coastal areas of the country. Based on the results of this project, the adverse effects of natural disasters on the public life of the coastal areas can be reduced by adopting a national integrated plan.

Photo Credit @ Geological Oceanography Division, BORI

Photo Credit @ Chemical Oceanography Division, BORI

CHEMICAL OCEANOGRAPHY DIVISION

Project Theme:
Adaptive responses to ocean warming and acidification of different marine invertebrates inhabit in Southeast coast of Bangladesh and to operate a seawater culture unit.

Duration:
February 2018 to June 2020

Implementation area:
Southeastern Coastal Area of Cox's Bazar.

Summary of project work:
Adaptation process and salinity of marine invertebrates have been determined with p^H condition of the area adjacent to the south-east coast and other important plant and animal culture units including green muscle or oysters, crabs, shrimps have been set up on the BORI campus. Extensive of this study is going on.

Roles in Public Welfare:
The salinity and p^H values of seawater are closely related to the adaptation of invertebrates in marine areas. These invertebrates have economic importance. Neither the cage culture nor the mericulture of these marine invertebrates will be profitable if the salinity and p^H valuesare not known properly. Considerably, the project has a robust public importance. Based on the results of the Biological Culture Unit on the BORI Campus, it will be possible to carry out large scaled marine culture in the coast in the future that will benefit the coastal fishermen and will play an important role in the national economy.

BIOLOGICAL OCEANOGRAPHY DIVISION

Project Theme:
Preparation of Preliminary Taxonomic Checklist of Marine algae (Seaweed) along the coast of St. Martin's Island, Monitoring quality of bottom sediment and physico-chemical parameters of water and extraction of economically important physico-colloids (agar-agar, carrageenan) after verification of available seaweed.

Duration:
February 2018 to June 2020

Implementation area:
St. Martin’s Island

Summary of project work:
Taxonomic lists of 103 species of Rhodophyta, Chlorophyta and Phyophyta have been prepared. Work is underway to verify the nutritional value of 11 seaweeds. Agar-agar of 3 species of seaweed are extracted and optimization is currently underway. Phytoplankton identification of 350 species has been completed from samples collected from Bay of Bengal area through Nansen Research Vessel. In addition, identification of 150 species of zooplankton and ichthyoplankton are completed.

Roles in Public Welfare:
Seaweed and seaweed are in great demand in the world market. Seaweed is used as food, medicine and cosmetics at the same time. Through this study, a taxonomic list of seaweed is prepared that will be a proper guidance in seaweed research and play role in national development. This will increase the production of seaweed in the country and will create employment opportunities. If it is possible to extract important phycocolloids from seaweed, it will play an essential role in the domestic pharmaceuticals, cosmetics, foods and beverage and toiletries industries.

Photo Credit @ Biological Oceanography Division, BORI


Photo Credit @ Environmental Oceanography & Climate Division, BORI

Project Theme:
Identification of marine pollution through seasonal quality monitoring and presence verification of marine organisms in the coastal area of Cox's Bazar.

Duration:
July 2019 to June 2020

Implementation area:
Coastal area of Cox's Bazar.

Summary of project work:
Various physico-chemical parameters (Temperature, Salinity, pH, TDS, TSS, DO & BOD_5) of Kolatali, Laboni, Sugandha and Inani Beach area, Teknaf Beach, Maheshkhali Channel, Jetty No. 6, Badarkhali Jetty area have been fixed.

Roles in Public Welfare:
Cox's Bazar beach and surrounding tourist areas are constantly facing severe pollution due to overcrowding, irresponsible behavior of domestic tourists, tour operators and hoteliers and unplanned waste management. Besides, due to lack of sewerage system, liquid waste from hotels and motels is flowing directly into the Bakkhali River. Then, it goes to the Maheshkhali channel and from the channel to the sea. First the river water, then the channel water, and finally the seawater are being polluted. In this way, the seawater is being polluted that has a devastating effect on the coastal environment, marine ecosystems and biodiversity of Cox's Bazar. This study will play an important role in determining the current state of pollution, identifying sources of pollution and preparing and making plans for pollution control.

Project Theme:
Determination of Marine Pollution through Marine Litter (Plastic) and Water Quality in Coastal Area.

Duration:
February 2018 to June 2020

Implementation area:
St. Martin's Island and Cox's Bazar coast.

Summary of project work:
The level of pollution has been determined by checking the quality of litter (plastic) and water in the coastal areas of St. Martin's Island and Cox's Bazar. A pollution map of the St. Martin's Island area has been published. Extension of this study is going on.

Roles in Public Welfare:
Excessive tourist pressure and mismanagement have resulted in severe plastic pollution on St. Martin's Island. Every year from November to March tourist ships reach St. Martin's Island from Teknaf Jetty every day. This allows the tiny sand particles from the bottom of the ocean to move into the aquatic environment through the propeller of the ship and spread the tiny sand to the east and southeast of the island with the help of ocean waves and currents created by the strong north winds of winter. Determining the quality of water around St. Martin's Island, it is found that the amount of Total Dissolved Solid (TDS) is higher in the east and east south of the island. In the light of this project, it will be an important tool in determining the national policy on the use and settlement in this island. Moreover, the project will also play an important role in making policies for the conservation of biodiversity along the Cox's Bazar coast.


Photo Credit @ Environmental Oceanography & Climate Division, BORI

Thesis activities

Sl	Name of Service	Receiver Organization	Department of Service Providers
1	University of Chittagong	4	Department of Biological Oceanography Department of Environmental Oceanography and Climate
2	Dhaka University	14	All research departments
3	Chittagong University Dhaka University Jahangirnagar University BSMR Maritime University	10	All research departments

Collaboration activities

Sl	Name of Collaborative Organization	Participating department	Participating scientists
1	Participated in the survey work at the Norwegian based NENSEN Research Vessel	Department of Biological Oceanography	1 person
2	Participated in the survey work at BNS Saibal Research Vessel of Bangladesh Navy	Department of Physical and Space Oceanography, Geological Oceanography and Chemical Oceanography	4 person

Service delivery activities

Sl	Name of Service	Serviced Organization	Department of Service Providers
1	Consultancy services on the impact of the ocean on the Marine Drive Road project	16 ECB, Bangladesh Army	Department of Geological Oceanography and Department of Physical and Space Oceanography
2	Provide technical support for Covid-19 test work using RT-PCR	Cox's Bazar Medical College and Hospital	Department of Biological Oceanography
3	Analysis and consulting services	FAO and the Department of Fisheries	Department of Biological Oceanography
4	Analysis Services	Jahangirnagar University, University of Dhaka, National Institute of Biotechnology (NIB) Sher-e-Bangla Agricultural University	Research Laboratories

Photo Credit @ Mir Kashem, SO, BORI

CHAPTER 3

Physical and Space Oceanography Division

Photo Credit @ Abu Sayeed Muhammad Sharif, SSO, BORI


Photo Credit @ Abu Sayeed Muhammad Sharif, SSO, BORI

Physical & Space Oceanography deals with the research and development of remote sensing data on the world's oceans, and calibrates instruments, verifies the data, and creates products to meet the needs of users for satellite data and other information on the oceans. PSOD also focuses on describing and understanding the evolving patterns of ocean circulation and fluid motion, along with the distribution of its properties such as temperature, salinity and the concentration of dissolved chemical elements and gases. Approaches include theory, direct observation, and computer simulation.

Research frequently takes place in the context of important multidisciplinary issues including the dynamics and predictability of global climate and the sustainability of human use in coastal and estuarine regions. Besides research activity, PSOD is giving oceanography based analytical service and technical support to different government and non-government institutions.

Detecting floating marine debris in the eastern coastal zone of Bangladesh using remote sensing technique

Muhammad Shahinur Rahman
Scientific Officer
Physical and Space Oceanography

Abu Sharif Md. Mahbub-E-Kibria
Senior Scientific Officer
Environmental Ocenaography and Climate

Photo Credit @ Sultan Al Nahian, SO, BORI

Abstract

Floating Marine debris is a global problem. A pilot experiment was conducted in the coastal area of Bangladesh. Four types of artificial floating objects (plastic bottle, polyethylene, fishing net and dry weed) were constructed and deployed on the sea surface. There were four remote sensing indices namely NDVI, kNDVI, Plastic Index (PI) and Floating Debris Index (FDI) were used in this study. The Signal to Noise Ratio (SNR) was applied to indicate these index performances in Sentinel-2 imagery for differentiating floating objects from sea water. SNR value of these remote sensing indices are promising for detecting floating object especially plastic bottle and polyethylene. NDVI gave the result for the SNR value which are 4.76, 3.72, 3.05 and 4.22 for plastic, polyethylene, fishing net and dry weeds respectively. The SNR value of kNDVIis 8.06, 5.44, 2.7 and 8.17 for plastic, polyethylene, fishing net and dry weeds respectively. The SNR value of PI are 13.4, 12.91, 6.15, and 6.81 for plastic, polyethylene, fishing net and dry weeds respectively. The SNR value of FDI is 6.75, 5.95, 0.40, and 4.48 for plastic, polyethylene, fishing net and dry weeds respectively. The result indicates that the plastic and polyethylene accumulation can identified by remote sensing technique. The PI index is most appropriate method for detecting floating object.

Key words: Floating marine debris, Remote sensing, Sentinel-2, NDVI, PI, FDI, SNR.

1. Introduction

Marine Floating debris (hereafter referred as MFD) includes any waste or plant life which floated along the water's surface and interferes with the ecosystem, navigability of the area or recreational use. It can be either natural or anthropogenic debris such as: plastics, floating trash, invasive aquatic plants (sargassum, algae, etc.), logs, sticks, rubber, textiles and any other marine litter. Multiplied negative effects on the ecosystem's health are reported due to many marine lives attracted by MFD (Moller et al., 2016). It also facilitates the transfer of non-native marine species (e.g., bryozoans, barnacles) to new habitats (Ghaderi and Henderson, 2013; Ojaveer et al., 2015). It is reported that during an era of global change, the dispersal of invasive alien species through MFD (prominently plastics) more than doubles the rate of natural dispersal processes (Barnes, 2009). It damages coral reef, impacts recreational activity and tourism economy by washed ashore (Moller et al., 2016). These entire threats can create the imbalance of marine ecosystems and resulting in costly control efforts, clean-ups, and negative economic impacts (Mouat et al., 2010).

Plastic materials are dominant in MFD and contributing to 60-80% of the total MD, which accounted 90-95% in many regions and keep floating in the marine system for a hundred to thousands of years due to their durability and large lifespan (Wang et al., 2016; Sannigrahi et al., 2021).

Coastal areas form an important interface between land and sea. Although they cover only 10% of the earth's land area, they are home to over 60% of the world's population (Lakshmi and Rajagopalan, 2000). Generally, Plastic debris is more common in coastal areas, predominantly in front of river mouths and coastal cities (Pasquini et al., 2016). By the combination of several processes, i.e., mechanical weathering, biodegradation and thermal-oxidative degradation by ultraviolet (UV) radiation, plastics has broken down into debris and more harmful near coastlines, where species abundance and biological diversity are highest (Schuyler et al., 2016, Sherman and Van Sebille, 2016; UNEP, 2016). The United Nations 2030 Agenda for Sustainable Development addresses the issue of plastic litter in water bodies through Sustainable Development Goals especially establishing a target specifically related to marine litter (SDG target 14.1 and the associated indicator 14.1.1b, "plastic debris") along with Goal 6 on "Clean Water and Sanitation", and Goal 12 on "Sustainable Consumption and Production".

Bangladesh is a densely populated country. Numerous no. of rivers is scattered in this country like a net. For this reason, the destination of all garbage is Bay of Bengal. The Bay of Bengal and the South China Sea are the new plastic hotspots in Asia. Every year about 2 lakh tons of plastics enter the Bay of Bengal from Bangladesh. Bangladesh is the 10th most plastic polluting countries in the world (Chowdhury et al., 2020). Population pressure, poor waste management practices and shipbreaking are primarily responsible for that. Every year, 60-65 ships are broken in Bangladesh which have serious threats to the ecosystem (Hossain 2015).

A large volume of MD mostly plastic bottles, fishing nets and buoys had washed onto the 120-kilometre (75-mile) beach along the largest uninterrupted sandy beach of cox's Bazar in 11 and 12 July, 2020. MFD research in the coastal areas of Bangladesh is now inadequate. MFD is predominantly composed by plastic and this research focus mainly floating marine plastic detection. This paper portrait the potentiality of MFD detection by remote sensing technology.

2. Materials and Methods

2.1 Study Area

Study area is considered in the eastern coastal zone of Bangladesh. This experiment performed inManglapara coast near Rejukhal and located about 2 km away from the Bangladesh Oceanographic Research Institute. Study area map is shown below.

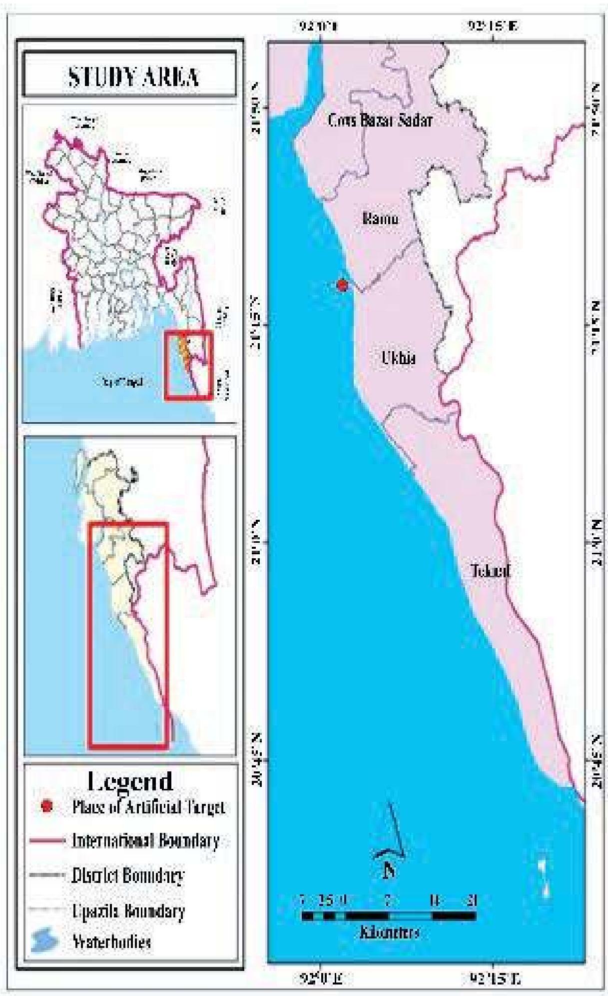


Figure 1: Study area. Red point indicates the experiment site

2.2 Methodology:

Traditionally MFD study is conducted by collecting field-based observation which is accurate but time-consuming, geographically constrained and require trained professionals and laboratory analysis. It is required real time or near real-time measurement for understanding the processes governing their spatial distribution. To overcome these problems, remote sensing technology provides spatially synoptic and near real-time measurements that can be effectively used for detection, mapping and tracking. Aerial and satellite remote sensing have been demonstrated as an effective tool in detecting and mapping marine debris (Sheavly, 2007; UNEP, 2009, Topouzelis et al., 2020, Ciappa 2021). An added advantage of remote sensing is that it provides information from remote areas.

2.3 Determining spectral signatures of floating debris:

Four artificial objects are constructed by plastic bottle, polyethylene, fishing net and dry weed are deployed on the sea surface for determining the plastics and plants derived spectral signatures. The size of these artificial objects is 10m x 10m like Topouzelis et. al. (2019). Our study site at Monglapara adjacent of Rejukhal, Cox's Bazar. We evaluate the target detection capabilities by using established remote sensing indicesin Sentinel-2 imagery acquired on 22nd February, 2021.

Figure 2: Schematic representation of the debris target with the different materials used as reference.
Target prepared from reeds (left 1), Polythene Sheet (left 2), Fishing Net (left 3) & Plastic bottles (left 4).

2.4 Sentinel-2 data description and access information:

Sentinel-2 is an Earth observation mission developed and operated by ESA under the Copernicus Programme. The Multi-Spectral Instruments (MSI) aboard Sentinel-2A and 2B work passively, and optical data is acquired along the orbital path at high spatial resolution (10 m, 20 m and 60 m) over land and adjoining coastal waters which generates 13 bands multispectral data in the visible, near infrared and short-wave infrared part of the spectrum (Table 1).

Table 1: Sentinel-2 MSI band characteristics, including descriptor, wavelengths and resolution. The selected bands for detecting floating debris are highlighted in bold.

MSI Band	Descriptor	S-2A Central Wavelength (nm)	S-2B Central Wavelength (nm)	Resolution (m)	Bandwidth (nm)
Band 1	Coastal Aerosol	442.7	442.3	60	20
Band 2	Blue	492.4	492.1	10	65
Band 3	Green	559.8	559	10	35
Band 4	**Red**	**665.6**	**665**	**10**	30
Band 5	Red Edge 1	704.1	703.8	20	15
Band 6	**Red Edge 2**	**740.5**	**739.1**	**20**	15
Band 7	Red Edge 3	782.8	779.7	20	20
Band 8	**NIR**	**832.8**	**833**	**10**	115
Band 8a	Narrow NIR	864.7	864	20	21
Band 9	Water Vapour	945.1	943.2	60	20
Band 10	SWIR Cirrus	1373.5	1376.9	60	30
Band 11	**SWIR1**	**1613.7**	**1610.4**	**20**	90
Band 12	SWIR2	2202.4	2185.7	20	180

The Sentinel-2 satellite data was considered in this study because (a) it provides free and open data as Level 1C products (at-sensor radiance) through The Copernicus program, (b) its overpass occurs at the same location in every five days because of twin Sentinel-2A and Sentinel-2B, which provides better temporal resolution, and (c), the spatial resolution of the Sentinel-2 satellite is better than other freely available satellite with, especially in the NIR and visible bands of spectrum.

2.5 Atmospheric correction:

The inherent optical properties (IOPs) of floating materials can be leveraged for detection in Sentinel-2 imagery if NIR to SWIR wavelengths are conserved during the atmospheric correction process (Goddijn-Murphy et al., 2018). Ocean and atmospheric components (scattering and absorption) were subtracted from surface reflectance values using ACOLITE (Atmospheric Correction for OLI lite version 20181210.0). This marine atmospheric correction was developed for coastal waters using high resolution data from Landsat 8 and Sentinel-2, and the process is scene-based, requiring no previously defined ‘dark band’ like the NIR or SWIR. Instead, using the Dark Spectrum Fitting (DSF) algorithm, darkest pixels are dynamically selected based on multiple dark targets in a given image (Vanhellemont& Ruddick 2016; Vanhellemont& Ruddick 2018). The DSF algorithm is described in detail in Vanhellemont and Ruddick 2018. Output for surface reflectance (rhos), (ρs) was computed using ACOLITE and visualised in the Sentinel Application Platform (SNAP) for further processing.




Field activity of "Detecting floating marine debris" Project in the study area.

Photo Credit @ Abu Sharif Md. Mahbub-E-Kibria, SSO, BORI

2.6 Remote Sensing Spectral Indices:

Based on literature, several indices are chosen for this research. We perform this research by using NDVI, RNDVI, kNDVI, FDI, PI indices.

2.6.1 Normalised Vegetation Index (NDVI):

The Normalised vegetation Index (NDVI) is one of the most used remote sensing indices for many applications. Rouse et al. (1973) developed this index for especially identifying and classifying vegetation land cover. This index developed as band ratio parameters for Landsat which is developed from the ratio between the difference and their addition of reflectance. This NDVI measured using the NIR and Red spectral pixel reflectance. For sentinel-2 MSI imagery this NDVI calculated by equation as follow.

NDVI= (Band 8- Band 4) / (Band 8+Band 4) ....(1)

The range of NDVI value is -1 to 1. The large positive value indicates healthy vegetation, lower value indicated a complexity zone primarily bare soil or built-up area. The negative values indicate generally water bodies. At present this index used by various satellite imageries.

2.6.2 kernel NDVI (kNDVI):

Sannigrahi et al., (2021) proposed another index by adopting a nonlinear kernel approach for eliminating linear assumption problem in NDVI calculation. By converting linear to a nonlinear one, NDVI has mapped in Hilbert spaces, and the radial basis function (RBF) was used for kernelization (Camps-Valls et al., 2021). The kernel NDVI (kNDVI) was calculated for sentinel-2 MSI as follows:

kNDVI = tanh ($NDVI^2$)..(2)

2.6.3 Plastic Index (PI):

Themistocleous et al. (2020) proposed another important index namely Plastic Index (PI) according to the spectral signature from his study. The range of PI is from -1 to +1. Higher value indicates the presence of plastic and lower value is for water. For sentinel-2, it can be written as follow

PI= Band 8 / (Band 4+Band 8)...(3)

2.6.4 Defining a Floating DebrisIndex (FDI):

For sentinel-2, the highest spatial resolution is 10x10 m. Generally, individual items of debris below that resolution aredifficult. It is possible to detect FMD when it aggregated into patches. Floating debris index (FDI) has developed for detecting of floating debris patches on ocean surface (Biermann et al, 2020). FDI use the MSI Red Edge (RE) band at approximately 740 nm in place of the 665 nm (red band). So, FDI leverages the difference between the NIR, and the baseline reflectance of NIR. This baseline is calculated by linear interpolation between the NIR-flanking RE2 and SWIR1 bands. For sentinel-2, we can write this equation as follow.

$R_{rs\ NIR} =$ Band 6+ (Band 11-Band 6) $_*$(833-665) / (1630-665)*10 ....(4)

FDI = Band 8 - $R_{rs\ NIR}$ ....(5)

2.6.5 Detectable Capability of Remote Sensing Indices

It is required to evaluate the performance of used remote sensing indices for detecting MFD. Signal to Noise Ratio (SNR) was applied in this study for this purpose according to Helder et al., (2003). SNR represented the direct metric calculation of the desired information (signal) and the undesired information (background noise). The value of less than 1 for SNR represented that the signal (desired information) sinks into the background noise (undesired information) and difficult to extract desired information. On the other hand, the desired information can be extracted if the value of SNR is greater than 1. The greater SNR value is easier to extract desired value. The SNR value is calculated by following equation.

SNR= μ / 6...(6)

Where μ is the average signal value for desired pixel, and denoted for the standard deviation (SD) value of the undesired pixel (background noise). In this study, the SNR is calculated by the difference between the maximumvalue of the targetandtheaverageofthebackgroundleveldivided bytheone-sigmaSDofnoise value according to Khetkeeree and Liangrocapart (2021). However, some remote sensing indices may generate smaller target value than the background value. To overcome this issue, we use the absolute value for the difference between target pixel and average of background data. It may be expressed by below equation.

$$\mu = \max | P_i - N_{avg} | \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (7)$$

Where, P_i is the value of target for the considered index at pixel i, and N_{avg} denoted for the non-target average value for that index which calculated from the mean value of that index value around/near target pixels. Same datasets are used for calculating the SD of the background noise ( ).

3. Result and Discussion

Four artificial objects constructed from common marine debris were placed on the sea surface and fixed with anchors in 22 February, 2021 before the Sentinel-2 satellite overpass. Sentinel-2 Level 1C products was downloaded through the Copernicus program. Open source Acolite has used for atmospheric correction. Further processing (remote sensing indices calculation) was completed using SNAP.

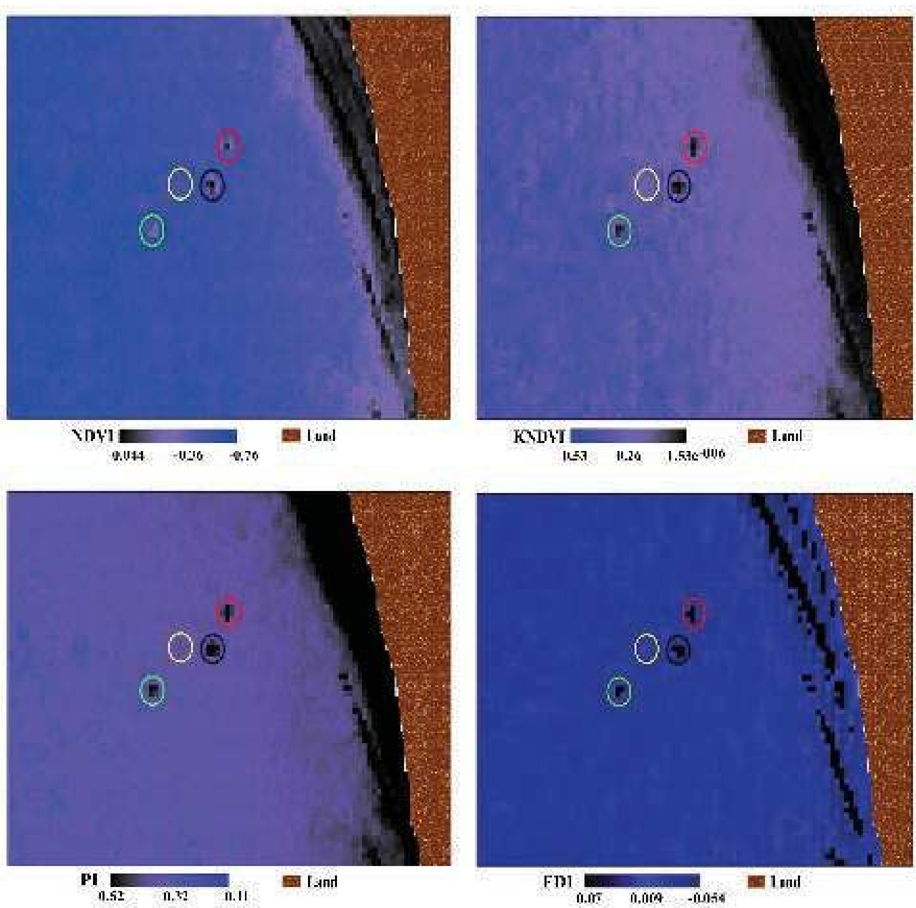


Figure 3: Panel represents the Sentinel-2 Satellite image (22 February, 2021) processed with the NDVI (upper left), kNDVI (upper right), PI (lower left), FDI (lower right). land is represented in brown with yellow shade. Red, black, yellow and green circle indicates the artificial object's location for plastic bottle, polyethylene, fishing net and dry weed/reeds respectively.

From the figure 3, the NDVI value of artificial objects is -0.17, 0.13, -0.43, -0.24, and -0.60 for plastic bottle, polyethylene, fishing net, dry weed/reed and sea water respectively. The kNDVI derived values of plastic bottle, polyethylene, fishing net, reeds and sea water were 0.03, 0.01, 0.18, 0.05 and -0.60 respectively. The Plastic Index (PI) derived calculated values were 0.41, 0.44, 0.28, 0.37 and 0.21 for plastic bottle, polyethylene, fishing net, reeds and sea water respectively.The values of FDI were 0.023, 0.036, 0.001, 0.007 and -0.003 for plastic bottle, polyethylene, fishing net, reeds and sea water respectively.

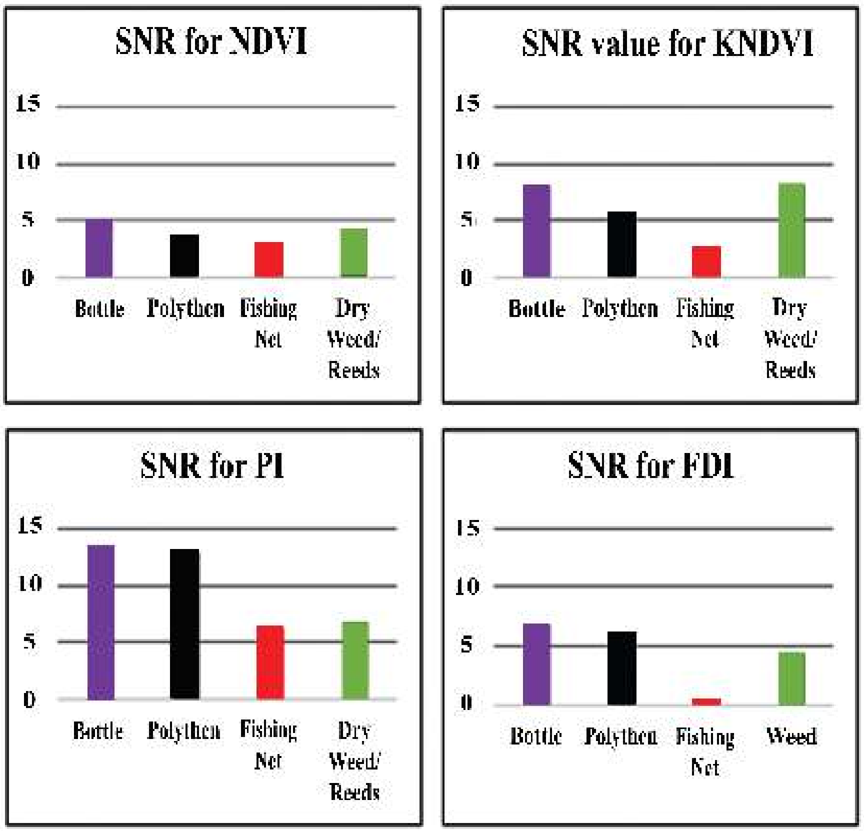


Figure 4: SNR value for NDVI (upper left), kNDVI (upper right), PI (lower left) and FDI (lower right). Violate, black, red and green bar represents the plastic bottle, polyethylene, fishing net and dry weed/reeds respectively.

Figure 4 represents the SNR value of different remote sensing indices which is used for the detection performance for these indices. The NDVI derived SNR value estimated 4.76, 3.72, 3.05 and 4.22 for plastic, polyethylene, fishing net and dry weeds respectively.The highest SNR for NDVI is seen in plastic bottle detection and lowest found in fishing net identification. The SNR value were 8.06, 5.44, 2.70 and 8.17 for plastic bottle, polyethylene, fishing net, and reeds respectively for kNDVI. The highest value of SNR has seen in reeds object and the lowest in fishing net identification.The SNR value were 13.39, 12.91, 6.15 and 6.83 for plastic bottle, polyethylene, fishing net, and reeds respectively. The highest value of SNR has seen in plastic bottles and the lowest in fishing net identification.The SNR values of FDI indicesindicates that this index also very useful for detecting floating object in sea water especially for plastic.

In this study, using existing remote sensing indices are applied for detecting floating object in oceanic system. We find better result for detecting plastic and vegetation. Detecting fishing net is problematic by existing indices. Generally fishing nets are sinking into water and thus it is difficult to distinguish from sea water. The SNR value suggested that all indices have capabilities to detect floating object in the experiment site. But PI perform relatively better result for detecting floating object.

4. Conclusion

Detection of floating marine debris using multispectral satellite imagery is promising but challenging. These types studies are conducted in various part of the world. But as per our knowledge, this is the first study in Bangladesh. The coastal area of Bangladesh is different from many parts of the earth. River derived huge sediment make this area unique. Bangladesh coast experienced a huge marine debris washed in Cox's Bazar in 2020. So, in order to find out the source and accumulation zone of marine debris, this type research will be required in future. This experiment also creates a valuable data source for the researchers who are interested in this field from different part of the world. Unmanned aerial vehicle (UAV) will be potential candidate for MFD study in coastal area for detecting smaller debris accumulation zone. The Sentinel-1 Synthetic Aperture Radar (SAR) images are also potential for future investigation.

Acknowledgement: BORI funded this project as a part of Blue Economy plan and regular research activity.

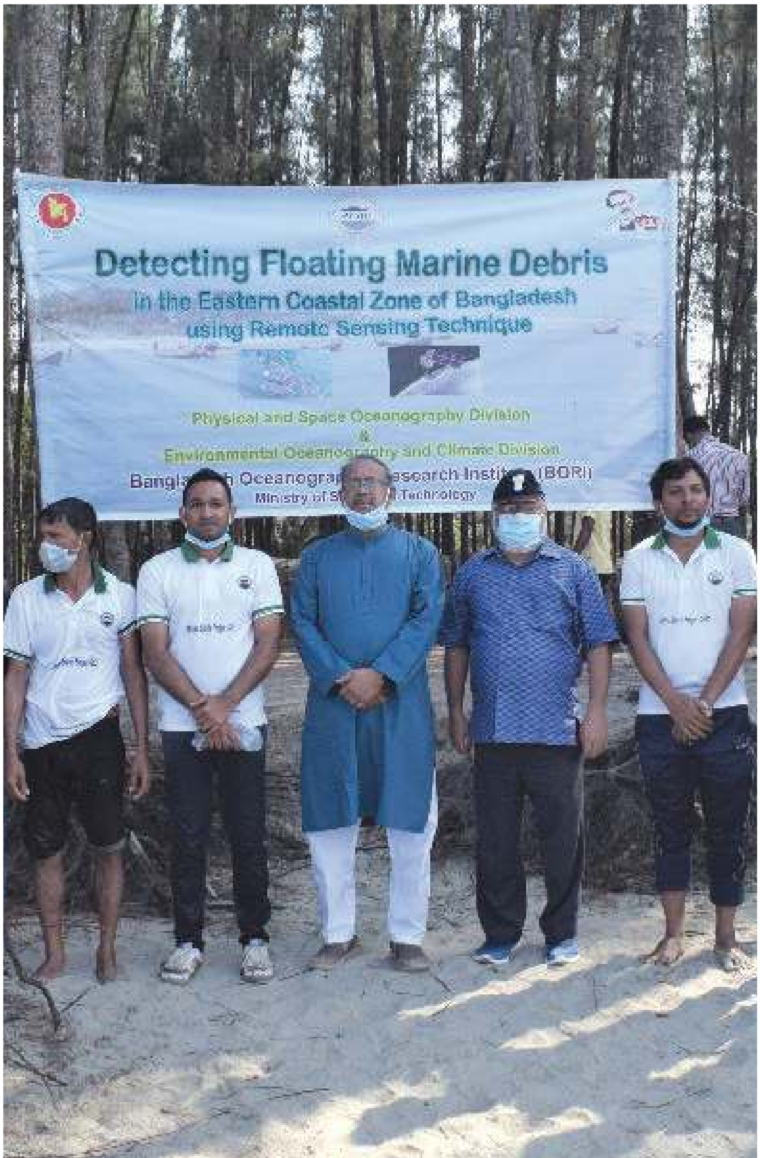


Photo Credit @ Shafiqul Islam Shafiq, BORI

Architect Yeafesh Osman, Minister, Ministry of Sciece and Technology visted "Detecting floating marine debris" project

Photo Credit @ Shafiqul Islam Shafiq, BORI

References:

1. Barnes, D.K., Galgani, F., Thompson, R.C. and Barlaz, M., 2009. Accumulation and fragmentation of plastic debris in global environments. *Philosophical transactions of the royal society B: biological sciences*, *364*(1526), pp.1985-1998.

2. Biermann, L., Clewley, D., Martinez-Vicente, V. and Topouzelis, K., 2020. Finding plastic patches in coastal waters using optical satellite data. *Scientific reports*, *10*(1), pp.1-10.

3. Camps-Valls, G., Campos-Taberner, M., Moreno-Martínez, Á., Walther, S., Duveiller, G., Cescatti, A., Mahecha, M.D., Muñoz-Marí, J., García-Haro, F.J., Guanter, L. and Jung, M., 2021. A unified vegetation index for quantifying the terrestrial biosphere. *Science Advances*, *7*(9), p.eabc7447.

4. Chowdhury, G.W., Koldewey, H.J., Duncan, E., Napper, I.E., Niloy, M.N.H., Nelms, S.E., Sarker, S., Bhola, S. and Nishat, B., 2020. Plastic pollution in aquatic systems in Bangladesh: A review of current knowledge. *Science of the Total Environment*, p.143285.

5. Ciappa, A.C., 2021. Marine plastic litter detection offshore Hawai'i by Sentinel-2. *Marine Pollution Bulletin*, *168*, p.112457.

6. Ghaderi, Z. and Henderson, J.C., 2013. Japanese tsunami debris and the threat to sustainable tourism in the Hawaiian Islands. *Tourism Management Perspectives*, *8*, pp.98-105.

7. Goddijn-Murphy, L. and Dufaur, J., 2018. Proof of concept for a model of light reflectance of plastics floating on natural waters. *Marine pollution bulletin*, *135*, pp.1145-1157.

8. Helder, D., Choi, T. and Rangaswamy, M., 2004. In-flight characterization of spatial quality using point spread functions. In *Post-launch calibration of satellite sensors* (pp. 159-198). CRC Press.

9. Hossain, K.A., 2015. Overview of ship recycling industry of Bangladesh. *Journal of Environmental & Analytical Toxicology*, *5*(5), p.312.

10. Khetkeeree, S. and Liangrocapart, S., 2021, May. Detecting Floating Plastic Marine Debris using Sentinel-2 Data via Modified Infrared NDVI. In *2021 18th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)* (pp. 633-636). IEEE.

11. Lakshmi, A. and Rajagopalan, R., 2000. Socio-economic implications of coastal zone degradation and their mitigation: a case study from coastal villages in India. *Ocean & Coastal Management*, *43*(8-9), pp.749-762.

12. Moller, D., Chao, Y. and Maximenko, N., 2016, July. Remote sensing of marine debris. In *2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)* (pp. 7690-7693). IEEE.

13. Mouat, J., Lozano, R.L. and Bateson, H., 2010. *Economic impacts of marine litter*. KommunenesInternasjonaleMiljøorganisasjon.

14. Ojaveer, H., Galil, B.S., Campbell, M.L., Carlton, J.T., Canning-Clode, J., Cook, E.J., Davidson, A.D., Hewitt, C.L., Jelmert, A., Marchini, A. and McKenzie, C.H., 2015. Classification of non-indigenous species based on their impacts: considerations for application in marine management. *PLoS biology*, *13*(4), p.e1002130.

15. Pasquini, G., Ronchi, F., Strafella, P., Scarcella, G. and Fortibuoni, T., 2016. Seabed litter composition, distribution and sources in the Northern and Central Adriatic Sea (Mediterranean). *Waste management*, *58*, pp.41-51.

16. Rouse, J.W., Haas, R.H., Schell, J.A., Deering, D.W., 1973. Monitoring vegetation systems in the Great Plains with ERTS. In Proceedings of the Ttiird Earth Resources Technology Satellite Symposium, NASA SP- 351, Washington, DC, USA, 31 December 1973; pp. 309-317.

17. Sannigrahi, S., Basu, B., Basu, A.S. and Pilla, F., 2021. Detection of marine floating plastic using Sentinel-2 imagery and machine learning models. *arXiv preprint arXiv:2106.03694*.

18. Schuyler, Q.A., Wilcox, C., Townsend, K.A., Wedemeyer Strombel, K.R., Balazs, G., van Sebille, E. and Hardesty, B.D., 2016. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. *Global Change Biology*, *22*(2), pp.567-576.

19. Sheavly, S.B., 2007. National marine debris monitoring program. *Final Program Report, Data Analysis and Summary. Prepared for US Environmental Protection Agency by Ocean Conservancy, Grant*, (X830534), pp.01-02.

20. Sherman, P. and Van Sebille, E., 2016. Modeling marine surface microplastic transport to assess optimal removal locations. *Environmental Research Letters*, *11*(1), p.014006.

21. Themistocleous, K., Papoutsa, C., Michaelides, S. and Hadjimitsis, D., 2020. Investigating detection of floating plastic litter from space using sentinel-2 imagery. *Remote Sensing*, *12*(16), p.2648.

22. Topouzelis, K., Papageorgiou, D., Karagaitanakis, A., Papakonstantinou, A. and Arias Ballesteros, M., 2020. Remote sensing of sea surface artificial floating plastic targets with Sentinel-2 and unmanned aerial systems (plastic litter project 2019). *Remote Sensing*, *12*(12), p.2013.

23. Topouzelis, K., Papakonstantinou, A. and Garaba, S.P., 2019. Detection of floating plastics from satellite and unmanned aerial systems (Plastic Litter Project 2018). *International Journal of Applied Earth Observation and Geoinformation*, *79*, pp.175-183.

24. UNEP, 2016 Regional Seas Programme. Regional Seas Strategic Directions (2017–2020); Regional Seas Reports and Studies No.201; UN Environment Regional Seas Programme: Nairobi, Kenya, 2016; Available online: www.unep.org/regionalseas

25. United Nations Environment Programme (UNEP). 2009. Marine Litter: A Global Challenge. UNEP, Nairobi, 232 p. National Oceanic and Atmospheric Administration (NOAA). 2010. 2008-2009 Progress Report on the Implementation of the Marine Debris Research, Prevention & Reduction Act. Silver Spring, MD, 70 p.

26. Vanhellemont, Q. and Ruddick, K., 2016, May. Acolite for Sentinel-2: Aquatic applications of MSI imagery. In *Proceedings of the 2016 ESA Living Planet Symposium, Prague, Czech Republic* (pp. 9-13).

27. Vanhellemont, Q. and Ruddick, K., 2018. Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications. *Remote sensing of environment*, *216*, pp.586-597.

28. Wang, J., Tan, Z., Peng, J., Qiu, Q. and Li, M., 2016. The behaviors of microplastics in the marine environment. *Marine Environmental Research*, *113*, pp.7-17.

29. Wang, M. and Hu, C., 2016. Mapping and quantifying Sargassum distribution and coverage in the Central West Atlantic using MODIS observations. *Remote sensing of environment*, *183*, pp.350-367.

Beach Profiling along the Coast of Cox's Bazar

Rupoa Loodh
Scientific Officer
Physical and Space Oceanography

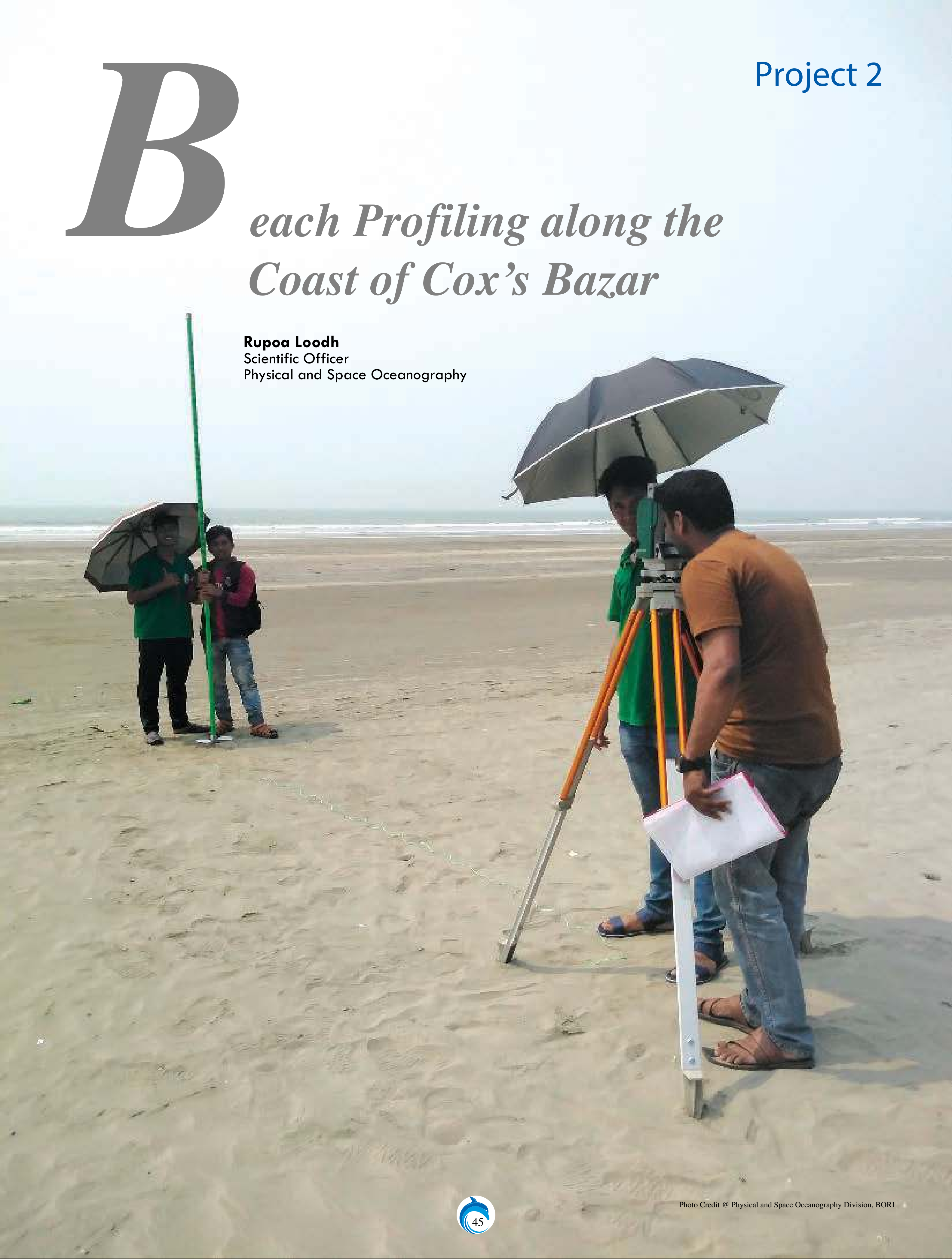


Photo Credit @ Physical and Space Oceanography Division, BORI

General
Discussions

The study was conduct to investigate the monthly and seasonal impact on beach morphologyand the relation with shoreline change rate along the study area. Stability of a beach can be assessed from the profile changes during rough and fair weather seasons and can be monitored by recording the winds, waves, currents, tides breaker characteristics, sediment characteristics. If the beach material is washed away during the rough weather season, they are re-deposited during fair weather. Thus erosion and accretion are continues processes. And these process are responsible for forming unique landforms like coastal plains, river deltas, wetlands, beaches and dunes, reefs, mangrove forest, and lagoons.The information from beach profile and beach dynamics processes are very useful for coastal planning authorities for their planning of new development (Cambers and Ghinna 2005). Long term shoreline change and the rate of shoreline change (yearly) will give the information of the erosion and accretion area of shoreline. The study reveal that the result of yearly shoreline change have direct relation with seasonal beach profile. The objective of present report analyses the results of the beach profiles carried out at different seasons along Taknaf, Samlapur, Inani coast along south of Cox's Bazar and their relationship with long term shoreline change.

Objectives of the study

- To investigate the seasonal impact on beach dynamics
- To investigate the long term variation of shore line changes
- Coastal erosion & accretion map for coast of Bangladesh.

Study Area

Marine Drive situated at the very coastline of Cox's Bazar to Teknaf coast of Bangladesh in northern Bay of Bengal. And the Marine drive has one side Bay of Bengal beach and the other side mostly covered by hills and other features like household, hotels, and agricultural fields. Pre-survey 10 permanent benchmarks (reference with Survey of Bangladesh, SOB bench mark) selected for the study (Figure 1).

Methodology

Bangladesh Navy Tide Table-2021 used for obtaining the information on the time of occurrence and the height of the high and low tide values (Figure 2). These, tidal data considered for beach profiling.

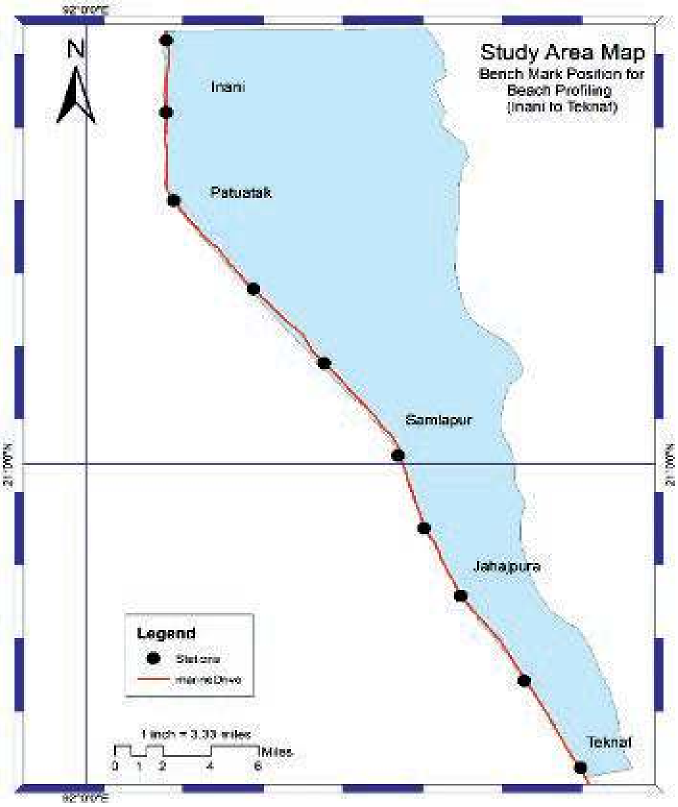


Figure 1. Study area map for beach profile

Field work of "Beach Profiling" Project

Photo Credit @ Physical and Space Oceanography Division, BORI

Total station was used to measure the beach profiles with monthly interval from February 21 to July 21. The profile of beach at each station was plotted and different features of beach like dune, berm, backshore and foreshore etc. were identified. The littoral currents were measured using the LEO plate technique.For shoreline detection Normalized Difference Water Index (NDWI) andModified Normalized Difference Water Index (MNDWI)(McFeeters 1996) is used in 31 years satellite data (Landsat 5 TM & Landsat 8 OLI).

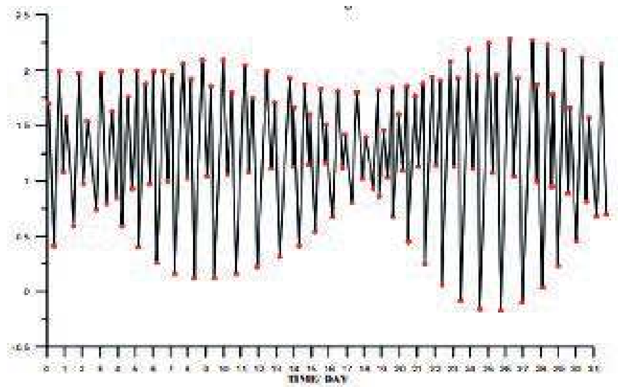


Figure 2. Measuring the profile using Total Station

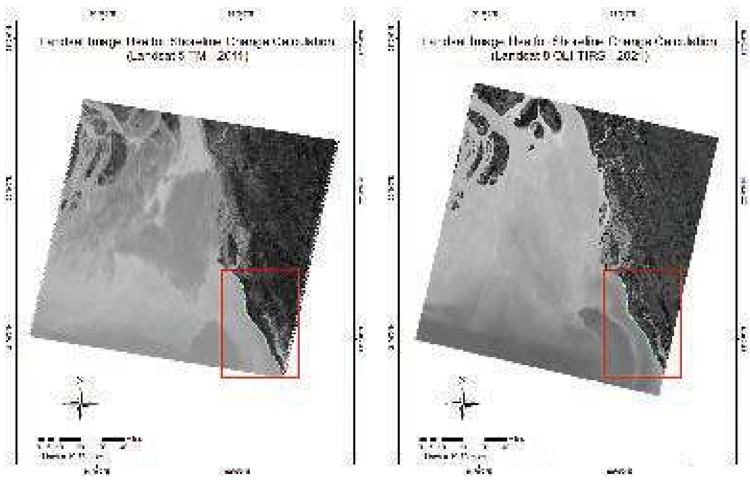


Figure 3. Satellite data (processed NDWI & MNDWI) that used in the study

DSAS v05 model (an extension of ArcGIS by USGS) used to calculate the rates of shoreline change along different parts of the coast with an interval of 30m transect (Himmelstoss 2018, Sarwar et. al. 2013).

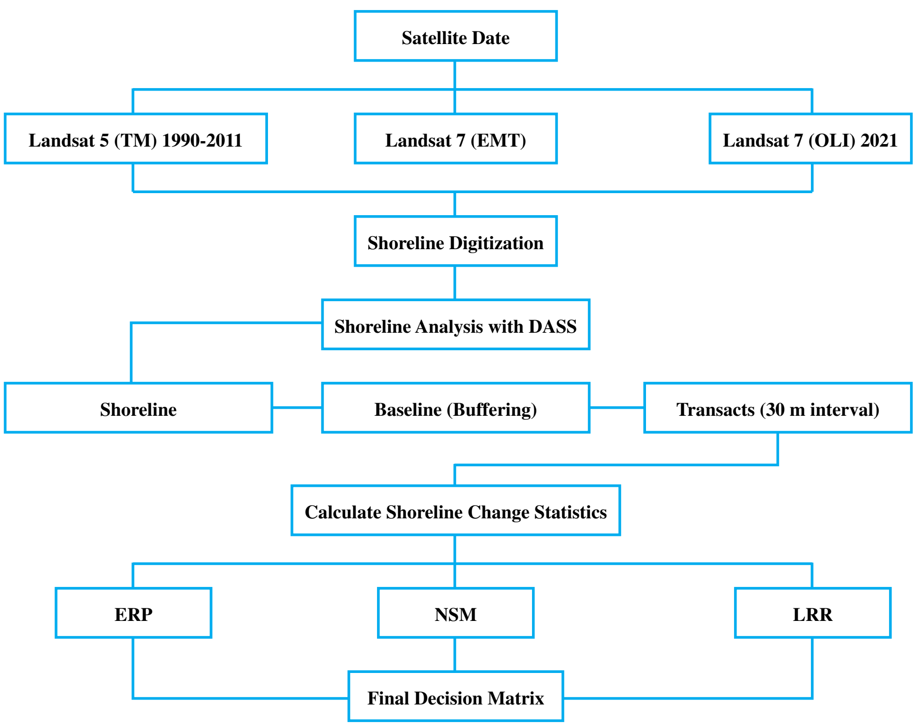


Figure 4. Shoreline Analysis workflow (DSAS v5 Modelling)

Results & Discussion

Beach Profiling

From the 10 stations, some stations profiles have considerable monthly topographical change, whereas some have comparatively less monthly changes observed as well as the seasonal change. Overall, we have a clear topographical changes between the months of February, 2021 and July, 2021.

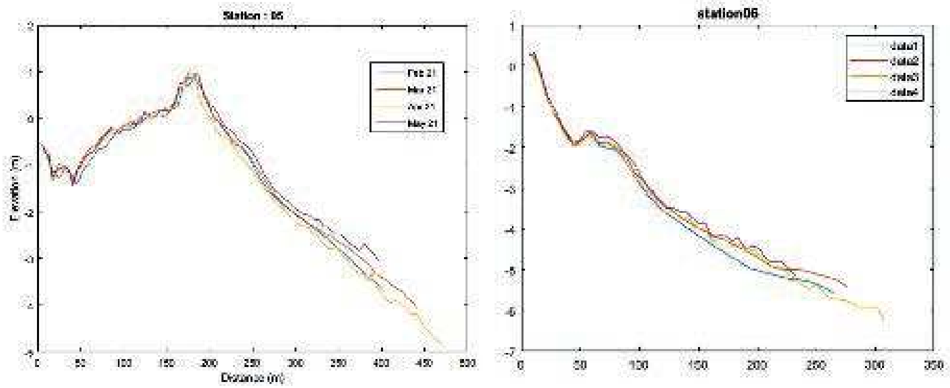


Figure 5. Beach profile at (a) station 5 (b) station 6

For example, in station 05, there observed a dune about 1.17m height which is almost stable in the pre-monsoon season. Behind the sand dune there are "V"-shaped a runnel. The profile have a little variation in the pre-monsoon season. Maximum beach length (about 469m) was found at the month of April, 21. A huge low water line changed observed for the next month, May 21 and the overall profile length became narrower about 398m and a small deposition observed over the hole profile. That is because of monsoon effect may be start on this month.

In station 06, no major changed observer in the pre-monsoon season. In the month of February, profile showed vertical distance about 5.9meter of total 265meter horizontal distance. A smooth foreshore slope observed in the month of February. Backshore have a "V" shaped runnel at about 40m from the benchmark, which was stable for the whole pre-monsoon season. Foreshore got some deposition at the month of April and May. In April, total profile length found about 308m, whereas in May, the length of profile became narrower about 232 m, due to monsoon effect.

Total shoreline and beach width change (Pre-monsoon to Monsoon)

The shoreline change is also noticed at different season as it isimportant to understand the change in beach morphology. Alongwith beach profiling, shoreline change analysisis also important for spatial analysis. During the pre-monsoon and monsoon period theshoreline was marked at High Water line with the help of a GPS. Oncomparing the shoreline of both the seasons, it was noticed that theshoreline has changed considerably (Fig. 6). During pre-monsoonseason the HWL was further away from the benchmark than theHWL of the monsoon season. This can be accounted for the highwave action during the southwest monsoon. A typical monsoonseason is characterized by strong winds and heavy rains. Asa result, erosion occurs and the HWL also changes. During themonsoon season the shoreline was shifted towards the benchmarkand away from the earlier shoreline.

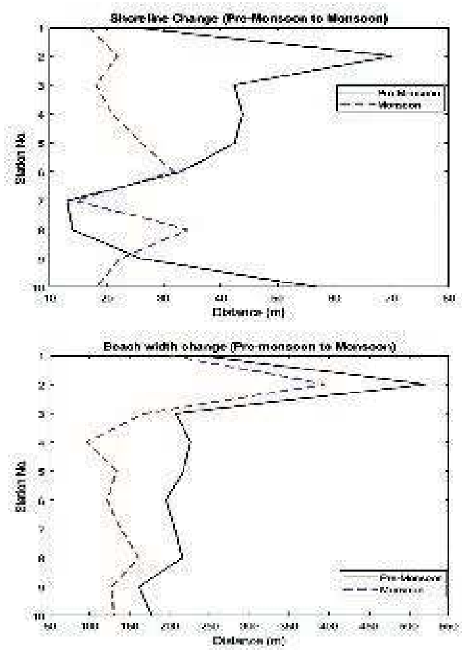


Figure 6. Beach profile at station 4
(a) monthly (left-side) (b) seasonally (right-site)

Shoreline Change Calculation from Remote Sensing (1990 to 2021)

The net shoreline movements (NSM) computed using DSAS v5 model for four different segments as thedistance of shoreline movement (south to north) by the time elapsed between the oldest and the newest one (Figure 7).

From the analysis, 2479 transectsfound negative shoreline movement where 240 transect have positive value indicate accretion. The Teknaf area covered high erosion (highest 432m) where Jahajpura area is comparatively stable area. On the other hand Inani region have both erosion and accretion (highest accretion about 214.96m).

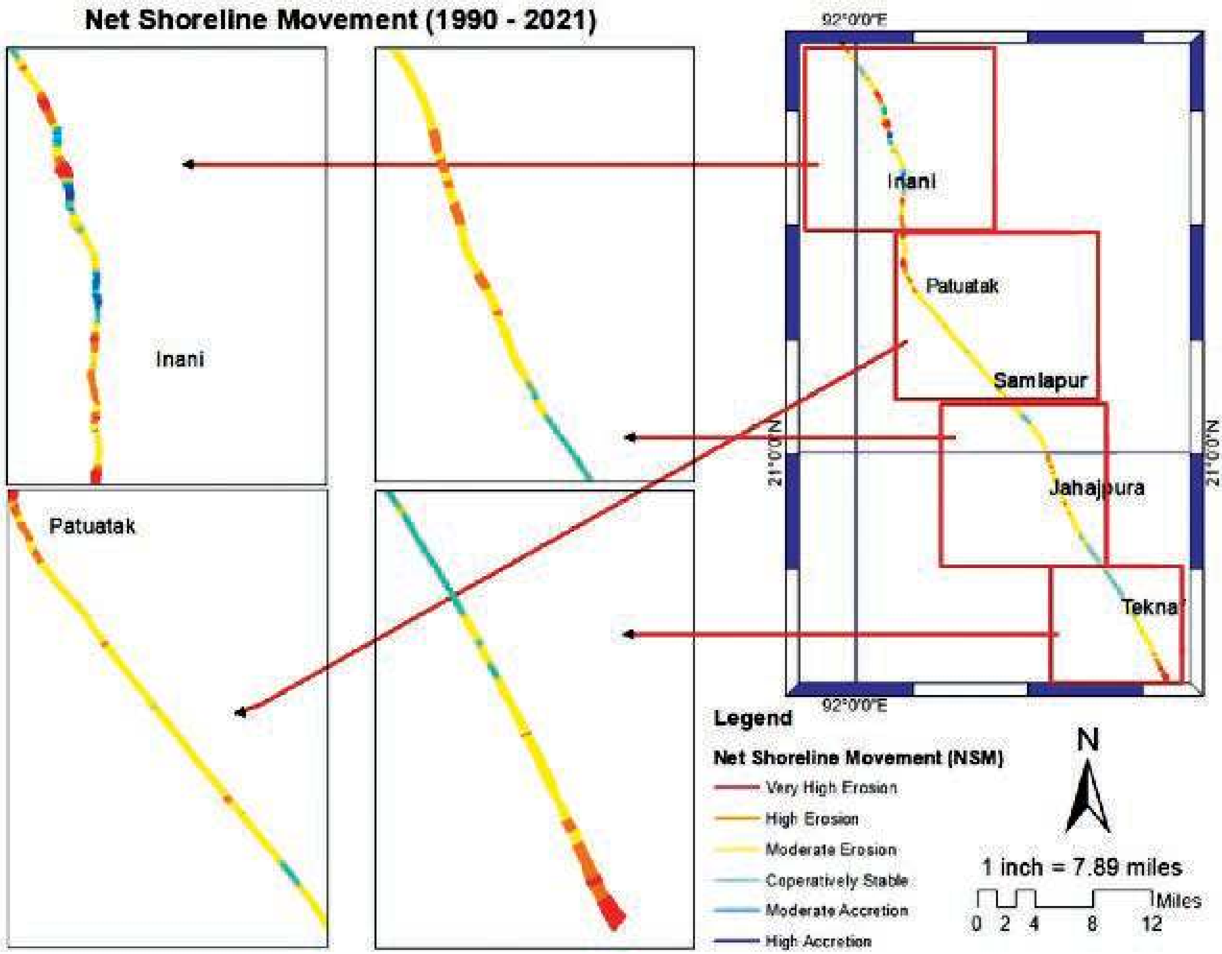


Figure 7. Net Shoreline Movement in Teknaf to Cox's Bazar. (a) Inani - Upper left Corner (b) Samlapur – Bottom left Corner (c) Jahajpura – Upper right corner (d) Teknaf - Bottom left corner

Final Word

- Beach topography have a large seasonal variation and have a relation with the speed of littoral current.
- The most prominent changes found in the berm, backshore and foreshore widths and in the slope of profile
- For all the station, the foreshore is eroded much compare to the backshore with the monthly interval as well as seasonal interval.
- Long shore current found a strong positive relation with shoreline change from 31 years satellite data. And current is much active where the erosion rate is higher or maximum.

References

Alam, M., N. E. Huq, & Rashid, M. (1999). Morphology and Sediments of the Cox's Bazar Coastal Plain, South-East Bangladesh. Journal of Coastal Research, 15(4), 902-908. Retrieved July 24, 2021, from http://www.jstor.org/stable/4299010

Alesheikh, A. A., Ghorbanali, A., & Nouri, N. (2007). Coastline change detection using remote sensing. International Journal of Environmental Science & Technology, 4(1), 61-66.

Andrews, P. B. and Vander Lingen, G. J., 1968. Environmentally significant sedimentologic characteristics of beach sands. New Zealand. Jour. Geol. and Geophys., 12, 119-137.

Cambers and Ghinna 2005, UNESCO, 2005. Introduction to Sandwatch: An educational tool for sustainable development. Coastal region and small island papers 19, UNESCO, Paris, 91 pp.

Chakrabarti, A., 1977. Polymodal composition of beach sand from east coast of India. Journal of Sedimentary Petrology, 47, 634-641.

Chandramohan, P. and Nayak, B.U., and Raju, V.S., 1988. Application of longshore transport equations to the Andhra Coast, east coast of India. Coastal Engineering, 12, 285-297.

Chauhan, O.S., 1992b. Sediment dynamics at Puri and Konark beaches, along northeast coast of India. Indian Journal of Marine Science, 21, 201-206.

Chrzastowski M.J. (2005) Beach Features. In: Schwartz M.L. (eds) Encyclopedia of Coastal Science. Encyclopedia of Earth Science Series. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3880-1_34

David, J. C., 1970. Information contained in sediment-size analysis. Mathematical Geology, 2(2), 105-112.

Emran, A., Rob, M. A., Kabir, M. H., & Islam, M. N. (2016). Modeling spatio-temporal shorelineand areal dynamics of coastal island using geospatial technique. Modeling Earth Systems andEnvironment, 2(1), 4, http://link.springer.com/10.1007/s40808-015-0060-z (January 26, 2017).

Greenwood, B. 1969. SedimentParameters and Environment Discriminations: An Application of Multi-Variate Statistics.Can. J. Earth Sc., 6, 1347-58.

Himmelstoss, E.A., Henderson, R.E., Kratzmann, M.G., and Farris, A.S., 2018, Digital Shoreline Analysis System (DSAS) version 5.0 user guide: U.S. Geological Survey Open-File Report 2018–1179, 110 p., https://doi.org/10.3133/ofr20181179.

Islam, M. A., Hossain, M. S., & Murshed, S. (2015). Assessment of coastal vulnerability due to sealevel change at Bhola Island, Bangladesh: Using geospatial techniques. Journal of the Indian Society of Remote Sensing, 43(3), 625-637, http://link.springer.com/10.1007/s12524-014-0426-0 (January 28, 2017).

Jaya Kumar, S., Yadhunath, E.M., Jishand, M., Gowthaman, R., Rajasekaran, C.,Pednekar, P.S., 2014. Post-monsoon equilibrium beach profile andlongshore sediment transport rates of Candoliam, Miramar and Keri beachof Goa, India. Current sciences 106(3), 408-416.

Liu, X., Gao, Z., Ning, J., Yu, X., & Zhang, Y. (2016). An improved method for mapping tidal flatsbased on remote sensing waterlines: A case study in the Bohai Rim, China. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 9(11), 5123-5129,http://ieeexplore.ieee.org/document/7707359/ (January 28, 2017).

Mason, C. C. and Folk, R. L., 1958. Differentiation of beach, dune and aeolian flat environments by size analysis Mustang Island, Texas. Journal of Sedimentary Petrology Vol. 28(2): 211-226.

McFeeters, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in thedelineation of open water features. International journal of remote sensing, 17(7), 1425-1432.

Mitra, S. S., Santra, A., & Mitra, D. (2013). Change detection analysis of the shoreline using Toposheet and Satellite Image: A case study of the coastal stretch of Mandarmani-Shankarpur, West Bengal, India. International Journal of Geomatics and Geosciences, 3(3), 425.

Murty, C.S.; Veerayya, M.; Sastry, J.S., and Var- Dachari, V.V.R., 1980. Beach morphological variations over micro-time scales. Indian Journal Marine Science, 9, 35-44.

Mwakumanya AM., 2000. The Impact of Sea Waves on beach morphology: A case study of Nyali and Bamburi Beaches in Mobasa, Kenya. Moi University. M.Phil. Thesis, 165p.

Mwakumanya, AM, Odhiambo BDO (2007). Beach morphological dynamics. A case study of Nyali and Bamburi beaches in Mombasa, Kenya. J. Coastal Res., 23(2): 374-379.

Niya, A. K., Alesheikh, A. A., Soltanpor, M., & Kheirkhahzarkesh, M. M. (2013). Shoreline ChangeMapping Using Remote Sensing and GIS-Case Study: Bushehr Province. International Journalof Remote Sensing Applications, 3(3), 102-107.

Reddy, M.P.M. And Varadachari, V.V.R., 1973. Sediment movement in relation to the waverefraction along the West Coast of India. Indian Geophysical Union, 10, 169-182.

Sarwar, M. G. M., & Woodroffe, C. D. (2013). Rates of shoreline change along the coast ofBangladesh. Journal of Coastal Conservation, 17(3), 515-526.

Md. Salauddin, Khandaker Tanvir Hossain, Istiaqe Ahmed Tanim, Md. Anisul Kabir, Mehedi Hasan Saddam, 2018. Modeling Spatio-Temporal Shoreline Shifting of a Coastal Island in Bangladesh Using Geospatial Techniques and DSAS Extension. Annals of Valahia University of Targoviste. Geographical Series (2018), 18(1): 1-13. DOI: 10.2478/avutgs-2018-0001

Samsuddin, M., 1985. Textural differentiation of foreshore and breaker zone sediments on thenorthern Kerala coast, India. Journal of Sedimentary Geology, 46, 135-145.

Wiegel, R. L. (1965), Protection of Crescent City California from tsunami wav e s, report, 112 pp., Redev. Agency of the City of Crescent City, Calif., Crescent City

Wilson, John; Sujitha, S.B.; Shruti, V.C.; Zaman Ahmed, Shaeema; Prasanna Kumar, S.; Chandrasekar, N. (2014): Seasonal variability of beach characteristics between Candoliam and Colva coast, Goa, India. figshare. Journal contribution. https://doi.org/10.6084/m9.figshare.1080516.v1

Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open waterfeatures in remotely sensed imagery. International journal of remote sensing, 27(14), 3025-3033.

Appendix-A (Source Code)

Data Analysis (Using Python & Matlab)
Python Codes (Shoreline Analysis from DSAS Model, Arc GIS):

Erosion Acreetion calculation

```
In [ ]: #box calculation zoning: and average
        teknaf_box_nsm = data_df[data_df['TransectID']<461]['NSM']
        jahajpura_box_nsm = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150)]['NSM']
        samlapur_box3 = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933)]['NSM']
        inani_box4 = data_df[data_df['TransectID']>=1933]['NSM']

        teknaf_box_epr = data_df[data_df['TransectID']<461]['EPR']
        jahajpura_box_epr = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150)]['EPR']
        samlapur_box3 = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933)]['EPR']
        inani_box4 = data_df[data_df['TransectID']>=1933]['EPR']

In [ ]: teknaf_box_epr.mean()

In [ ]: teknaf_box1.sum()

In [ ]: #teknaf erosion
        teknaf_erosion_nsm = data_df[(data_df['TransectID']<461) &  (data_df['NSM']<0)]['NSM']
        teknaf_erosion_epr = data_df[(data_df['TransectID']<461) &  (data_df['NSM']<0)]['EPR']
        teknaf_erosion_nsm_lenght = len(teknaf_erosion_nsm)*30
        teknaf_erosion_epr_lenght = len(teknaf_erosion_epr)*30
        #teknaf accretion
        teknaf_accretion_nsm = data_df[(data_df['TransectID']<461) &  (data_df['NSM']>=0)]['NSM']
        teknaf_accretion_epr = data_df[(data_df['TransectID']<461) &  (data_df['NSM']>=0)]['EPR']
        teknaf_accretion_nsm_lenght = len(teknaf_accretion_nsm)*30
        teknaf_accretion_epr_lenght = len(teknaf_accretion_epr)*30
        #highest & lowest
        teknaf_erosion_nsm.min(),teknaf_accretion_nsm.max(),teknaf_erosion_epr.min(),teknaf_accretion_epr.max()

In [ ]: #jahajputa erosion
        jahajputa_erosion_nsm = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150) &  (data_df['NSM']<0)]['NSM']
        jahajputa_erosion_epr = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150) &  (data_df['NSM']<0)]['EPR']
        jahajputa_erosion_nsm_lenght = len(jahajputa_erosion_nsm)*30
        jahajputa_erosion_epr_lenght = len(jahajputa_erosion_epr)*30
        #jahajputa accretion
        jahajputa_accretion_nsm = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150) &  (data_df['NSM']>=0)]['NSM']
        jahajputa_accretion_epr = data_df[(data_df['TransectID']>=461) & (data_df['TransectID']<1150) &  (data_df['NSM']>=0)]['EPR']
        jahajputa_accretion_nsm_lenght = len(jahajputa_accretion_nsm)*30
        jahajputa_accretion_epr_lenght = len(jahajputa_accretion_epr)*30
        jahajputa_erosion_nsm.min(),jahajputa_accretion_nsm.max(),jahajputa_erosion_epr.min(),jahajputa_accretion_epr.max()

In [ ]: #samlapur erosion
```

Erosion & Accretion in NSM

```
In [ ]: teknaf_accretion_nsm_lenght

In [ ]: print(f"Total erosion of Teknaf is {teknaf_erosion_nsm.sum()} and number of transect is {len(teknaf_erosion_nsm)} which represen

In [ ]: print(f"Total erosion of Jahajpura is {jahajputa_erosion_nsm.sum()} and number of transect is {len(jahajputa_erosion_nsm)} which

In [ ]: print(f"Total erosion of Samlapur is {samlapur_erosion_nsm.sum()} and number of transect is {len(samlapur_erosion_nsm)}, which r

In [ ]: print(f"Total erosion of Inani is {inani_erosion_nsm.sum()} and number of transect is {len(inani_erosion_nsm)}, which represent
```

Erosion & Accretion EPR

```
In [ ]: print(f"Total erosion of Inani is {inani_erosion_epr.sum()} and number of transect is {len(inani_erosion_epr)}, which represent

In [ ]: print(f"Total erosion of Samlapur is {samlapur_erosion_epr.sum()} and number of transect is {len(samlapur_erosion_epr)}, which r

In [ ]: print(f"Total erosion of Jahajpura is {jahajputa_erosion_epr.sum()} and number of transect is {len(jahajputa_erosion_epr)}, whicl

In [ ]: print(f"Total erosion of Teknaf is {teknaf_erosion_epr.sum()} and number of transect is {len(teknaf_erosion_epr)}, which represe
```

```
In [ ]: #samlapur erosion
        samlapur_erosion_nsm = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933) &  (data_df['NSM']<0)]['NSM']
        samlapur_erosion_epr = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933) &  (data_df['NSM']<0)]['EPR']
        samlapur_erosion_nsm_lenght = len(samlapur_erosion_nsm)*30
        samlapur_erosion_epr_lenght = len(samlapur_erosion_epr)*30
        #teknaf accretion
        samlapur_accretion_nsm = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933) &  (data_df['NSM']>=0)]['NSM']
        samlapur_accretion_epr = data_df[(data_df['TransectID']>=1150) & (data_df['TransectID']<1933) &  (data_df['NSM']>=0)]['EPR']
        samlapur_accretion_nsm_lenght = len(samlapur_accretion_nsm)*30
        samlapur_accretion_epr_lenght = len(samlapur_accretion_epr)*30
        samlapur_erosion_nsm.min(),samlapur_accretion_nsm.max(),samlapur_erosion_epr.min(),samlapur_accretion_epr.max()

In [ ]: samlapur_accretion_nsm

In [ ]: #inani erosion
        inani_erosion_nsm = data_df[(data_df['TransectID']>=1933) &  (data_df['NSM']<0)]['NSM']
        inani_erosion_epr = data_df[(data_df['TransectID']>=1933) &  (data_df['NSM']<0)]['EPR']
        inani_erosion_nsm_lenght = len(inani_erosion_nsm)*30
        inani_erosion_epr_lenght = len(inani_erosion_epr)*30
        #teknaf accretion
        inani_accretion_nsm = data_df[(data_df['TransectID']>=1933) &  (data_df['NSM']>=0)]['NSM']
        inani_accretion_epr = data_df[(data_df['TransectID']>=1933) &  (data_df['NSM']>=0)]['EPR']
        inani_accretion_nsm_lenght = len(inani_accretion_nsm)*30
        inani_accretion_epr_lenght = len(inani_accretion_epr)*30
        inani_erosion_nsm.min(),inani_accretion_nsm.max(),inani_erosion_epr.min(),inani_accretion_epr.max()

In [ ]: # testing the lenght
        # len(inani_erosion_nsm) + len(inani_accretion_nsm) == len(inani_box4) #true
        # len(jahajpura_box2) == len(jahajputa_erosion_nsm)+ len(jahajputa_accretion_nsm) #true
```

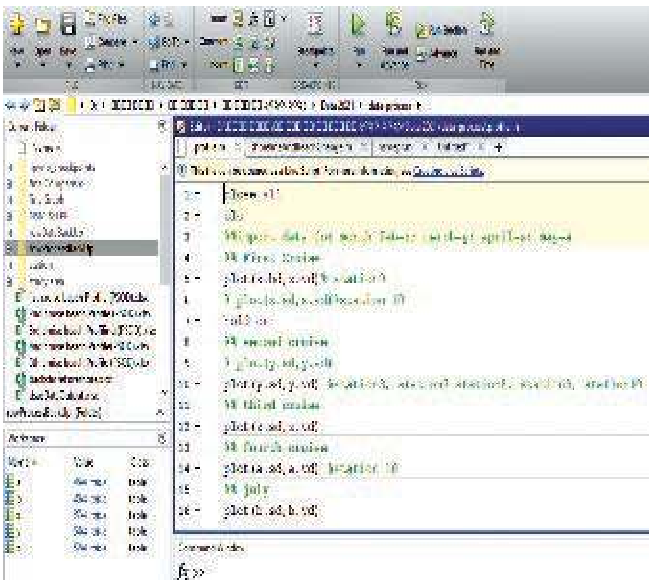
Erosion & Accretion in NSM

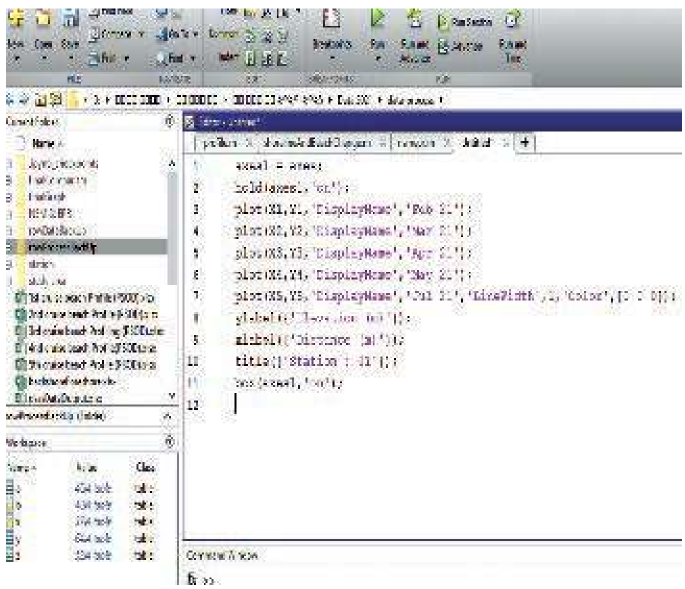
```
In [ ]: teknaf_accretion_nsm_lenght

In [ ]: print(f"Total erosion of Teknaf is {teknaf_erosion_nsm.sum()} and number of transect is {len(teknaf_erosion_nsm)} which represen

In [ ]: print(f"Total erosion of Jahajpura is {jahajputa_erosion_nsm.sum()} and number of transect is {len(jahajputa_erosion_nsm)} which
```

Matlab Code (Plotting Beach profile):





Muhammad Shahinur Rahman

Scientific Officer (SO)

CONTACT

Marine Drive, Cox's Bazar
+88-01925-555797
+88-034152549
shahin@bori.gov.bd

EDUCATION

B.Sc. & M.Sc.
Geography and Environment
Jahangirnagar University
Bangladesh

M.S.
Oceanography
University of Dhaka
Bangladesh

SKILLS

Matlab, Octave, R, Arc GIS 10.x, QGIS, SNAP

ENVI, MOHID.

PROJECTS

- Investigate the status, Coastal Upwelling and Spatial-temporal variability of stratification with reference to Chlorophyll & Nutrients around Saint Martin's Island, Bangladesh.
- Study Spatio-temporal variability of stratification along theCox's Bazar Coast.
- Spatial and temporal variations of surface Chlorophyll and nutrient in the coastal area of kutubdia Island.
- Detecting Floating Marine Debris in the Eastern Coastal Zone of Bangladesh using Remote Sensing Technique.

RESEARCH INTEREST

Remote Sensing & GIS, Marine Spatial Planning, Bio-physical Coupling of the Ocean, Blue Carbon, Climate Change.

TRAINING

- Ocean Research: Basics of Observation and Instrumentation at NIO, Goa, India.
- Operational Ocean Data Use & Visualization at INCOIS, Hyderabad, India

Rupak Loodh

Scientific Officer (SO)

CONTACT

Marine Drive, Cox's Bazar
+88-01912-696029
+88-034152628
rupak@bori.gov.bd

EDUCATION

B.Sc.
Geography and Environment
Jahannath University
Bangladesh

M.S.
Oceanography
University of Dhaka
Bangladesh

SKILLS

Python, Machine learning, Matlab, R, MIKE 2014, MOHID, ROMS, ArcGIS, JMA (Storm Surge), WRF

PROJECTS

- Investigate the status, Coastal Upwelling and Spatial-temporal variability of stratification with reference to Chlorophyll & Nutrients around Saint Martin's Island, Bangladesh.
- Study Spatio-temporal variability of stratification along the Cox's Bazar Coast.
- Beach profiling along marine drive road Cox's Bazar.
- Beach profiling along the coast of Cox's Bazar.

RESEARCH INTEREST

Ocean Dynamics & Modeling, Operational Oceanography & Forecasting, Remote Sensing & GIS, Computer Simulation.

TRAINING

- Ocean Research: Basics of Observation and Instrumentation at NIO, Goa, India.
- Indian Ocean Circulation and Sea, Level Variation-INCOIS, Hyderabad

CHAPTER 4

Photo Credit: Abu Sayeed Muhammad Sharif, SSO, BORI

Geological Oceanography Division

Research Activity

The activity of Geological Oceanography Division (GEOD) started by the mandate of BORI Act, 2015 (article 8) with the starting of BORI. Research activity has been started on 2017-2018 FY with taken a R&D project in the nearshore area of Saint Martin's Island. In the next FY 2018-2019, another R&D project has been taken on the nearshore area of Teknaf to Maheshkhali Island. During research and survey,seabed sediment sample has been collected in the coastal and nearshore area of north-eastern part of Bay of Bengal covered about 3100 sq. km. The field activity during 2018-2019 FY, a cruise has been operated with the help of Bangladesh Navy R/V Saibal and the survey area was about 900 sq. km, distance 50 km seaward from the coastline of Cox's Bazar.In 2019-2020 FY, two R&D project have been taken from GEOD where the research topic of first R&D is sedimentological and mineralogical investigations in the marine area from Maheshkhali to Chottagram and the research topic of second R&D is the sea level fluctuations and effects of tectonic activity in the eastern coastal area of Bangladesh.

Photo Credit: Geological Oceanography Division, BORI

Determination of Sediment Texture to Delineate Sediment Deposition Process of the Kutubdia and Kuhelia Channel of Bangladesh

Md. Zakaria
Senior Scientific Officer

General Discussions

The coastal ocean, located between coastline and edge of the continental shelf owing to terrestrial, biological and oceanographic influence, in particular; those within the first few kilometers from the shore and less than 20 m deep, has complex sedimentary regime. But this zone has received much less attention than waters further offshore, especially in the high-energy environments. Near shore region extends from beach ridges or sandy plain on landward to the edge of the outer shelf, approximately coincides 20m water depth and contain micro sedimentary environment such as inner shelf, surf zone, foreshore etc. Nearshore oceanographic studies become slowed because of physical marine system complexes as well as logistics difficulties (accessibility of large vessel and instrument deploying). Sedimentation process in this region is complex, and is the net result of various aspects such as inland geology, geomorphic features, past and present climate changes including eustatic sea level change, near-shore oceanographic conditions, tectonics and nature of sediments. In addition to the terrestrial inputs (freshwater, nutrients and sediments), the flows of water and air, which cause convergences and divergences in currents of greater intensity than in theopen sea, sometimes neutralizing the effects of wind forcing (Tomezak and Godfrey, 1994) makes the sedimentation process more complex in this region. Further, the shallower depth of near shore waiter increases the importance of bottom layer friction (Lentz and Trowbridge, 1991) and intensifies the tidal currents (Tomezak and Godfrey, 1994). The interaction of these factors makes the near shore sedimentation process, a complex system.

Boggs (2009), mentioned that geologist used grain-size characteristics to understand depositional process, environment and hydrodynamic conditions. Edwards (2001) mentioned importance of grain-size tools for the study of sediment properties, sedimentary rock classification and depositional environment where Blott and Pye (2001) mentioned its importance for the study of sediment provenance and transportation mechanism.Several researchers including Boggs S. Jr., (2009) and other many authors have shown that indeed each sedimentary environment supposedly exhibits distinctively different grain-size characteristics that distinguish them from sediments deposited in different environments. However, [Boggs, 2009, Boogs, 1995, Tucker, 2001] emphasized on ambiguity of the grain-size analysis for depositional environment study. Along with the grain-size characteristics, heavy minerals are valuable for the study of sedimentation which is linked to tectonic uplift of orogenic belts, as they are reflected in their foreland sediments (Mange and Maurer, 1992). Heavy mineral deliver valuable information about provenance and the source rock complexes nature, specifically about the specific rock types, i.e., ophiolites and high-pressure rocks (Faupl et al., 1998). Morton and Hallsworth (1999) have re-examined heavy mineral assemblages to understand physical sorting, mechanical abrasion, dissolution functioning at the different sedimentary cycle stages which can change the original provenance signal.

Objectives

- To know the surface sediment composition of the study area
- To know the sediment deposition process and environment of the area.
- To identify mineral composition of the study area.

Study Area

The study area lies in the Kutubdia Channel and Kuhelia Channel of Cox's Bazar district. The Kutubdia Channel is surrounded by Kutubdia island in west, PekuaUpazila in east, north and south is open to Bay of Bengal. The Kutubdia Island is a separated off-shore island in the Bay of Bengal and detached by Kutubdia Channel from main land. The Kuhelia Channel surrounded by Matarbari island in west and Maheshkhali island in east. Locally the Kuhelia Channel is called Kuhelia river where it is connected to some branches of Matamuhuri river in the north. The Matarbari island is small island separated by Kuhelia Channel from mainland. The study area is bounded by N 21.65 to N 21.92 latitudes and E 91.84 to E 91.92 longitudes.

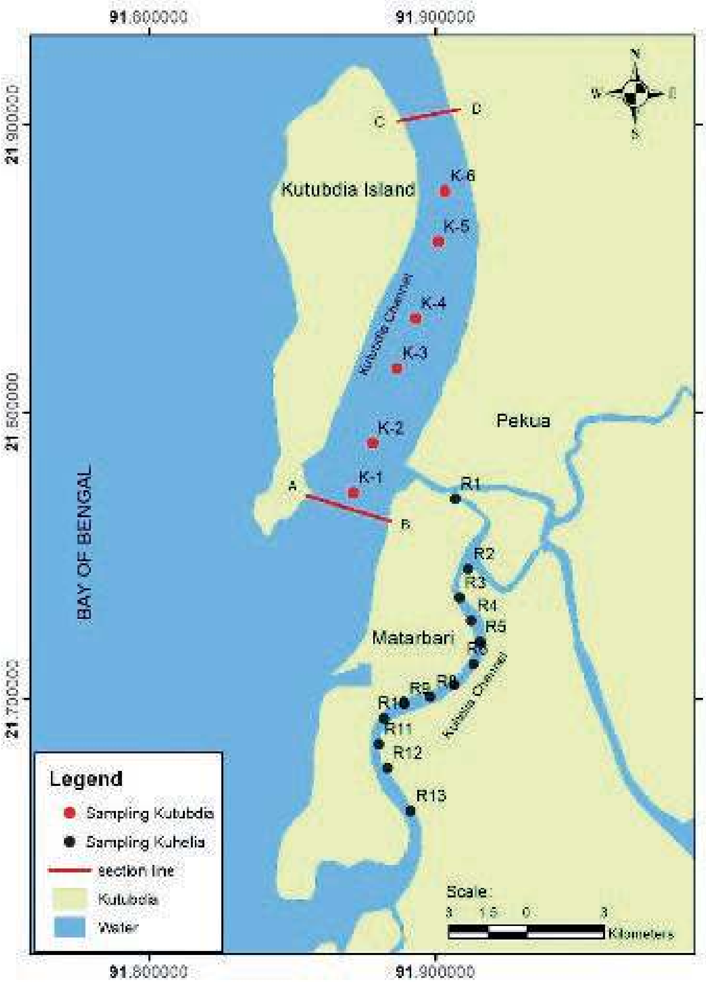


Figure 1: Study area of sampling Location in Kutubdia and Kuhelia Channel, Cox's Bazar.

Materials and Methods

Field Investigation

The field investigation and sample collections will be carried out in the Kutubdia Channel area. For systematic study of the area, GPS as well as traversing and spot location methods were used. Samples will be collected along the Channel mid-line. Sampling has been be done using Van Veen Grab through local fishing boat. Surface and near bottom water samples has been collected using Niskin bottle for investigations of hydrographic parameters such as temperature, total suspended sediments (TSS), salinity etc. Secchi depth has been measured using Secchi disk in the area. Discharge of the cross-section A-B and C-D has been calculated directly from ADCP along the section.


Bokabil Formation of Dakshin Nhila Anticline. Oldest outcrop of the anticline found in Noakhali Chara section. The thickness of the bed indicate it may be lower to middle Bokabil Formation.
Photo Credit @ Md. Zakaria, SSO, BORI

Sedimentary Texture

At first sedimentary texture has been delineated using laboratory measurement. After field investigation, grain size distribution measured by sieve and hydrometer methods. At first samples are dried naturally, then Calcium Carbonate ($CaCO_3$) has been removed by Hydrochloric Acid (HCl), then organic matter has been removed by Hydrogen peroxide (H_2O_2) treatment. The remaining sediment sampled dried in oven to perform sieve analysis. To perform sieve analysis 100 gm samples are taken. All the samples are falls in lower than 2mm size. So 10, 18, 35, 60, 120, and 230 US Standard sieve mesh used to perform sieve analysis. After complete sieve analysis, finer than 0.063mm samples are grain size has been measured with Hydrometer method using 152H type hydrometer.

The statistical parameters of grain-size distribution were calculated using equation proposed by (Folk & Ward, 1957). The parameters employed to describe the grain size distribution are categorised into four main groups that include, the mean, standard deviation, skewness, and kurtosis. Graphic mean, Standard Deviation, graphical Skewness and graphical Kurtosis calculated from cumulative graph value (Ø10, Ø25, Ø60, Ø75, Ø99) using equation stated below-

Graphic mean (M_Z)	$M_Z = \frac{\varnothing_{16} + \varnothing_{50} + \varnothing_{84}}{3}$
Inclusive graphic standard deviation (σ_I)	$\sigma_I = \frac{\varnothing_{84} - \varnothing_{16}}{4} + \frac{\varnothing_{95} - \varnothing_{5}}{6.6}$
Inclusive graphic skewness (SK_I)	$SK_I = \frac{(\varnothing_{84} + \varnothing_{16} - 2\varnothing_{50})}{2(\varnothing_{84} - \varnothing_{16})} + \frac{(\varnothing_{95} + \varnothing_{5} - 2\varnothing_{50})}{2(\varnothing_{95} + \varnothing_{5})}$
Graphic kurtosis (K_G)	$K_G = \frac{(\varnothing_{95} - \varnothing_{5})}{2.44(\varnothing_{75} - \varnothing_{25})}$

Where $\varnothing_5$, $\varnothing_{16}$, $\varnothing_{25}$, $\varnothing_{50}$, $\varnothing_{75}$, $\varnothing_{84}$ and $\varnothing_{95}$ represents 5^{th}, 16^{th}, 25^{th}, 50^{th}, 75^{th}, 84^{th} and 95^{th} percentile, respectively, on the cumulative curve.

Bivariate scatter plots were employed to discriminate between depositional settings based on the textural variations of sediment. Bivariate plot of Graphic mean vs. Skewness, Graphic mean vs. Kurtosis and Skewness vs. Kurtosis has been done using MS Excel. The Sahu's [1962, 1964] linear discriminant function (LDF) used to determine and distinguish processes and environments of deposition. To delineate depositional environment Linear Discriminate Function (LDF) has been applied by below equation-

Equation (i) will be used to distinguish between shallow agitated water (SA) and beach (B) environments.

$$Y_{1(SA:B)} = -3.5688M + 3.7016r^2 - 2.0766SK + 3.1135KG \quad \text{.................................. (i)}$$

If Y1 is < -2.7411, the environment is "shallow agitated water" and if Y1 is > -2.7411, the environment is "beach".

Equation (ii) will be used to distinguish between beach (B) and shallow marine (SM) environments.

$$Y_{2(B:SM)} = 15.6534M + 65.7091r^2 + 18.1071SK + 18.5043KG \quad \text{........................... (ii)}$$

If Y_2 is < -63.3650, the environment is "beach" and if Y_2 is > -63.3650, the environment is "shallow marine".

To distinguish environment of deposition between shallow marine (SM) and deltaic or lacustrine (L), equation (iii) was applied:

$$Y_{3(SM:F)} = 0.2852M - 8.7604r^2 - 4.8932SK + 0.0482KG \quad \text{..................................... (iii)}$$

If Y_3 is > -7.4190, the environment is "shallow marine" and if Y_3 is < -7.4190, the environment is "deltaic or lacustrine".

To discriminate between deltaic (D) and turbidity current deposit, equation (iv) below was applied:

$$Y_{4(F:T)} = 0.7215M - 0.4030r^2 + 6.7322SK + 5.2927KG \quad \text{...................................... (iv)}$$

To discriminate between deltaic (D) and turbidity current deposits, equation (iv) below was applied:

If Y4 is < 9.8433, it indicates turbidity current deposition and if Y4 is > 9.8433, it indicates deltaic deposition, where M, r, SK and KG represents mean grain size, standard deviation, skewness and kurtosis, respectively.

Total Suspended Solid (TSS) measurement:

To measure the mean concentration of suspended Sediment, the water sample from different depth of the river water column has been collected using Niskin Water sampler. The collected water sample has been carried out through water sample bottle to laboratory. After that Vacuum pump and filtration unit has been be used to separate solid particle from the water. Whatman 1 type filters will be used to collect solid and dried in oven to measure Total Suspended Solid (TSS) in gm per liter of the water sample.

Turbidity Measurement:

Secchi depth is a measure of water transparency, where transparency increases with increasing secchi depth. The secchi depth is the depth of water beyond which a high-contrast pattern on a submerged disk is no longer visible.

Secchi depth (feet) can be estimated on the basis of measured turbidity data (http://pubs.usgs.gov/tm/tm3c4/). Measurements of the secchi depth near the monitor location have been used to create a regression model of secchi depth as a function of turbidity:

$$\text{SecchiDepth} = 11.123 \times \text{Turbidity}^{-0.637}$$

Where Secchi Depth is in feet, Tbdy is turbidity in FNU. So, the Turbidity of the area can be calculated as:

$$Turbidity = \sqrt[0.637]{\frac{11.123}{SecchiDepth}}$$

Heavy Mineral distribution:

At first samples are dried naturally, then Calcium Carbonate ($CaCo_3$) has been removed by Hydrochloric Acid (HCl), then organic matter has been removed by Hydrogen Peroxide (H_2O_2) treatment. The remaining sediment sampled dried in oven to perform sieve analysis. To perform sieve analysis 100 gm samples are taken (samples taken less amounts because of sample shortage). All the samples are falls in lower than 2mm size. So, 10, 18, 35, 60, 120, and 230 US Standard sieve mesh used to perform sieve analysis.

Heavy Mineral concentration has been measured with heavy liquid separation method using Bromoform (BrH_3). To separate heavy mineral 25gm of samples has been taken and Bromoform taken three times higher (1:3). Then heavy and light mineral has been weighted and calculated the percentage. A total of 8 samples has been investigated for the heavy mineral study. Following the procedure mentioned in Faupl et al. (1998), heavy minerals were separated from both loose sand samples. 25 g has been taken from each sample for heavy mineral analysis. Carbonate minerals will be dissolved in acetic acid or wet chemistry method will be applied for carbonate remove. Gravitational heavy liquid separation of the sieve fraction 0.5-0.063 mm (500μm-63μm) was carried out using Bromoform as heavy liquid (density 2.89 g/cm3). After mounting the grains in Canada balsam, the grains will be examined under the polarizing microscope. More than 450 translucent grains of each sample have been counted with the ribbon count method.

Suspended Sediment Discharge calculation:

Discharge rate is very important for channel input of sedimentation in the area. So discharge rate of the north and south mouth of Kutubdia Channel has been calculated using ADCP. At the same time water sample collected from different depth to calculate sediment discharge. Mean concentration of suspended sediment measured to in laboratory using filter method. After calculating water discharge and sediment discharge, suspended sediment discharge (tons per day) calculated using below equation (Porterfield, 1972):

$$Qs = Qw \times Cs \times k$$

Where,

- Qs = suspended sediment discharge (sediment flux) in tons per day.
- Qw = Water discharge in cubic meter per second
- Cs = Mean concentration of suspended sediment (mg/liter)
- k = a coefficient based on the unit of measurement of water discharge that assumes a specific weight of 2.65 for sediment, and equals 0.0027 in inch-pound units, or 0.0864 in SI units.

Photo Credit @ Geological Oceanography Division, BORI

Sediment Sampling

Photo Credit @ Geological Oceanography Division, BORI

Results

Basic Classification of sediment

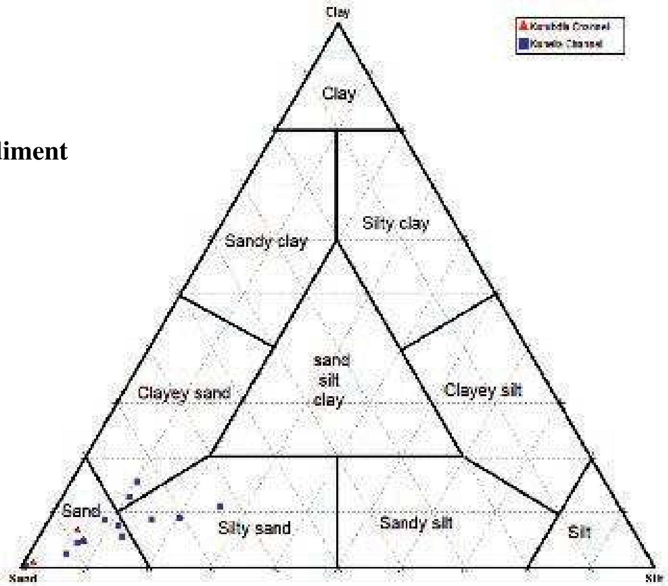


Figure 2: Triangular diagram for basic classification of sediment in the Kutubdia and Kuheliaa Channel.

Graphic classification of sediment

1. Frequency curve

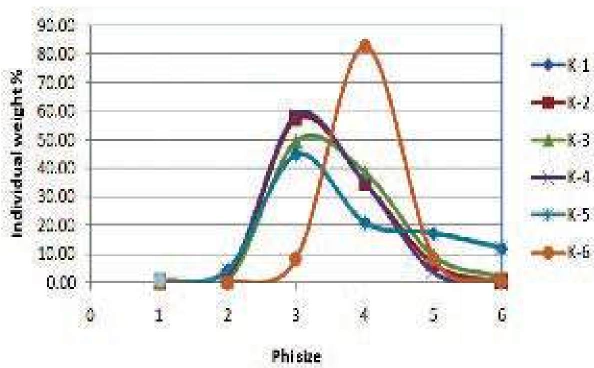


Figure 3a: Frequency curve based on sediment size and individual weight percentage of The Kutubdia Channel

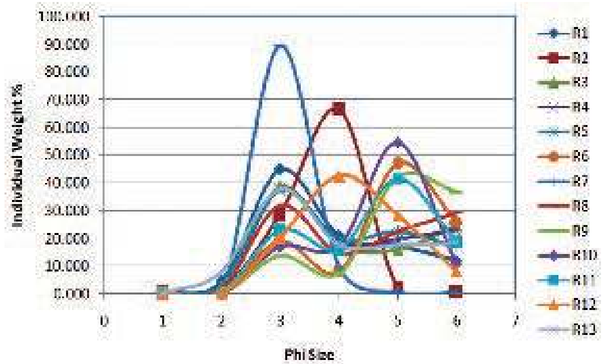


Figure 3b: Frequency curve based on sediment size and individual weight percentage of the Kuheliaa Channel.

2. Cumulative curve

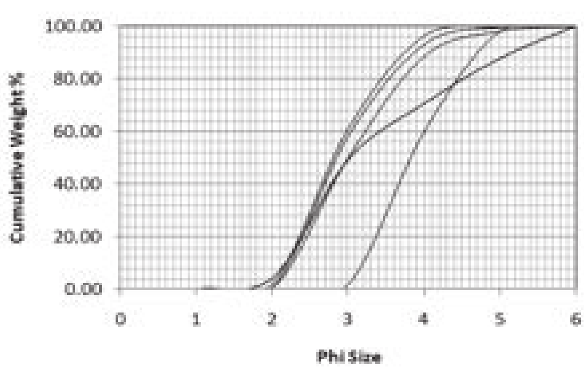


Figure 4a: Cumulative weight percentage logarithmic curve based on grain size of the Kutubdia Channel

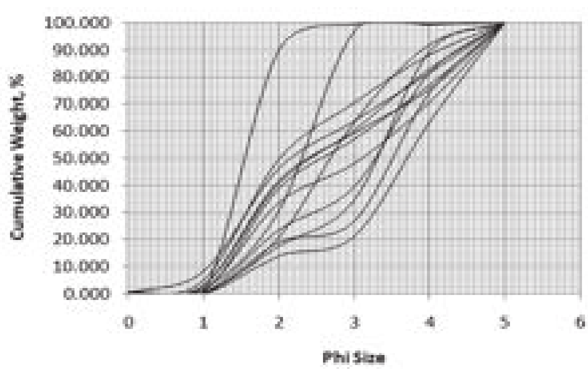


Figure 4b: Cumulative weight percentage logarithmic curve based on grain size of the Kuheliaa Channel

3. Grain-size parameters

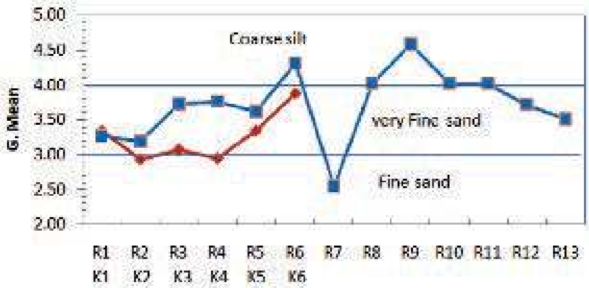


Figure 5a: Graphical plot of mean size of the sediment

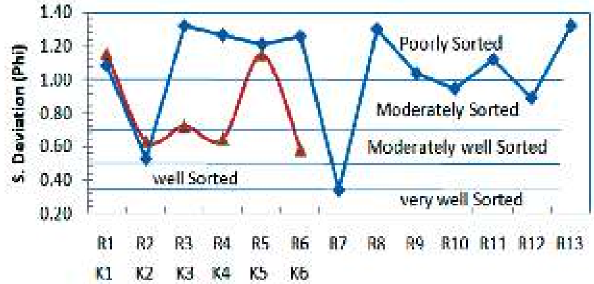


Figure 5b: Graphical plot of standard deviation (sorting) of the sediment

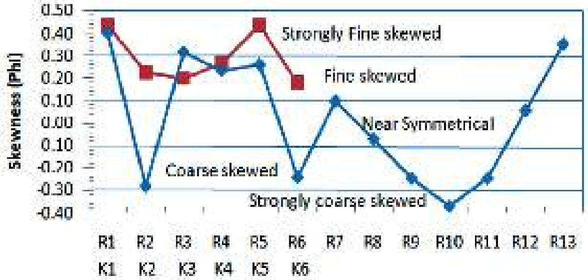


Figure 5c: Graphical plot of skewness of the sediment

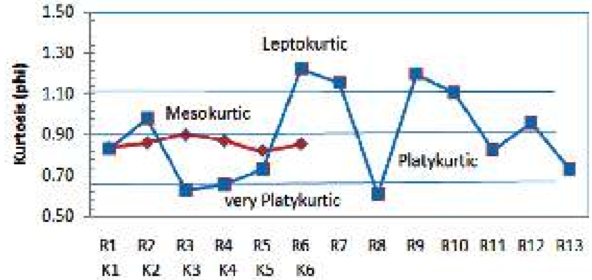
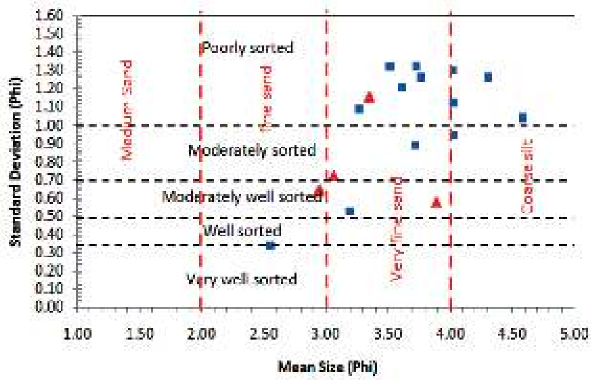
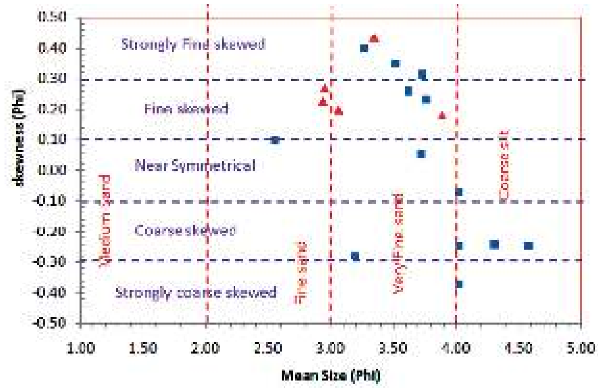


Figure 5d: Graphical plot of kurtosis of the sediment

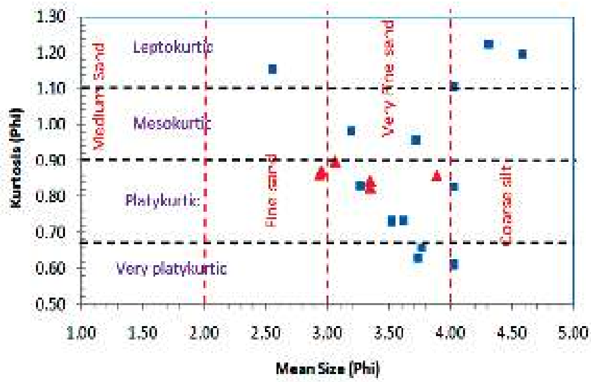
4. Bivariate plots



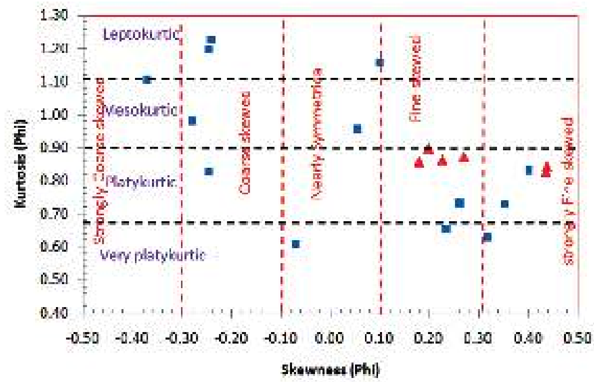
6 (a)



6 (b)



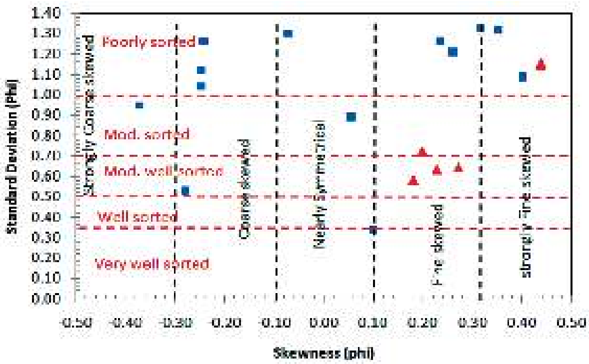
6 (c)



6 (d)

Shows oblique joint in the fisile shale in the axial plane of the Dakshin Nhila Anticline. Location of the picture is Noakhali Chara section Teknaf, Cox's Bazar.

Photo Credit @ Md. Zakaria, SSO, BORI



6 (e)

Figure 6:
(a) Bivariate plot between mean size vs standard deviation (sorting),
(b) Bivariate plot between mean size vs skewness,
(c) Bivariate plot between mean size vs kurtosis,
(d) Bivariate plot between skewness vs kurtosis,
(e) Bivariate plot between skewness vs standard deviation (sorting)

5. Visher diagram

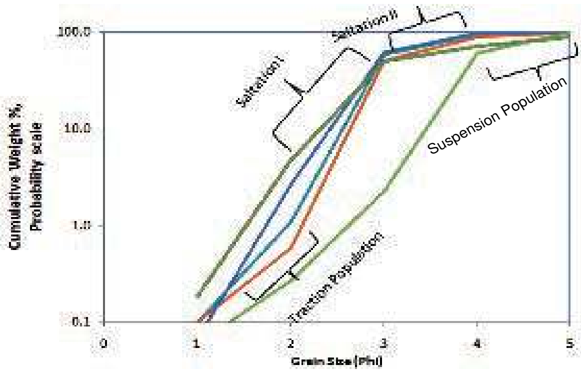


Figure 7a: Cumulative weight percentage probability curve (Visher diagram) of the Kutubdia Channel

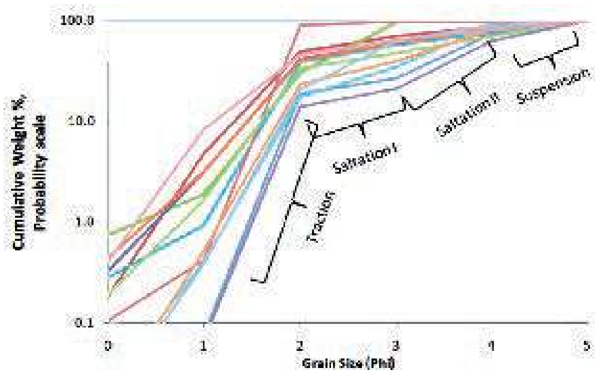


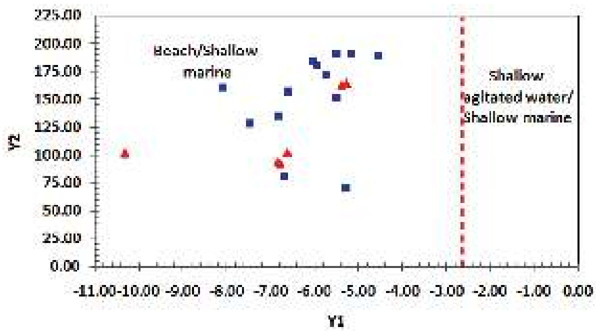
Figure 7b: Cumulative weight percentage probability curve (Visher diagram) of the Kutubdia Channel

Environmental classification based on Linear discriminate function (LDF)

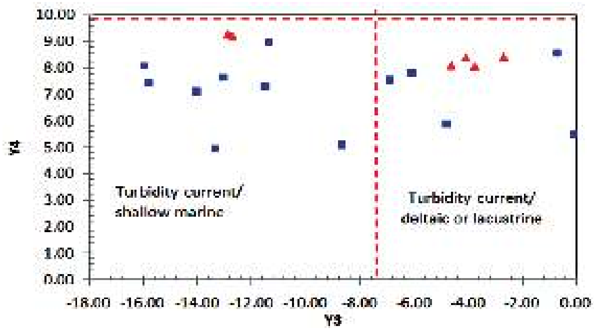
Table 1: Calculation of linear discriminant functions and associate depositional environment of area

ID	Y1	Environment	Y2	Environment	Y3	Environment	Y4	Environment
K1	-5.2736	Shallow Agitated Water	164.0502	Shallow Marine	-12.8863	Deltaic/ Lacustrine	9.2775	Turbidity
K2	-6.7812	Shallow Agitated Water	92.6279	Shallow Marine	-3.7666	Shallow Marine	8.0499	Turbidity
K3	-6.6210	Shallow Agitated Water	102.5788	Shallow Marine	-4.6320	Shallow Marine	8.0800	Turbidity
K4	-6.8335	Shallow Agitated Water	94.5918	Shallow Marine	-4.0925	Shallow Marine	8.3884	Turbidity
K5	-5.3873	Shallow Agitated Water	162.5772	Shallow Marine	-12.7286	Deltaic/ Lacustrine	9.1902	Turbidity
K6	-10.3286	Shallow Agitated Water	102.2956	Shallow Marine	-2.6969	Shallow Marine	8.4209	Turbidity
R1	-5.5197	Shallow Agitated Water	151.5292	Shallow Marine	-11.3539	Deltaic/ Lacustrine	8.9740	Turbidity
R2	-6.7166	Shallow Agitated Water	81.5737	Shallow Marine	-0.1364	Shallow Marine	5.5090	Turbidity
R3	-5.5203	Shallow Agitated Water	190.8829	Shallow Marine	-15.7985	Deltaic/Lacustrine	7.4443	Turbidity
R4	-5.9622	Shallow Agitated Water	180.1808	Shallow Marine	-14.0223	Deltaic/Lacustrine	7.1179	Turbidity
R5	-5.7514	Shallow Agitated Water	170.9901	Shallow Marine	-13.0191	Deltaic/Lacustrine	7.6452	Turbidity
R6	-5.1546	Shallow Agitated Water	190.3940	Shallow Marine	-11.4852	Deltaic/Lacustrine	7.3268	Turbidity
R7	-5.2913	Shallow Agitated Water	70.6944	Shallow Marine	-0.7041	Shallow Marine	8.5748	Turbidity
R8	-6.0366	Shallow Agitated Water	184.3700	Shallow Marine	-13.3262	Deltaic/Lacustrine	4.9672	Turbidity
R9	-8.1121	Shallow Agitated Water	160.5028	Shallow Marine	-6.9010	Shallow Marine	7.5565	Turbidity
R10	-6.8504	Shallow Agitated Water	135.4806	Shallow Marine	-4.8092	Shallow Marine	5.9086	Turbidity
R11	-6.6176	Shallow Agitated Water	156.6912	Shallow Marine	-8.6470	Deltaic/Lacustrine	5.1125	Turbidity
R12	-7.4805	Shallow Agitated Water	128.9005	Shallow Marine	-6.0877	Shallow Marine	7.7988	Turbidity
R13	-4.5461	Shallow Agitated Water	189.5253	Shallow Marine	-15.9550	Deltaic/Lacustrine	8.0740	Turbidity

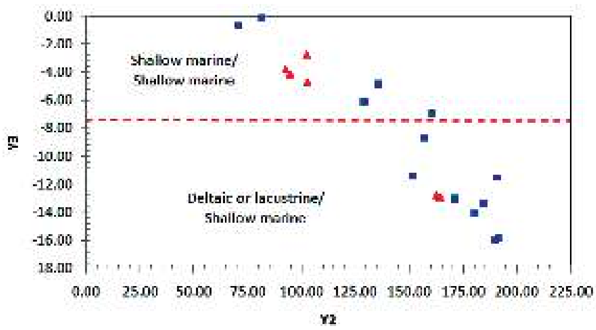
Bivariate plot of LDF



8 (a)



8 (c)



8 (b)

Figure 8: (a) Bivariate plot between Y1 vs Y2, (b) Bivariate plot between Y2 vs Y3, (c) Bivariate plot between Y3 vs Y4.

Heavy Mineral Concentration

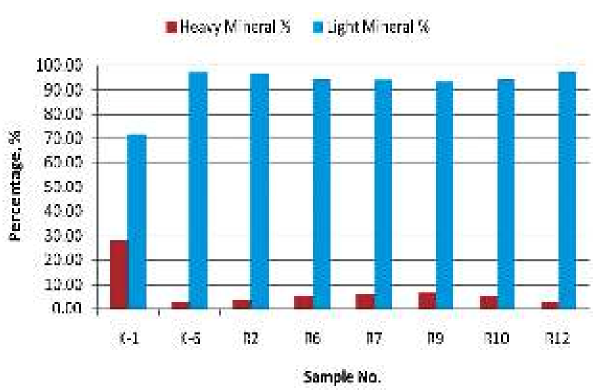
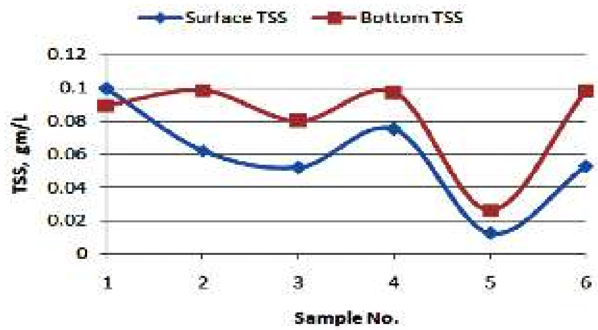
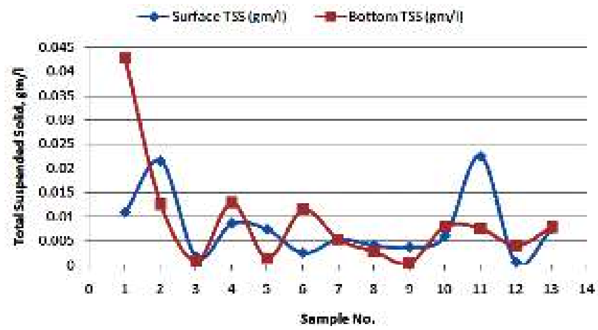


Figure 9: Heavy mineral and light mineral percentage graph.

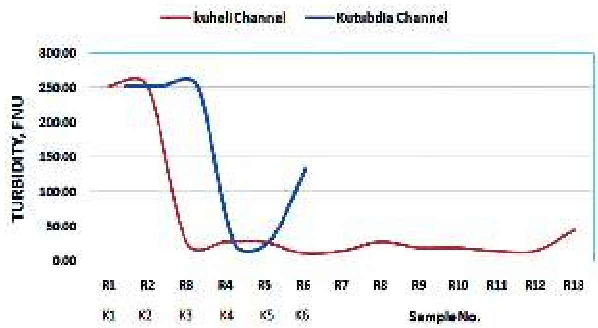
Total Suspended Solid and Turbidity of area



9 (a)



9 (b)



9 (c)

Figure 9: (a) total suspended solid of surface and bottom water of Kutubdia Channel, (b) total suspended solid of surface and bottom water of Kuheliaa Channel, (c) Turbidity graph of the study area

Sediment discharge in the Kutubdia Channel

Table 2: Calculations of average total suspended solids (TSS)

Section	Surface TSS, mg/l	Mid TSS mg/l	Bottom TSS, mg/l	Average TSS, mg/l
A-B section	0.0994	0.0944	0.0891	0.0943
C-D section	0.0516	0.0759	0.0972	0.0749

Table 3: Calculations of sediment discharge

Section	Mean current speed, m/s	Water Discharge, m^3/s	Average TSS, mg/l	Sediment Discharge, tons/day
A-B section	0.812	-679.19	0.0943	-5.5337
C-D section	0.753	146.41	0.0749	0.9475

Conclusions

This study deals with the determination of sediment depositional process of the Kutubdia Channel and Kuhelia Channel of the Cox's Bazar area. The study area lies in the complex as well as diverse geological and hydrodynamic conditions. Both channels mainly consist of fine sand sediment. The Kutubdia Channel has more connection with the Bay of Bengal in the north and south than Kuhelia Channel where narrow mouth in north and south connected to Bay of Bengal. Different grain-size parameter has been studied to delineate sediment distribution of the study area. Grain-size parameter such as mean size, sorting, skewness, kurtosis, histogram, cumulative curve, provability curve along with bivariate plots of each parameter performed in the study to delineate sediment depositional systems and source of the sediment. Linear discrimination function applied to differentiate sedimentary subenvironment. Besides heavy mineral, total suspended solid, turbidity and sediment discharge have been studies to match the depositional process in the study area. From the analysis it is observed that the depositional system of the Kutubdia Channel is more active than the Kuhelia Channel where sedimentary subenvironment shows similar. The source of sediment of the Kuhelia Channel may be near than the Kutubdia Channel. Also the both channel faced uniform energy condition along the channel.

References

Blott S.J., Pye, K., 2001, GRADSTAT: A Grain Size Distribution and Statistics Package for The Analysis of Unconsolidated Sediments. Earth Surface Process. Landforms, 26, 1237-1248

Boggs S. Jr., 2009, Petrology of Sedimentary Rocks, Second Edition. Cambridge University Press, UK,

Boggs S., 1995, Principles of Sedimentology and Stratigraphy, 2nd ed., Prentice Hall, Upper Saddle River, NJ,

Edwards A.C., 2001, Grain size and sorting in modern beach sands. Journal of Coastal Research, 17, 38-52

Faupl, P., Pavlopoulos, A. and Migiros, G., 1998: On the provenance of flysch deposits in the External Hellenides of mainland Greece: Results from heavy mineral studies, Geological Magazine, 165, 421-442.

Folk, R.L. & Ward, W., 1957. Brazos river bar: a study in the significance of grain size parameters. Journal of Sedimentary Petrology 27, 3–26.

Lentz, S. J., and J. H. Trowbridge, 1991. The bottom boundary layer over the northern California shelf. Journal of Physical Oceanography, 21(8), 1186-1201.

Mange, M.A. and Maurer H.F.W., 1992. Heavy minerals in Colour. Chapman and Hall, London, 147 p.

Morton, A.C. and Hallswoth, C.R., 1999: Processes control ling the composition of heavy mineral assemblages in sandstones. Sedimentary Geology, 124, 3-29.

Porterfield, G. 1972. "Book 3, Chapter C3: Computation of fluvial-sediment discharge." Techniques of Water-Resources Investigations Repor, U.S. Geological Survey, Reston, Va., http://pubs.er.usgs.gov/pubs/twri/twri03C3> (Oct. 6, 2005).

Sahu B.K., Depositional mechanism from the size analysis of elastic sediments. Journal of Sedimentary petrology, 1964, 34(1), 73-83

Sahu B.K., Environments of deposition from the size analysis of clastic sediments: Ph.D. thesis, Univ. of Wisconsin, Madison, Wis., 1962

Tucker, M. E., 2001, Sedimentary Petrology, 3rd ed., Blackwell Publishing Company, Oxford

U.S Geological Survey (USGS) http://pubs.usgs.gov/tm/tm3c4/

Photo Credit @ Geological Oceanography Division, BORI

Chevron Fold in the axal plain region of the Dakshin Nhila Anticline. Location: Noakhali Chara of Teknaf, Cox's Bazar.

Photo Credit @ Md. Zakaria, SSO, BORI

Md. Zakaria

Senior Scientific Officer (SSO)

CONTACT

Marine Drive, Cox's Bazar
+88-01917019838
+88-034152552
zakaria@bori.gov.bd

EDUCATION

B.Sc. & M.Sc.
Geological Sciences
Jahangirnagar University
Bangladesh

SKILLS

Matlab, ArcGIS 10x, QGIS, Auto CAD, Rockware, geophysical and structural geological software such as Stereo Win, Schlum, Mag2dc Gav2dc, SeisVision Potent etc.

PROJECTS

- Determination of Sedimentological & Mineralogical Distribution to delineate sedimentary process of the Nearshore Area of Maheshkhali-Kutubdia, Bangladesh.
- Determination of Sedimentological & Mineralogical Distribution and Sediment Province of the Nearshore Area of Cox's Bazar-Teknaf, Bangladesh.
- Determination of Sedimentological & Mineralogical Composition and Sediment Province Analysis of the Nearshore Area of Saint Martin Island, Bangladesh.

RESEARCH INTEREST

Mineralogy & Metallurgy, Sedimentary Oceanography, Coastal Geomorphology, GIS & RS.

TRAINING

- Study and Exploitation of Mineral Resources in the Ocean at Saint Petersburg State, University.
- Understanding sea level: data analysis and applications at ITCOocean, INCOIS
- Ocean Research: Basic of Observation and Instrumentations at NIO, Goa
- MSP for Bangladesh, Blue Economy Cell, MOST, Bangladesh and FJIO, China.

Photo Credit: Abu Sayeed Muhammad Sharif, SSO, BORI

CHAPTER 5

Chemical Oceanography Division

Photo Credit @ Abu Sayeed Muhammad Sharif, SSO, BORI