2021–2030

UN Decade of Ocean Science

Imperatives for Bangladesh

BSMRMU International Seminar 2022

Seminar Proceedings

2021-2030 UN Decade of Ocean Science Imperatives for Bangladesh

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on

UN Decade of Ocean Science Imperatives for Bangladesh

Thursday, 17 November 2022
Krishibid Institution Bangladesh, Khamar Bari Road, Dhaka.

Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh

January 2023

Seminar Proceedings on
UN Decade of Ocean Science
Imperatives for Bangladesh

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Editorial Note

Scientists believe that life in ocean is 3.3 billion years older than that of life on land and about 80% of all life in our planet is found in oceans. This is why it is absolutely necessary to keep our oceans healthy. Father of the Nation, Bangabandhu Sheikh Mujibur Rahman realized the tremendous significance of the oceans, estuaries and river systems for our national prosperity and wellbeing and therefore, he promulgated 'Territorial Waters and Maritime Zones Act No. XXVI of 1974'. Based on the solid foundation left by Bangabandhu, our Hon'ble Prime Minister Sheikh Hasina has set in front of us examples of her indomitable spirit and farsighted vision by embarking upon excellent initiatives in order to harness the blue economy potentials to achieve the Vision 2041, Sustainable Development Goals 2030 and Bangladesh Delta Plan 2100.

Bangladesh ranks as the 7th most vulnerable country to climate change. Bangladesh's potential to sustain its development is faced with significant challenges posed by climate change with risks to life, infrastructure, and the economy. With a sea area of 118,813 square km, Bangladesh needs to be committed towards protecting ocean sustainability. However, as a coastal country Bangladesh often struggle to maintain a balance between maritime industry and ocean conservation, the protection of marine species and ecosystems in oceans. This is primarily due to lack of investment, scientific knowledge and technology to compensate for the harmful effect of the maritime industries. The Vision 2041, SDG 2030 and Bangladesh Delta Plan 2100 will in turn support the efforts to reverse the cycle of declining ocean health and create improved conditions for oceans.

The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support the efforts to reverse the cycle of declining ocean health. All nations of the world have acknowledged the huge significance of ocean science in achieving national prosperity. It is expected that the outcomes of Decade of Ocean Science would be (i) a clean ocean, (ii) a healthy and resilient ocean, (iii) a productive ocean, (iv) a predicted ocean, (v) a safe ocean, (vi) an accessible ocean and (vii) an inspiring and engaging ocean.

Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU), Bangladesh has taken a unique initiative of arranging the country's first international seminar titled, "UN decade of Ocean Science - Imperatives for Bangladesh", at the Krishibid Institute, Khamar Bari, Dhaka, Bangladesh on Thursday, 17 November 2022. More than 800 scientists from home and abroad attended the seminar. In this one-day seminar one keynote lecture, eight plenary lectures in two plenary sessions, fifteen oral presentations in three parallel technical sessions, and 38 posters were presented. BSMRMU is looking forward to organizing more seminars, workshops and symposium during UN Decade of Ocean Science in coming years.

The proceeding sub-committee (editorial board) of this international seminar has the task to publish the proceedings. Responding to our request, a few distinguished speakers handed over soft copies of their presentations but rest of the presentations had to be edited by the members of editorial board from the audiovisual recordings and power point presentations. We tried our best to publish the proceedings as presented in the seminar however, minor changes were made here and there, keeping the theme of the paper intact.

We are grateful to the Hon'ble Vice-Chancellor of BSMRMU for his kind support and constant guidance during the preparation of this seminar proceedings. An international seminar of this magnitude owes its success to all participants. We sincerely thank teachers, officers, students and staff members of BSMRMU for their support and cooperation.

It was possible to publish the seminar proceedings only because of very hard and dedicated team work of the members of the editorial board – thank you.

Professor Dr Altaf Hussain
Academic Adviser, BSMRMU.

Concept Note

BSMRMU International Seminar 2022 on

UN Decade of Ocean Science–Imperatives for Bangladesh

Background:

The ocean, our planet's largest ecosystem, stabilizes climate, stores carbon, nurtures unimaginable biodiversity, and directly supports human well-being through food and energy resources, as well as by providing cultural and recreational services.

Despite the improved management and conservation actions, the ocean is now seriously degraded. As the world population will reach an estimated 9 billion people by 2050, impacts on the ocean associated with human activities will increase. Without effective intervention, degradation of the Ocean will continue to worsen our blue planet's health and thus our lives. Action can only be effective if it is based on sound knowledge informed by science. There is an increasing need to find scientific solutions that allow us to understand the changes taking place in our ocean, and to reverse its declining health.

Objective of Decade of Ocean Science:

The UN Decade of Ocean Science, which runs from 2021 to 2030, was officially proclaimed by the United Nations General Assembly in 2017. In fact, almost all the nations of the world have acknowledged the huge significance of ocean science in achieving a sustainable development and national prosperity. The key objective of this ocean decade is to support efforts to reverse the cycle of deteriorating ocean health and bring ocean stakeholders around the world behind a common framework. This will enable marine science to empower countries to create improved conditions for sustainable ocean development. Indeed, a scientific understanding of the ocean's response to pressure and management behavior is fundamental to sustainable development. Ocean observations and studies are also essential for predicting the consequences of change, designing mitigation, and guiding adaptation. Mandated by the United Nations General Assembly, UNESCO's Intergovernmental Oceanographic Commission (IOC) will coordinate a ten-year preparatory process to bring marine science and technology together for the global marine community to achieve "The Ocean we need for the future we want". To meet its responsibilities, marine science must fundamentally change its approach to research and practice, paves the way for this revolution: a sustainable world that strengthens the connection between land and sea.

The Ocean Decade provides a 'once in a lifetime' opportunity to create a new foundation across the science-policy interface to strengthen the management of our oceans and coasts for the benefit of humanity. The Ocean Decade will strengthen the international cooperation needed to develop the scientific research and innovative technologies that can connect ocean science with the needs of society.

Bangabandhu's Vision for Maritime Bangladesh:

Our Father of the Nation Bangabandhu Sheikh Mujibur Rahman realized the tremendous significance of the oceans, estuaries and river systems for our national prosperity and wellbeing. Bangabandhu left no stone unturned to revitalize the maritime sector soon after our independence and took significant initiatives for the exploration of our sea resources through the application of ocean science. Based on the solid foundation left by Bangabandhu, our Hon'ble Prime Minister Sheikh Hasina has set in front of us examples of her indomitable spirit and farsighted vision by embarking upon excellent initiatives in order to harness the blue economy potentials to achieve the Vision 2041, Sustainable Development Goals 2030 and Bangladesh Delta Plan 2100. These will in turn support the efforts to reverse the cycle of decline in ocean health and create improved conditions for sustainable development of the Ocean.

Declining Ocean Health:

Bangladesh ranks as the 7th most vulnerable country to climate change. Bangladesh's potential to sustain its development is faced with significant challenges posed by changing climate with risks to life, infrastructure, and the economy. With a sea area of approximately 118813 square km, Bangladesh needs to be committed towards protecting ocean sustainability. However, as a coastal country Bangladesh often struggle to maintain a balance between maritime industry and ocean conservation – the protection of marine species and ecosystems in oceans, primarily due to lack of investment and scientific resources to build technology to compensate for the harmful effect of the maritime industries. As such UN Decade of Ocean Science has provided the timely impetus to draw everyone's attention to ocean health from a science-based informed perspective.

About the BSMRMU International Seminar 2022:

BSMRMU is the first maritime university in Bangladesh, and it offers courses and programs at the undergraduate and post-graduate levels in a wide variety of ocean-related disciplines, such as oceanography, marine biotechnology, marine fisheries, safe shipping management and administration, naval architecture and marine engineering, offshore engineering, environment and climate change, etc. On the occasion of the UN Decade of Ocean Science, BSMRMU has taken this unique initiative of arranging the country's first international seminar on the UN Ocean Decade entitled "UN decade of Ocean Science-Imperatives for Bangladesh", on 17 November 2022. The seminar will be conducted in two plenary sessions and one technical session.

Goal of the Seminar:

The goal of this seminar is to generate the scientific knowledge and underpinning infrastructures and partnerships needed for sustainable development of the ocean in support of all sustainable development goals of 2030 Agenda. The seminar aims to discuss the 7 ocean decade outcomes namely a clean ocean, a healthy and resilient ocean, a productive ocean, a predicted ocean, a safe ocean, an accessible ocean and an inspiring and engaging ocean.

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Dr Md. Niamul Naser, Professor & Chairman, Department of Zoology,
Dhaka University, Bangladesh.

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Vote of Thanks by

Cdre Sheikh Firoz Ahmed, (H1), NGP, psc, BN, Registrar, BSMRMU

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Glimps of BSMRMU International Seminar 2022

Inaugural Session

Welcome Address by Vice-Chancellor, BSMRMU
Rear Admiral M Khaled Iqbal, NBP, BSP, ndc, psc (retd)

Keynote Presentation on, Ocean Science - Gateway to Sustainable Development by Rear Admiral Md Khurshed Alam (retd), Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs, Bangladesh.

Speech by Chief Guest Barrister Mohibul Hassan Chowdhoury, MP, Hon'ble Deputy Minister, Ministry of Education, Bangladesh.

Welcome Address by Vice Chancellor, BSMRMU

Rear Admiral Mohammad Khaled Iqbal, NBP, BSP, ndc, psc (retd)

The Chief Guest of today's seminar Hon'ble Deputy Minister, Ministry of Education, Barrister Mohibul Hasan Chowdhury, MP.

The Keynote Speaker, Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs, Rear Admiral Khurshed Alam (retd), who is the Chair of the UN Ocean Decade in Bangladesh,

Learned Session Chairs, Panelists, Distinguished Academicians, Scientists, Maritime Experts, Government Officials, and My Dear students,

Assalamu Alaikum and very Good Morning to you all.

1. On behalf of all members of the Bangabandhu Sheikh Mujibur Rahman Maritime University, I would like to extend a hearty welcome to you all to this very important seminar on 'Un Decade of Ocean Science 2021-2030: Imperatives for Bangladesh'. We have selected this important theme to generate some worthwhile discussion in order to share our ideas and thoughts on the ocean science, which is absolutely important for achieving our goals and objectives of blue economy. We are privileged to have amongst us Barrister Mohibul Hassan Chowdhoury, M.P, the Hon'ble Deputy Minister, Ministry of Education as the Chief Guest in spite of his busy schedule in the Education sector. In fact, our Maritime University is always blessed with his unflinching support in the growth and capacity building of our Maritime University.

2. Dear audience, Bangladesh being located at the confluence and convergence of the Ganges-Brahmaputra-Meghna Delta is truly a riverine and maritime nation. At this juncture, I would like

to pay our deepest tribute to the Father of the Nation Bangabandhu Sheikh Mujibur Rahman, with whose name our University has been proudly glorified. As a great visionary leader, Bangabandhu was truly aware of our maritime heritage and the potentials of the riverine and oceanic sector for our national prosperity and wellbeing. Bangabandhu soon after our independence, left no stone unturned to revitalize the maritime sector, gave us a maritime vision for future and took significant initiatives for the exploration of our sea resources through the application of ocean science. Based on the strong foundation left by Bangabandhu, our Hon'ble Prime Minister Sheikh Hasina has set in front of us examples of her indomitable spirit and farsighted vision by embarking upon excellent initiatives in order to harness the blue economy potentials to achieve the Vision 2041, Sustainable Development Goals 2030 and Bangladesh Delta Plan 2100. Specially, the goals of SDG 2030, particularly SDG Target 14, 'Life Below Water' is being implemented with various maritime development agendas in Bangladesh. However we also believe that the SDG and Blue Economy are mutually reinforcing and SDGs can serve as a guiding methodology for governments to implement, calibrate and prioritize national programs on Blue Economy.

3. The UN Decade of Ocean Science, which runs from 2021 to 2030, was officially proclaimed by the United Nations General Assembly in 2017. The main objective of this Ocean Decade is to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the ocean. In fact, scientific understanding of the ocean's responses to pressures and management action is fundamental for sustainable development. As mandated by the UN General Assembly, the Intergovernmental Oceanographic Commission (IOC) of UNESCO is coordinating the Decade's preparatory process, inviting the global ocean community to plan for ocean science and technology to deliver, together, "the Science we Need, for the Ocean we Want". On the occasion of the UN Decade of Ocean Science, BSMRMU has taken this unique initiative of arranging the country's first international seminar on the UN Ocean Decade, when we aim to discuss about the 7 ocean decade outcomes namely, a clean ocean, a healthy and resilient ocean, a productive ocean, a predicted ocean, a safe ocean, an accessible ocean and finally an inspiring and engaging ocean. The seminar has accordingly been divided into two plenary sessions, three parallel technical sessions and a Poster Presentation Contest on Oceanography, Marine Biotechnology and Marine Fisheries.

4. Ladies and Gentlemen, BSMRMU is the first maritime university in Bangladesh, and it offers courses and programs at the undergraduate and post-graduate levels in a wide variety of ocean-related disciplines, such as oceanography, marine biotechnology, marine fisheries, naval architecture and marine engineering, offshore engineering, environment and climate change, so on so forth. However, in near future, we nurture the ambition of having our own Oceanographic Research Vessel, which can be extensively used in the Bay of Bengal by all the ocean science students and researchers across the country for primary data collection and analysis for the optimum exploration and exploitation of our sea resources. We seek kind support and blessings at the appropriate level of the government.

5. In order to pursue the overall vision of ocean science and integrated ocean management, BSMRMU is also going to sign MoU for academic collaboration with University of Goa. I thank the Vice Chancellor of University of Goa Prof Harilal Menon for kindly accepting our invitation for this noble initiative.

6. Finally Ladies and Gentlemen, I hope this seminar will be a great learning experience for all the participants. Before I conclude, I would once again extend my heartfelt thanks to the Chief Guest Hon'ble Deputy Minister for Education Barrister Mohibul Hasan Chowdhury, MP. My gratitude to the Distinguished Session Chairs, Panelists, Seminar Sponsors, our strategic partners from Netherlands under Nuffic Project namely STC International, CINOP and IHE Delft and all the participants for being with us for this day long seminar.

Thank you, Ladies and Gentlemen.

Joy Bangla.

Speech by Chief Guest

Barrister Mohibul Hasan Chowdhury, MP

Deputy Minister, Ministry of Education,
Government of the People's Republic of Bangladesh

The Keynote Speaker, The Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs, Rear Admiral Khurshed Alam (retd)

The Vice Chancellor, Bangabandhu Sheikh Mujibur Rahman Maritime University, Rear Admiral Khaled Iqbal (retd),

Distinguished Session Chairs, Scholarly panelists from both home and abroad, Senior Govt Officers, Academicians, Maritime Stakeholders, Dear Students of BSMRMU

Ladies and Gentlemen, Assalamu Alaikum and Good Morning.

1. It gives me immense pleasure and satisfaction to express my sincere appreciation for the excellent initiative by Bangabandhu sheikh Mujibur Rahman Maritime University (BSMRMU) in arranging an international maritime seminar on 'Un Decade of Ocean Science 2021-2030: Imperatives for Bangladesh'. I am indeed delighted to be part of this very important seminar that attracts a great deal of focus and interest all over the world, especially those who have identified Blue Economy as a thrust sector for country's sustainable development. I am sure the audience and specially the academic community are very much excited to learn from the viewpoints and ideas of the experts and other learned intellectuals present today about this highly relevant theme on ocean science.

2. At the outset, I would like to pay my sincere homage to the greatest Bengali of all times our father of the nation Bangabandhu Sheikh Mujibur Rahman whose visionary leadership has given us an independent Bangladesh with a lofty aspiration of peace, progress and development. Iimmediately after our independence, he made his all-out efforts for the revival and reconstruction of our country and laid a strong foundation in every sector of national development. Bangabandhu revived our maritime glory and realized the indispensable significance of the maritime resources and industries in order to achieve national prosperity. Inheriting the vision and foresight from Bangabandhu, his able daughter the Hon'ble Prime Minister Sheikh Hasina has launched our country along the highway of development as a happy, prosperous and developed Bangladesh by 2041. In addition to a large number of national mega projects, the maritime industries and resources like ports & shipping, ship building, ship recycling, oil & gas, marine fisheries & aquaculture etc also received substantial boost. Her successful leadership in the peaceful delimitation of our maritime boundary in the Bay of Bengal, Bangladesh Delta Plan 2100 for next Century and other prudent and visionary Blue Economy initiatives have also given us the hope and courage for a developed Maritime Bangladesh. It is high time that we refine our knowledge of marine science and make sustainable use of our sea areas based on ocean science and technology.

3. Ladies and gentlemen, the oceans are intertwined with every aspect of human life. The very reason our blue planet looks blue is the oceans, which cover more than 70% of the Earth's surface. In addition, the ocean is crucial to our economies and livelihoods. It is thus needless to explain that if we do any harm to the oceans, we do it to our own detriment. UN declaration of Ocean Decade is a commendable initiative in bringing this issue under the spotlight. This special seminar on ocean science will surely trigger our thought process about optimum utilization of our ocean resources without compromising with the biodiversity and ecosystem integrity of our oceanic system. Now that we have set our eyes on reversing the cycle of declining ocean health in a concerted manner, it is essential for us to bridge the knowledge gap between the scientific community and other stakeholders related to the oceans. As such the theme of today's seminar on ocean science is absolutely critical for our survival as a self reliant nation.

4. It is encouraging to note that the seminar topics have been chosen very carefully, covering wide-ranging disciplines of ocean science, ranging from oceanography to marine biotechnology to marine fisheries. I am particularly happy to see that in addition to the plenary sessions, the University has also included separate technical and scientific sessions and poster presentations in the daylong seminar.

5. Ladies and gentlemen, the objectives of the UN Decade of Ocean Science cannot be achieved by a single actor alone, rather it would entail a regional approach and sometimes global. We can achieve the expected outcome only if we adopt a united and holistic approach so that we can leave behind a sustainable and productive ocean for our future generations. However, we should not lose sight of the fact that all the Universities with ocean science faculties and other research institutes have to work in coherence for the greater cause of a productive, predicted and a safe ocean.

6. Ladies and Gentlemen, I would like to express my sincere thanks to all the distinguished speakers and participants for joining this Seminar making important contribution. My appreciation to the Vice-Chancellor of BSMRMU Rear Admiral Khaled Iqbal and his team for organizing this seminar. I'm certain that this seminar will facilitate marine professionals, researchers, policymakers and stakeholders to develop their understanding of ocean science and thereby promote ideas and thoughts not only to recover our ailing oceans but also to maintain them in a healthy state.

7. I wish BSMRMU every success in its future endeavors for transforming into a Regional Centre of Maritime Excellence.

Joy Bangla.

KEYNOTE PAPER

Ocean Science – Gateway to Sustainable Development

Rear Admiral Md Khurshed Alam (retd)

Abstract

With a view to support the realization of Sustainable Development Goal 14 of the 2030 Agenda for Sustainable Development along with the associated targets and indicators, the UN General Assembly proclaimed a Decade of Ocean Science for Sustainable Development ('Ocean Decade') to be held from 2021-2030, that coincided with the final ten years of the 2030 Agenda. The proclamation is an acknowledgment of the importance, need for and role of ocean science, data and information exchange for sustainable development, and that science can play an important role in helping the ocean support the 2030 Agenda. The Decade requires response and delivery from the IOC and other UN bodies, the scientific community as a whole, working in close contact with governments, industry, and business, as well as with the civil society.

The ocean plays a vital role in sustainable and equitable development. Sustainable development in general, largely depends on having sustainable ocean. According to Ocean Decade Implementation Plan, 'Ocean science encompasses natural and social science disciplines; the technology and infrastructure that supports ocean science; the application of ocean science for societal benefit, including knowledge transfer and applications in regions that are lacking science capacity; and the science-policy and science-innovation interfaces. It considers the land-sea, ocean-atmosphere and ocean-cryosphere interactions. Ocean science recognizes, respects and embraces local and indigenous knowledge'. As such the idea of the Ocean Decade is to achieve a major change in the knowledge and management of the ocean. It is reflected in the two over-arching goals that provide the high-level motivation for the Decade, which are (1) to generate the scientific knowledge and underpinning infrastructure and partnerships needed for sustainable development of the ocean; and (2) to provide ocean science, data, and information to inform policies for a well-functioning ocean in support of all Sustainable Development Goals of the 2030 Agenda.

The Decade will aim to achieve considerable progress in a number of research and technology development areas with a view of generating the following six societal outcomes all of which requires significant amount of ocean related scientific observations, data, research works, etc.

a. A clean ocean, whereby sources of pollution are identified, quantified, and reduced and pollutants removed from the ocean in an efficient manner.

b. A healthy and resilient ocean, whereby marine ecosystems are mapped and protected, multiple impacts on them, including climate change, are quantified and, where possible, reduced and provision of ocean ecosystem services is maintained.

c. A predicted ocean, whereby society has the capacity to understand current and predict future ocean conditions and their impact on human well-being and livelihoods.

d. A safe ocean, whereby human communities are much better protected from ocean hazards and where the safety of operations at sea and on the coast is ensured.

e. A sustainably harvested and productive ocean, ensuring the provision of food supply and alternative livelihoods.

f. A "transparent and accessible" ocean, whereby all nations, stakeholders and citizens have access to ocean data and information technologies and the capacities to inform their decisions.

Introduction

In the Ocean, the effects spread far and wide. The sea as a whole is therefore called one of the global commons, and that creates concern, especially when it comes to management. Whatever is common, nobody owns it, no one looks after it. Managing such area thus becomes difficult. For the same reason today the Ocean is under threat both from shore based as well as seaborne activities. In areas beyond national jurisdiction, virtually no one regulates human activities. Nonetheless, it can still be achieved through awareness building in line with the climate change and its impact on the nature, which is the result of harnessing the ocean resources unsustainably due to lack of proper ocean management. It is our fault. May not be Bangladesh's fault to a great extent, rather all the developed countries are mostly responsible for it. Climate change is having a lot of effects; sea is getting warmer, cyclones are frequent, sea level is rising, erosion, tidal surges, the list will go on and on. Impact of climate change are now being experienced almost everywhere.

Ocean as One of the Global Commons

Let me begin with a little bit of history. During the Jurassic period, i.e. two hundred million years ago, the earth's continents were lumped together and then the tectonic plates started to shift and probably fifty million years ago, the Indian plate, with the would be Bangladesh, was an island just like Australia. The Atlantic Ocean was not there and was just being created. The thickness of the solid Earth's crust is only about 80 kilometers and underneath it, up to two thousand eight hundred kilometers, is the mantle with full of lava. The temperature there is about seven hundred Celsius - very high temperature unleashing energy capable enough to move the tectonic plates, both oceanic as well as continental. Indonesia is located between two such continental plates: The Australian Plate and the Eurasian Plate; and between two oceanic plates: The Pacific Plate and the Philippine Sea Plate. The subduction of the Indian Plate beneath the Eurasian Plate formed the volcanic arc in western Indonesia, one of the most seismically active areas on the planet with a long history of powerful eruptions and earthquakes, which sometimes result in Tsunamis like that of 2006. That Tsunami not only affected Indonesia, its waves travelled up to the shores of India and Sri Lanka.

SDG 14

If we consider the 3 tiered conceptual arrangement of the Sustainable Development Goals (SDGs), we shall find the biosphere related goals at the base level, of which, Goal 14 or 'Life below Water' is one. (figure 1). The 3 tier concept denotes that the middle and top tiers, i.e. 'Society' and 'Economy' respectively, can thrive only if the base layer is strong. Society or economy, can only flourish if biosphere, i.e. the land as well as of the sea, is understood and taken care of. We need to be cognizant about the fact that 71% of this biosphere is sea which is looked after by Goal 14 of the SDG, and perhaps that is where we are committing much of the mistakes. We are so busy in the in the land, that we hardly care about the health of our Ocean, especially in terms of sustainable development goals.

Sustainability depends on three things: ecology, economics and society. Ecology plays a very important role in achieving sustainability. Today we are ignoring the ecology at our own peril, while economy is what we are all after. But for something to be economically viable, it has to be efficient, as well as competitive; only then growth will follow. Most of the nations in the world today, are after these three things – efficiency, competitiveness and growth. Everybody would like to have efficient mechanisms, efficient machineries, efficient methods/ processes so as to attain the desired level of competitiveness, and through these two, a healthy GDP growth rate.

UN Decade of Ocean Science

Since, a healthy biosphere is a pre-requisite to economic prosperity as well as for achieving SDG 14, the United Nations General Assembly (UNGA) proclaimed a Decade of Ocean Science for Sustainable Development ('Ocean Decade') starting from the year 2021, that coincided with the final ten years of the 2030 Agenda. The proclamation is an acknowledgment that the scientific knowledge and understanding the oceans along with effective measures is a must for sustainable societal development, and that science can play an important role in helping the ocean support the 2030 Agenda. The Ocean Decade harnesses, stimulates and coordinates interdisciplinary research efforts at all levels, in order to generate and use knowledge for the transformational action needed to achieve a healthy, safe, and resilient ocean for sustainable development by 2030 and beyond. Accordingly, the stated mission of the Ocean Decade is to achieve transformative ocean science solutions for sustainable development, connecting people and our ocean. The Decade thus requires response and delivery from the IOC and other UN bodies, the scientific community as a whole, working in close contact with governments, industry, and business, as well as with the civil society.

In the eighties we could only go down fifty meters of the water, but today science has given us the capability to go down up to eleven thousand meter, albeit available for the developed countries only. No transfer of technology has taken place in this regard. Although there is an entire chapter in the united Nations Convention on the Law of the Sea (UNCLOS) on the transfer of technology, but in the last forty years of its existence there is hardly any transfer of technology from the developed countries to the developing countries. UN decade of ocean science has rightly identified the need to bridge the gaps of technological disparities by improving the scientific knowledge base through capacity development in regions and groups that are presently limited in capacity and capability.

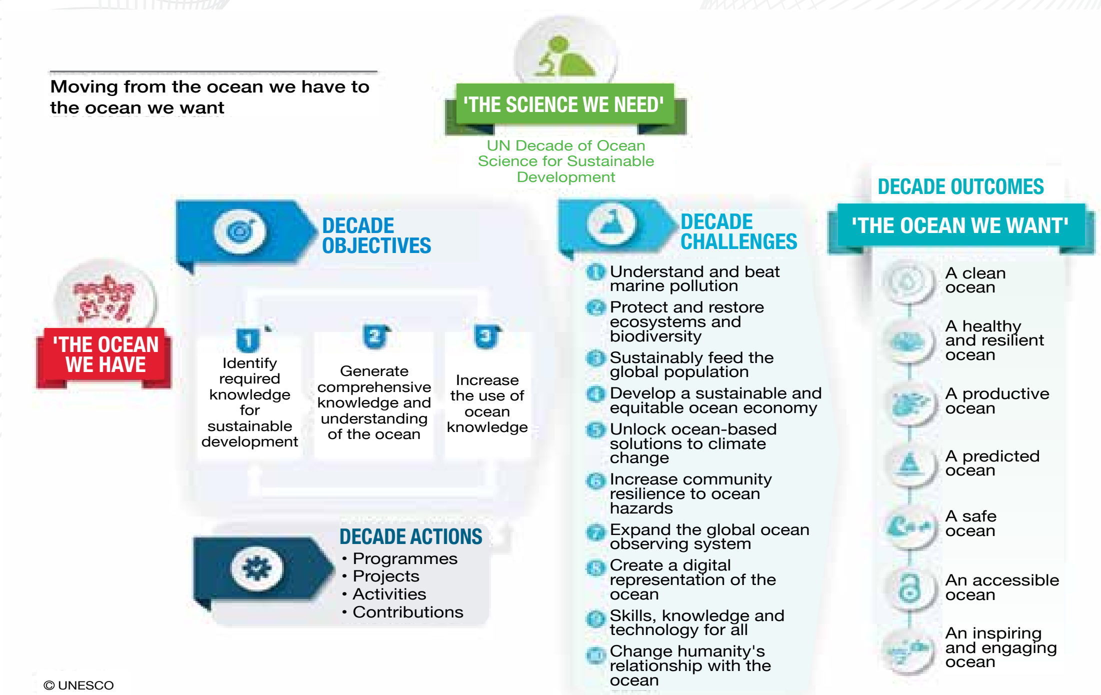
The Ocean Decade Outcomes

UN has outlined seven decade outcomes that would represent the ocean we want for a sustainable future which are: a clean ocean where sources of pollution are identified and removed, a healthy and resilient ocean where society has the capacity to understand current and future ocean conditions, a predicted ocean where society has the capacity to understand current and future ocean conditions, a safe ocean where people are protected from ocean hazards, a sustainably harvested and productive ocean ensuring the provision of food supply, a transparent ocean with open access to data, information and technologies, and an inspiring and engaging ocean where society understands and values the ocean. In order to achieve these goals, we need conduct research and developments in these priority areas. Again, these are all interlinked. For instance, if we talk about having a sustainably harvested sea, then we shall also require a clean ocean. It is not possible to single out one of these seven outcomes and work on it, leaving behind the rest six.

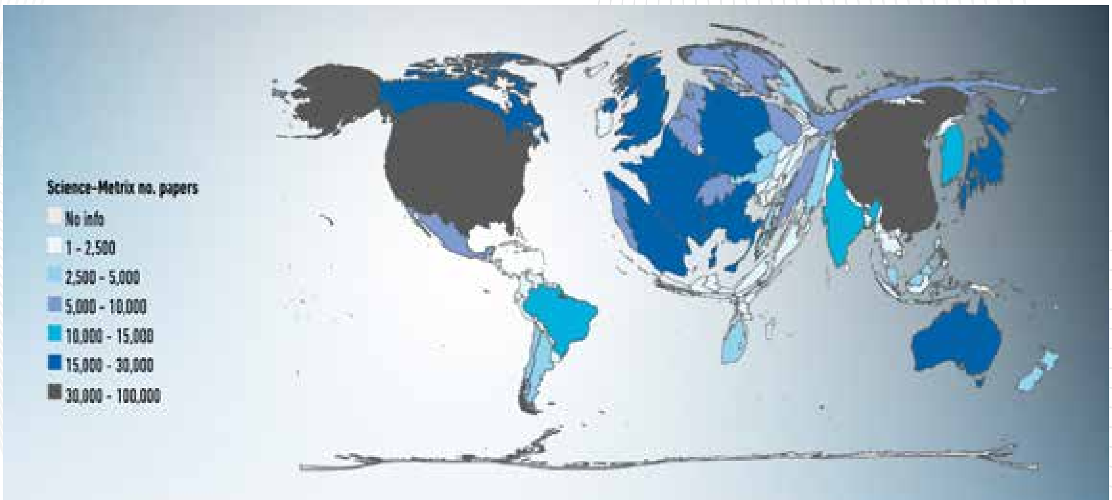
Not only to have fish and other animals or other living beings under the sea, we need these ocean decade outcomes to transform our ocean by adopting science-based solutions to sustainable development, by connecting people and our ocean. Unless we, the human beings - eight billion of us, understand and realize that ocean plays an important part, science alone cannot help us. Eight billion of us must understand that we must adopt and accept this science so that the ocean we have can be transformed into the ocean we want. So it has to be an all-out effort involving not only scientific community but also the society at large, the governments, the private sectors, business community, etc. Only then we can possibly formulate a pragmatic policy; a policy which will keep the ocean predicted, clean, safe, transparent, and useful for the human being. The Ocean Decade provides a lifetime opportunity for all of us, to work together at the global scale to achieve our shared goal from our shared ocean.

The Ocean Decade Challenges

The challenges in achieving the Decade Outcomes are many. The major challenges that have been identified are shown in figure 2. These are, to understand and beat marine pollution, protecting



and restoring ecosystems and biodiversity, to sustainably feed the global population (although much of the food for the human population doesn't come from the sea - it produces only four percent), developing a sustainable and equitable ocean economy also called blue economy, unlocking ocean-based solutions to climate change, increasing community resilience to ocean hazards, expanding global ocean observing system, to create a digital representation of the ocean, to develop skills, knowledge and technology for all, and finally to change humanity's relationship with the ocean. The climate change phenomenon, especially is going to eat up much of the works we have done for the benefit of mankind. Global ocean science capabilities on the other hand are unevenly distributed as can be seen in figure 3. Much needs to be done to minimize such disparities, but the starting point should be building awareness. Such awareness building efforts should not remain confined within the four walls of academia, rather it should spread across the wider social spectrum involving scientists and researchers, policy makers, business community, service users, etc. The universities have a bigger role to play here not only by research and analysis, but also through developing ocean-science oriented human resources.



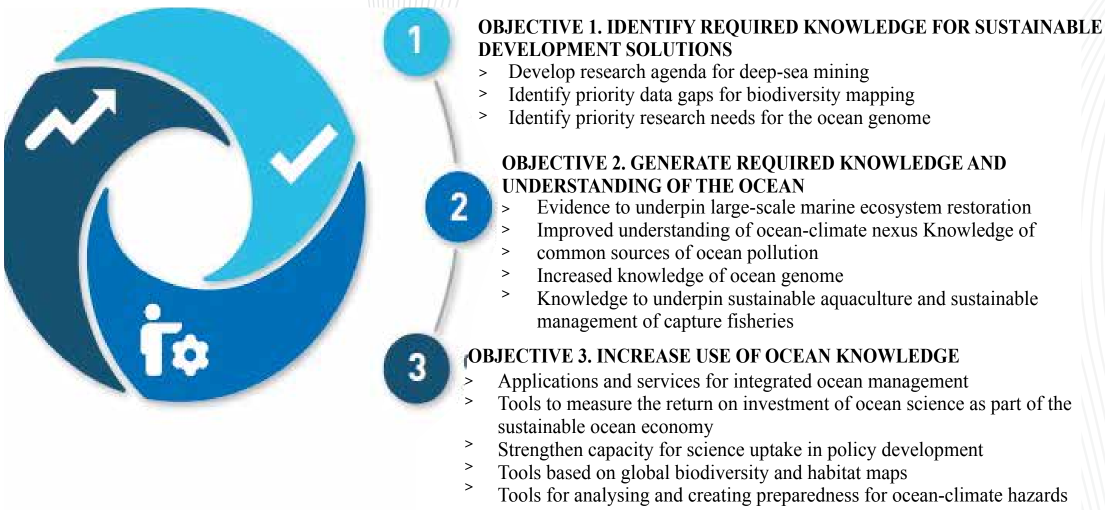
Publication map of the world. The area of each country is scaled and resized according to the number of ocean science publications. Different colours indicate a different number of publications.

Source: Global Ocean Science Report, IOC/UNESCO, 2017

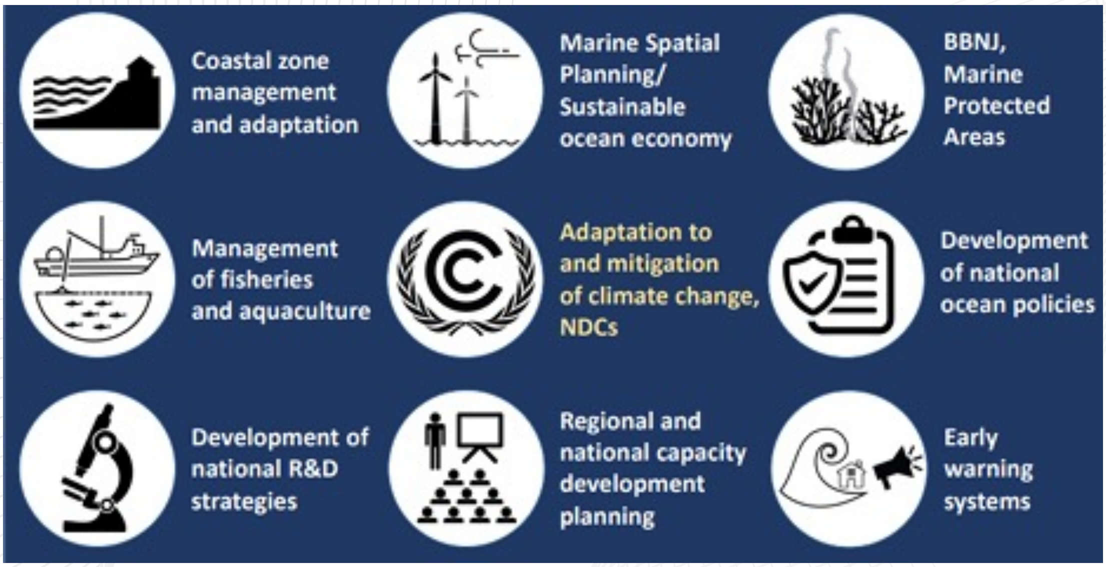
The Ocean Decade Implementation

To achieve the vision of 'the science we need for the ocean we want', the Ocean Decade – via its Implementation Plan – sets out a framework to catalyze transformative ocean science solutions for sustainable development, connecting people and the ocean. Besides the ten Ocean Decade Challenges the Ocean Decade Action Framework contains three objectives that represent three critical steps in the ocean science value chain, i.e. the identification of knowledge needs, the generation of knowledge and the use of that knowledge, all supported by extensive capacity development (figure 4). To achieve these objectives, action plans will be formulated in the form of programme, projects, activities, and contributions (figure 2). These actions plans can be based on various subjects, such as marine pollution, coastal zone management, marine protected area, fisheries management, marine spatial planning, developing national ocean policy, etc. (figure 5).

National Ocean Policy, especially, is of utmost importance. Many issues can be easily resolved with a national ocean policy.



Source: IOC-UNESCO. 2021.



National R&D strategy, is yet another aspect which we are lacking at present. We have very less amount of money allocated for research and scientific studies - it is not worth mentioning how much money is apportioned from our annual budget. We need to improve upon this. Whatever we may have, until and unless we allocate more money, it is not going to help us.

There is also the need for regional capacity development. The Intergovernmental Oceanographic Commission (IOC) functions under the auspices of UNESCO which has a regional committee for Indian Ocean named 'IOC Regional Committee for the Central Indian Ocean' (IOCINDIO) since 1980s. It's a Paris based organization. Under the IOC, no other ocean remained at the level of committee except Indian Ocean. We have sub-commission in the IOC Western Pacific Ocean (WESTPAC), we have sub-commission in the Africa (IOCAFRICA), we have sub-commission in the Caribbean (IOCARIBE), and all other areas, but not the Indian Ocean. However, as the incumbent Chair of the IOCINDIO, Bangladesh has taken up initiative to upgrade it to a sub-commission.

Establishing Early Warning Systems is also an important requirement which cannot be fulfilled without having regional cooperation. As regards to Coastal Zone Management, a lot of studies have been going on. Marine Spatial Planning is again a challenging area where we haven't done much. but we need to probably do. In establishing Marine Protected Areas, encouraging progress is visible as we have brought 8.83% of our total area under Marine Protected Areas. We need to increase it to 30%, while having 10% would suffice to meet the international requirement. In terms of management of fisheries, a lot needs to be done. Nevertheless, we have signed the national plan of action on IUU fishing. Every year, we are successfully implementing a sixty-five days' prohibition on fishing besides putting a seven months long halt on the Jatka (immature Hilsha) fishing, and a twenty-two days of fishing ban on Hilsha. I wish that our neighboring countries would followed the same. We should also make national contributions to the UNFCCC.

So we need ocean policies and sustainable development in line with UN entities and intergovernmental organizations on the one hand, and civil society, and the ocean science and technology on the other. Business and industrial sectors must also come up. That is an important area. Donors and foundations must be persuaded to contribute to the development of the maritime sector. Maritime professionals who are at an early stage of their carrier, must develop a better understanding of the ocean. Only then the ocean decade's objective will be fulfilled. The media also has a vital role to play here. But unfortunately, even in Bangladesh, we don't see much coverage on the ocean. There are many maritime professionals capable of prolific writing, do not write on the ocean and bring awareness among the peoples. Although the peoples from the locality of coastal areas have some indigenous knowledge, but it does not reach the public sphere.

Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU) can play a pivotal role in engaging all the diverse stakeholders while building public awareness. To move forward towards achieving the ocean decade goals, we can establish a network of stakeholders or become a member of the ocean decade alliance, and join the other groups and engage both nationally as well as internationally. Central to the ocean decade is its goals. If we want to achieve all these goals, we have to design our transformative actions, i.e. who should do what and based on which policy. If those policies are shared openly and available for everybody, only then probably it will be helpful for all of us. We need physical essential ocean variables, we need physical, biological and biochemical actions to be taken together and that is not very far if we can widen the ocean literacy, which has already started taking pace through the universities, colleges and other areas. We also need the state of the art equipment and gadgets for enhancing the ocean literacy, where we still lack. Yet, we have to commit ourselves to increase the ocean literacy despite all the shortcomings. To that end, we would have to understand the challenges.

We also need to increase the community resilience to ocean hazards, e.g. the cyclones, the erosion, tidal surge, etc. We are not getting much from the global ocean observation system. Not much contributions are being made to create the digital representation of the ocean. Data, information and knowledge, which are essential for global observation systems or digital representation of the ocean are so less, in fact we almost don't have any primary data in this country. Most of the data that are used by our teachers and researchers are secondary data. In many cases these are not even related to Bangladesh. So, whatever researches are conducted, utmost efforts are needed to use primary data, which means the researcher must travel to the sea to collect the data, and also share it with the universities like BSMRMU or Bangladesh Oceanographic Research Institute. That is how we would get the people we need for the ocean we want. It is not only the science we need for the ocean; we also need the people. That means each one of us must play the role wherever we are, be it industry, or agricultural field, universities, we must come together. We need to put more efforts in the field of research, especially during the monsoon. Our next door country India has gone much ahead, but Bangladesh, Myanmar and many other countries are far behind in the research using ocean data during the monsoon. If all of these are accomplished properly, we can hope to have an ocean we want.

Bangladesh, let me come back to this very small country, as we call it, but is it so? The map viewed upside down (figure 6) changes our perception of its size in terms of territorial boundary, because of its access to the ocean beyond national jurisdictions. You don't need passport and visa to go to this vast ocean, nobody will even ask you. All you need is a ship and skilled manpower to steer it. Such skilled manpower is being created in the universities and institutes like BSMRMU, marine academies, BORI, etc.

In Africa, when a gazelle wakes up, it knows that it must outrun the fastest lion, otherwise it will be its last day of life, on the other hand, when a lion in Africa wakes up, it knows that it must outrun the slowest gazelle otherwise it will starve to death. Likewise, for the survival of our planet, whether we are in the industry or in the government or in the school, living whether or not in the coastal areas, we all need to act fast. We all have a duty to save our oceans. If we can perform that duty well, only then the decade of ocean science will be successful. The efforts of the BSMRMU in arranging the seminar will have some influence towards achieving the objectives set by the decade of ocean science.

Conclusion

We are polluting the ocean at a massive scale which must be reduced immediately, especially the use of plastics. Although in Bangladesh, use of thin polythene and plastic bags has been banned by the government since 2002, but many other forms of plastics are in use. For instance, cosmetics items like lipsticks, foundation cream, etc. contains micro plastics which ends up at sea, as a major pollutant which are in turn eaten by the fishes. Since plastic cannot be digested, when we eat that fish, we take the micro plastics along with it, which can ultimately cause cancer. Probably that is why if we carry out a survey today, we would find that in every hundred families there is one cancer patient. Whereas if we look back to the nineteen seventies, there were not so many cancer cases. Another big polluter in the ocean are the ships. All the merchant ships, more than one hundred and fifty thousand ships are moving around the globe providing the much needed transportation of about eleven billion tons of goods from one country to another at the cheapest cost. But we need to minimize the pollution these ships are causing to the ocean in the form of oil leakage, or carbon emission, or in any other forms, to an acceptable level. Although at the end of the day, all we want is economic prosperity, GDP growth, profit maximization of the country. But for us, the human society, what we need is 'Bionomy', a growth involving life-science that strikes a peaceful balance between economy and livability. We want GDP plus ecology. If we do not look after the ecology, our apple of economic growth will have worms inside. Our growth could be eight percent, nine percent or in double digits, but if we destroy the rivers and oceans they wouldn't have oxygen. Without oxygen, there will be hypoxia and many other problems. Such growth of our economy will happen at our own peril. So the ultimate aim or objectives of any government or any policy maker should be to achieve the optimal development and marginal happiness. for you and me, that marginal happiness will not be there. It's the time to decide whether we should go for the economy or GDP plus ecology.

DISCUSSIONS/ Q & A

Q.1. Dr. Zahid Khan a retired Bangladesh Air Force Group Captain from Bangabandhu Sheikh Mujibur Rahman Aviation University asked whether or not there is any possibility to move from a the presently held legally non-binding notion to a binding regime when it comes to ocean-governance?

Ans. In fact, international conventions are bindings such as UNCLOS. For the Parties to the UNCLOS, it is legally binding to comply the convention which includes protection of marine environment. Even the areas beyond national jurisdiction, i.e. the High Seas, that lies beyond 200 nautical miles from the baseline of the Coastal States, fall not only under the laws of UNCLOS but also under 70 odd regulations of IMO. Besides, in addition to the Coastal Biodiversity Regulations of the 1990s, another regulation is being formulated for the last 5 years, known as Biodiversity Beyond National Jurisdictions (BBNJ). There is another authority called International Seabed Authority, which regulates the exploration and exploitation of seabed minerals. However, despite their efforts to formulate various rules and regulations, they could not make much of a headway yet, primarily due to varied views on the impacts of minerals extraction.

Q.2. Dr. Zahid Khan asked if there is a regulation governing the detection, attribution and compensation for man-made environmental disasters such as oil spills occurring in our water?

Ans. If there is any oil spill in the Bay of Bengal it may spread across the maritime boundaries of the littoral states. Therefore, regional cooperation is needed to deal with such situations. Regarding the compensation, there exists mechanism for that, which can be availed provided the charges have been payed to the insurance company such as P&I Club and other charges prescribed by the relevant conventions. There are also detail procedures laid down for approaching the international authorities related to such conventions. These procedures and conventions are not taught in Bangladesh, as such we are more or less ignorant on this issue. For instance, during the Shela river oil spill incident, it took four days to sort out as to which ministry ought to look into the incident. There was a Japanese report for Bangladesh on the suggested procedures and actions during any oil spillage submitted seven years ago to the Ministry of Shipping, but has not yet been acted upon. However, since a committee as well as the sea ports are working on this issue as of now, soon a comprehensive mechanism to deal with oil spill is expected to be established. Nonetheless, a skeleton mechanism is there in place.

Q.3. Commodore Mahmudul Hassan (retired) highlighted that the ocean data collected by various entities for varied purposes needs to be stored in a central repository as the developed countries, so as to allow smooth data sharing, avoid duplication of efforts, and enable future use in research activities. He then asked about government's views and efforts taken (if any) on facilitating data collection from the sea as well as on establishing such repository along with relevant policies, guidelines and instructions on its use, data formats, etc.

Ans. We need to be cautious while following the developed countries. What is applicable for the US or the UK may not be suitable for us is the same manner. We may need to customize according to our context and requirement. We are lagging far behind. Presently, Bangladesh is at the stage of building the basic institutions. It is just recently, that BSMRMU and BORI have been established. Once these institutions would come up with enough data, perhaps then it would be appropriate to work on establishing a central repository. At this stage all the stakeholders may not agree upon data sharing or data formats, it would require some time for them to gain required experience and expertise. Having that said, still we should continue to try and establish a central repository may be at BORI – the largest maritime institute of the country. All the universities can store and share their data through BORI.

Q.4. Dr. Muniruzzaman Khandakar from Dhaka University asked if the government has any plan to acquire any Oceanographic Research Vessel which is an imperative for collecting ocean data.

Ans. We are still in growing up stage in the realm of ocean science. Each year our Ministry of Science and Technology allocates budget for research work which is very meager for conducting an oceanographic research. The fund allocated is not enough for even hiring a boat at sea. Efforts are underway to increase the funding so as to enable the researcher to go out at sea for collecting primary data. However, it wouldn't serve the purpose of a research vessel. In fact, the government wanted to buy a research vessel, but due to lack of experience and various stakeholder organizations' pressure to put their respective equipment, it could not be materialized. GSB also took an effort to acquire such a vessel, but that project also fizzled out due to manning issues. Now the BORI is getting a 20-meter vessel. Although it is small but it would at least resolve the boat hiring problem to a greater extent. Moreover, Bangladesh Navy (BN) has always been very generous in providing support to the universities and institutions for collecting ocean data at sea onboard BN ships. Such support if needed needs to be sought to the Navy through the Armed Forces Division (AFD). The stakeholders should utilize every opportunity to take up the matter to the policy makers.

Q.5 Keeping the objectives of Ocean Decade in view, Mr. Shanto, a senior reporter from Jamuna TV asked about the government's policy on utilizing the resources and economic opportunities in the maritime sector while combatting challenges like lack of skilled manpower, financial constraints, etc.

Ans. Although there is no government policy as such, but the country is not sitting idle. Already a work plan has been formulated on Blue Economy with the assistance of experts provided by the EU. If this plan can be materialized, then we would be able to sustainably utilize our ocean resources and thereby augment our sustainable development agenda. We have conducted a study on seaweeds with the financial aid of 300,000/- USD and expert consultant support from the Netherlands. It has been found that soap ingredients, fish feed and agar-agar yearly import of which is worth 35,000 crore taka, can be found in the seaweeds. A pilot project is being planned on seaweeds with a view to attract potential entrepreneurs. In BORI, many scientific studies are going on, similar activities would be seen in the labs of BSMRMU. Many progresses are being made but these efforts do not get the publicity through the media, especially the electronic media. The media houses thus should increase their coverage on the maritime sector.

Rear Admiral Md Khurshed Alam (retd)

Secretary, Maritime Affairs Unit
Ministry of Foreign Affairs, Bangladesh.

Plenary Session - I

Riding the Waves of Challenges of our Weary Ocean

Session Theme

There are major challenges and threats facing our ocean today, and, in turn, these lead to adverse consequences to human society. To this effect, reducing the climate change impacts, unsustainable use of the ocean, human activities that threaten & endanger the marine ecosystems, etc. need to be urgently & effectively addressed besides removing the barriers to conducting associated studies. Meeting the challenges of effective and sustainable ocean management begins with informed decision-making, which in-turn requires the capacities to produce and transfer knowledge. From such perspective, identifying and filling the critical knowledge gaps is important. The threats and challenges to the ocean health are many. Riding the waves of these challenges for achieving our goal to have the ocean we want, although seems to be a daunting task, but may not be so, when powered by scientific knowledge and bolstered by the committed engagement of all stakeholders.

Plenary Session I, Talk - 1

Reversing the planetary crisis of climate change with ocean-science

Marine Atmospheric boundary layer dynamics-a factor controlling direct aerosol radiative forcing (DARF) and atmospheric heating rate in the Indian Ocean sector of Southern Ocean

Professor Dr. Harilal B. Menon

Abstract

One of the greatest challenges of analysing climate impacts is incorporating the effects of aerosols due to their immense diversity, not only in terms of particle size, composition and origin, but also their spatial and temporal distributions (IPCC et al, 2014). Such variability makes it interesting to assess the aerosol radiative forcing on a global scale. An understanding of their chemical composition is essential in identifying their sources, sinks and their impact on insolation. Emissions from organically produced, phytoplankton, and those of wind-mediated sea spray and anthropogenic activities are the major sources of aerosol over a marine environment. Though many studies have been reported from Pacific and Atlantic sectors of Southern Ocean, there was hardly any attempt to analyse the thermodynamics characteristics of MABL and its associated effect on aerosol distribution in the Indian Ocean sector of Southern Ocean. Present study has been carried out from data generated during three Southern Ocean cruises conducted between 30°S and 67°S between 57°E and 77°E. The measurements were carried out particularly over planetary scale oceanic fronts such as Subtropical, Sub-Antarctic and Antarctic Polar fronts. Therefore, in the study, attempt has been made to understand the science behind frontal based air-sea coupling in modulating MABL and the resultant spatial variability of columnar aerosols, including those of man-made ones. Subsequently, radiative forcing and heating rate were estimated. In addition to data from in-situ, re-analysis, modelled and satellite derived have also been used for the study. The in-situ data comprises of surface meteorological parameters, aerosol optical depth (AOD) and black carbon mass concentration, while the vertical distribution of thermodynamic structure was derived from radiosonde measurements. Cloud-aerosol Lidar and Infrared pathfinder satellite observations (CALIPSO), derived aerosols were used to study the vertical distribution of aerosols and cloud phases. Hybrid-single particle Lagrangian integrated trajectory (HYSPIT) version 4 of NOAA-ARL was used to analyse the remote advection of aerosols. A distinct spatial variability in the meteorological conditions have been observed near surface and at different altitudes over various frontal zones. These features further shows that there is a large accumulation of aerosols in the lower atmosphere confined below 1500 m indicating the role of inversion and subsidence in restricting the vertical dispersion of aerosols. Atmosphere over Polar front revealed a significant loading of dust aerosols along with elevated concentration of Black Caron (BC). Another interesting phenomenon seen is prevalence of anthropogenically originated aerosols (elevated smoke) at 3.7 km, which is likely to be originated

from South African continent. Similarly, various distinct observations were made at each frontal zones. Another significant result is a high concentration of BC, 250 ng m-3, at Polar front, highest concretion is 297 ng m-3 at 50°S. The estimated direct aerosol forcing (DARF) in the atmosphere was found to be varying across fronts with maximum over PF, which was between 1.33 to 1.98 W m-2. The corresponding heating rate was between 0.21 and 0.032 K day-1.

Introduction

For generations, the ocean has appeared to most humans as vast and impenetrable. Mysterious, dangerous, unfathomably large, but certainly not susceptible to being significantly altered by something humans might do. But over the past century, that understanding has changed—first slowly and then more dramatically—and now, the ocean appears smaller and more fragile than we once thought. We have unimpeachable evidence that humans can have a devastating footprint on the ocean: 20th century whalers decimated global populations of blue, fin, and sperm whales over just a few decades; factory trawlers are depleting today's fisheries; agricultural runoff has created enormous dead zones in the ocean; and plastic waste litters most of the ocean.

The rise in global atmospheric temperatures, Melting of Polar Ice - Icebergs are seen in polar waters. The Arabian Sea is getting warmed up, Cloud burst and instant flooding across the Indian subcontinent and elsewhere, Cyclones in the Arabian Sea and particularly along the coastal waters of the eastern Arabian sea during May, Vagaries of Monsoon, Heat waves are main concerns in ocean atmosphere.

And there is a far more dangerous human-caused stressor that has largely gotten a pass from scrutiny, even though it is creating existential threats to the ocean. That stressor is the carbon dioxide pollution we have released into the atmosphere over the past 200 years, with a significant portion finding its way into the ocean's upper layer. Over this time, we have increased CO2 levels by 50% in the atmosphere and by 30% in the upper layer of the ocean. This enormous amount of CO2 pollution has already had, and will continue to have, dangerous effects on the ocean.

Heat Budget of the Earth

The effects of CO_2 pollution on the ocean can be grouped into two large categories: thermal stress and chemical stress.

Thermal stress comes as the massive amounts of excess CO_2 we have put into the air trap an enormous amount of energy from the sun that would otherwise have dissipated into space—about 93% of all this excess heat is absorbed into the ocean. The quantity we are talking about is staggering, calculated at about 14 zetta joules of heat every year. For context, a joule is a basic measure of heat energy, and a zetta joule is that single unit with 21 zeros after it. As that amount is still difficult to comprehend, let's give it some additional context. Researchers have translated this into an equivalent measure: the amount of heat energy released by an atomic bomb the size of the one that detonated over Hiroshima. Fourteen zetta joules of heat energy going into the ocean each year is roughly equivalent to five atomic bombs' worth of heat energy going into the ocean every second of every minute of every day, year after year.

This means that, every day, 432,000 atomic bombs' worth of excess heat energy enters the ocean. And the quantity of heat has risen as atmospheric concentrations of CO_2 have increased. All this excess heat going into the ocean is literally unraveling the fabric of the system. Warmer ocean water holds less oxygen; already, there has been about a 2% average decrease in dissolved oxygen throughout the ocean. Warmer upper layers of the ocean inhibit mixing with the middle layer of

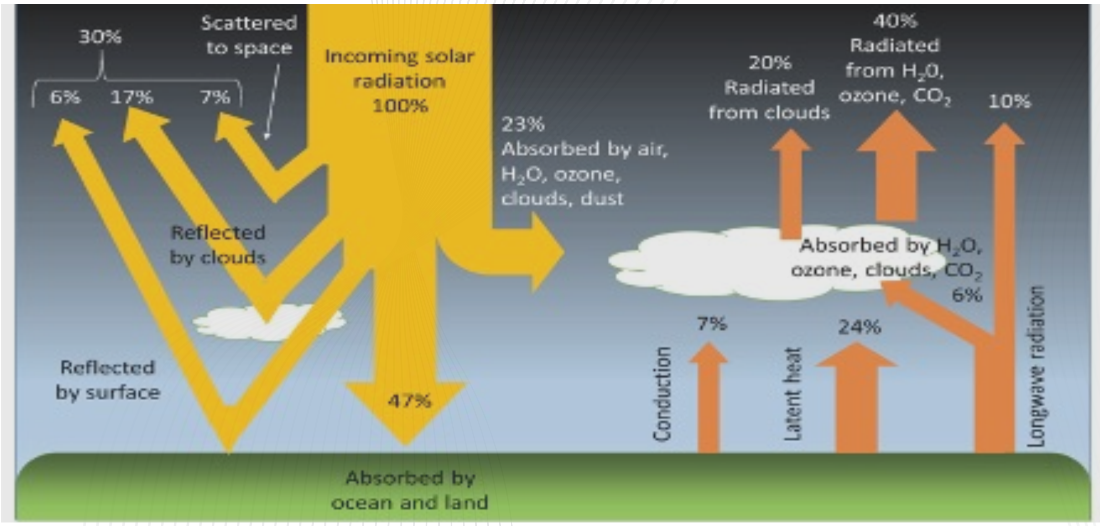


Figure 1*. The heat budget of Earth. Schematic is adopted from Webb (2021).*

the ocean, which is a primary exchange system that brings nutrients into the global food web. These warmer waters expand, and that expansion is causing a significant portion of the sea-level rise that coastal ecosystems and communities have been experiencing. Warmer waters also lead to marine heat waves that decimate coral reefs; we have already lost more than half of the Earth's tropical coral reefs primarily due to heating and bleaching. In addition, warmer waters are driving species that can migrate to do so; their move toward cooler water is leading to large-scale migrations of fish stocks poleward. And warmer waters mean less Arctic sea ice, which has functioned like a planetary air conditioning system that we all depend on (Brad Ack, 2022).

Carbon Cycle

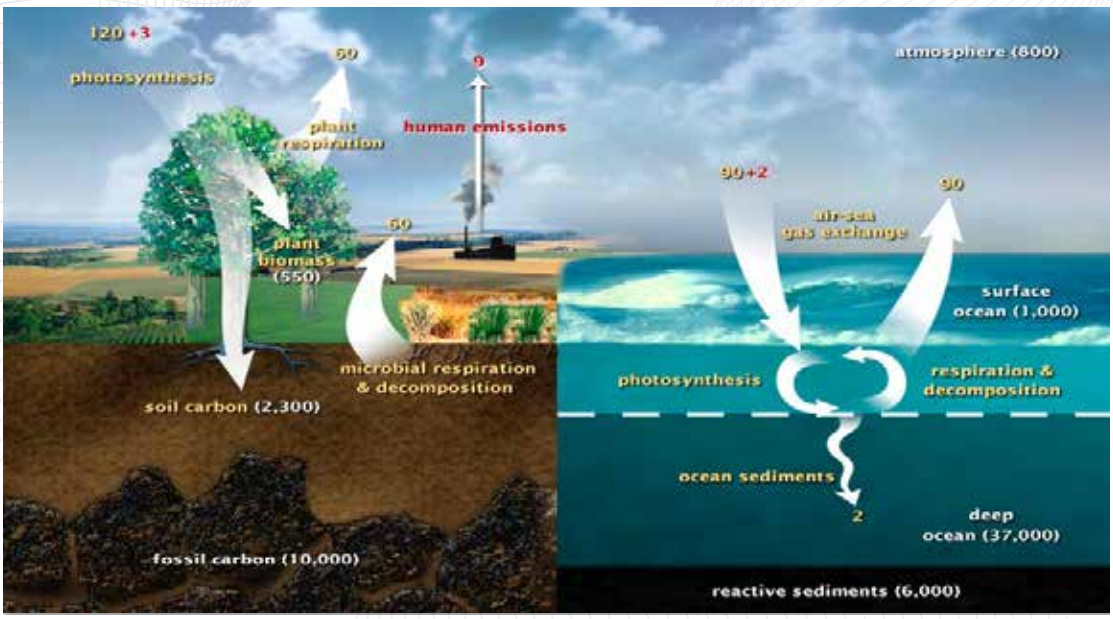


Figure 2. Fast carbon cycle showing the movement of carbon between land, atmosphere, and oceans. Diagram adopted from U.S. DOE, Biological and Environmental Research Information System. Retrieved from https://earthobservatory.nasa.gov/features/CarbonCycle.

Chemical stress is caused by about 25% of the total CO_2 pollution emissions being absorbed into the upper layer of the ocean, creating a chemical reaction known as ocean acidification. As the ocean absorbs this excess CO_2, it becomes increasingly acidic; today, the global ocean has become about 30% more acidic, on average, than it was in preindustrial times. As this massive shift in ocean chemistry increases, the ocean becomes less hospitable to all life that forms a shell. This notably includes many phytoplankton and zooplankton—the microscopic life forms that sit at the base of a number of oceanic food webs and are major producers of the oxygen we rely on.

Sea Surface Temperature Projections

The loss of Arctic sea ice means that more heat is being trapped on the planet rather than reflected back into space. This is leading to thawing of permafrost, which contains enormous stores of greenhouse gases. Regional warming is also accelerating the melting of the Greenland ice sheet, which appears to be slowing a critical ocean current in the north Atlantic—altering how the waters naturally circulate. We can now see and measure the harm that humans have done, and the conclusion is inevitable:

The climate crisis is an ocean crisis, and the ocean crisis is a climate crisis. Now, the question is, what can we do about it?

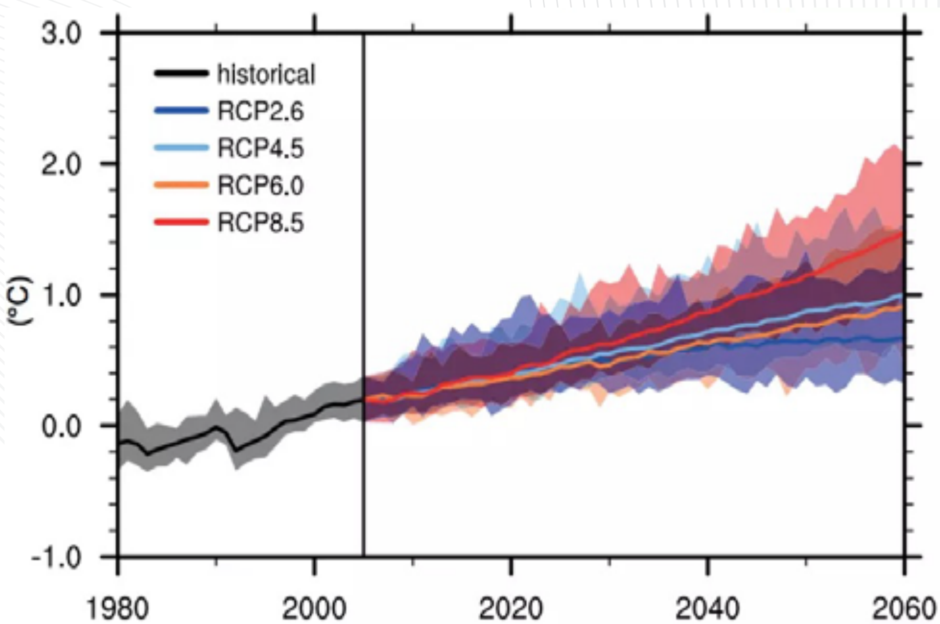


Figure 3. Representative Concentration Pathway (RCP) by IPCC under different 21st century scenarios. Shading indicates the 90% range of projected annual global mean SST anomalies. Retrieved from https://www.climatesignals.org/resources/chart-projected-changes-global-sea-surface-temperature.

Until recently, most efforts to mitigate climate change have focused on stemming the flow of greenhouse gas emissions into the atmosphere. But the world's leading body on climate science, the Intergovernmental Panel on Climate Change, has made it clear that at this late stage, even dramatically reducing CO_2 pollution emissions won't keep global warming from exceeding 1.5 degrees Celsius, which scientists describe as the tipping point of dangerous and potentially irreversible climate disruptions. We also need to remove billions of tons of "legacy" carbon dioxide pollution that is already overheating the planet and acidifying the ocean.

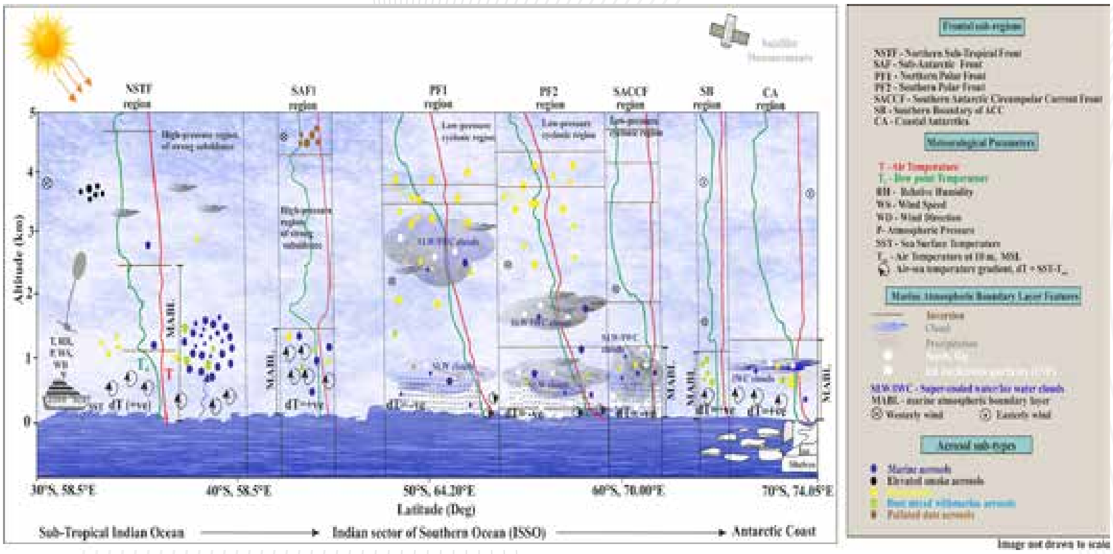


Figure 27: *A schematic depicting important thermodynamics in the low level atmosphere over the Indian sector of Southern Ocean (ISSO).*

The Climate System

This means quickly developing a host of technologies that can remove CO_2 from the air and water and safely store it as permanently as possible. These tools and techniques will range from the most natural, such as planting trees, to the most industrial, like employing direct air capture plants that operate as CO_2 removal factories and using electrochemistry to essentially strip CO_2 from the atmosphere. And there will be many other options in between, some of which have not been invented yet. When all is said and done, cleaning up the legacy carbon pollution that we have created is essential to slowing and ultimately reversing the ocean-climate crisis. Carbon cleanup will also have to become an enormous economic sector if it is to achieve a scale relevant to the problem. And the ocean will likely have an important role to play.

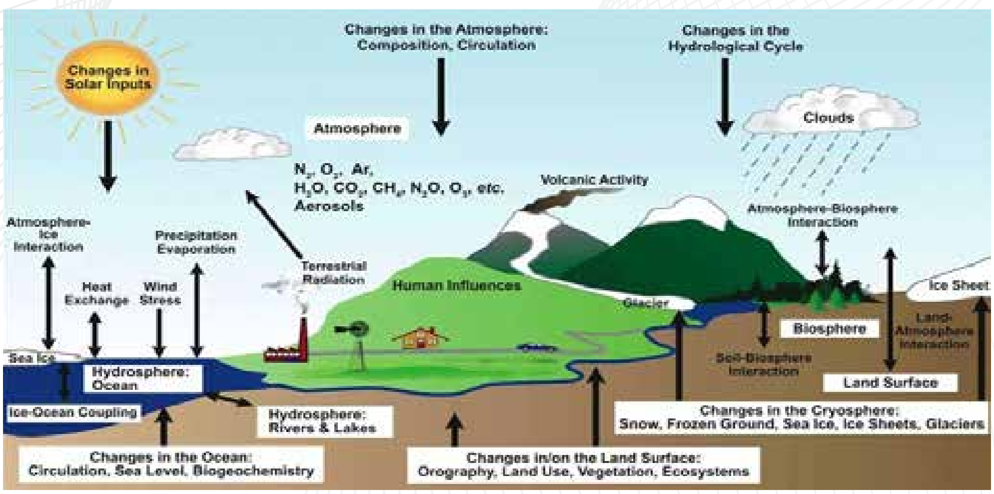


Figure 4. *Schematic of the components of the climate system, their processes and interactions. Source: Le Treut et al. (2007), Climate Change 2007: The Physical Science Basis. WG-I Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press.*

The ocean has enormous potential to safely draw down and sequester additional CO_2. The reasons are simple: The ocean is already the largest carbon cycler on the planet, using both biological and biogeochemical processes to move CO_2 from the air and land into the deep ocean. In fact, there is already roughly 50 times more carbon at the bottom of the sea than in the atmosphere. If we could increase that ratio by 1% to 2%, we could have a massive impact on reducing atmospheric concentrations of CO_2 and slowing, and potentially even reversing, the climate and ocean crises Ocean-based carbon dioxide removal (CDR) is a field that is in its infancy but growing up fast. Ocean-based CDR techniques essentially mimic, enhance, and/or accelerate oceanic biological and geological processes already underway.

Aerosols

Aerosols are one of the important components affecting global climate. They perturb weather and climate pattern either by scattering or absorbing incoming solar radiation. Being heterogeneous in spatial, temporal and global distribution, they are characterized by their shape, size and chemical composition. Therefore, multiple source generated aerosol species affect earth-radiation balance. This makes the estimate of global mean aerosol radiative forcing in the range -0.65 to -1.6 W m-2 at 68% confidence interval. Studies have revealed a large spatiotemporal variability in concentrations and optical properties of aerosols over different regions of the world ocean (Krishnamoorthy et al., 1998; Ramanathan et al., 2001; Menon et al., 2015) and the important factor that controls their variability is the dynamic state of Marine Atmospheric boundary layer (MABL); particularly its role in lower atmospheric stability, physical process, characteristics of cloud and atmospheric inversions (Turner 2020; Prasad et al., 2021). MABL acts as a shield for aerosols, produced in-situ and remotely originated. The coupled interaction of aerosols and MABL based on seasons and location makes it challenging to quantify the effect of aerosols on its evolution and thermodynamics. This leads to uncertainties in satellite retrievals of aerosols and radiative forcing, particularly in remote region like Southern Ocean where 80% cloud cover throughout the entire year adds further to estimate the forcing.

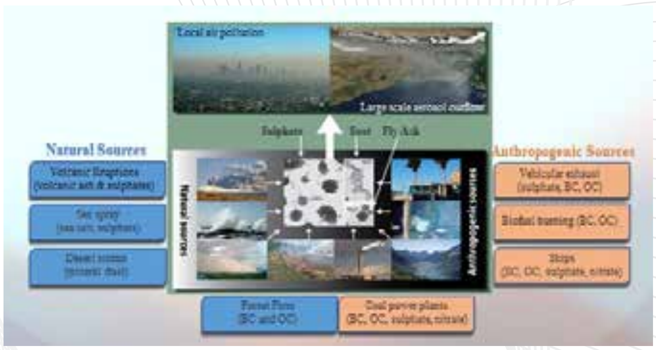


Figure 5: Classification of aerosols based on sources. Inset are SEM images of sulphate, soot and fly ash. Retrieved from https:// www.nature .com/scitable /knowledge/library/aerosols-and-their-relation-to-global-climate-102215345/.

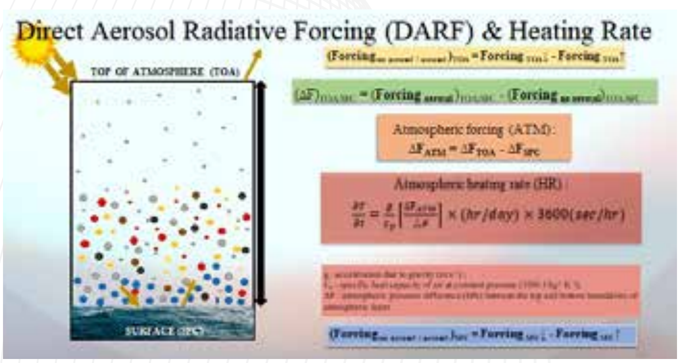


Figure 6: A schematic of clear-sky Direct Aerosol Radiative Forcing (DARF)

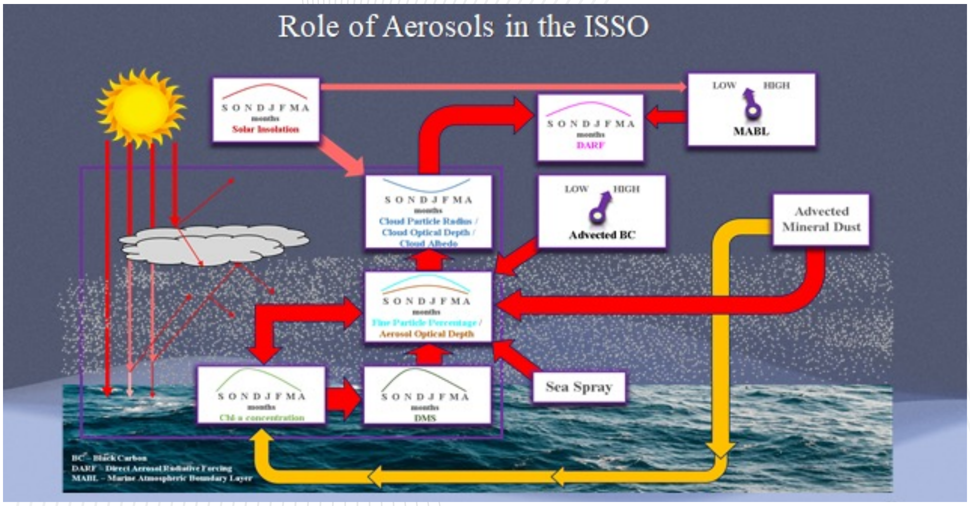


Figure 7: Schematic depicting the role of both locally produced natural aerosols and advected (anthropogenic and natural) aerosols in modulating the local weather in the ISSO

Conclusion

Technologies are being developed in each of these five domains to test the potential for permanent carbon removal and the associated economic, social, and environmental costs. For example, some people are building large autonomously operated platforms for growing seaweed in the open ocean and then using robotic harvesters to cut, bale, and sink it to the deep. Others are using wave-powered upwelling pumps that bring nutrients from the deep to the upper photic zone of the ocean to drive blooms of phytoplankton. And yet others are testing an array of ways to disperse alkaline material and liquids into the ocean to create chemical reactions that lead to CO_2 being moved to the deep. And this is just the beginning; as humans come to grips with the massive opportunity and challenge we face in cleaning up carbon, we will see a host of iterations as well as new ideas. But we are now in a race against time. There are only two ways to reduce atmospheric concentrations of CO_2—reduction and removal—and they have to be done together.

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Plenary Session I, Talk - 2

Capitalizing on Marine Biotechnology for a Sustainable Blue Economy

Professor Deborah M. Power

Abstract

The UN Ocean decade heralds a time when the world is facing new challenges that arise from continued population growth and decades of socioenconomic and developmental strategies based on terrestrial ecosystems. Exploitation of the worlds aquatic ecosystems that cover approximately 75% of the planet's surface can contribute to advance several of the UN sustainability goals, including no poverty (goal 1), zero hunger (goal 2), good health and wellbeing (goal 3), climate (goal 13) and life below water (goal 14). But how can Blue Biotechnology, the exploitation of biodiversity in marine environments, contribute to the revolution needed to achieve the ambitious UN targets? Marine ecosystems and organisms are largely unexplored and underutilised and marine biotechnology by generating knowledge about marine resources can unlock their potential so they can be the basis of new products and processes. The scope of activities in marine biotechnology includes pharmaceuticals, industrial enzymes, food ingredients, new chemicals, drug delivery systems and innovative and sustainable food production. There is no doubt that the marine domain has massive potential for biodiscovery and products, starting from the highly abundant and biodiverse microorganisms, through to plants (sea weeds, seagrasses) and up to the less abundant large animals. However, the pace of development of marine biotechnology has been slow and a new disruptive roadmap designed on ecological and sustainability principles and tailored to the needs and characteristics of each countries marine ecosystem will be important. Bangladesh with its vast and diverse maritime region has a unique opportunity to develop strong and sustainable processes based on marine biotechnology.

Introduction

Science and technological advance are context dependent and there needs to be social acceptance and engagement in the process of change so that it has strong foundations and does not fall when "winds are less favourable"! Keeping this in mind and considering the challenge that was set and was the genesis of this short essay I aim to provide an overview and some considerations of the factors that can hinder or promote a role for marine biotechnology in the blue economy. I make no excuse for not providing the answer to the challenge, there is no single solution or route towards sustainability, and only after deciding the objectives and desired outcomes can a strategy be defined for any area of the economy. I was asked to reflect and present a consideration about "Capitalizing on Marine Biotechnology for a Sustainable Blue Economy", an exciting question particularly considering the treasure chest of wealth and riches that Bangladesh holds in its numerous river systems (the major networks of the Brahmaputra-Jamuna, the Ganges-Padma, the Surma-Mehgna and the Chittagong) and the Bay of Bengal into which they flow, a unique ecosystem and environment.

As pointed out above, when charting a course for the capitalization of marine biotechnology the context is important. From a global perspective the UN agenda and sustainable development goals until 2030 that embrace the Ocean Decade that foresees ocean science for sustainable development (2021 – 2030) gives an ideal platform to launch an agenda for marine biotechnology and stimulate the creation and growth of a sustainable blue economy (https://en.unesco.org/ocean-decade). To efficiently develop a strong and resilient blue economy it is essential that there is a common language between all stakeholders, and this means the scope of marine biotechnology should be clearly defined and the promise and constraints of the sector be embraced from an ecosystem perspective, both environmental and socioeconomic so that priorities can be identified, and strategic decisions taken about how to pursue them. Realism must be an important component of the expectations for the growth of marine biotechnology within the blue economy, it cannot be put on the same footing as for example the well-developed areas of shipping and tourism. A specific program of investment, time, infrastructures, and training are essential if marine biotechnology is to reach the same development level as other sectors of the blue economy. Lessons can be learnt by examining the blue biotechnology sector and its contribution to the blue economy internationally so that effective policies and measures tailored to the unique opportunities and needs of Bangladesh can be established for the development of a flourishing marine biotechnology sector.

The UN2030 Agenda

The sustainable development goals were developed as far as was possible using available data, although it is clear when talking about the oceans they are underexplored and so exploitation must take place “hand-in-hand” with better characterization of the seas and oceans, together with realistic and easy to implement management plans. Marine biotechnology can make a multitude of contributions to the UN2030 agenda, some will be direct and others indirect, but for the still young field of marine biotechnology it seems unlikely that a decade will be long enough for it to make an effective socioeconomic contribution to the blue economy (e.g. by 2030)! The recent report on the status of the UN sustainable development goals is alarming as it suggests progress is failing due to the consequences of the COVID-19 pandemic, the war in Ukraine and the growing impact on many economic sectors of the climate emergency (The UN Sustainable Development Goals Report 2022). If the sustainable development goals are to be met, then the global community as a whole must commit to deliver them.

When considering the characteristics and scope of the marine biotechnology sector, the outcomes can contribute to the success of goals, 1, 2, 3, 13 and 14 (no poverty, zero hunger, good health and wellbeing, climate action, and life below water, respectively). The establishment of a diverse, active and productive marine biotechnology sector can contribute to diversify the economy and create more jobs and wealth and, in this way, contribute to goals 1 and 2. Since the marine biotechnology sector encompasses activities directed at the production of high quality and nutritious food and related products this will contribute to goals 2 and 3. The exploration of marine biodiversity from a bioprospecting perspective can yield a vast diversity of unique chemicals, materials and other products that can contribute to health and well-being (goal 3). To secure sustainable growth of marine biotechnology it is important to explore, document and characterise marine ecosystems and this will allow their health status can be measured and management plans developed to safeguard and restore when necessary ecosystem health (goal 14). Ultimately, the shift of economic activities from land to rivers and oceans and the development of sustainable activities can alleviate the pressure on terrestrial systems and their current unsustainable production systems and in this way contribute to climate positive actions.

Marine Biotechnology – Promises and Challenges

Marine or blue biotechnology is defined as the application of science and technology to living aquatic organisms for the production of knowledge, goods and services (OECD, 2016). In the

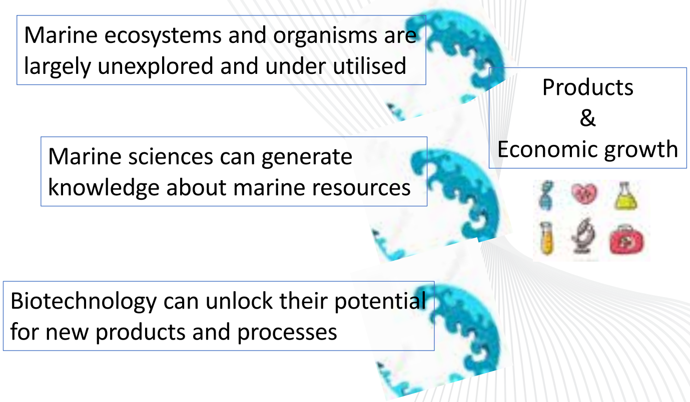

Figure 1. The key elements of the blue biotechnology ecosystem. For sustainability holistic research actions in the marine domain are essential.

current decade, partly due to the attention that the UN has drawn to the role of the marine domain, many countries are investing in this area, and at the level of Europe there are a series of initiatives and a "Blue biotechnology forum" directed at increasing the pace of development across Europe (https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/). However, it is not possible to consider the development of a blue biotechnology sector in isolation since sustainability implies that the exploited resource is not depleted or permanently damaged.

Since blue biotechnology is directed at the exploitation of a vast ecosystem that is very underexplored (for an example see: Priorities for ocean microbiome research, Nature Microbiology, 7, 937 – 947). This means that to ensure sustainable exploitation of marine biotechnology for blue growth an integrated, holistic approach is needed (Figure 1). The approach must build in multiple interlocking strands including exploration of marine ecosystems and organisms, development of enabling technologies and infrastructures to support marine exploration and biotechnology, well qualified human resources to enable biodiscovery and actors that can develop the market and promote and further develop commercial activities from blue biotechnology.

For those looking for inspiration or that do not believe the promise of blue biotechnology there are a number of notable success stories. One such story is the exploitation of the haemolymph of the coastal dwelling horseshoe crab (Limulus polyphemus), a marine invertebrate, that is frequently considered a living fossil since it appeared on earth over 200 million years ago (Walls et al., 2002, Reviews in Fisheries Science, 10(1): 39–73). The haemolymph from this crab is used for the Limulus Amoebocyte Lysate (LAL) assay and has become the pharmaceutical industries standard for detecting bacterial endotoxins and the market value is estimated at more than 200 million US dollars annually (Moss, http://www.mnn.com/earth-matters/animals/stories/why-is-horseshoecrab-blood-so-vital-to-pharmaceuticals). However, this is not a particularly good example of sustainable exploitation since mass harvesting is now threatening the species survival (Krisfalusi-Gannon et al., 2018, Frontiers in Marine Science, 5: 185). Additional examples of marine derived discoveries of commercial importance include Green fluorescent protein (GFP) from jellyfish (Aequorea victoria) that underpins the molecular biology revolution and gained scientists Roger Y Tsien, Osamu Shumomura and Martin Chalfie the 2008 Nobel Prize in Chemistry and the anti-cancer drug for metastatic breast cancer, Halaven®, bioinspired by unique chemical compounds produced by the Japanese deep-water sponge (Halichondria okadai, for further examples see Sigwart et al., 2021, Nat. Prod. Rep., 2021, 38) and developed through chemical synthesis and taken to market by the Japanese pharmaceutical company Eisai.

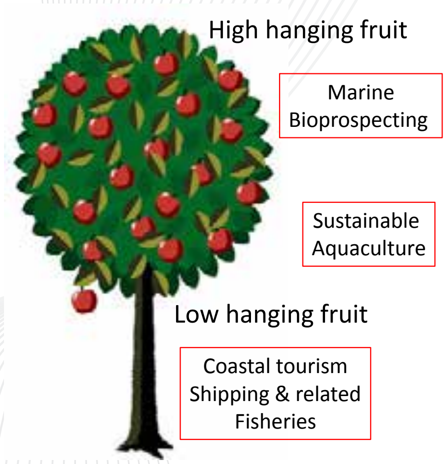

Figure 2. Elements of the blue bioeconomy. The low hanging fruits would be conventional industry, which is relatively low risk such as coastal tourism and shipping. While the high hanging fruit is Marine biotechnology and bioprospecting.

A unifying feature of discoveries in marine biotechnology is the time taken to go from the preliminary research observations through to applications and exploitation. The biodiscovery pipeline is long particularly since there are many hurdles to overcome including species identification, access to biomass, target identification and screening, scale-up and the regulatory framework, through to the market. Considering one sector of the blue economy that has a nexus with blue biotechnology, namely aquaculture, the timeline for the development and maturation of this industry gives some ideas about the timeline for development of the higher risk but potentially higher gain sector of bioprospecting. Recent mapping of the performance of global aquaculture of fish and shellfish, and more recently for other invertebrate species and algae reveals a slow development initially from the mid 90's followed by a steadier growth of the sector once initial technological issues linked to species characteristics and closing the lifecycle were overcome (Naylor et a., 2021, Nature 591, 551 – 563). This sector was initially viewed from a food production perspective but now through diversification of species and products has been highly valorised and new added value products have been developed by the application of blue biotechnology concepts (see the Icelandic company, Kerecis producing grafts from fish skin, www.kerecis.com).

From this brief consideration it should be clear therefore that for sustainable development of blue biotechnology a blend of activities involving both low risk and high risk should be planned (Figure 2). Similarly, short-term, medium-term and long-term ambition and investment are essential if the benefits of blue biotechnology are to come to fruition. The nexus of conventional activities of the blue bioeconomy with aquaculture, added value products of aquaculture derived by biotechnology and marine bioprospecting will create an appropriate environment, critical mass and conditions to promote a buoyant sector with sufficient economic outcomes to stimulate investment and valorisation of marine biotechnology.

Mapping a Route for Marine Bioprospecting

As pointed out above development of the blue biotechnology sector is context dependent since it will depend on the characteristics of the marine domain, the scientific strengths and priorities of governments and an available, highly trained, and motivated workforce. Having said this however, there are a combination of measures that can be taken to promote efficient and effective growth of blue biotechnology. The first step is to build a critical mass: encourage and promote research institutions both marine and non-marine to work together and create interdisciplinary approaches to foster biodiscovery in the marine domain, while remembering the importance of mapping biodiversity and ecosystems so they can be protected, preserved and in this way contribute to a long term, sustainable development trajectory. Leverage tools: the rapid advance in science over the last 30 years means that there is a vast diversity of research equipment and approaches that can speed up the pace of discovery. The diversity of cutting-edge equipment and what it can deliver is astounding but there is a cost both of purchase, maintenance, and a need for highly trained personnel. To exploit effectively the wealth of cutting-edge equipment dedicated research infrastructures should be established to host the equipment and to make it accessible to all scientists and sectors of society (public and private). An access model to equipment should be established and include costs to ensure optimal use of resources and easy access to all that are interested but also a budget to ensure continuous running and maintenance to ensure long-term availability (for an example see CCMAR research services: https://www.ccmar.ualg.pt/en/page/research-services).

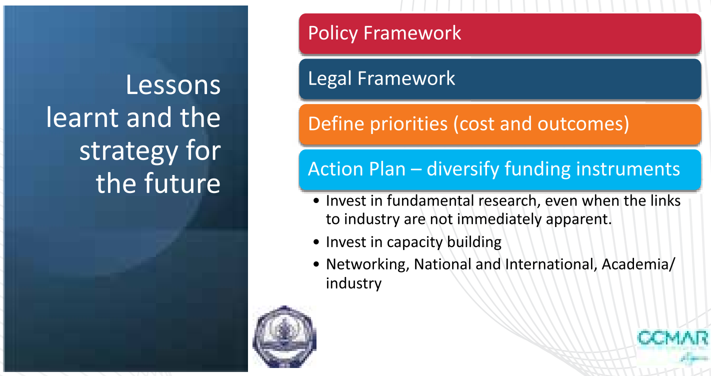

Figure 3. A framework for action towards the development of the marine biotechnology sector in Bangladesh.

Conclusion

The future is bright with many young talented scientists, extensive underexploited and unique aquatic resources, so that Bangladesh is on the crest of the wave! However, stewardship of these resources is essential as the health and wealth of future generations and the world depends on increased awareness of the importance but fragility of the living worlds and it's amazing ecosystems. By developing a framework for action then it should be possible to develop a sustainable exploitation plan for marine biotechnology, which will generate health, socioeconomic development, and wealth. The framework needs to cover a range of domains from policy through to an action plan to ensure the benefits of the blue economy can be shared by all (Figure 3).

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Plenary Session I, Talk - 3

Trends in Oceanic Dissolved Organic Carbon and Acidification

Md. Shajedul Islam, and **M. G. Mostafa***

Abstract

Rising atmospheric CO2 and temperature reduce ocean pH and increase dissolved organic carbon (DOC), causing wholesale shifts in seawater carbon chemistry with predictions of broad-scale ecosystem impacts. This study aimed to conduct a systematic review to understand the chemistry of oceanic dissolved organic carbon, future predictions of natural and human-induced changes, their impact on the marine ecosystem, and the blue economy. According to the review study, Antarctica, the southern shallow polar oceans, and any coastal area are especially vulnerable to ocean acidification and disrupted DOC cycles. Based on over a thousand studies, the following observations are illustrated: (a) Ocean acidification and the DOC cycle are intrinsically difficult to understand phenomena; (b) these two facts are interconnected to each other and associated with global change; and (c) the potentiality of these perils is highly spatial, seasonal, and stratified. (d) The ocean is unpredictable in the future due to the mood of global change stressors. The acidity of the ocean surface has already increased by about 30% in the last 50 years and is predicted to increase by 150% at the end of this century. Such an abrupt change in acidification and DOC in ocean chemistry would pose a threat to marine life.

Keywords: *Blue economy; Carbonate chemistry; DOC; Marine ecosystem; Ocean carbon cycle; pH; Stratification*

Introduction

The global climate has continuously changed for centuries. Our continued burning of fossil fuels is increasing the levels of carbon dioxide (CO2) in the atmosphere. As a result, the oceans have been absorbing large amounts of CO2 since the industrial revolution (before 1750). This rising amount of CO2 in the oceans is causing ocean acidification. At what time CO2 enters the ocean, it combines with marine water to produce carbonic acid (H2CO3), which increases the acidity of the water, lowering its pH value. While the beginning of 1750, approximately one-third to one-half of the CO2 released into the atmosphere by anthropogenic activities has been absorbed by the oceanic system. Several scientists guess that the pace of marine acidification since the beginning of the eighteenth century has been roughly 100 times more rapid than at any other time during the most recent 650,000 years. In addition, they showed that levels of atmospheric CO2 between 1000 and 1900 current era (CE) ranged between 275 and 290 ppm(V). In 2010 the average level was 390 ppm(V), and scientist expects the concentration to rise to between 413 and 750 ppm(V) by 2100, depending on the level of greenhouse gas emissions. With extra CO2 entered to the seas, the pH would decline further and marine water pH would drop to 7.8 from 7.9 by 2100. Generally, 23 to 30% of the total CO2 in the atmosphere dissolves into oceans, rivers, and lakes. Not only the absorbed CO2 by the oceans, but other chemical phenomena in the ocean can also cause acidification as the sea absorbs CO2, and marine water chemistry changes, which changes the living conditions of oceanic species. Many different species are affected; particularly organisms that rely on calcium carbonate (CaCO3) shells and skeletons. As a whole, the changed marine chemistry highly impacted the food chain of marine biota and the global green economy.

Changes in seawater chemistry - mechanism of acidification

Anthropogenic activities such as the excess use of fossil fuels and land-use diversity have led to new unrest of the CO2 budget in the atmosphere. Among the total CO2, about 45% remains in the atmosphere; about 23% is absorbed by the ocean, and 32% is taken up by upland plants. More atmospheric CO2 means absorbed more and more by an ocean that makes acidify the ocean water. The acidity of an aqueous solution is determined by the corresponding concentration of hydrogen ions (H+). A larger level of H+ ions in an aqueous medium corresponds to higher acidity, which is measured as a less pH. When CO2 intake by seawater, it creates carbonic acid (H2CO3) and liberates H+, which consequently reacts with carbonate ions (CO32−) and calcite (the stable form of calcium carbonate) to form bicarbonate (HCO3−) (Fig. 1). At present marine water is enormously rich in dissolved carbonate minerals. Nonetheless, as ocean acidity increases CO32− ion concentrations fall. The absorption of CO2 in seawater largely results from the dissolution of the gas into the top layers of the ocean, but CO2 is also brought into the ocean's water through the photosynthesis and respiration of marine plants and microbes. Algae and other oceanic photosynthesizes take in CO2 and store it in their tissues as carbon. Carbon is then passed to plankton and other microorganisms through the food chain, and these organisms can release CO2 to the oceans through respiration. Besides, when marine organisms die and accumulate in the ocean bed, CO2 is released through the process of decomposition. So, the CO2 budget in the oceanic system is not only depending on the concentration of it in the air. As a whole, all types of incoming CO2 may take part in the process of acidification in seawater.

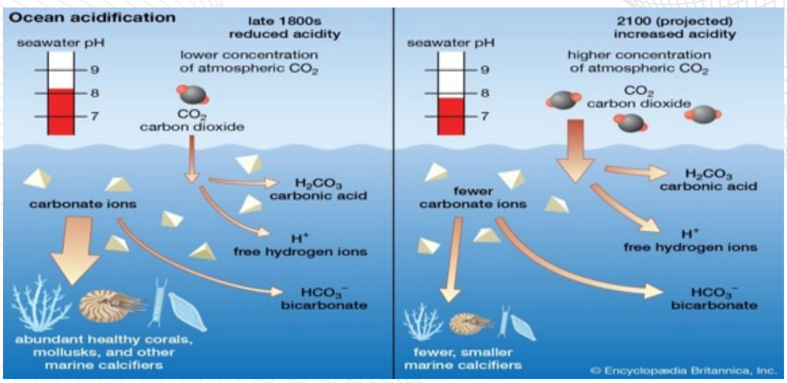

Fig. 1. Relative picture of marine acidification history and their impact on oceanic calcifiers

The above-mentioned mechanism may be influenced by the rate of surface ocean warming because warm waters will not absorb as much CO2. Thus, greater seawater warming could limit CO2 absorption and lead to a small change in pH for a given increase in CO2. The difference in changes in temperature between basins is one of the main reasons for the differences in acidification rates in different locations. Currently, the surface ocean is acidifying at a rate of 0.003-0.026 units (pH value) per decade. However, this rate is faster in the polar regions (-0.002 to -0.026 per decade) than in the tropical regions (-0.016 to -0.020 per decade). According to a statement in July 2012 by U.S. National Oceanic and Atmospheric Administration (NOAA), marine surface waters are changing much more rapidly than initial calculations have suggested. This U.S. organization makes a graph (Fig. 2) in which they showed the relation between atmospheric CO2 and marine pH from 1958 to 2018 (station Mauna Loa). It illustrated that marine acidification steadily increases with the increase of partial pressure on marine CO2 (station Aloha).

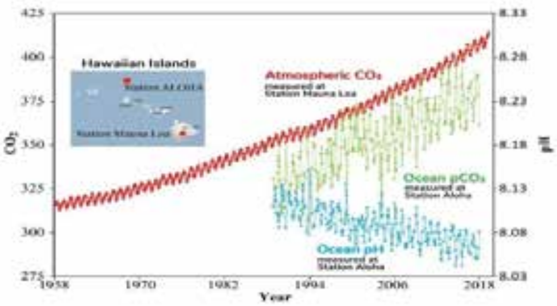

Fig. 2. Marine pH changes with atmospheric CO2 from 1958 to 2018

Physiological and ecological effects of marine acidification

Physiological changes brought on by increasing acidity in the oceans have the potential to change prey-predator relationships. Seawater pH dropped to between 7.8 and 7.9 in the last 100 years, resulting in CO32- ion concentrations decreasing by at least 50%. The global coral reefs, which provide habitat for many species, could decline and even disappear if ocean acidification intensifies and CO32- concentrations continue to fall. The oceanic calcifiers are large and small organisms that use carbonate and calcium ions dissolved in seawater to construct their shells and skeletons. Due to a lower concentration of carbonate, oceanic calcifiers would have significantly less material to maintain their shells and skeletons (Fig. 1). Field experiments in which the pH of marine water has been lowered by 7.8 have shown that organisms placed in these environments do not grow as well as those placed in environments characterized by early 21st-century levels of oceanic acidity (pH = 8.05). For this reason, their small size places them at a higher risk of being eaten by predators. In addition, the shells of some organisms, which serve as food for krill and whales, dissolve significantly after only 40 days in such highly acidic environments. Bigger animals such as squid and fish may also feel the effects of increasing acidity as H2CO3 concentrations rise in their body fluids. This situation is called acidosis, which may cause problems with the respiration of animals as well as with growth and reproduction. Besides, many marine scientists believe the significant decline in oyster reefs along the West Coast of the USA since 2005 is caused by the increased ocean acidification placed on oyster larvae. Some studies have illustrated that the carbonate skeletons of sea urchin larvae are smaller under the situation of increased acidity; such a decline in overall size could make them more edible to predators who would avoid them under a normal situation (Fig. 6). Consecutively, decreases in the abundance of pteropods (sea snails), foraminiferans (a technical term for internal shells), and coccoliths (individual plates of calcium carbonate) would force those animals that eat them to switch to other prey (Orr et al. 2005). Many marine scientists are concerned that a lot of marine species will become extinct if the pace of ocean acidification continues because they will not have sufficient time to adapt to the changes in marine water chemistry.

Effect on green economy

The possible economic effects of ocean acidification are a comparatively new field of research. This topic was first recognized in published academic literature in 2007, and by 2021, this study identified over 100 published papers on it. In most of these studies, the connection between ocean acidification and saturated sea CO2 economic effects were discussed. Though, several challenges were observed when assessing these effects due to the involvement of numerous disciplines. In the majority of studies, the forecasted impact of ocean acidification is negative, and only one assessment in this review identifies positive economic effects (Table 3). These negative influences are likely observed as most investigations focus on calcifying organisms and the habitats they form (e.g., mollusks, crabs, corals, and other invertebrates), which are predictable to respond negatively to ocean acidification rather than non-calcifying organisms that may respond positively (e.g., sea grasses and algae). Oceanic species and habitats offer a range of ecosystem services to human societies, and this review identified that many of these services may be influenced by ocean acidification (Fig. 1). The majority of studies have considered the ecosystem services of sea animals and their outputs provided by mollusks, crustaceans, fish, or coral reefs (Table 1). Marine acidification may have economic impacts on a range of geographical scales, which is reflected in the assessment conducted that has considered global, national, sub-national, and regional scales.

Timescale	Species/ habitat	Spatial scale	Biological response included in the analysis	Ecosystem service(s)	Response variable forecasted economic effect reported in terms of	Economic effect
2060	Mollusks	National and sub-national	Calcification	Wild animals and their outputs	Net present value, economic revenue losses	Negative
2100	Mollusks	Global and regional/ national	Calcification and survival	Wild animals and their outputs and animals from in situ aquaculture	Total economic cost, consumer and producer surplus	Negative
Through 2100	Coral reefs	Global	Area	Experiential use, physical use, wild animal and their outputs, mass stabilization and control of erosion rates, maintaining nursery populations and habitats, bequest	Net present value, annual economic damage	Negative
2050	Fish and invertebrates	Regional and national and sub-national	Metabolic rate, larval mortality, adult mortality	Wild animals and their outputs	Total revenue, fishers' incomes, total fishing cost, economic rents, economic impacts, income impacts, landed value	Negative
2100	Seagrass beds	Global and national	Biomass	Global climate regulation by reduction of greenhouse gases	Net present value, carbon sequestration	Positive
Through 2100	Red king crab	Local	Juvenile survival	Wild animals and their outputs	Maximum economic yield and profit	Negative
2100	Norwegian coastal cod	Local	Larval mortality	Wild animals and their outputs	Total profits	Negative
Through 2100	Mollusks	National	Growth rate	Wild animals and their outputs	Net present value, compensative surplus, and equivalent surplus from avoided ocean acidification	Negative

Marine acidification - Bangladesh perspective

The study reveals that the pH value in the Bay of Bengal on average is around 7.73, and this value dropped by 0.2 between 2012 and 1994 (pH 7.95). Marine planktons are the base of the oceanic food chain, upon which all other marine life depends. Ocean acidification could influence the seafood chain and lead to significant changes in oceanic biodiversity, which may threaten the protein supply and food security for millions of people as well as the big fishing industry in Bangladesh. Ocean acidification may directly affect some oceanic species that supply many services to humans. For example, mollusks and crustaceans support important commercial and recreational fisheries. Lowering the pH of the ocean results in coral bleaching, slow growth, and decreased coral biodiversity. In the coastal marine area of Bangladesh, among the 66 coral species recorded in 1997, only 40 species were recorded in 2008, which indicates 26 coral species were lost within 11 years, posing a serious threat to the coral biodiversity in the northern Bay of Bengal, Bangladesh. When the entire marine and coastal food web may have to face acidic marine water, the food web and food chain will be at risk. This total biodiversity will be disrupted shortly if these terrible situations continue.

Responses to carbon emissions

Hence, what can be done about ocean acidification and decreasing marine dissolved organic carbon (DOC)? The noticeable solution is to slow and ultimately eliminate carbon dioxide emissions from the excess burning of fossil fuels and to develop approaches for removing carbon dioxide from the atmosphere. At the same time, there is no single universal remedy, a collection of promising technologies is emerging that focuses on increased energy efficiency, renewable energy sources such as wind, solar, and biofuels, and carbon capture, where CO2 produced by power plants is pumped deep into the earth rather than being released to the atmosphere. It is needed to take action soon, nevertheless, to ensure the long-term health of the ocean, which we depend upon for fisheries, tourism, coastal protection, and biodiversity.

Conclusion

The scientific and field investigation of marine water chemistry changes owing to increasing atmospheric CO2 and the sensitivity of oceanic life to elevated CO2 as well as acidity has advanced dramatically in the past three decades. For this reason, in the current past, Antarctica, the southern shallow polar oceans, and some coastal areas are especially vulnerable to ocean acidification and disrupted DOC cycles through the potentiality of these perils is highly spatial, seasonal, and stratified. This study conducted a systematic review to identify the changes in chemical processes involving shifted marine pH and dissolved organic carbon. In addition, the study illustrated that due to natural and human-induced global changes, oceanic acidification highly influences marine biology, the ecosystem, as well as thre total blue economy. It was found that every year in recent times, the atmospheric CO2 concentration increased from 3 to 4 ppm(V). With extra CO2 entering the oceans, the pH would decline further, and marine water pH would drop to 7.8 from 7.9 by 2100. Since the industrial revolution, more CO2 has been absorbed by the ocean, and the equilibrium of carbonate chemistry is dramatically hampered. Marine DOC regulates the survival of calcified species, and this organic carbon is maintained by the partial pressure of saturated CO2 and seawater pH. Due to the lowering of calcification, loss of shellfish harvests, and decline in coastal protection by coral reefs, coastal human communities are facing economic losses. Numerous existing policies utilized to regulate seawater quality and marine species conservation can also help address acidification, with no minimum amendment. This study observed similar many adaptive actions used to address other issues in some countries, such as strengthening the shellfish aquaculture industry overall, which can have co-benefits in addressing acidification. A high priority for policymakers should be improving education and public awareness about marine acidification and its potential influences on the ocean ecosystem and the carbon cycle.

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Plenary Session I, Talk - 4

Importance of climate and oceanographic research for Risk assessment for coastal cities and deltas

Dr Assela Pathirana

Abstract

Flooding is one of the most frequently occurring and damaging natural disasters in the world. Coastal and delta areas are among the most flood hazard-prone areas in the world and flood intensity and frequency are already increasing, especially in the coastal and delta cities, due to changes in river flows, downstream sea level and local changes in rainfall and land use coastal and delta regions are also among the most densely populated areas of the world, which have experienced a rapid expansion of settlements, urbanization, infrastructure, economic activities and tourism especially over the last five decades. Therefore, quantification of the flood risk and its effective management depends not only on understanding the city itself but critically on the climate and oceanographic research outcomes that explain the external drivers in the water systems. The Mekong delta is the largest delta Vietnam and is located in the lower Mekong River Basin, spanning latitudes 8° 33' N and 11° 01'N and longitudes 104° 26'E and 106°48'E with the total land area of about 4 million ha. The Mekong delta has a population of approximately 17.5 million, accounting for 19% of Vietnam's population, while this region accounts for only 13% of the country's area. The livelihoods of a majority of the population (85%) in the region depend on agriculture activities. Can Tho is the largest city within the Mekong Delta, with the population of around 1.6 million as of 2016, is the city located on the South Bank of the Hau River, one of two major branches of the Mekong River in Vietnam, at a distance of about 80 km upstream of the Indian Ocean Can Though has a dense system of rivers and canals, and therefore, it is also known as "the municipality of river water region".

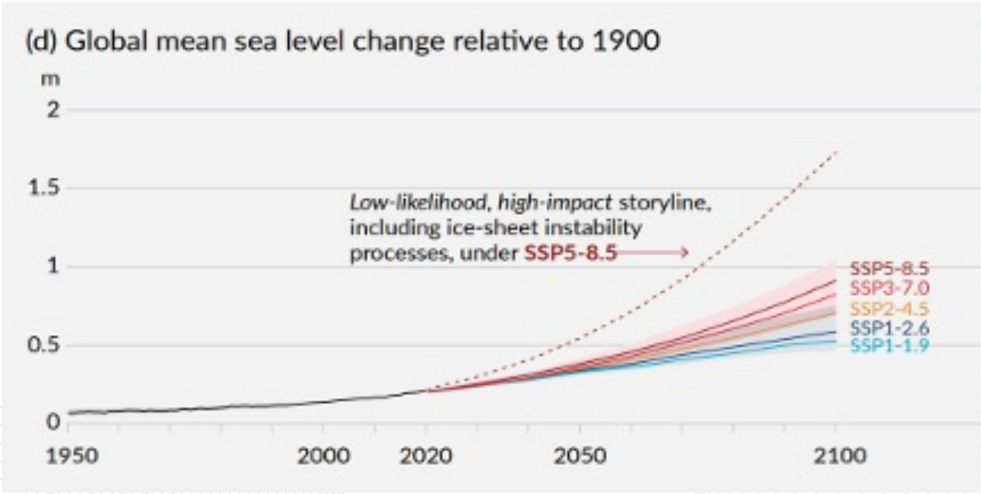
Serious flooding is frequent in Can Tho City, which leads to significant impacts on the environment, economy and society. Flood occurs at least 2-3 times a year during the monsoon season, with flood water depths ranging from a few centimeters up to 20-30 cm (even up to 50 cm in some places such as Ninh Kieu district). Flooding in the city is significantly impacted by three factors: (1) sea level (tide, storm surge, sea-level rise) has a direct impact on the river level near Can Tho and hence the dynamics of flooding (2) Changes in the upstream river flow, which is impacted by land-use change, construction of hydraulic structures such as dams; and (3) Urban hydrology (changes in local rainfall, land-use, etc.) To represent the first two factors above, a physically-based simulation model of the river system of the Mekong Delta is essential. With such a model it is possible to use sea-level changes and upstream flow changes as boundary conditions to ascertain their impact on the river water level near Can Tho city and therefore the impact on floods in the city.

In this lecture, we discuss research conducted during the last decade or so on quantification of flood hazard and risk assessment in the city. We discuss how the changing climate, rising sea levels, as well as change of dynamics of the ocean, impact of the flood risk.

Introduction

Coastal cities are among the most urbanized and populated areas of the world. In 1990, 23% of the global population lived within 100 km of the coast and less than 100 m above sea level. Thus, flooding can cause serious effects on human activities and properties in coastal cities and it is predicted that, the economic losses due to flooding alone in coastal cities are expected to be around US $1 Trillion by 2050.

"By 2300 Sea level rise greater than 15 m cannot be ruled out with high emissions"



The Flood Risk:

The latest IPCC report is published and the situation is not very promising. When we look at the different scenarios, the future of the world due to our inaction is going to be serious. In certain situations, by 2300 the sea level rise of greater than 15 meters cannot be ruled out with high emissions. Off course, the probability of that particular thing happening is low but the probability is there never the less.

Now, I want to zoom down in a very small town in Vietnam and that is not very far from Bangladesh. Flood risk in a city which is 80 kilometers up stream of the Mekong River called Can Tho. This can be a representation of any number of large and medium sized cities of Bangladesh. There are up stream floods that happens from the river and that depends on climate change as well as the activities of the developing countries and the sea level rise effect. All risk factors impact the total effect. Flood is a major problem for this city. Here, more than twenty small scale floods can happen every year, most of them are not catastrophic but they can cause a lot of economic damage.

Once in a while a catastrophic flood occurs and for this is not unusual for Bangladeshi context. we did some baseline studies some years back and we used a number of state-of-the-art simulation model starting from sea level data downstream and starting from the river level data upstream also using advanced atmospheric model to see what happens around the city and around Mekong delta. We tried to find out the future state of the flood in the city. What we can see is a combination of the local and the adverse effect because of the sea level rise and the changes in the upstream flow. The flood risk situation exists very much.

Causes of Flood:

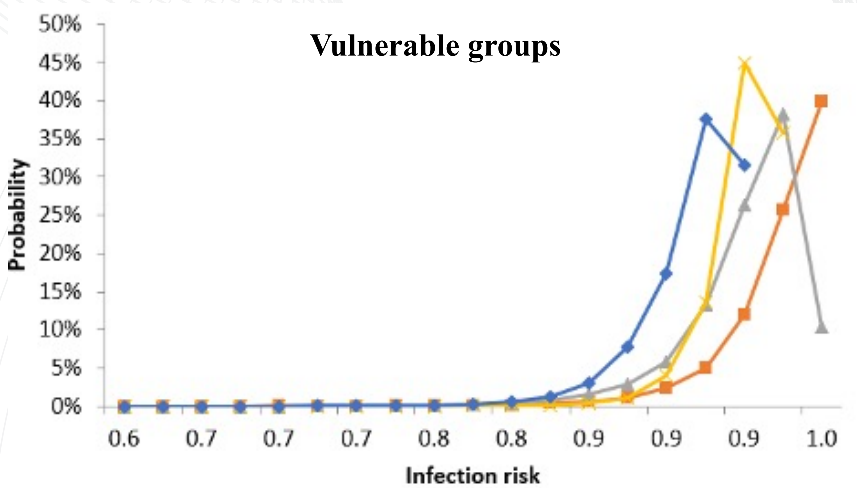
-Floods from the upstream, high tides, heavy local rainfall

- Land subsidence

- Poor infrastructure (e.g. inefficient urban drainage system)

This is why the floods are happening and the flood risk is going to increase quite a lot in the future. We can develop different models and suggest various remedies but if the policymakers and stakeholders do not understand all this then all these efforts will be useless.

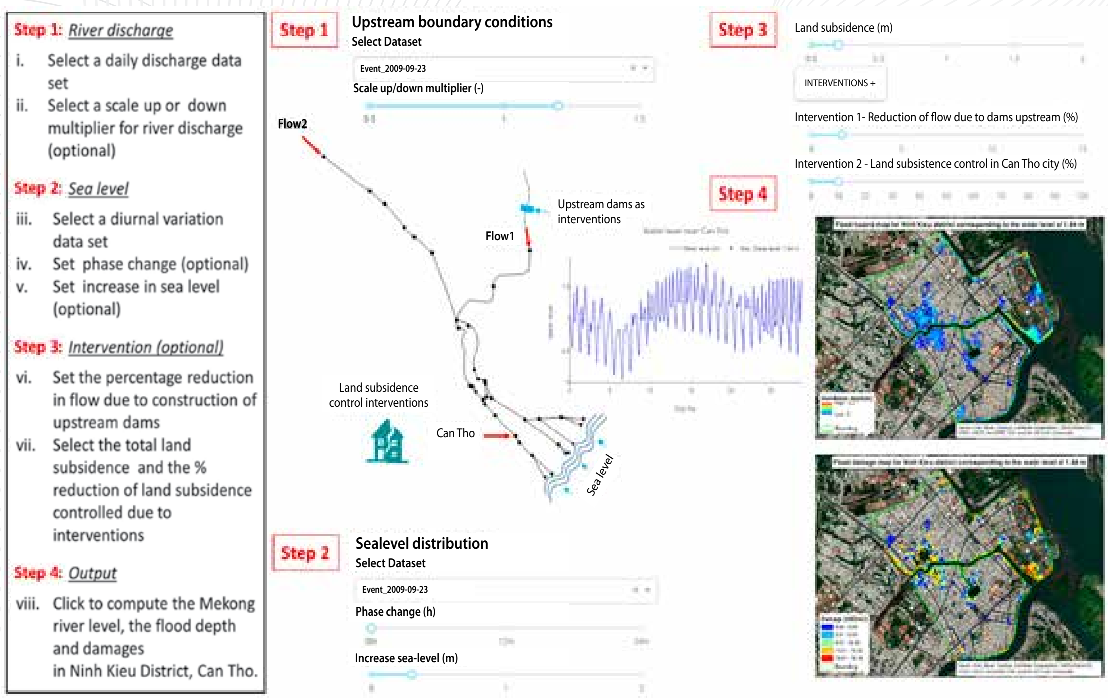
So, we sat down for a major simplification exercise and try to make these models as simple as possible without losing the essence. We created modeling pictures that could point to climate city scenarios and then bring it back to the risk picture of the city. We went up to creating a web application so that the stakeholders can sit down and play with different scenarios in our computers.



At the same time, we looked at what happens due to the flood in the aspect of health. We can ascertain connection of this study with health sector of the city. Due to the polluted condition of the city with the combination of floodwater and sewage, the floodwater becomes as bad as the sewage water and the people are literally not living with floodwater but living with sewage water. The city dwellers cannot see the dangers of contaminated water. When the flood water was tested in laboratory, it was found full of harmful bacteria and virus. Different vulnerable groups are more prone to the risk of health, for example, children, the pedestrians, people who use bicycles and motorcycles are more vulnerable when compared to others.

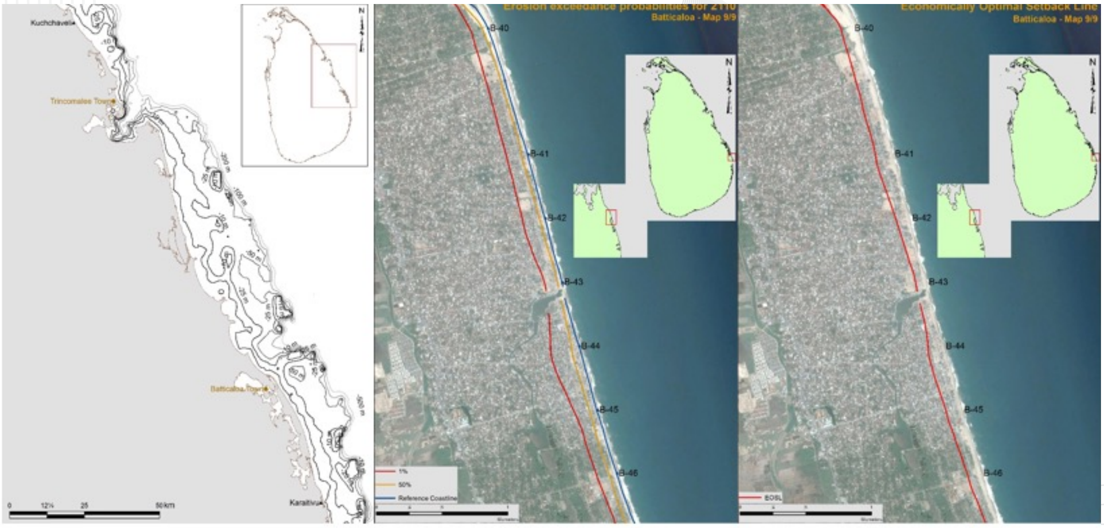
Development of web application

We combined all these features together and developed a web application. First the case study was on Can Tho city and now our idea is to expand this endeavor to different cities of the world where policymakers can play with different climate scenarios, different mitigation actions, different adaptation possibilities just to see how all that affects the flood risks of different cities that leads up to different adaptation possibilities and actions and the cost associated for all these endeavors. But different actions have different levels of sustainability. This is one way of looking at it using so-called adaptation pathway because this pathway shows how we can adapt overtime because climate change is a fact but its magnitude is uncertain. Depending on the magnitude we can take different actions at different point of time and those point in time can change also with the magnitude of the climate change progression for our actions to mitigate it.

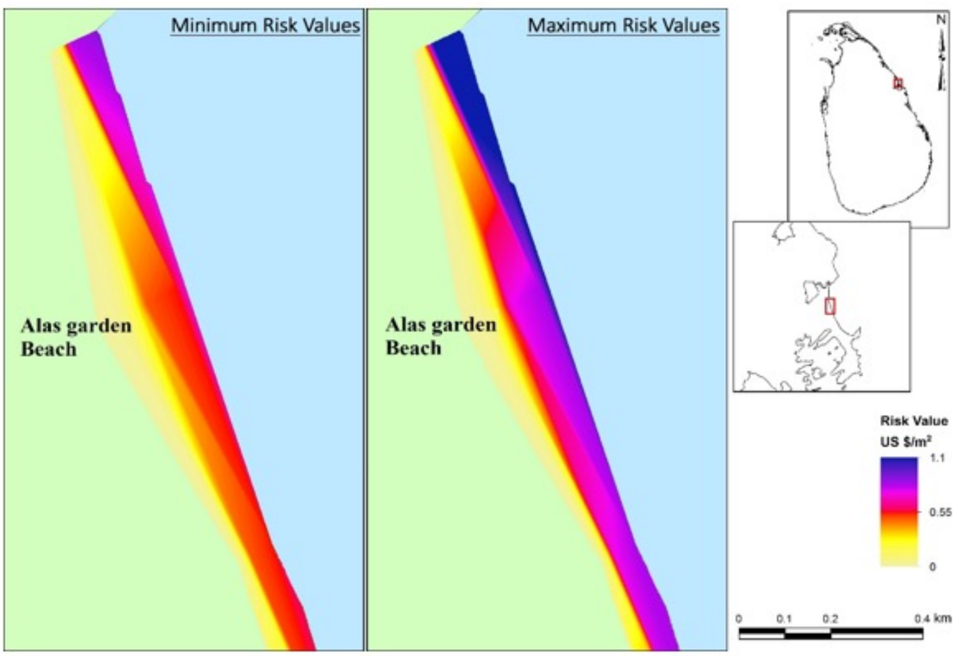


When we look at the sea level rise then we think about the risk for coastal regions that causes people to retreat and at same time we may ask what is the optimal distance that people should retreat in order to compensate because when people retreat people use new land and at the same time people reduce the risk of inundation and storm surge. So how people can balance these two, we started our study in Australia first in a well-known coastline of Sydney but we applied that later into several places like in some coastal areas of Sri Lanka.

Sri Lanka: Regional Application

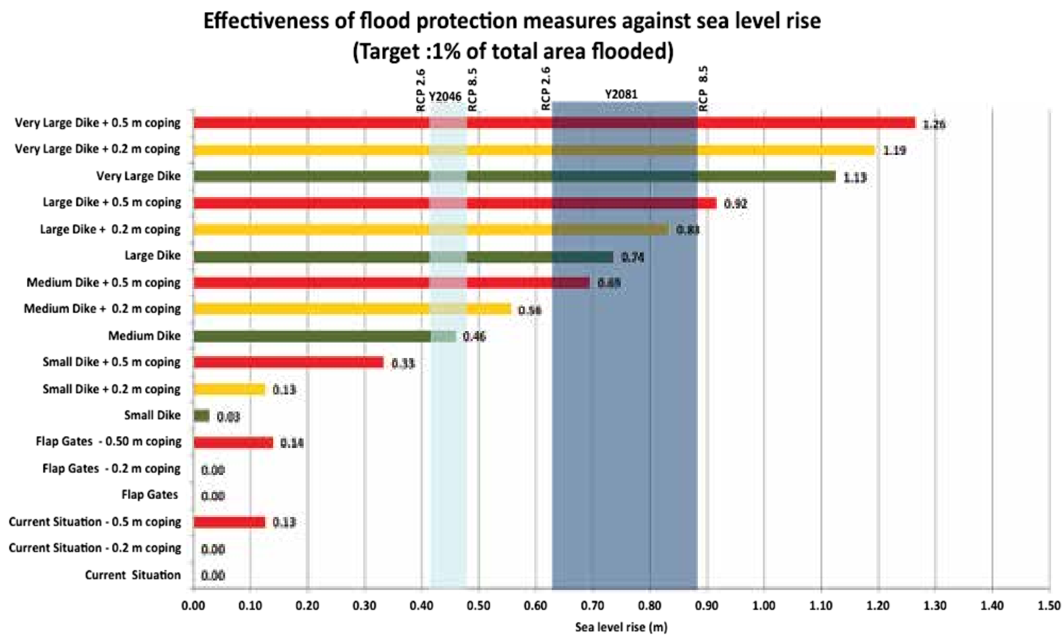


Quantifying environmental risk due to Climate Change

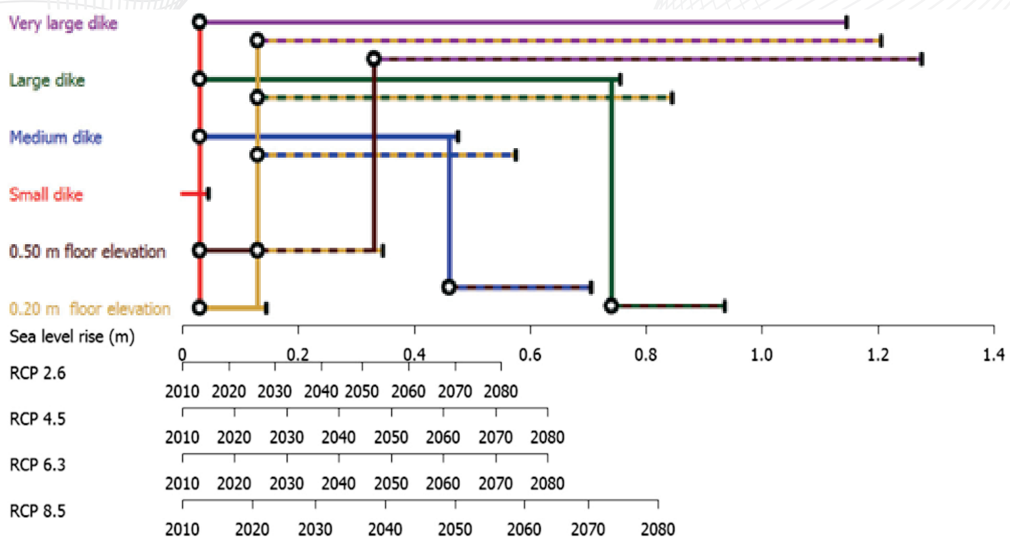


When people move away from the coast of basically, they use land away from the sea and it cost money at the same time it reduces the amount of risk due sea level rise. So how to make sure that, at a given scenario what is the optimal distance from the shore to escape sea level rise. The optimal distance that people should move from the coast but obviously this system depends on different climate scenarios, how the world progresses, how much sea level rise will occur. So, this is a very dynamic process and this is what we are trying to achieve.

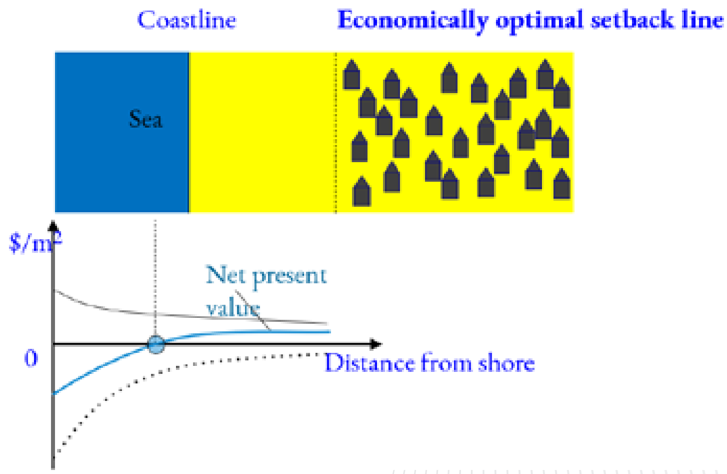
Adaptation



Adaptation Pathways



At this moment we are in a process of building a web application and ultimately, we want provide it to the people of the world. It will be possible that, anybody would select the coastline in somewhere in the world and select different climate scenarios and they might have to go back in order to minimize the risks.



So, what I want to say is, how our good work connects to the world we are living and I worry about the flood risk in cities. I am concerned about the risk on the land affected by state of the ocean flood, storm surge etc. I did not mention about other equally important direction that is, how the people on land impact the ocean.

Conclusions:

As we know, the human activities damage to the ocean as well. When we look at oceanography and find the state of ocean and flood risks, we see different areas but these problems are very much connected. It should be our aim to preserve the marine environment as well, because we cannot achieve one at the expense of the other as both are intimately connected.

Therefore we recommend, Ocean and land systems are needed to be connected intimately. Climate & Oceanographic research impact all of us. Investment in risk reduction should be dictated by economic assessments based on C&O research.

Dr Assela Pathirana

Associate Professor in Water Infrastructure Asset Management
UNESCO- IHE Delft Institute of Water Education, Netherlands.

Comments of Session Chair

Mr Fakrul Ahsan

First of all, session chair thanked expert panel and all participants. He mentioned that the economy moved from land centric economy to water centric economy. He pointed out:

The health of the ocean in not repairable once it has passes a certain threshold. By 2050, 50% of the blue water will be polluted mostly by the plastic. The land mass is smaller than the water mass. We must take action to prevent the ocean pollution to save the blue water. The SDG is encompassing goals and target so that people in this planet have better life in the dawn of 2031. Blue water and climate change are the integral part of the SDG.

The endangered species and the wealth of the Bay of Bengal is unknown to us. For balance life and living we have to ensure what we have. One study by UN says, our ocean is worth 6.2 billion USD though I believe it is underestimated. Details study need to be done to estimate the worth of the Bay of Bengal by the proper institution with equipment. In the COP-27, it is said if we do not take any action the entire world will be in danger including the southern part of Bangladesh will be submerged. We have to stop carbon emission for our future generation otherwise they will curse us that we have exploit everything and left nothing for their living.

In the recent times, country like Pakistan is facing flooding and on the other hand Europe is facing heat wave. Our chief guest mentioned that we have to act and thing as a global citizen. We need trans-boundary cooperation and solution. Unless this is done as responsible global citizen, we cannot save mankind. With the urge for a collective action I conclude the session.

Mr Fakrul Ahsan

Chief Technical Advisor, UNDP, Bangladesh.

Plenary Session - II

Rethinking Ocean Science for Sustainable Development

Session Theme

Ocean science has made great progress over the last century in exploring, describing, understanding and enhancing our ability to predict changes in the ocean system. In the coming decade, we have a tremendous opportunity to harness interdisciplinary advances in ocean science to achieve a better understanding of the ocean system. This will enable the delivery of timely information about the state of the ocean, and will allow us to define interconnected scenarios and pathways for sustainable development.

Ocean science can help us to address impacts from climate change, marine pollution, ocean acidification, the loss of marine species and degradation of marine and coastal environments. To achieve sustainable development, good science is needed to inform policies, increase the knowledge of all stakeholders and ultimately deliver solutions to address the decline in ocean health.

The Ocean Decade will provide a unifying framework across the UN system to enable countries to achieve all of their ocean-related 2030 Agenda priorities. For example, the Decade will help strengthen the development and implementation of science-based solutions for fisheries management. This alone will have a significant impact on helping many countries to achieve the Sustainable Development Goals needed to support the health and wellbeing of their communities and to achieve food security.

Plenary Session II, Talk - 5

Green Technology Sustainable & Resilient Port Development

Adson Hofman

Abstract

With about 80% of global trade carried by sea according to UNCTAD, maritime ports have evolved to play an integral part of international logistics chains, and therefore the global economy. Both intra and inter port competition, coupled with increased global container traffic as a result of globalization and containerization, have significantly influenced the port geography and international traffic flows.

While it is true that maritime transport has been regarded as an environmentally-friendly mode of transport in terms of emissions per ton/kilometre, the negative impacts of port and maritime related activities cannot be neglected. On the port side, major sources can be energy consumption from buildings, plants or equipment, dredging oil disposal, effluent discharge, noise or light, among others. All these are having a detrimental environmental impacts in port areas, as well as neighbouring populations and wildlife.

Introduction

In maritime trade, inefficient port call process can lead to a “hurry and wait” behaviour for ships steaming towards ports, resulting in a sub-optimal use of fuel by vessels, and therefore GHG emissions. Other sources from vessels can be illegal waste disposal, introduction of invasive species from ballast water or accidental spills, among others. Given this picture, ports have in this sense been under pressure to cope with increasing traffic demand, while complying with tightening regulatory requirements for more sustainability of port-related activities.

At the same time, ports are being challenged by sudden disruptions of different natures. These are affecting resiliency of essential functions within ports, and therefore are spilling over to the rest of supply chains. Some sources have been known for a while, such as those induced by the effects of climate change (e.g. rising sea levels and extreme weather conditions), by increased concerns on secured IT systems against cyber-attacks, or by social conflicts between different stakeholders (e.g. labour strikes). Other sources are more recent and have reshape the way port resilience is conceived, such as the COVID-19 pandemic, or the blockade of the Suez Canal.

In an increasing competitive landscape, ports need to be able to respond to these challenges, ensuring that port activities comply with economic, environmental or societal goals, while at the same time remained unaltered.

Port Sustainability & Resilience

One of the most internationally accepted studies on port sustainability comes from PIANC1, which define a sustainable port as:

“A port in which the port authority together with port users, proactively and responsibly develops and operates, based on an economic green growth strategy, on the working with nature philosophy and on stakeholder participation, starting from a long-term vision on the area in which it is located and from its privileged position within the logistic chain, thus assuring development that anticipates the needs of future generations, for their own benefit and the prosperity of the region that it serves."

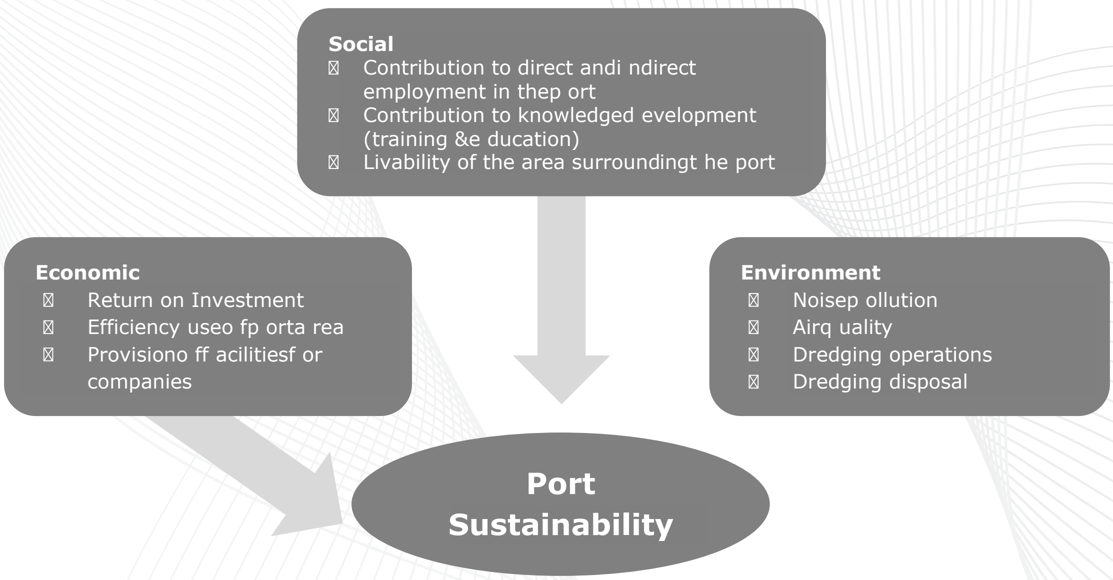
This broad definition can be rooted in the three pillars of sustainable development, which embrace environmental, social, and economic goals. According to Lim et al (2019)2, a sustainable port seeks to find a balance between the following:

a) minimise negative environmental impacts engendered by the different port activities within the vicinity of the port;

b) contribute to enhance people's quality of life by improving social stability of the vicinity area, and

c) maximise the economic performance resulting from implementing sustainable development initiatives

In line with the Sustainable Development Goals (SDGs), the main purpose of port sustainability is 'to seek safe, socially acceptable, energy-efficient, and environmentally friendly port management approach, while at the same time maximising profits'. Related to this, the triple bottom line concept of port sustainability can be defined (see Figure 1).



'Resiliency' is also another term which has gained significant attention recently, especially in 2020 as a result of the global pandemic caused by COVID-19.

Due to the configuration of global trade flows, where China played a pivotal role and therefore a state of dependency with major flow patterns, the pandemic has completely shaken resiliency of global supply chains. Aside from the previous, port resiliency has generally been focusing for quite some time on the ability of ports to remain operationally unaltered in the face of sudden events of different nature, such as extreme weather conditions, cyber-attacks or labour strikes.

The linkages between port sustainability and resilience can be well represented in the latest report4 from the World Port Sustainability Program (WPSP), a broad think tank which aims to contribute to sustainable development of world ports, in line with the 17 Sustainable Development Goals (SDGs).

Five overall areas of interest are covered, which fall under the umbrella of port sustainability:

1. Resilient infrastructure;

2. Climate and energy;

3. Community outreach and port city dialogue;

4. Safety and security;

5. Governance and ethics. The first area expands on the definition, adding a forward-looking component to it. Besides focusing on sudden operational challenges, it also pays attention to longer term developments, and whether the existing infrastructure is prepared for it. Given the complexity of ports and all the users involved, we can scope it down to a few elements of relevance, namely the capacity of the port development company (usually port authority) to plan ahead with flexible master planning tools, whether the workforce is upskilled and whether the current infrastructure has capacity to sustain future cargo flows.

In this sense, port resiliency is defined broadly as a "port that has the capacity to anticipate to future developments and demands, and also has the capacity to remain unaltered or return to normal operations quickly against forces of different nature".

Applications in the Port of Rotterdam

There is rich literature on the success case of Port of Rotterdam (PoR) around several fields, ranging from digitalization or sustainability. It is usually compared vis-à-vis Port of Singapore in the literature. Considering the best practices of the Port of Rotterdam, reference is made to the table below.

Table 1: Identified best practices on port sustainability[5]

Domain	Identified best practices
Economic	[1] Financially self-sustained port authority [2] Broad focus of the port authority as enabler and facilitator of a business cluster within the port area
Societal	[3] Continuous engagement with stakeholders [4] Knowledge and talent hub
Environmental	[5] Extensive collection and monitoring mechanisms on environmental (and other sustainability) indicators
Governance	[6] Concrete sustainability roadmap [7] Extensive compliance and reporting on different international regulations

It must be noted that the Port of Rotterdam is an important industrial cluster, mainly comprising of oil refining, chemical manufacturing and power and steam generation. In 2015, the area accounted for 18% of total CO2 emissions in The Netherlands. In this sense the Port of Rotterdam Authority has for many years been aware that the port's business would be increasingly exposed to future global and EU de-carbonization policies, as the bulk of its activities have traditionally focused on trading, handling, converting and using fossil fuels6. This can be coupled with the port operating in a highly competitive geographical zone, the Hamburg-Le Havre region, where some of the largest European ports compete for similar types of cargo and vessels to serve the same hinterland.

Against the previous challenges, and also with the mission to remain relevant by creating economic and social value in the region, the Port of Rotterdam Authority has organized its "port of the future" strategy around three main pillars: digitization, energy transition and innovation7. Sustainability crosses each of these verticals as an important component.

First of all, the digitalization journey began several years ago by setting a lab where digital products could be tested for added value with the customers at the port. Over time, this lab would evolve into a dedicated digitalization department for the development of digital solutions. Several entrepreneurial initiatives have resulted from these efforts, many of which are focused on more environmentally-friendly port sector.

For instance, PortXchange©, a spin-off the Pronto project8, aims to help shipping companies, agents, terminals or other service providers to optimize the planning, execution and monitoring of a port call process. This Just-in-Time approach can reduce the inherent cost and environmental inefficiencies around a port call.

Second of all, new technologies, revenue models and collaborative partnerships are being established in the overall energy transition roadmap of Port of Rotterdam towards CO2 neutrality. After many years of intense research, three steps have been established9:

- In a first step (2018-2025), the focus will be on the efficiency of current energy systems and the development of Carbon Capture, Utilization and Storage (CCUS) systems. On the flagship initiatives under this step is Porthos, which involves transporting CO2 from the industrial cluster via a pipeline network and storing it into empty gas reservoirs, 3 km beneath the seabed of the North Sea10.

- The second step (2020-2030) concerns increasing capacity of the energy infrastructure coming from sustainable sources. This means (i) replacing coal or gas-based (grey) electricity with offshore wind-based (green) electricity to power the port; and (ii) transitioning from natural gas-based (grey) hydrogen with (blue and green) hydrogen. The later makes use of CCUS systems such as those depicted above to progressively switch from grey-to-blue hydrogen, thus making the transition economically viable over the time period. Moreover, with increased offshore electricity capacity generation, green hydrogen can be produced.

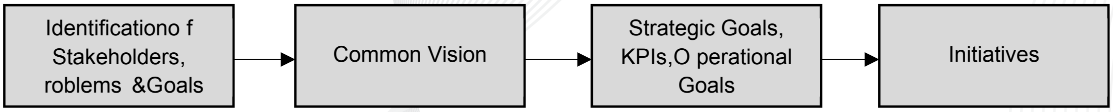
- The last step (2030-2050) concerns promoting a complete circular economy in the industry cluster via the renewal of raw materials and the fuel system. Renewable energy sources (green electricity, green hydrogen, biomass) supply the entire port industry, from which fuels and products are made for the rest of the supply chain, including end consumers. The CO2 emitted in this process will be used as raw material to produce more biofuels. Moreover, the waste of the industry is also recycled as raw material for new products.

Third of all, achieving the digital transformation and energy transition requires groundbreaking ideas. This is being possible by revitalizing old port areas into a testing ground for innovative solutions. In this sense, the Rotterdam District Makers (RDM), was created as an open space where start-ups and scale ups can develop their solutions11.

The previous paragraphs show the scale and ambition to radically transform the largest port of Europe into a sustainable port in less than 30 years. Some recent efforts are already being subject to international distinction, such as the IAPH World Port Sustainability Award 2021, in the section of Climate and Energy12. Under the Zero Emission Services (ZES) project, a new energy system was introduced for making inland navigation more sustainable. This is done by powering a fleet of inland barges with an interchangeable battery container, which can make use of different docking stations around the inland transport network.

An important common element behind the success case of Rotterdam has been on the one hand the proactive and entrepreneurial mentality that the port authority has played over the years. This meant embracing a culture of openness towards changing trends such as digitization or the energy transition, seeing them as an opportunity rather than a threat. On the other hand, rather than working as siloed organizations, the port authority needed the collaborative efforts within the entire port community and cluster, including private as well as public stakeholders.

Figure 2. Framework to elaboratea port sustainability roadmap[13]



Conclusion

This part aims to build on the current status of sustainability of the chosen ports by proposing a roadmap for each of them. From desk research, stakeholder consultation and internal brainstorming, this has been done in a step-wise approach, which is outlined in the figure below.

In a first step, the main stakeholders of the ports have been identified, including a list of problems and goals that are unique to them. This helps bring parties together to engage in a common vision, which tries to include, insofar as possible, the unique goals of all stakeholders.

The vision can then be broken down into a set of strategic goals, performance indicators and operational goals. For consistency reasons, the strategic goals are generally aligned with the framework, thus distinguishing between Economic, Societal, Environmental, and Governance strategic goals. For each of them, a set of sub-goals are provided, allowing to adjust or expand the framework to the unique context of each port. Each sub-goal has in turn a measurable performance indicator, to assess the progress during the proposed timeframe, as well an operational goal.

Adson Hofman

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Plenary Session II, Talk - 6

Oceans as a Critical Enebler for Energy Security

Dr. Badrul Imam

Abstract

Bangladesh secured a sovereign territorial sea of more than 118000 sq km following the verdict of international tribunal which settled the maritime boundary dispute with its Myanmar and India. This has given Bangladesh ample opportunity to harness a potentially large hydrocarbon resource base in the offshore. Can the Bay of Bengal lift Bangladesh out of its gas crisis? Myanmar and India have successfully proved the hydrocarbon potentials of their offshore in the Bay of Bengal. Bangladesh is yet to prove its potential primarily due to lack of major exploration drive, although its location just off the largest delta in the world makes it equally potential to its neighbors, if not more. The offshore exploration drive of 1974-1978, initiated by Bangabondhu government was the first and the only comprehensive campaign encompassing the whole offshore area of the country. Since then exploration in the offshore were rather few and far between. Among the two gas discoveries, the Sangu gasfield had a production life of several years before being depleted in 2013.

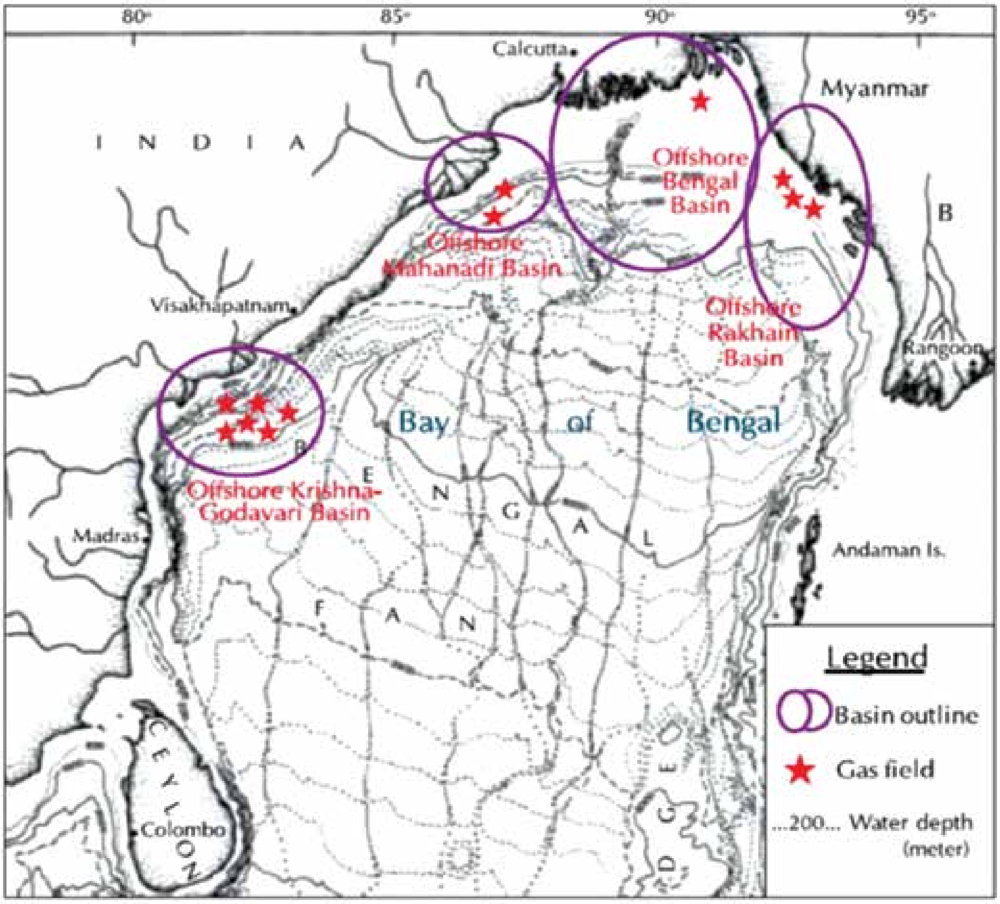
The major successes in hydrocarbon finds in the offshore Rakhain basin, Myanmar, happened due to a reinterpretation of subsurface geology and recognition of deep sea turbidite model in the late Tertiary succession. The reservoir facies including basin floor fan, sand filled channel, clay fill channel forming lateral seal against shelfal sand, channel levee complex were the major exploration targets. Similar targets drilled in the Indian offshore also brought successes. Recent interpretation of the seismic sections in the Bangladesh offshore blocks have shown reservoir plays and drillable structures similar to the Rakhain offshore gas fields. However, these plays are not tested in Bangladesh water till date. A major exploration drive in Bangladesh offshore is likely to unfold major gas reserves and this may contribute significantly to overcome the present energy crisis of the country

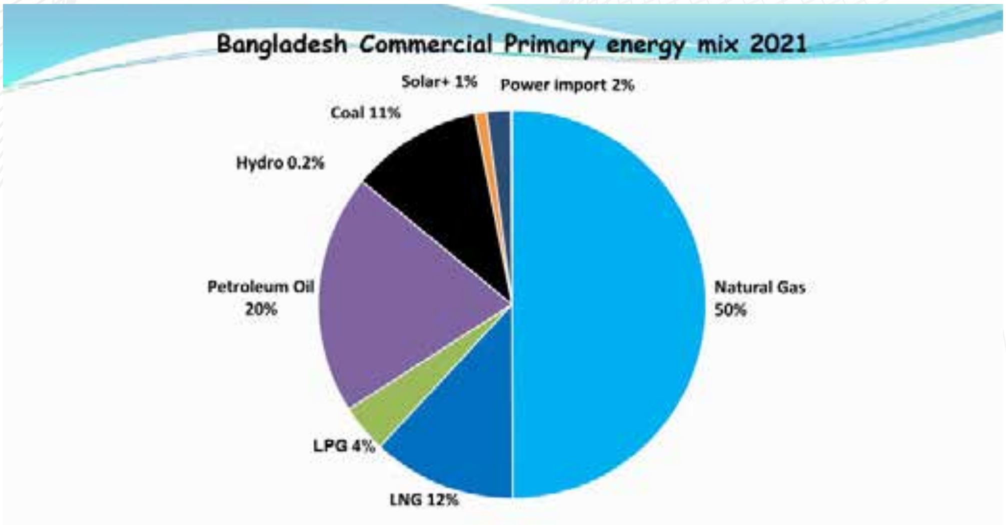
Introduction

The Bay of Bengal is a subregional area located in the eastern Indian Ocean. It is roughly triangular in shape and while the definition of the Bay varies, historian Sunil S. Amrith, from the perspective of political and cultural history, defined the Bay as stretching from west to east covering seven littoral countries, namely, Indonesia, Malaysia, Thailand, Myanmar, Bangladesh, India and Sri Lanka, all of which are dynamic emerging economies with a combined Gross Domestic Product of USD 6.26 trillion in 2019. The growing attention on the Bay is the result of its conceptualisation as a new important economic and strategic subregion. The Bay of Bengal is an important dimension of Asia's including Bangladesh's evolving energy landscape, given its growing energy demand, abundance in natural resources and importance in the seaborne energy trade.

Bay of Bengal

The triumph over the maritime area in the Bay of Bengal not only brought about an expanded area of exclusive economic zone but also opened a door of unprecedented opportunities in the blue economy of Bangladesh. After settling the maritime disputes with Myanmar and India in 2012 and 2014 respectively, Bangladesh achieved 118,113 sq km maritime area. Now the country has an unmitigated prospect over this vast area regarding any economic activities.





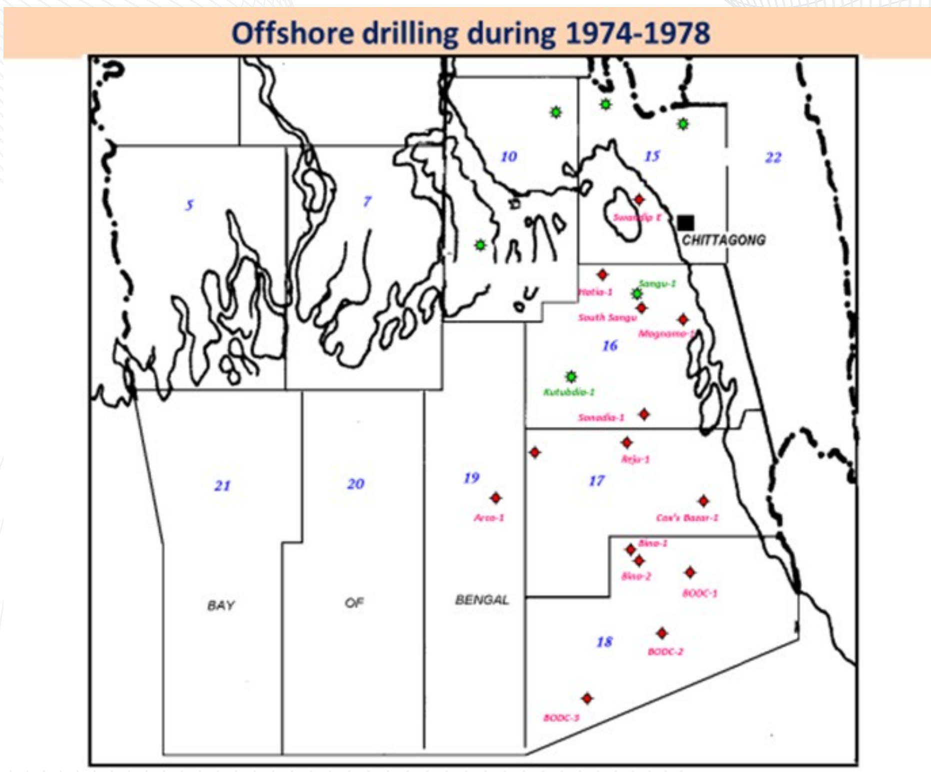
The ocean is a unique reservoir of resources and various components of limitless possibilities. Natural resources like gas and oil, are the most coveted ones among them. With the current skyward industrialisation, economic growth and outspread usage of technology, countries are dependent on these energy resources more than ever. Therefore, the Bay of Bengal has unlocked new scopes for Bangladesh in terms of valuable resources that might be stored right under the achieved vicinity.

Even so, regardless of achieving such a tremendous exclusive economic zone, Bangladesh is lagging behind in gaining the mileage over blue growth. Blue growth is the long-term strategy to support sustainable growth in the marine and maritime sectors as a whole. This growth includes aquaculture, coastal tourism, marine biotechnology, ocean energy and sea-bed mining. In the current scenario, proper natural resource management is necessary for any kind of economic development.

Energy Resources

The world has witnessed numerous natural resources in the African region. However, the poor management by the government could not earn long-term economic development and are still surrounded by poverty. On the other hand, Scandinavian countries, as well as our neighboring countries, are doing well in this sector and making impressive economic development.

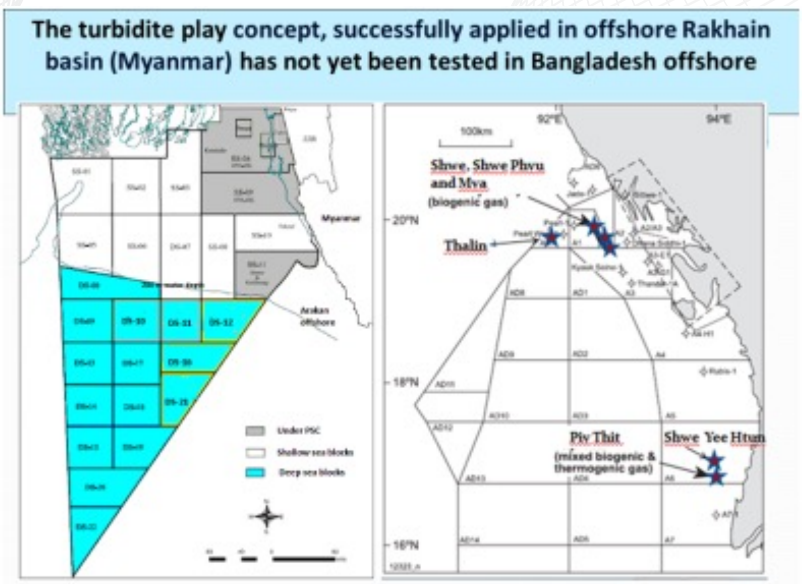
Bangladesh has an inadequate amount of natural resources and most of its extractions are from the on-shore sources. In Bangladesh, 63 percent demand of the energy is met by natural gas, although the country itself doesn't have any substantial reserve of gas. On that account, for the energy security of Bangladesh, the Bay of Bengal can play a vital part.



In the Bay of Bengal, there are three large basins: the Krishna Godavari basin of India, the Rakhine basin of Myanmar, and the Bengal basin of Bangladesh. Geologists consider that the Bengal basin is one of the resourceful basins in the Bay of Bengal after the Krishna Godavari basin of India.

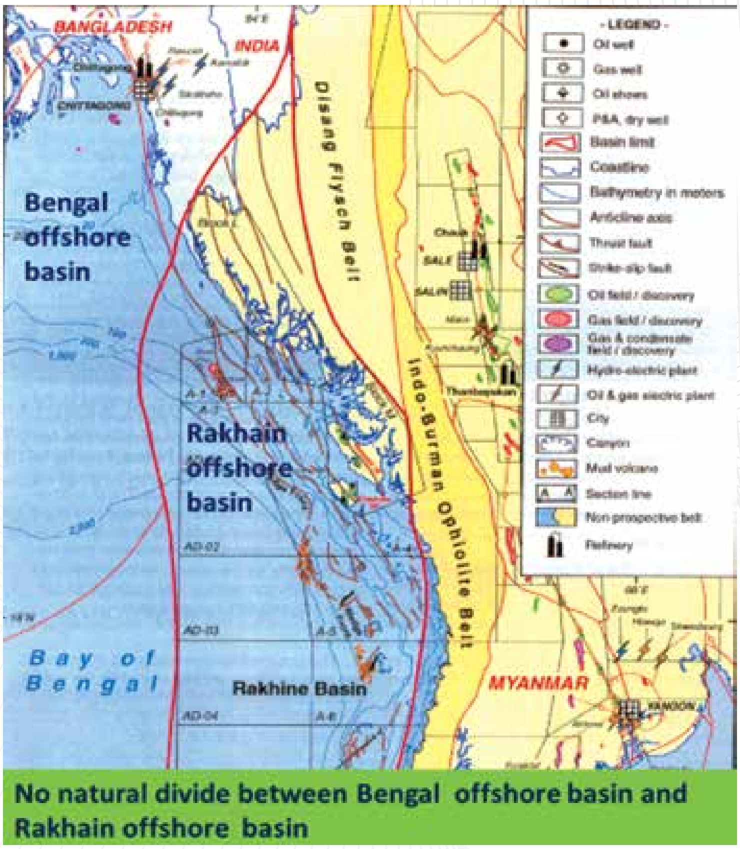
The Regional Aspects

There is increasing recognition among the littoral and neighbouring landlocked countries surrounding the Bay that closer integration and enhanced connectivity in this subregion are useful means to facilitate economic growth at home and shared prosperity across this emerging subregion. In tandem with their economic rise, energy demand is growing in this area and greater energy cooperation and cross-border connectivity can facilitate a new phase of regional cooperation, especially given the natural resource potential within this subregion. The Bay is believed to be rich in offshore natural gas deposits and gas hydrates in the exclusive economic zones of India, Bangladesh and Myanmar. However, the Bay remains underexplored to date, especially by Bangladesh.



A more promising sector for energy cooperation is in cross-border electricity trade, as a regional grid would enable economies of scale for efficiencies and cost reduction. There is a complimentary profile between Nepal and Bhutan as hydropower producers and energy hungry importers such as India and Bangladesh. The Bay also has rich potential for other renewable energy developments such as solar and wind. According to the Integrated Research and Action for Development (IRADe) in November 2018, cross-border electricity trade in South Asia has the potential to grow to 60,000 megawatts (MW) through 2045.

However, progress towards development of a regional grid is slow. There are currently only bilateral trades for electricity and petroleum products within the subregional BBIN (Bangladesh, Bhutan, India and Nepal) network, with India taking most of the electricity. Specifically, PTC India Limited has purchased 1,400 MW of hydropower from Bhutanese hydropower plants—such as the Chhukha project (336 MW capacity) since October 2002, the Tala project (1,020 MW capacity) since August 2006 and the Kurichhu project (60 MW capacity) since October 2002—which are supplied to the Eastern and Northern Indian states.



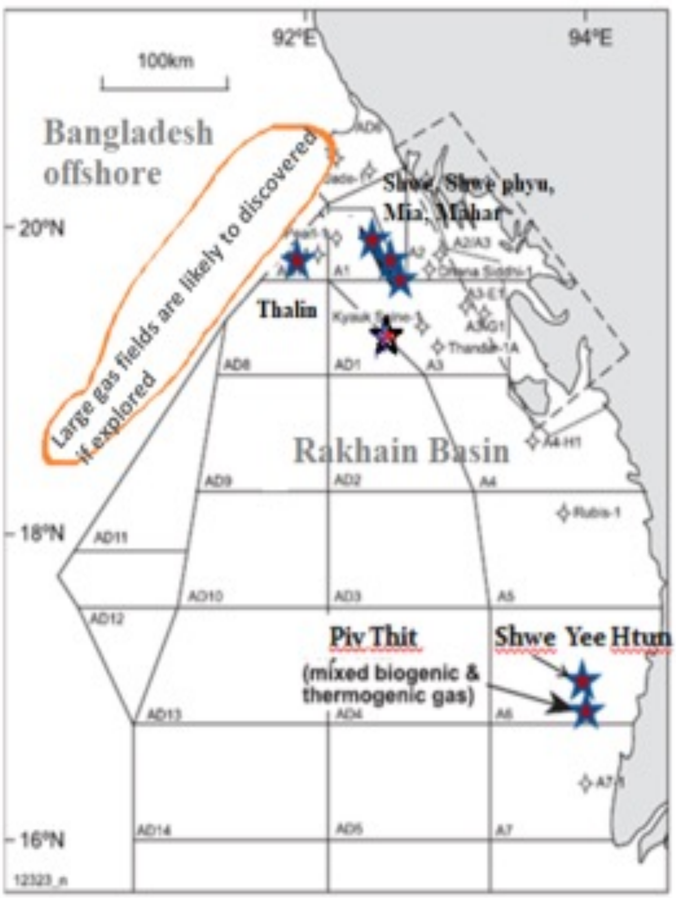
No natural divide between Bengal offshore basin and Rakhain offshore basin

Bangladesh Energy Scenario

Bangladesh imports 100 MW of electricity from Tripura, India to Comilla, Bangladesh, and 250 MW of electricity from India through the Indian government electricity board's National Thermal Power Corporation Limited (NTPC), and another 250 MW through PTC India Limited. Nepal, which generates hydropower, trades 400 kilovolts (kV) of electricity between Muzaffarpur, India and Dhalkebar, Nepal during the dry season, and exports 350 MW from India through crosscountry lines. India has also been in talks with Sri Lanka to establish electricity transmission links since 2007 although none has been established to date. Meghalaya in India also has huge hydropower and natural gas reserves which can be traded with Bangladesh. ONGCTripura Power Company (OTPC), a natural gas-based power company located in the Tripura state in India, adjacent to the eastern borders of Bangladesh, has been supplying electricity to Bangladesh, starting with 100 MW in March 2016, which has since increased to 190 MW. It also started supplying 40 MW of power to Nepal in April 2019. Discussions are also underway to build a 765-kV transmission capacity mounting from Assam in Northeast India, crossing Dinajpur District in Bangladesh to Bihar in West Bengal, which will enable trilateral cross-border electricity trade to take place between Bhutan, Bangladesh and India.

Bangladesh could utilize the Bay of Bengal to mitigate her energy demand, But since independence, Bangladesh did not explore the Bay of Bengal very much. Till today, 20 exploratory wells were drilled here, resulting in only two gas discoveries, i.e. the Sangu and the Kutubdia, with small reserves.

The Sangu reserves of 0.8 Tcf have already depleted, whereas the Kutubdia reserves 0.04 Tcf are yet to be extracted. Less than one percent of the gas supply was coming from those gas fields. As those two gas fields had very low amounts of reserves, hence, they are not in production in recent times.



Myanmar has recently discovered around 4 TCF (Trillion Cubic Feet) extractable gas at Mahar #1 well located in the Rakhine basin in 2020. Earlier in February 2016, gas was being discovered in Thalin-1A well in Myanmar's block AD-7 adjacent to Bangladesh's deep-sea block DS-12.

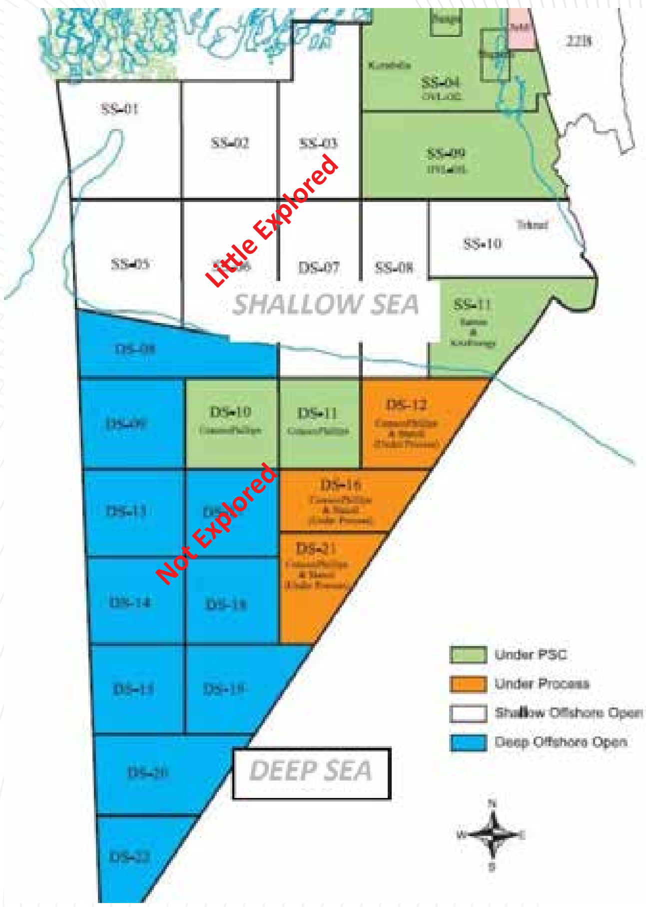
Geologists confer that Bangladesh's DS12 and Myanmar's AD-7 are located in the same geological structure in the Bay-of-Bengal. The recent discovery of huge gas reserves by India and Myanmar in the Bay of Bengal near Bangladesh's economic zone is an obvious reason to go for robust deep-sea exploration now.

Local Initiatives

Recently, government organisation Petrobangla divided the Bay of Bengal into twenty six blocks. Eleven of them are shallow offshore blocks and the remaining fifteen are deep offshore blocks. The government initiated 2D and 3D seismic survey projects in order to know the volume of natural resources under the Bay of Bengal. Petrobangla awarded two of its off-shore blocks to ONGC (Oil and Natural Gas Corporation) and OIL (Oil India Company) in February 2014 through the process of bidding. Three other offshore blocks have been designated to Santos-Kris Energy (UK) and Posco Daewoo Corporation (South Korea). But any remarkable source of oil or gas is yet to be found.

In 2019 the Government of Bangladesh approved the draft of "Bangladesh Maritime Zones Act-2019". This act looks very much promising for natural resource management. However, implementing the act will be challenging for the government.

It would be a highly commendable initiative if the government assigned BAPEX (Bangladesh Petroleum Exploration & Production Company Limited) as the only company to extract natural resources from the Bay of Bengal. However, BAPEX has no major drilling experience in offshore gas and oil fields.



Increasing the infrastructural capacity of BAPEX and creating trained manpower in this sector will be a whole new challenge for the Government of Bangladesh. Therefore, the government needs to increase budget allocation for the modernisation of this company and set up a new institution to increase manpower.

Above all, the statistics of importing oil and LNG are giving off a premonition on our dependence on imported energy. According to Bangladesh Petroleum Corporation (BPC), only in the financial year of 2019- 20, Bangladesh imported oil from the international market worth Tk21,587.49 crore. Although the country has a significant reserve of coal but it is quite not used here.

Moreover, taking climate change into account, Bangladesh does not have commensurable equipment or technology to prevent the pollution from coal mining. Bangladesh is committed towards climate agendas of Sustainable Development Goals. Specially, SDG-14 is absolutely related to the blue growth and blue economy.

Now, the government must decide how they will extract and utilise these natural resources from the Bay of Bengal. Natural resources like oil and gas are exhaustible, and partly renewable but it takes a hefty amount of time to restore. Therefore, utilising resources in the proper way is very much essential for our energy security.

With the help of the Bay of Bengal, Bangladesh can also direct its focus on renewable energy e.g. hydroelectricity, windmill and solar energy. Countries like Norway, Sweden, Netherlands, UK, China, and Germany and even our neighbouring country India installed windmills to mitigate the pressure on the non-renewable energy sources. While achieving sustainable development, the concept of Inter and Intra generational equity term holds the highest priority. So, we must ensure energy security for the current and future generations. In the same way, the Bay of Bengal, with its huge potential, can accommodate resource supplies to the present and future generations of Bangladesh.

Conclusion

The Bay of Bengal in Bangladesh is an underexplored area with very high potentials of natural gas. The offshore Rakhain Basin (Myanmar) lying to the east and the offshore Mahanadi basin and Krishna Godavari basin (India) to the west are both proven natural gas rich Basins. The Bangladesh offshore in the middle is also believed to be rich in NG. This is based on the similarities of geologic environments and settings between these areas. The next group of large gas fields in Bangladesh are likely to be discovered in the SE offshore of Bangladesh adjacent to Myanmar offshore.

Dr. Badrul Imam

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Plenary Session II, Talk - 7

Linking marine chemical ecology with bioprospecting: A case study of sponges

Dr. Narsinh L. Thakur

Abstract

Numerous diverse classes of marine natural product based new chemical entities (NCEs) have been isolated and their therapeutic potential has been reported in the past. However, the success rate of NCE discovery was found to be low in random exploration of marine organisms. Ecological observation is another way to obtain bioactive leads (NCEs) from marine organisms. Understanding the ecological and evolutionary pressures that drive the biosynthesis of metabolites provides a rational approach for selecting marine organisms for this purpose. The research work under the theme 'linking marine chemical ecology and bioprospecting' is being pursued at CSIR-NIO by studying chemical ecology of different sponge species from the Indian coast. In these efforts, the compounds having ecological roles were isolated from the sponges like Cinachyrella cf cavernosa, Ircinia fusca and Biemna fortis. These compounds were found to have potent pharmacological activities as well. This presentation highlights the success of ecological approach in the discovery of marine natural products by showcasing the results of sponge based compounds. In this presentation marine bioprospecting opportunities from Bangladesh perspective will also be discussed.

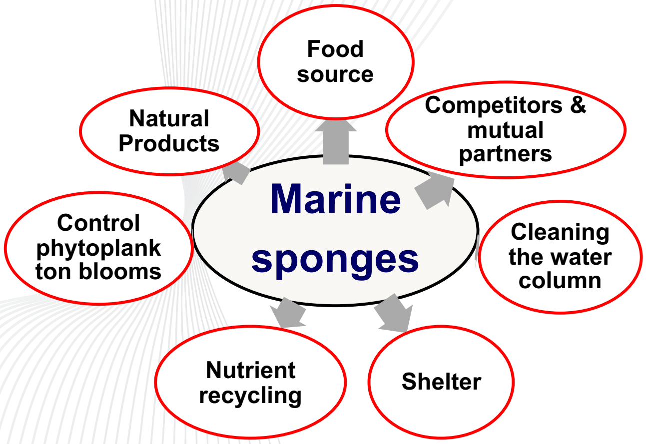
Introduction

Sponges (phylum Porifera) are sessile, benthic invertebrates, pore-bearing animals, asymmetrical in shape; size varies from 1 cm to 6-7 feet, found in both fresh and saltwater. They are very efficient filter feeders that filter microscopic food particles and take up dissolved organic matter. Approximately 11,000 species of sponges have been formally described, out of which, 8500 are considered valid. Sponges are fundamental in all marine ecosystems because they perform various functions like: food source, competitors & mutual partners, cleaning the water column, shelter, nutrient recycling, control phytoplankton blooms, natural products to support marine biodiversity and ecosystem. Extensive ecological pressures like: competition for space, predation and associated fauna are being tolerated by sponges because they are soft bodied, sessile and have no physical defense.

In 1815 Ebermaier mentioned the medical application of the roasted bath sponge as well as of the horse sponge in a topical and surgical way. Chinese pharmacopoeia recommends seaweed-based recipes for number of disorders like pain, abscesses, menstrual difficulties and cancer. Ayurveda, the ancient Indian medical system recomends marine products such as praval (coral), mukta (pearl), kapardika (cowry), Shukti (oyster shell), Shankha (conch), Agnijara (amber) etc.

Marine sponges:

But they have defensive chemical weapons (secondary metabolites) for their protection and armed with an arsenal of potent chemical defense agents like amino acids, nucleosides, macrolides, porphyrins,

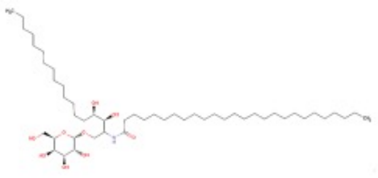


terpenoids to aliphatic cyclic peroxides and sterols. There is evidence documenting the role of sponge metabolites in chemical defense against predators and epibionts. Sponges being a filter feeder can reduce pathogen transmission by removing pathogens from the water column via degradation and release of pathogens in pseudofeces. Sponge-derived or other marine microorganism's associated bioactive substances have possessed cytotoxic, antibacterial, antiviral, antifungal, antimalarial, anthelminthic, immunosuppressive, muscle relaxants and anti-inflammatory activities.

Historical records show that humans have become aware of the importance of sponge: In 1815 Ebermaier mentioned the medical application of the roasted bath sponge as well as of the horse sponge in a topical and surgical way, Chinese pharmacopoeia recommends seaweed-based recipes for number of disorders like pain, abscesses, menstrual difficulties and cancer, sponges were used to cure eye infection too. Currently over 20000 different marine natural products have been described and hundreds of patents have been filed.

KRN7000: **Antitumor agent**

Molecular Weight: 842.323 g/mol
Molecular Formula: $C_{50}H_{99}NO_8$
Source: Analog derived from the sponge Agelas mauritianus. (PORIFERA)
Activity: antitumor, immunostimulatory
Status: Phase I clinical trials (Europe and Asia)



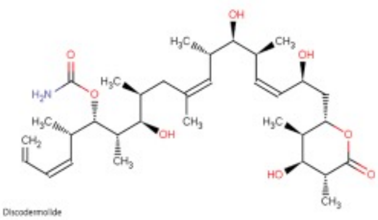
KRN7000

Agelas clathrodes. The closely related species A. mauritianus is the source of KRN7000.

Drugs in clinical trials

DISCODERMOLIDE: **Microtubule interfering agents**

Molecular Weight: 593.792 g/mol
Molecular Formula: $C_{33}H_{55}NO_8$
Source: The Caribbean deep-sea sponge Discodermia dissoluta (PORIFERA)
Activity: tubule interactive agent
Status: Phase I /II clinical trials



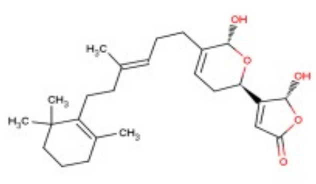
Discodermolide

Discodermia dissoluta

Drugs in clinical trials

MANOALIDE: **Anti-inflammatory agent**

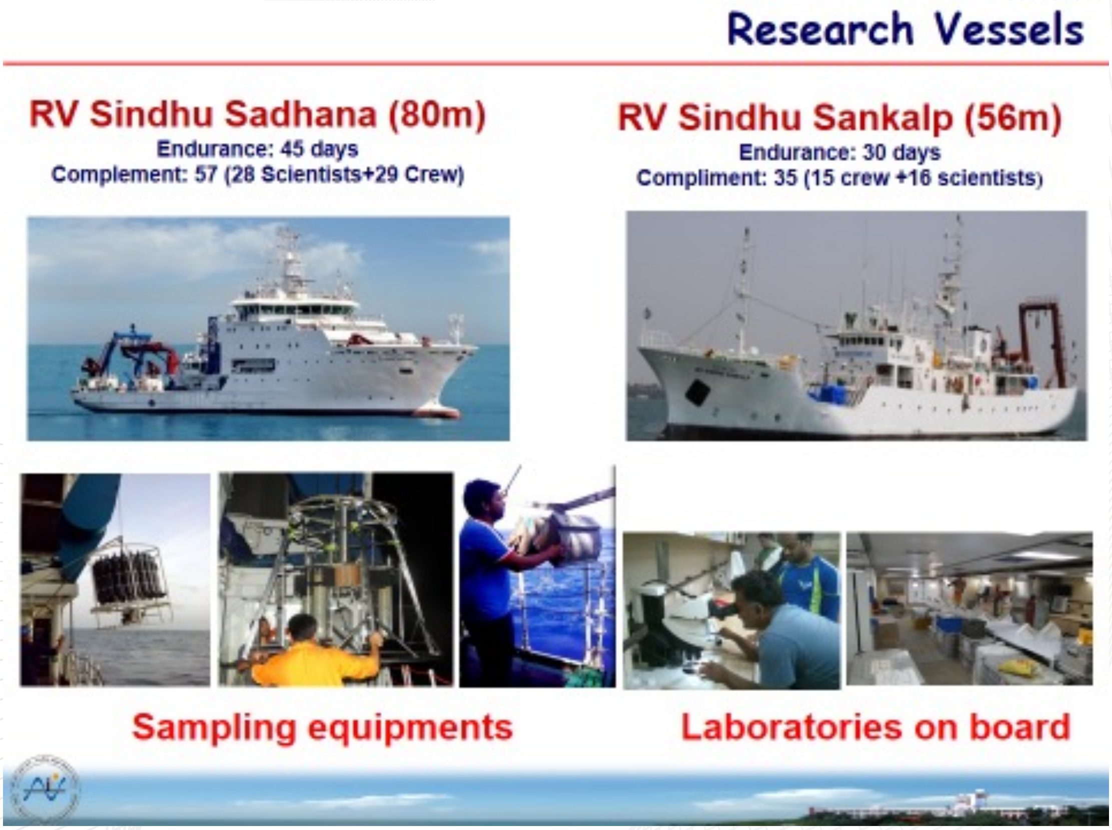
Molecular Weight: 418.566 g/mol
Molecular Formula: $C_{25}H_{38}O_5$
Source: Indo-Pacific sponge Luffariella variabilis (PORIFERA)
Activity: anti-inflamatory, analgesia
Status: Withdrawn from Phase II clinical trials.



Manoalide

Luffariella variabilis

At present there are many sponge derived drugs such as: KRN7000, DISCODERMOLIDE, MANOALIDE that are going through clinical trial. But the lack of sufficient material is in fact the major limiting factor for the development of marine derived compounds to commercial drugs. An annual need of sponge (Lossodendoryx sp.) derived anticancer molecule Halichondrin is 5 kg per year. To get this much material one has to harvest 16,000 metric tons of sponge biomass. To address this issue, processes such as mariculture, cell culture, chemical synthesis, and molecular biology should be used and made widely accessible.



Sponge derived drugs in market / clinical trials				
Compound	**Mode of Action**	**Application**	**Status**	**Company**
Cytarabine (Ara-C)	DNA Polymerase Inhibitor	Anti-cancer drug	Market	Bedford, Enzon
Vidarabine (Ara-A)	DNA Polymerase Inhibitor	Anti-viral drug	Market	King Pharmaceuticals
Eribulin Mesylate (E7389)	Microtubule interfering agent	Anti-cancer drug	Market	Eisai Inc.
Gemcitabine (GEM) (Gemzar)	Ribonucleotide reductase inhibitor replaces cytidine during DNA replication	Anti-cancer drug	Phase II	Eli Lilly and Company
IPL576,092 (Contignasterol derivative)	Inhibition of leucocyte infiltration and hypersensitivity during allergy	Anti-inflammatory drug	Phase II	Aventis Pharma

PM-10450 (Zalypsis®)	Transcription inhibitor	Anti-cancer drug	Phase I/II	PharmaMar
Discodermolide	Microtubule interfering agent	Anti-cancer drug	Phase I/II	Novartis
HT1286 (Hemiasterlin derivative)	Microtubule interfering agent	Anti-cancer drug	Phase I	Wyeth
LAF389 (Bengamide B derivative)	Methionine aminopeptidase inhibitor	Anti-cancer drug	Phase I	Novartis
Hemiasterlin (E7974)	Microtubule interfering agent	Anti-cancer drug	Phase I	Eisai Inc.
KRN7000 (Agelasphin derivative)	Immunostimulatory (Va24 þ NKT cell activation)	Anti-cancer drug	Phase I	Kirin
PM-060184	Microtubule interfering agent	Anti-cancer drug	Phase I	PharmaMar
NVP-LAQ824 (Psammaplin derivative)	Histone deacetylase (HDAC) inhibitors or DNA methyltransferases (DNMT) inhibitor	Anti-cancer drug	Phase I	Novartis Pharma [166]

Conclusion

Despite massive research investments and significant efforts and advances in the search for new sources of medicine and anticancer drugs in recent decades, it remains formidable challenges. Many sources, including plants, animals, and minerals, have been investigated in this field in order to identify novel molecular therapeutics. Secondary metabolites are abundant in marine sponges, and several of them have shown intriguing tumor chemo-preventive, medicinal and chemotherapeutic properties. So, further emphasized on this field is crying need to keep up with the medicinal crisis.

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Plenary Session II, Talk - 8

Catching-up with the UN Decade of Science for ocean: some perspectives

Professor Pierre Failler

Abstract

The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean. Cooperation among scientists, including the enlargement of the UNESCO Chairs in Ocean and related Themes, will lead to the adaptation strategies and science-informed policy responses to global change. The challenge is then to organise the collective scientific initiative.

Introduction

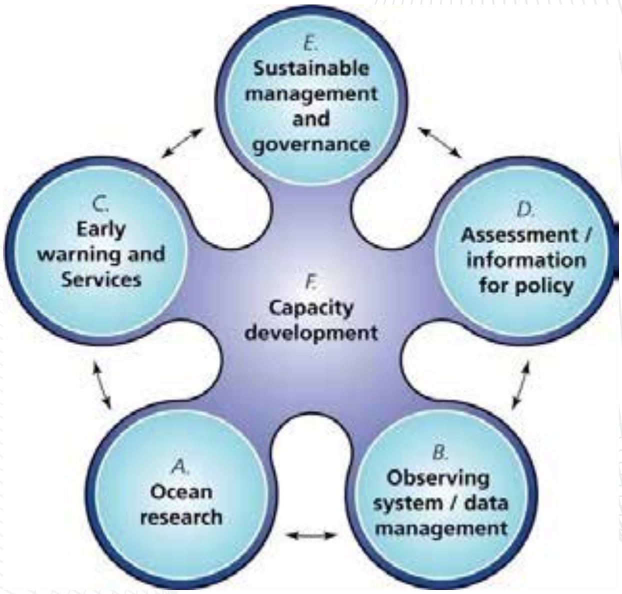
The United Nations has declared the years 2021–2030 as the Decade of Ocean Science for Sustainable Development in order to aid efforts to stop the cycle of ocean health decline and unite ocean stakeholders from all over the world around a common framework that will ensure ocean science can support countries in improving the circumstances for ocean sustainability. Sustainable development requires a scientific understanding of how the ocean reacts to stresses and management decisions. In order to forecast the effects of change, develop mitigation strategies, and guide adaptation, ocean observations and research are also crucial. Science-based policy responses to climate change will result from collaboration among researchers, including the expansion of the UNESCO Chairs in Ocean and Related Themes. The challenge is then to organize the collective scientific initiative.

The greatest part of the Earth's system that maintains climate stability, supports life on Earth, and promotes human welfare is the marine domain. The First World Ocean Assessment, published in 2016, discovered that a significant portion of the ocean is now substantially deteriorated, with modifications and losses in the structure, functionality, and benefits from marine systems. The impact of numerous stresses on the ocean is also anticipated to worsen as the global population rises toward the estimated 9 billion people by 2050.

Role of IOC on UN Decade of Ocean Science

As mandated by the UN General Assembly, the Intergovernmental Oceanographic Commission (IOC) based in Paris of UNESCO will coordinate and lead the Decade's preparatory process and develop its Implementation Plan in consultation with Member States, UN partners as well as other relevant stakeholders for the next ten years in ocean science and technology. There were just 40 member states when the IOC was founded in the 1960s; today, there are around 150. So, it is quite a good improvement, quite a good number of states. By coordinating programs in areas including ocean observations, tsunami alerts, and marine spatial planning, the IOC enables its 150 Member States to collaborate to maintain the health of our shared ocean. Since its founding, the IOC has served as a focal point for all other UN agencies working to comprehend and enhance the management of our oceans, coasts, and marine ecosystems.

We must increase our knowledge of the possibilities and changes taking place throughout the Ocean, especially the deep water. In order to deal with these growing concerns successfully, inform policy, and advance solutions in a prompt and transparent manner, the IOC's duty is to promote scientific research, technological assessments, and synthesis of scientific knowledge. The goal is to make sure that all ocean activities, particularly those of research programs, use the IOC oceanographic data and information management system as their system of choice. It is crucial that the system be based on working national, regional, and global mechanisms that are currently in place.



The functions of the IOC value chain which is described in the IOC Medium Term Strategy are:

A. Foster ocean research to strengthen knowledge of ocean and coastal processes and human impacts upon them [Ocean research]

B. Maintain, strengthen and integrate global ocean observing, data and information systems [Observing system / data management]

C. Develop early warning systems and preparedness to mitigate the risks of tsunamis and ocean-related hazards [Early warning and services]

D. Support assessment and information to improve the science-policy interface [Assessment and Information for policy]

E. Enhance ocean governance through a shared knowledge base and improved regional cooperation [Sustainable management and governance]

F. Develop the institutional capacity in all of the functions above, as a cross-cutting function [Capacity Development]

For some activities you always start with the research. The research is also most of the time directed or asked by the policy, by some society or societal request. So, you can go from A to B to C to D, but you can also make some shortcuts and go from E to A as well.

Ocean Literacy and Capacity Development

Initiatives for capacity building throughout the Ocean Decade will work to improve institutional and individual skills. Throughout the Ocean Decade, capacity improvements will be tracked as part of the monitoring and evaluation process. The Global Ocean Science Report's second edition, which was published in 2020, provided baseline data against which capacity development progress will be evaluated. By expanding knowledge of how humans affect the ocean and how the ocean affects people, efforts to enhance ocean literacy will aid in the development of capacity. The Ocean Decade will support governments and other stakeholders in creating national ocean literacy projects and improving monitoring and assessment of the results of increased ocean literacy.

To meet the challenge presented by the ocean decade, capacity development initiatives will be needs-driven with adequate investment in tools that can match the demand for capacity development to different opportunities.

Some institution involved in Capacity to Build Capacity (C2C) on Oceanography listed below:

- Regional Education and Research Centre on Oceanography for West Asia (RCOWA), I.R. of Iran
- International Training Centre for Operational Oceanography (ITCOOcean), India
- International Centre for Capacity Development, Sustainable Use of Natural Resources and Societal Change (GRO), Iceland

Ocean Decade Outcomes & Challenges

The following 7 outcomes of UN Decade of Ocean Science describe the Ocean We Want:

1. A clean ocean where sources of pollution are identified and reduced or removed.
2. A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed.
3. A productive ocean supporting sustainable food supply and a sustainable ocean economy.
4. A predicted ocean where society understands and can respond to changing ocean conditions.
5. A safe ocean where life and livelihoods are protected from ocean-related hazards.
6. An accessible ocean with open and equitable access to data, information and technology and innovation.
7. An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.

At the global, regional, national, and local levels, the Ocean Decade Challenges highlight the Decade's most urgent and immediate issues. The 10 Ocean Decade Challenges for overall impact are as follows:

1. **Challenge 1:** Understand and beat marine pollution
2. **Challenge 2:** Protect and restore ecosystems and biodiversity
3. **Challenge 3:** Sustainably feed the global population
4. **Challenge 4:** Develop a sustainable and equitable ocean economy
5. **Challenge 5:** Unlock ocean-based solutions to climate change
6. **Challenge 6:** Increase community resilience to ocean hazards
7. **Challenge 7:** Expand the Global Ocean Observing System
8. **Challenge 8:** Create a digital representation of the ocean
9. **Challenge 9:** Skills, knowledge and technology for all
10. **Challenge 10:** Change humanity's relationship with the ocean

Coastal vulnerability and Climate Change

The identification of resources at risk from coastal hazards is known as coastal vulnerability and is a spatial concept that identifies people and places that are susceptible to disturbances resulting from coastal hazards. Physical, economic, and social systems along the shore are seriously threatened by hazards in the coastal environment, such as coastal storms and erosion.

The rising seas' cost may be US$27tn a year for the world by 2100 if it fails to meet the UN's 2ºC global warming limit by then, with sea level rise of, at its worst, almost six feet (nearly two metres). It will cost £3.3 billion to maintain and improve the current flood risk management assets in the Thames Estuary and one flood event equals to £1.8 billion of damages.

As per studies undertaken by The Energy Institute (TERI), a one-meter rise in sea level would displace approximately 7.1 million people in India within the coastal population, and place about 5,764 sq km of land at risk of getting submerged. In an article titled "The Unfolding Tragedy of Climate Change in Bangladesh" author Robert Glennon claimed that A three-foot rise in sea level would submerge almost 20 percent of the country and displace more than 30 million people—and the actual rise by 2100 could be significantly more. Robert Glennon is a Regents' Professor at the University of Arizona College of Law and author of Unquenchable: America's Water Crisis and What to Do About It.

Most countries still lack a thorough understanding of climate change, its possible outcomes, and its detrimental effects and therefore for the time being many (national) authorities tend to respond to climate change in a reactive manner. Although differences exist at national level, the actual coastal protection expenditure in Europe, amounting to on average € 0.88 billion per year over the period 1998-2018, is in line with the projected adaptation cost of 0.49-0.85 billion per year. The countries that have experienced extreme weather events in the past, in particular, have taken the initiative to investigate the potential impacts of climate change for their country, but research results on climate impacts (including Coastal Vulnerability) remain hazy and less suitable for policy development.

Coastal Vulnerability and policy agenda

- Coastal vulnerability should be clearly mentioned in the National Determined Contribution (both for Mitigation and Adaptation)
- Coastal vulnerability has to be within the Blue Economy Policy Framework (such as in Bangladesh)
- In the Marine and Coastal planning with associated Risks

Instead of reacting to the climate change and reacting to what is going on, the less costly solution is to not only to adapt, but to prevent. For mitigating and managing risk of coastal hazard and sea level rising, nature-based solutions like planting more mangroves can be an effective way to tackle the issues.

Insurance issues: costs and risks

Many general insurance policies exclude the coastal risks of storm surge, coastal erosion, and gradual sea level rise. Consumers should make sure they are knowledgeable about their insurance and aware of the hazards to which it will not provide coverage. Governments are anticipated to release projections and predictions for properties that could be vulnerable to gradual sea level rise in due course. Consumers who are concerned about this issue should take note of the timeframes around the forecasts in connection to how long they anticipate staying at the house, and if they have specific issues, they can get in touch with their local council.

The general insurance sector is still urging governments to concentrate on the following four adaption initiatives:

- Strengthening building codes, to prevent brittle building syndrome in the future.
- Risk appropriate land use planning, to limit exposure to current and future hazards.
- Upgrading mitigation infrastructure, to protect existing communities.
- Removing taxation disincentives on insurance products, to encourage individual to take responsibility for their own recovery

Conclusion

Oceans are currently dealing with a number of environmental stresses brought on by human activity, such as ocean acidification, marine pollution, and climate change and resulting in the loss of marine species and degradation of marine and coastal environments. The Ocean Decade strives to stimulate “the science we need for the ocean we want” and aims to ensure that ocean science fully supports nations' efforts to manage the ocean sustainably and to fulfill the goals of the 2030 Agenda. It focuses on addressing ten challenges, which highlight the Decade's urgent goals and seek to engage its partners in coordinated action.

Professor Pierre Failler

UNESCO Chair in Ocean Governance
Director of the Centre for Blue Governance
University of Portsmouth, UK

Comments of Session Chair

Professor Dr. Md. Niamul Naser

First of all, the session chair briefed the audience about the talks and the speakers. He mentioned that, when we are moving toward the ocean we have lots of challenges, but while we are working on the ocean science, we have to think how we will work on the ocean. Today I am very delighted to have four distinguished speakers who will show us the path.

He pointed out that this session is very unique as it has the other side of the blue economy, the port economy. We are developing our ports so we should focus on the science of this. The port management, pollution control, as well as the economic issues need to be addressed. In Bangladesh the course Maritime Science is being taught in BSMRMU which is a very encouraging.

Ocean is critically enabler for our energy security which is very well explained in the plenary talks. It is also related to the geopolitical issue of the region. Various countries and institutions have common interest in energy. Energy is a big issue in the world politics.

The sponge is one of the ancient multi cellular animal which is being discussed by the speaker. The chemicals from the sponges can be used for human. In Bangladesh, 20-30 years ago we have seen few sponges but now we don't see them, we may have to find an alternate way to find another sources of the same chemical in the region.

The discussion on Blue economy with EU prospective is a timely one and thought provoking. All of the talks in this session was very interesting especially the green technology for ocean science, port development, ocean for energy security, linking marine chemical ecology for bio prospecting using sponges.

At the end of the session, the session chair showed his satisfactions regarding the learned audiences and their intriguing questions. He thanked BSMRMU for allowing him to preside the session.

Professor Dr. Md. Niamul Naser

Chairman, Department of Zoology, University of Dhaka, Bangladesh.

Parallel Technical Sessions

Marine Technology and Biodiversity

Oceanography and Energy

Marine Aquaculture and Fisheries

Parallel Technical Session I, Oral Presentation: 013

Biosecurity measures for controlling bacterial infection in Mud crab Scylla olivacea hatchery in Bangladesh

A. F. Md. Hasanuzzaman[1]*, Ghausiatur Reza Banu[1], Md. Rashedul Islam[1]

Abstract

Mud crab (Scylla spp.), with its high demand in sea food market, is an important export commodity. Bangladesh exports Mud crabs (hard-shell in live and soft-shell in frozen form) to Taiwan, China, Hong Kong, Thailand, Korea, Singapore, Japan, USA and EU. About cent percent of the crabs are being caught from natural sources, which is putting natural stock at the risk of depletion. Accordingly, crab seed production in hatchery condition is very indispensable option for sustainable aquaculture of this species. In the recent years, few attempts have been taken to produce crab seed in the hatchery; but larval survival rate has not been satisfactory enough for commercial hatchery operation. Lately, Mud crab brood, larvae, water and feed samples were collected from BFRI-Brackishwater station Mud crab hatchery, and analyzed for pathogenic bacteria. Vibrio spp., Aeromonas spp. and Pseudomonas spp. were detected in some samples. The investigation found association of larval feed and hatchery water with the occurrence of these pathogenic bacteria in the hatchery. To control infection and increase larval survival, the practice of bio-security protocols, especially feed and water quality management measures, is highly recommended.

Keywords: *Mud crab, larvae, pathogens, feed, biosecurity.*

Introduction

Mud Crabs (Scylla spp.), a key artisanal coastal fisheries resource in many tropical and subtropical Asian countries, are important export commodity with its high demand in sea food market. Bangladesh exports Mud crabs to Taiwan, China, Hong Kong, Thailand, Korea, Singapore, Japan, USA and EU. Mud crab from Bangladesh is being exported mostly hard-shell crabs in live forms and soft-shell crabs in frozen forms. In 2019-20, Bangladesh earned $24.85 million by exporting crabs (EPB 2020).

Given wider environmental adaptation, less disease susceptibility, easy live transportation and feasibility to low-input farming technology, the potentiality of Mud crab species for coastal aquaculture diversification has been well addressed (Marichamy and Rajapackiam 1996; Baliao et al. 1999; Primavera and Trino 2001; Shelley and Lovatelli 2011). In Bangladesh, Mud crab aquaculture took its root along the coastal belts in late 1980s (Hasanuzzaman et al. 2014), and was developed in the form of fattening wild lean crab harvested from the forests and rivers around the Sundarbans and the Chakaria Sundarban in Bangladesh. Being an important livelihood option for coastal fisher-folks, Mud crab farming is increasingly practised, even recently intensified with advances in technology (e.g. cage and pen) and farming management (e.g. feeding).

To fulfil the requirement of small crabs for stocking in such myriad of farms, cent percent of the crabs are being caught from natural sources, which is putting natural stock at the risk of depletion; particularly a large quantity of small crabs harvested from natural sources are being stocked in soft-shell farms, but a significant mortality (10-30%, sometimes >60%) occurs. So, seed production in hatchery condition and development of nursery management are very crucial options for sustainable aquaculture of the species S. olivacea, most predominant Scylla species in Bangladesh.

In Bangladesh, Department of Fisheries (DoF) and Bangladesh Fisheries Research Institute (BFRI)- Brackishwater Station conducted research projects for Mud crab seed production; the projects successfully produced seed. BFRI produced the larvae in hatchery condition during 2015-2017, but had low survival. There have been increasing reports on infection and/or disease incidence in Mud crabs (Fig.1,2); particularly in hatchery and farms (Lavilla-Pitogo et al., 2001; Poornima et al., 2008; Jithendran et al., 2010), which is a global concern. Recently, BFRI-Brackishwater Station have found survival up to 7% of Mud crab larvae produced in the hatchery condition through a collaborative research project implemented BFRI- Brackishwater Station and Fisheries and Marine Resource Technology Discipline-Khulna University.

Fig.1. Bacterial shell disease

Fig.2. lesion on chelate leg of diseased Mud crab

Samples were collected from various batches of crab larvae production in the BFRI-BS (Bangladesh Fisheries Research Institute- Brackishwater Station) hatchery in Bangladesh, and analyzed at the laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University. Vibrio spp., Aeromonas spp. and Pseudomonas spp. was detected (Fig. 3,4,5) in some samples including Mud crab brood, larvae tank water and larval feed samples (Artemia and rotifer). Based on the obtained data, this document was developed to provide biosecurity guidelines toward controlling bacterial infection in Mud crab hatchery in Bangladesh.

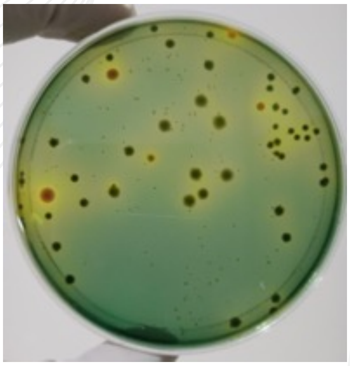


Fig.3. Vibrio colonies

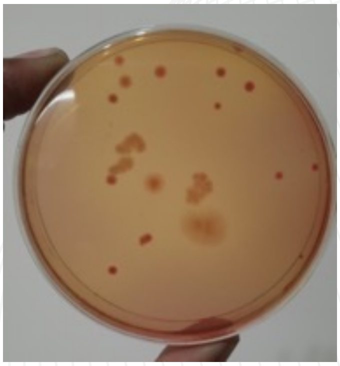


Fig.4. Aeromonas colonies

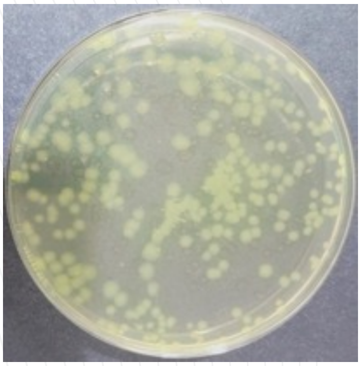


Fig.5. Pseudomonas colonies

Biosecurity protocols for Mud crab hatchery:

To reduce infection as well as increase larval survival in the hatchery, good husbandry facilities, maintenance of hygiene, quality feed and feeding practice are to be ensured. Accordingly, Biosecurity, a basic but straightforward and often cost-free approach of avoiding contact between animals and pathogen, must be followed. The present study has prepared this document describing standard and specific biosecurity protocols (Fig.6):

Standard operating procedures (SOPs):

- The hatchery should be established in the area where minimal pollution risk takes place and the sources of pollution can effectively be controlled or mitigated.
- There should be sufficient light and aeration.
- Good transportation and uninterrupted electricity supply should be ascertained.
- There must be a reservoir or header tank to supply pure water round the year.
- In the hatchery, there should be isolated rooms/compartments wherein various activities such as broodstock management, hatching, larval rearing, nursery etc. are executed; each room/ compartment must have separate foot bath, and facilities for washing hand and materials.
- All tanks, equipments and other materials (e.g. pumps; filters; pipes; trays, nets; buckets; boots; etc) being used in the hatchery are to be cleaned and disinfected (using chlorine 100-200 ppm) at the end of every production cycle and before introducing any new crabs; if required, all materials are to be dried.
- The water being used in the hatchery must be of standard quality, and water is to be treated for killing pathogenic microbs.
- All veterinary drugs and other chemicals must be used in the hatchery following the national and international laws and guidelines.
- There should be separate baskets/bins/containers for effectively collecting and storing different types of wastes.
- Wastewater and all others wastes must be properly treated and disinfected before disposing them in the designated disposal and treatment areas.
- Movements within the hatchery premises should be limited, and entry of disease-vectors such as dogs, cattle, rats; mice; squirrels; cockroaches; other stray animals must be restricted.
- Staff personal hygiene must be maintained; there should be footbath and hand washing facilities at all entrances. They should wash and disinfect their hands during the start of their shift, after use of the toilet, after eating, when the shift end, and whenever deemed necessary.
- There should be good record keeping system for maintaining daily records of various activities during the production cycle, such as hatchery visitors, purchase and introduction of new brood crabs, water exchange, water quality monitoring, behavior of crabs, larvae and crablets, feeding, growth, disease occurrence and investigation, handling, disease control and preventive measurements, mortality, production and sell of crab larvae and crablets, changes in hatchery operations (e.g. water supply changes, new feed; new disinfectants, medicines and new dosages), staff training programmes etc.

Specific Operating Protocols and Management for Mud crab hatchery:

Layout and design:

To ensure effective biosecurity management, the hatchery should have well-designed layout (Fig.6):

- The layout should limit access to the hatchery provided with fences and clearly marked restriction signs, entrance and exit places with footbath and hand washing facilities for both people and their vehicles.
- The floor and wall of tanks should be smooth and painted.
- The corner of the walls and tanks should be round for easy and effective cleaning and sanitizing.
- Each tank must have own water inlet and outlet lines so as to avoid water flow from other tanks and thus limit the cross-contamination.
- The layout should include personal hygiene facilities including toilets, footbaths and hand washing services at strategic locations.

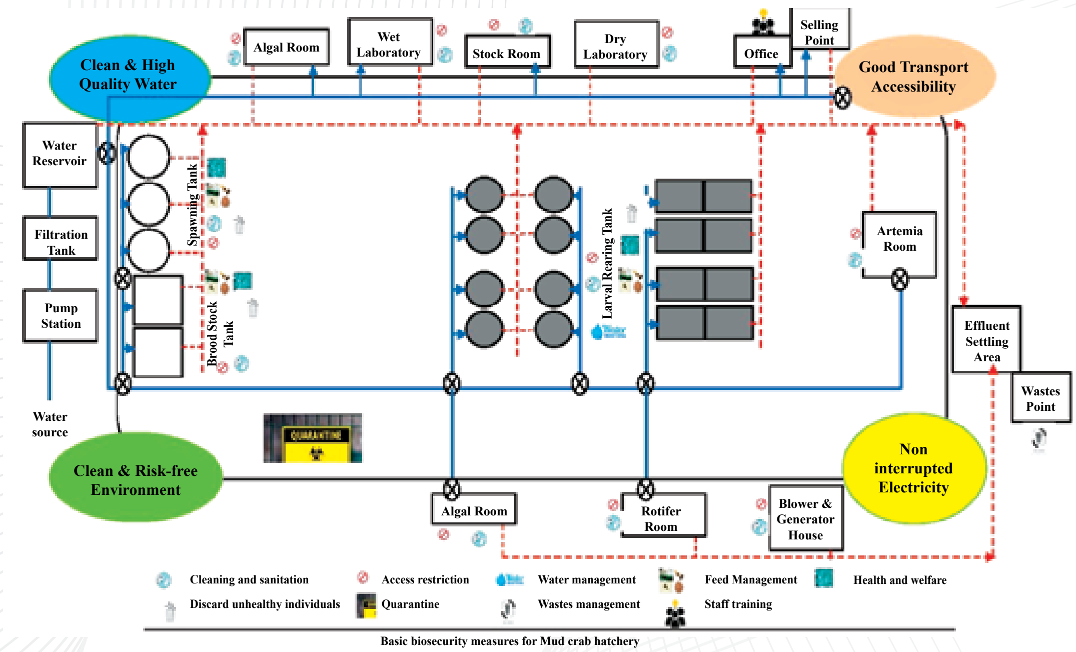


Fig.6. Biosecurity layout for Mud crab hatchery

Water quality parameters and monitoring:

- The water being supplied to the hatchery must be filtered using sand filters, cartridge/bag filters, 0.45 micrometer filter, etc, and treated using chlorination and dechlorination or UV light or ozone before use.
- Sufficient aeration must be maintained in crab larval rearing tanks.
- There should be gentle water circulation so to keep larvae suspended singly within the water column, and constant water temperature as well.
- An airlift system can be used in case of sandy broodstock unit, and larval rearing units.

- Daily water change during larval rearing; on the first 2-3 day, 10-30% water can newly be added without replacing water; after then, about 30% of water should be replaced daily, and up to 80% as the larvae grow bigger.
- For increasing survival rates and reducing ammonia and nitrite levels in larval rearing tanks, specifically at larval stage Z3 or above, installing microalgae-enriched recirculating systems with biofilters and good water exchange rate might be more effective.
- There should be no high organic matter accumulation in the tanks; excess food, moulted exoskeletons and other debris must be removed.

Feed Management

- Nutritionally balanced food and feed should be provided in sufficient amount
- Live feed such as algae, rotifer, Artemia are to be cultivated in axenic condition.
- Rotifer (Brachionus spp.) and Artemia can be fortified with EPA and DHA rich microalgae (e.g. Chlorella spp., Nannochloropsis) i.e. applying bioencapsulation process.
- Enrichment of rotifers with histidine, and Artemia with leucine and tryptophan are recommended to enhance larvae production.
- Artemia enriched with DHA (25 µl) and soybean lecithin (0–40 µl; source of phospholipid) can also be used.
- Supplementation of hormone ecdyson and cholesterol may result in reduction of larval mortality.
- Mixed feed (i.e. live food and other natural food such as minced fish or mussel) is more preferable, especially for the megalopae stage and onward.
- Excess feed must be removed by siphoning.

Health and disease management

- Broodstock should be healthy and from reliable and authorised suppliers; SPF (specific pathogen free) broodstock will be better.
- Selection and collection of broods from wild sources, transportation and acclimatization at the hatchery environment should be accomplished properly and carefully.
- New crabs outside the facility must not be introduced without implementing quarantine for ensuring that crabs are free of biohazard; brood crabs should first undergo a health assessment, specifically for pathogenic microbes' presence, and thereafter should be quarantined.
- Optimum stocking density must be maintained; stocking density of zoeae at 100–150 Z1/L is recommended for Scylla spp.
- Routine examination such as gut fullness, larval discoloration, appetite lack (or none at all), slower movement, spots and/or necrosis on shell, luminous (greenish)larvae, larval settlement at the bottom, whitish mass at the bottom of larval tank, dark hepatopancreas, missing appendages or body parts, abdominal or appendage deformities, erosion, pigmentation, fouling, etc. by health experts are to practiced.
- In case of newly-hatched zoea, a formalin stress test (3 h exposure to 40 mg/L of formalin) can be carried out to evaluate the quality of the newly-hatched Z1; 0%–18% mortality rate indicates that the batch of larvae is healthy and can be transferred to suitable clean rearing

tanks immediately after hatching to reduce chances of bacterial infection, and acclimatized by placing the zoeae in a basin and float the basins in the larval rearing tanks for approximately 20–30 min if there is a temperature difference between the spawning tank and the larvae rearing tanks.

- If necessary, disinfection of egg, larvae and crabs is to be practiced for eradicating pathogens; chlorine and UV-ray can be used to disinfect brood and larval tanks. If chlorinated, de-chlorination with sodium thiosulfate has to be done.
- Though routine application of antibiotics is not desirable, antibiotics (e.g. Oxytetracycline, Penicillin, Polymixin) and fungicide are still used throughout the world to control egg loss, zoea larvae mortality due to bacterial (e.g. Vibrio spp.), fungal infection and ciliate infestation; particularly during live food feeding, antibiotics can be used very carefully.
- Commercially available hatching chemicals, e.g. INVE Hatch Controller can be used to control pathogenic bacterial load.
- As alternatives to antibiotics, commercially available potential probionts and probiotics (e.g. Bacillus sp., Streptococcus sp., Pseudomonas sp.,) can be used in the larval rearing units.
- Dead and moribund crabs, larvae, crablets should be handled and disposed of in a sanitary way

Conclusion:

Mud crab is one of the most important potential crustacean aquatic species for coastal aquaculture in Bangladesh. The farming and export of Mud crabs substantially contribute to the livelihood of people and national economy. It is a must to produce Mud crab larvae and crablets in the hatchery for sustainable development of Mud crab industry. But, the hatchery production has been at the risk of diseases; the present study found bacterial infection in some samples collected from the hatchery. To control bacterial infection and lessen larval mortality rate, effective implementation of biosecurity measurements in the hatchery must be carried out.

Acknowledgment:

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Parallel Technical Session I, Oral Presentation: 026

Blue biotechnology to white biotechnology: challenges and prospects in the perspectives of Bangladesh

Md. Mehadi Hasan Sohag

Abstract

In 2012, one of the landmark achievements of the government is none other than winning of the sea border dispute and this outstanding victory has opened a door of enormous prospects in future. For the last twelve years, we have achieved an envious success in inland aquaculture and fisheries which are inevitably proven in the time of COVID pandemic. But till now, we have to go more ahead with our extended sea resources to attain the goal number 14 "Life below water" of SDG. Sea and Ocean are the unique and abundant harbor of natural resources including marine fisheries, bio-fuel and others. Sea fishes (wet and dry both), Agar, Neutracuiticals, Functional Foods and other Cosmeceuticals would be derived from sea resources and definitely this product will significantly increase the GDP of our country. To make sure the sustainable bioeconomy, blue or marine biotechnology should be converted into white or industrial biotechnology. In this article, we have put our though to industrialize the marine product which ensures the sustainable economy and established a new sector of development and progress. Despite this scope and prospects there are lot of challenges like policy making, awareness, lack of skilled people, ill management are the obstacle pillar in the path of progress. Already World Bank (WB) has been reported that blue economy has contributed more than 3% in total economy of our country. So, it is certain that proper policy making and implementation could increase three to five times of the current contribution.

Keywords: *Blue Biotechnology, White Biotechnology, Functional Foods, Cosmeceuticals, Sustainable Bioeconomy*

Introduction

As we know from the childhood that three fourth of the biosphere is covered with water and the rest is land. The Oceans has covered almost over 70 percents of the earth surface with a rich combination of biodiversity as well as profound harbor of microorganism, makes the marine biosphere is the treasure of the universe. We are blessed with bay of Bengal and having the inherent biodiversity of the Indian Ocean.

Bioresource component of our sea: As we are in third position for the inland aqua-culture, we are not given our prime focus on marine fisheries, though Bay of Bengal is like a bed of treasure. Only ten percent of total fish demand is taken from marine sources. So, fisheries would be the prime component of blue biotechnology. Besides this, other resources like marine microorganisms can produce extra-cellular novel metabolites, pharmaceuticals, neutracuiticals and cosmetics. Algae (Micro and macro) and other plantains are also regarded as asset that

Figure 1: Bay of Bengal is our potential treasure

produces fuels and so on. However, a vast area of the sea contain minerals are the sole raw material in chemical and other industries.

Wheel of Blue Economy- blue biotechnology:

As we are getting versatile products from marine bio-resources, so the economy related with the bio-resources derivatives is nothing other than blue economy. So, for the economic growth, biotechnological approaches are the ultimate transporter. This is why; blue biotechnology is called as the wheel of bioeconomy. A generalized representation of the biotechnology applications related to marine bio-resources depicts the prospects of omics technology (Genomics, Proteomics, Transcriptomics, and Metabolomics) as well as the bio-prospecting to produce value added products.

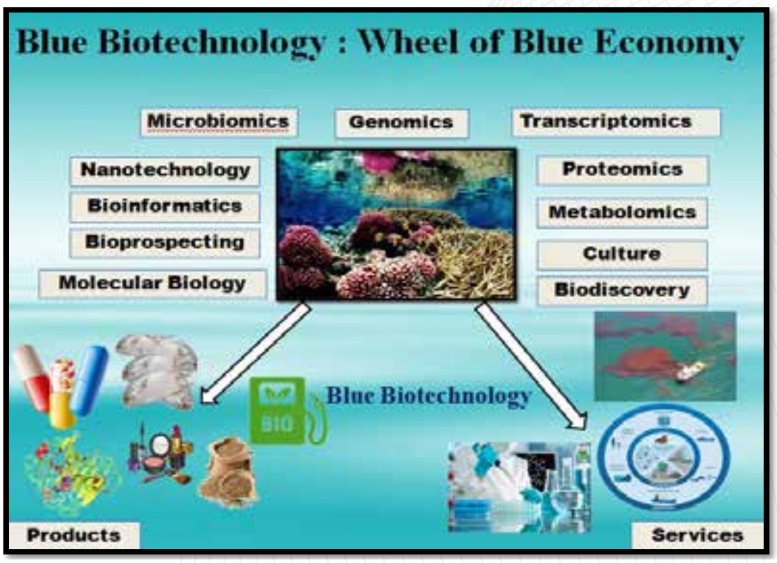

Figure 2: Overview of blue biotechnology

As we have a huge marine boundaries after the victory against India and Myanmar, if we just focus our biotechnology tools to produce agar-agar and textiles enzymes we can save almost five hundred thousand USD per year. However, there are some other precious products like cosmetics and neutracuiticals can be derived from marine organisms.

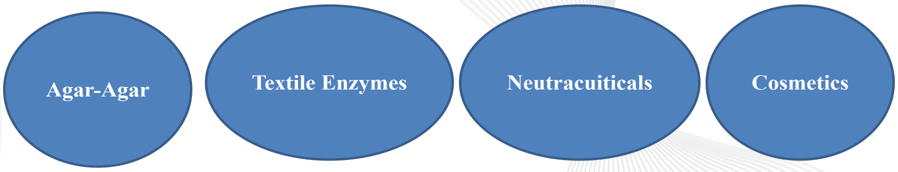

Figure 3: Possible prospects of marine bio-resources in our context

Blue Biotechnology to White Biotechnology- a potential shift:

Colors of biotechnology are an eminent expression of the application and implementation of the biotechnology in generating value added products and services. When the biotechnology tools and strategies are applied marine bio-resources, this phenomenon is termed as blue biotechnology. On the contrary, if the bio-resources are converted into industrially significant product (e.g. enzymes, peptides, cosmetics, hormone, ethanol and so on) in an industrial process, then we can call it white biotechnology. This presentation depicts that prospects of blue biotechnology is generating revenue by being utilized through white biotechnology. This shift makes a positive contribution in our national economy and boost up the GDP as well as the conomic growth. On that context, we can recognize this shift as a positive one.

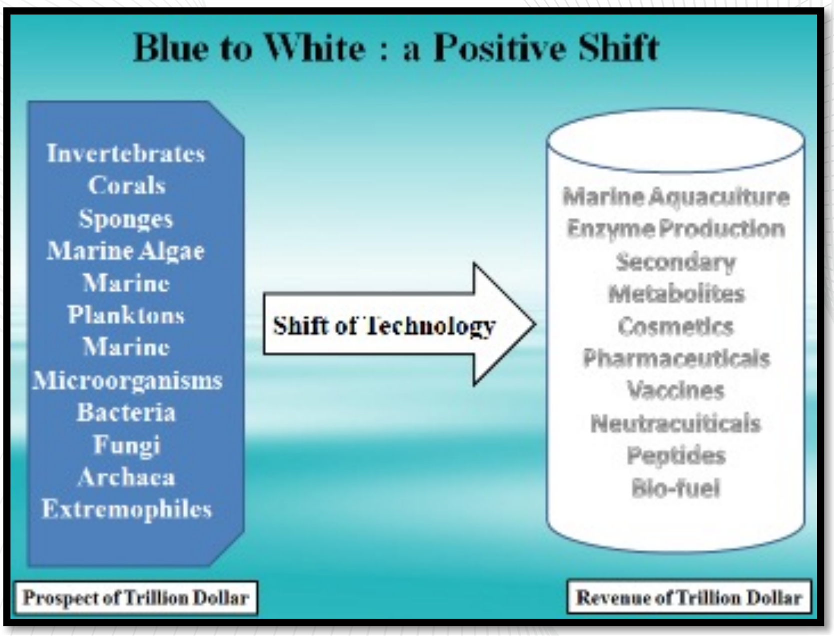

Figure 4: Blue Biotechnology to White Biotechnology- a Positive Shift

Marine Biotechnology is the anchor of SDG:

In 2015, UN has decided to make the earth free from any types of discrimination. World leaders has committed on that meeting to maintain the seventeen goals which is synonymously termed as sustainable development goals (SDG). Blue biotechnology has covered almost seven goals. Though blue biotechnology has direct impact on Goal-14 (Life below water), but it also produces food and feed supplement which is prime focus of Goal-2 (Zero hunger), affordable clean energy (Goal-7), Decent work and economic growth (Goal-8), Industry (Goal-9), reduce inequalities (Goal-10), responsible consumption and protection (Goal-12), and the climate action (Goal-13).

Figure 5: Blue biotechnology and SDG

Recommendations:

As a country of the Lower and middle income countries (LMICs), we must put our concentration on the development of marine biotechnology to give a sustainable shape to the blue economy. We need a concrete plan and then build up the capacity to implement the plan. Nevertheless, we need skillful personnel who can do their best to utilize the bio-resources. Moreover, awareness campaign is a must to save our ocean pollution free. However, community engagement, stakeholder attachment, lawful monitoring and environment friendly policy will be the sustainable solution to flourish the blue economy in Bangladesh.

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Comments of Session Chair

Professor Dr. Mohammad Nazir Hossain

Professor Abdullah Harun Chowdhury from Khulna University expressed his concern about the Algal Flora of St. Martin's Island of Bangladesh and their sustainable Conservation. Dr. A.F.Md. Hasanuzzaman talked about the necessity of Biosecurity measures for controlling bacterial infection in Mud crab Scylla olivacea hatchery in Bangladesh while Md. Mehadi Hasan Sohag in his talks discussed the challenges and prospects of Blue biotechnology to white biotechnology: in Bangladesh perspectives. He suggested that to make sure the sustainable bioeconomy, blue or marine biotechnology should be converted into white or industrial biotechnology.

Professor Ashan Habib in his paper showed the diversity of marine life on Saint Martin's Island in the northern Bay of Bengal, Bangladesh. In the end, the floor was open for questions and answers and the participants interacted lively with the distinguished speakers asking high-level of questions. Professor Nazir Hossain expressed his gratitude to all the distinguished scientists to present their research works at BSMRMU international Seminar 2022. He also thanked the BSMRMU authority for making him the session chair. He also hoped that graduates from BSMRMU especially from the Dept of Genetic Engineering and Biotechnology will make a positive contribution to the Blue economy of Bangladesh. The session ended with a warm round of applause.

Professor Dr. Mohammad Nazir Hossain

Head of the Department, Genetic Engineering and Biotechnology, BSMRMU

Parallel Technical Session II, Oral Presentation: 001

Impacts of Sea Level Rise and Utilization of Unmanned Aerial Vehicles (UAVs) for Coastal Monitoring in Bangladesh: Prospects, Challenges and Way Forward

Dr. Hosnay Nasrin

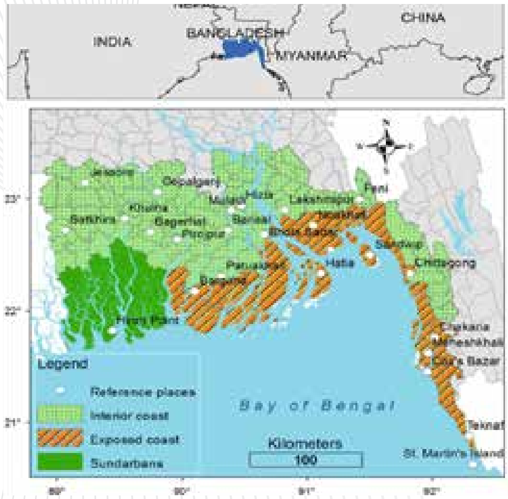
Abstract

Bangladesh is recurrently cited as one of the most vulnerable countries to climate change. Many of the anticipated adverse impacts of climate change, such as sea level rise, higher temperatures, enhanced monsoon precipitation, increase in cyclone intensity etc aggravate the existing stresses that already hindered socioeconomic development of Bangladesh. Sea level rise affects the vast coastal areas and flood plain zone of Bangladesh and gradually the situation would be worsened if appropriate measures are not taken timely. Both livelihood options of coastal communities and the natural environment of the coastal zone of the country will be affected adversely by the anticipated sea level rise (50 cm by 2050). On the other hand, the utilization of Unmanned Aerial Vehicles has rapidly evolved over the past decade in different parts of the world involving a variety of fields ranging from agriculture, commercial, coastal monitoring and becoming increasingly used in disaster management or humanitarian aid. Hence, this article aims to determine the impacts of sea level rise in coastal areas of Bangladesh and explore the prospects of utilization of Unmanned Aerial Vehicles for coastal monitoring. This study has been initiated by collecting and reviewing primary and secondary data. Mixed-method research methodology has been used which includes both quantitative and qualitative approaches. It is evident that applications of Unmanned Aerial Vehicles need to be further explored examining the existing challenges; to focus further on drone assistance for coastal monitoring. It is envisaged that with the sufficient supportive actions and policy measures, the application of Unmanned Aerial Vehicles for coastal monitoring including disaster management in Bangladesh appears to be promising and will improve its effectiveness.

Keywords: *Climate Change, Sea Level Rise, Unmanned Aerial Vehicles (UAVs).*

Introduction

Bangladesh is frequently cited as one of the most vulnerable countries to climate change because of its geographic location; flat and low-lying topography; reliance of many livelihoods on climate sensitive sectors; and inefficient institutional aspects. The total land area of the country is 147, 570 sq km and consists mostly of low, flat land; 80 per cent of the land is floodplain, and only in the extreme northwest do elevations exceed 30 metres above mean sea level, making the majority of Bangladesh (with the exception of the highlands) prone to flooding. The coastal area of Bangladesh (Map 1) and the Bay of Bengal are located at the tip of the northern Indian Ocean, which is frequently hit by severe cyclonic storms, generating long tidal waves that are aggravated by the shallow bay. Coastal areas in Bangladesh are on the 'front line' of climate change, directly affected by storm surges, drainage congestion, and sea level rise. Sea level rise in Bangladesh is higher than the mean average rate of global sea level rise over the past century, because of the effects of tectonic subsidence.



Map 1: Coastal Zone of Bangladesh
Source: *warpo.portal.gov.bd*

Sea level rise will directly result in increased coastal flooding, which will increase in the event of storm surges. In Bangladesh, about 46% of its total population live within 10 m above sea level and approximately 50 million people live 5 m above the mean sea level. With sea levels expected to rise by an average of two to three mm per year during the first part of this century, the effects on the coastal areas will be severe including erosion, coastal land subsistence, siltation of river estuaries, reduced sedimentation, waterlogging, and saltwater intrusion. Although Bangladesh now has good early warning systems and cyclone shelters have been constructed along much of the coast, infrastructure and livelihoods are still threatened and severely affected, hampering further development of the coastal areas. In the coastal regions including Sundarbans salinity intrusion is brought about by sea level rise resulting in saline water intrusion in the estuaries and into the groundwater. If sea levels rise up to one metre this century, Bangladesh could lose up to 15 per cent of its landmass and up to 30 million Bangladeshis could become climate refugees. In their research Mehvar et al.(2018) quantified the total loss of about US$ 0–1 million to US$ 16.5–20 million to different ecosystem services due to the different levels of relative sea level rise (RSLR) under different Representative Concentration Pathways (RCPs) until 21st century in the west coast of Bangladesh. Islam et al. (2018) have also found in their study that a considerable amount of areas in the south-western part of Bangladesh have been suffering from waterlogging condition. Bangladesh government introduced policies and action plans namely Coastal Zone Policy (CZP) in 2005, Bangladesh Climate Change Strategy and Action plan in 2009 and formulated National Adaptation Program of Action (NAPA) in 2005 at national level to address the SLR induced impacts. Bangladesh is also a leading example for the implementation of community-based adaptation (CBA) measures among least developed countries. Development of adaptation policies for different sectors will help Bangladesh to deal with the crucial hazards of sea level rise. Lobby in the international communities would be helpful to mitigate CO2 emissions, which is responsible for global warming and sea level rise. Proper mitigation plan and formulating adaptation policies are emerging need to minimize the impacts of sea level rise upon the country. To implement the mitigation and adaptation plan, adequate data, information and coastal mapping are very crucial. Hence, in recent years many countries are successfully using Unmanned Aerial Vehicles (UAVs) for coastal monitoring, mapping and disaster management, such as USA, UK, Australia, New Zealand etc. Whether mapping natural resources or coastal environment through 3D models, simple off-the-shelf drone technology has proven to be an affordable and accessible option for these and similar tasks. So, there is an ample opportunity for concerned authorities to effectively monitor and assess the coastal resources of Bangladesh by adopting simple and easy-to-use methodologies for the utilization of UAVs/drones to support their decision-making processes. Hence the purpose of this paper is to examine the impacts of sea level rise in the coastal region of Bangladesh and explore the potentiality of the uses of UAVs for monitoring coastal environments, bio-diversity and habitats.

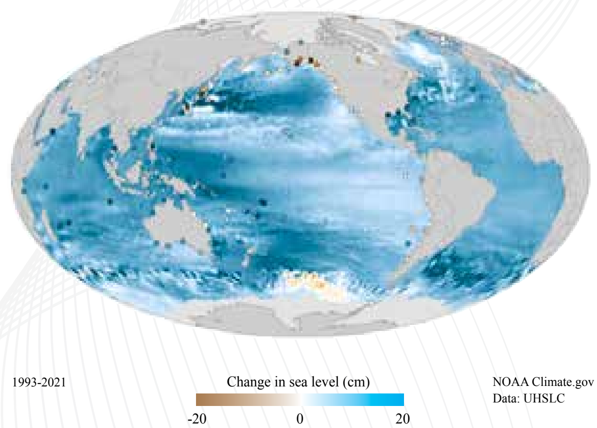
Methodology

This study has been initiated by collecting required data and information from several research-based databases, peer-reviewed journals, newspapers, e-magazines, and relevant organization's websites to delineate the scenario. Relevant literature on impacts of sea level rise and utilization of UAVs for coastal monitoring and disaster management have been also reviewed. Mixed-method research methodology has been used to conduct the research which includes both quantitative and qualitative approaches. Primary cross-sectional data has been collected using purposive sampling technique, through- direct/telephonic interview, emailing by with semi-structured questionnaire (using 5-point Likert-scale, ranging from 1= strongly disagree to 5= strongly agree), meetings, seminars and FGDs. Qualitative data have been gathered by informal discussion/interview conducted on academia, Govt. officers, researchers, representatives of NGOs/Development partners, students and so on. Data collected from primary sources has been analysed through various analytical tools and techniques. Furthermore, statistical software SPSS 17 has been used to analyse the data. In this research utilization of UAVs for coastal monitoring has been considered as dependent variable and research & development (V1), interagency coordination (V2), price and import tax of UAV (V3), capacity building (V4) and technological cooperation (V5) have been considered as independent variables. This study has been conducted under the statistics of inferential analysis consisting t-test, Pearson correlation analysis and regression analysis. It has also considered ANOVA one way test to examine the significant relationship among the variables.

Sea Level Rise Scenario: Global and Bangladesh

Climate change-induced Sea Level Rise (SLR) has been a major concern for coastal and low-lying areas of the world since these areas undergoes several morpho-dynamic processes due to several geomorphological, climate change and oceanographic factors. The rate of global sea level rise is accelerating: it has more than doubled from 0.06 inches (1.4 millimeters) per year throughout most of the twentieth century to 0.14 inches (3.6 millimeters) per year from 2006–2015. By the end of the century, global mean sea level is likely to rise at least one foot (0.3 meters) above 2000 levels, even if greenhouse gas emissions follow a relatively low pathway in coming decades. IPCC estimated that sea level rise would be 66 cm under business-as-usual conditions by 2100 with a range of uncertainty of 13 to 110 cm.

In 2021, global sea level set a new record high—97 mm (3.8 inches) above 1993 levels (Figure 1). According to the 2022 IPCC WGII Sixth Assessment Report the "population potentially exposed to a 100-year coastal flood is projected to increase by about 20% if global mean sea level rises by 0.15 m relative to 2020 levels" According to the Global Climate Risk Index of 2021, five of the top ten nations most affected by long-term climate-induced risks were Asian countries. Bangladesh ranked seventh in both the 2020 and 2021 reports.



Between 1993 and 2021 mean sea level has risen across most of the world ocean (blue colors). In some ocean basins, sea level has risen 6-8 inches (15-20 centimeters). Rates of local sea level (dots) on the coast can be larger than the global average due to geological processes like ground settling or smaller than the global average due to processes like the centuries-long rebound of land masses from the loss of ice-age glaciers. Map by NOAA Climate.gov based on data provided by Philip Thompson, University of Hawaii.

***Figure 1**: Global Sea Level Change (1993-2021)*

Impacts of Sea Level Rise in the Coastal Region of Bangladesh

A considerable number of empirical studies have been carried out with respect to SLR induced impacts and associated extreme events in Bangladesh. Ahmed et al. (2020) reported that among the coastal zones of Bangladesh, the central zone is highly susceptible to erosion being influenced by the different hydro-climatic factors including sea level rise. The higher variation of mean SLR along with varied degrees of river discharge contributes to the high rate of erosion in the country. UN High Commissioner for Human Rights and the Environmental Justice foundation stated that around 16330.6 to 25238.2 square kilometers of Bangladesh–especially around the low-lying coastal regions–will be submerged due to rising sea levels by 2050.

Bangladesh may have almost 20 million internal climate migrants by 2050 – corresponding to roughly 12% of the entire population of Bangladesh with a projected 50 cm rise in sea level and the country may lose approximately 11% of its land by then. Environmentalists and geologists

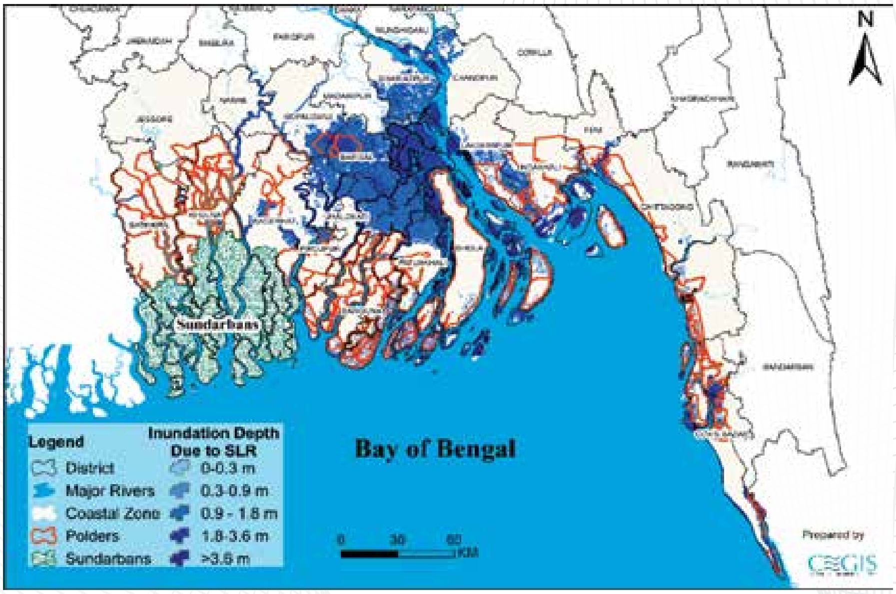


Figure 2: *Potential Inundation in Bangladesh by 2050*
Source: *CEIGS, BoB Model 2021*

emphasize that if the seas level rises even by 1 meter, 70% of Sundarbans will be submerged. It is estimated that each year, in communities like Khulna, Bagerhat, Barguna, Barisal, Bhola, Khulna, Jhalakati, Pirojpur, and Satkhira increased salinity, siltation, flooding, and worsening cyclones have devastated the agriculture sector, affected living and working conditions. This means Bangladesh is very vulnerable to rising sea levels due to global warming as low-lying lands will get submerged first. Climate change will further aggravate historical sea-level rise and projections for the coastal areas, affecting coastal communities, infrastructure and livelihoods (Figure 2).

Climate change and SLR will have a detrimental impact on all of the forest ecosystems in Bangladesh, and the Sundarbans are likely to be the worst affected. Low lying coastal cities are at the forefront of climate change impacts, directly vulnerable to the risks of sea level rise and storms. Direct impacts will occur through the increased floods, drainage congestion and water logging, as well as further infrastructure damage during extreme events. Milliman et al. (1989) reported 1.0 cm per year sea level rise in Bangladesh. World Bank (2000) showed 10 cm, 25 cm and 1 m rise in sea level by 2020, 2050 and 2100; affecting 2%, 4% and 17.5% of total land mass respectively (Table-1). A 1m rise in sea level would submerge around 18 % of the total land area in Bangladesh (Minar, Hossain, and Science 2013). Maximum rise in the water level is observed in the South East region at the Maheshkhali which is 7.4 mm/year followed by 7.04 mm/year in the Sandwip and 5.05 mm/year in the Cox's Bazar (Nishat and Mukherjee 2013). The south-east and eastern coastal area (SEE) has an area of 13,891 sq. km and 10.93 million vulnerable people.

***Table 1:** Sea Level Rise in Bangladesh and its Possible Impacts*

Year	2020	2050	2100
Sea level rise	10 cm	25 cm	1 m (high end estimate)
Land below SLR	2% of land (2,500 km²)	4% of land (6,300 km²)	17.5% of land (25,000 km²). Patuakhali, Khulna and Barisal regions will be most affected
Storm surge		1991 cyclone happens again with a 10% increase in intensity, wind speed increases from 225 to 248 km/h; storm surge goes from 7.1 to 8.6 m with 0.3 m SLR.	Storm surge goes from 7.4 to 9.1 m with 1 m SLR.
Flooding	20% increase in inundation.	Increase flooding in Meghna and Ganges floodplain. Monsoonal floods increase yield loss.	Both inundation area and flood intensity will increase tremendously.
Agriculture	Inundate 0.2 Mmt. of production; <1% of current total.	0.3 m SLR inundate 0.5 Mmt. of production; 2% of current total.	Devastating flood may cause crop failure for any year.
Ecosystem	Inundates 15% of the Sundarbans	Inundates 40% of the Sundarbans.	The Sundarbans would be lost. Loss of the Sundarbans and other coastal wetlands would reduce breeding ground for many estuarine fish, which would reduce their population.
Salinity	Increase	Increase	Increase

(Adapted from World Bank, 2000)

The region faces hazards similar to those in the south-western coast. It includes the major industrial areas, ports and some forests. A large percentage of households have faced damages due to cyclones (29 percent), salinity (2.5 percent) and lightning (7.2 percent) in recent years (BBS, 2022a). Average losses and damages due to disasters were BDT 17.2 billion during 2016-2021, mainly driven by climatic stresses (BBS, 2022a). Future climate change will intensify these stresses. The impact of climate change on livelihoods may propel approximately 19.9 million internal climate migrants by the 2050s, half the projected climate migrants of the entire South Asia region (NAP, 2022). In 2020, Cyclone Amphan affected more than a million people in 26 districts and caused 26 deaths. It damaged 55,667 houses, 149,000 ha of agricultural lands, 1,80,500 hatcheries, 150 km of embankments, 200 bridges and culverts, and 100 km of roads, causing a total loss of BDT 11 billion (IFRC, 2021). Future 50 cm sea-level rise combined with a SIDR/Amphan equivalent cyclonic storm surge could potentially inundate large parts (11%-12%) of the coastal area of Bangladesh (DoE, 2020).

Utilization of UAVs for Coastal Monitoring: Global Perspective and Prospects in Bangladesh

In relation to sea-level rise, the most important early measure required is to start making more detailed assessments of different physiographic regions and sub regions within and adjoining the coastal zone in order to provide a comprehensive factual basis for planning current and future development. Existing institutions for monitoring tide levels, river flow, soil and water salinity need to be strengthened. The geographical diversity and complexity of Bangladesh's coastal zone and the multidisciplinary nature of many of the mitigation measures identified that a comprehensive Integrated Coastal Zone Management Plan is needed, along the lines of the Dutch Delta Management Plan, with appropriate staffing to prepare, operate, monitoring and oversee it. National and Local authorities who manage the coastline and are engaged to implement national mitigation and adaptation plan need to take effective decisions on the basis of real time data. Collecting data with UAVs could lead to significant efficiencies in coastal monitoring, management and maintenance apart from improve effectiveness of erosion mitigation measures. The Civil Aviation Authority of Bangladesh (CAAB) approved a regulation for operating remotely piloted aircraft systems in 2016. From coastlines to inland flood plains, gaining a more accurate and accessible view of our environment using drones will help concerned authority and researchers to manage and adapt to environmental pressures as climate change and SLR increasingly affect Bangladesh. Modern geospatial technology is used to enhance disaster preparedness as well as response activities. UAVs can be used for data collection through coastal monitoring that assists in disaster risk reduction efforts in the country. These data can be fed into modelling systems that provide valuable insights which can assist the Government in better planning of disaster relief management as well as response services. In Bangladesh, geological surveys reveal that Bangladesh itself is lying over as well as surrounded by three fault zone topography. UAV as a tool can be used for mapping fault zone topography. This could be used to coastal management decision-making as well as record the coastal response to specific storm events. UAVs/Drones can be used for coastal and landscape mapping in Bangladesh to provide precise pictures for valuation, monitoring as well as research. Drones may play an effective role in checking illegal intrusion in the coastal zone of the country including Sundarbans, identifying illegally net fishing in the forest too. The ortho maps can help to improve forest management (Sundarbans) as well as operational planning, poaching of endangered species, unsustainable uses of forest resources, land occupancy as well as encroachment. It can also assist in tracking native species, monitoring biodiversity as well as ecological landscape features. It is very useful for coastal area & forest inventories including adaptive planning, high project customization, and rapid implementation, even under challenging weather conditions. In Bangladesh UAVs can be used to map waterlogged areas, identify the causes as well as take quick and necessary actions to free submerged roads from waterlogging in coastal areas. During flash flooding, water levels rise and fall rapidly with little or no warning. However, drone technology can resolve this drastic problem. With the application of high-resolution infrared cameras, health of habitat in the coastal areas can be assessed and adequate emergency measures can be undertaken as well. A smart coastal environment monitoring (Smart EM) method can be implemented in Bangladesh by using an Unmanned Aerial Vehicle (UAV) to collect and process the data. UAV-based data acquisition is an effective solution for retrieving sensor data, even from inaccessible locations.

Primary Data Analysis and Findings of the Study

In this research, primary data has been collected from 350 respondents to identify the major determinants that affect the utilization of UAVs for coastal monitoring in Bangladesh.

Pearson Correlation Analysis: Pearson correlation is used to determine the relationship between any two variable or more in which they vary across a period, Correlation can vary from +1 to -1, where values close to +1 are highly correlated while values close -1 are lowly correlated.

Table 2: *Pearson Correlation Analysis*

	V1	V2	V3	V4	V5
Pearson Correlation	0.427**	0.497**	-0.209**	0.345**	0.552**
Sig. (2 -tailed)	0.000	0.000	0.000	0.000	0.000
N	350	350	350	350	350

** Correlation is significant at the 0.01 level (2-tailed)

In this research, the above table of Pearson correlation analysis shows that V5 technological cooperation has the highest and positive correlation with dependent variable (p=0.552) while V2 interagency coordination and V1 research and development have almost average and positive correlation of (p=0.497) and (p=0.427) respectively. V4 capacity building has a p value 0.345 with positive correlation with dependent variable, but V3, price and import tax of UAVs has a p value -0.209 which shows negative relationship with the dependent variable. Overall, the Pearson correlation result shows that all the independent variables are more or less positively correlated with dependent variable except V3.

Table 3: *Regression F Values*

Model		Sum of Squares	Degree of Freedom	Mean Square	F Value	Sig-(2 tailed)
1	Regression	29.916	5	5.983	49.265	.000b**
	Residual	41.778	344	.121		
	Total	71.694	349			

a. Dependent Variable: Utilization of UAVs for Coastal Monitoring

b. Predictors: (Constant), Research & Development, Interagency Coordination, Price and Import Tax of UAVs, Capacity Building and Technological Cooperation.

c. Significant at 5% level of confidence.

The value of F test in this model is 49.2651, which indicates high F value, But the p value .000b (b= predictors: Constant) of all the independent variable are significant at 5% level of confidence. As a result, all the null hypotheses are rejected and alternate hypotheses are accepted. So, there are significant relationship between dependent and independent variables.

Table 4: *ANOVA One way T test*

	F Value	Utilization of UAVs: Sig.(2 tailed)
Research & Development	9.261	.000**
Interagency Coordination	10.360	.000**
Price and Import Tax of UAV	3.645	.000**
Capacity Building	4.047	.000**
Technological Cooperation	13.607	.000**

**Significant at 5% level of confidence

Based on the findings of ANOVA one way T test, the p value of each five independent variable are 0.000 (less than α=0.05) which represents significant relationship between dependent and independent variables. All the independent variable has direct impact upon dependent variable. It has been realized from the research result that if research and development concerning UAV increases then scope of utilization of UAVs for coastal monitoring in Bangladesh will be increased, same as, if interagency coordination increases for the development and uses of UAVs for coastal monitoring then scope of utilization of UAVs will be increased. Further if capacity building and technological cooperation locally and globally enhances, then utilization of UAVs for coastal monitoring in the country will also be enhanced. Therefore, it is measured by the data analysis that if the price and import tax of UAVs or relevant equipment for building a UAV increases then scope of utilization of UAVs for coastal monitoring in the country will decease as in this research, data shows that there is a negative relationship between price and import tax of UAVs and utilization of UAVs for coastal monitoring.

Challenges and Recommendations

Most experts agree that climate change is one of the biggest challenges to face mankind in recent memory. Sea level rise is one of the symptoms of the phenomenon. Managing coastal and ocean activities is a big challenge for the days ahead. The use of drone technology can go a long way in the effort to protect coastal environment around the world. There are several challenges to the successful implementation of UAVs in Bangladesh for coastal monitoring and disaster management, such as: high initial cost, import tax and requirement of quality software; lack of clarity around how drone data influences decision-making; lack of institutional buy-in or support; cost of hiring drone services; limited technical expertise and availability of trained personnel; technical and environmental constraints (weather dependency); data privacy and security; flight time and range; legal aspects and interference with the airspace; lack of research and capacity building; limited interagency coordination; lack of technological cooperation etc. For the successful utilization of UAVs in Bangladesh for coastal monitoring and disaster management, the existing challenges need to be addressed with adequate measures. Although there is no lack of laws, policies and strategies in Bangladesh and each and every law is satisfactory, but the problem lies with the comprehensiveness and that most of the laws, as adopted, cannot reach the phase of implementation. The Territorial Waters and Maritime Zones Act, 1974 is the first law in independent Bangladesh that governs the coastal issue, especially delimiting maritime territory. In South Asia, Bangladesh is a pioneer in initiating the integrated concept for coastal management in this region. To monitor and manage coastal and marine resources and environment utilizing drone data, the following recommendations can be taken into consideration and incorporated into the policy framework;

i. Research and development are crucial for the expansion of UAV industry in Bangladesh. To utilize the drone technology adequately for coastal monitoring in Bangladesh, concerned organizations can undertake research projects collaboratively.

ii. Integration, harmonization and consistency of strategies for coastal monitoring is required to turn them into a single comprehensive policy document. Interagency coordination can be strengthened by establishing a lead agency and placing it at the highest level of government to work as the catalyst to translate the programs into action.

iii. Facilities and capacities in the existing institutions and organizations must be increased to turn their weaknesses into strengths and capacity building of the human resources who are engaged in coastal management must be given top priority.

iv. There should be a long-term sustainable funding mechanism through Public Private Partnership (PPP). Technical capacities must be enhanced with global technological cooperation by providing appropriate training for operating UAVs properly. Financial support could be provided through government incentives, foreign investment, and public-private partnerships, ensuring Industry-University collaboration, capacity building in relevant research projects. Drone industry in Bangladesh may flourish if Govt. rebate tax for the import of UAV/drone or necessary equipment.

v. ICT services need to be promoted by developing effective and need-based ICT tools to translate and transform drone-based data and climate information services among value chain actors, for sustainable coastal risk management.

vi. A practical implementation framework for coastal monitoring could be developed that coordinates effective institutional arrangements, locally led as well as socially inclusive in an integrated manner.

vii. Global historical success stories regarding the utilization of UAVs for coastal monitoring must be analysed for developing country-specific need based strategies and action plan. Scientific and traditional knowledge must be combined with past experiences to develop a baseline on which management can be established and at the same time a strong monitoring and evaluation mechanism should be developed and ensured.

viii. Proper planning for regional initiatives, bi-lateral and multi-lateral agreements which are now in place could be strengthened, and implemented to deal with trans-boundary issues surrounding Bay of Bengal and find the further scope of cooperation for successful utilization of UAVs for coastal monitoring in the region.

Conclusion

Availability of precise and reliable 'Drone data' would help immensely in launching effective coastal monitoring and coastal resources management plans in our country as well as its appropriate implementations. At present, Drones are used at a very limited scale in Bangladesh. Even then, the authorities have imposed various restrictions to regulate Drone flights in the country. Small and medium-size drones are mostly used for conducting atmospheric research including studies on atmospheric composition, pollution, vertical aerosol distribution, as well as surface temperatures. The researcher could be able to motivate the policymakers for undertaking further actions to address the underscored challenges for exploring utilization of UAVs in Bangladesh for coastal monitoring. Mass awareness could be built up among people regarding UAV uses as well as concerned policy. Besides these, the concerned authority could take assistance from foreign experts to build up UAV industry in Bangladesh. Civil Aviation Authority of Bangladesh could use advanced technologies, navigation aids, and modern equipment such as surveillance radar (TCAS) Traffic collision avoidance systems to avoid mid-air collision as well as maintain safety concerns. Using drones for geographical research can increase the accuracy of field data and save time as well. Moreover, instead of focusing on regulations restricting UAV usage, it's time for the authorities in Bangladesh to take a proactive role in catalysing the growth of UAV start-ups for service innovation, through liberal regulations, research, and development (R&D) supports as well as lead usages. The fact that UAVs will be increasingly utilized in the future but for now, this study has discovered the areas on which we need to focus and pay further attention.

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Parallel Technical Session II, Oral Presentation: 007

Development of a Tropical Cyclone Triggering Mechanism for Anticipatory Actions in the coastal region of Bangladesh

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Abstract

Bangladesh, a nation that frequently experiences natural disasters, is frequently hit by ocean storms, which significantly harm both the economy and people's lives. To mitigate and/or minimize the effects of hazards on at-risk communities, an end-to-end early warning system (EWS) must be developed. The framework or anticipatory action (AA) is developed by identifying the triggers by analyzing wind speed, rainfall, sea level pressure (SLP), sea surface temperature (SST), damage history of rice crops, houses, and lives, and overall damage for the historical cyclones in the northern Bay of Bengal (BoB) and related damage data of coastal and neighborhood region. Making decisions on the five categorical ranges for the trigger, which is followed by the correlation matrix, is made simpler by the probability analysis of the interactions between the parameters. The location of the disaster's landfall, the geography, and the time of year all affect the impact curve analysis' ability to identify the disaster's most closely associated and damaging aspects. Trigger 1 is based on SST, SLP, and Trigger 2 is dependent on wind speed and rainfall. Both of these triggers can be used to start an AA. The model's chronology is also shown, showing how if it can't be triggered in time, the likelihood of damage will rise. In this study, the best numerical model forecast was also evaluated based on storms track, wind and rainfall for implementing AA. After a natural disaster like a cyclone, this triggering mechanism can be utilized to activate EWS that can save lives, critical assets and livelihoods.

Keywords: *Ocean storms, Anticipatory Action, BoB, EWS*

Introduction

Bangladesh is particularly vulnerable to cyclones because of its location at the triangular head of the Bay of Bengal, the geography of its coastal region at sea level, its high population density, and the lack of coastal protective structures. Bangladesh has had the deadliest storms in terms of fatalities and casualties over the last 50 years, accounting for 40% of all storm surges ever recorded worldwide (Haque et al., 2012). Bangladesh ranked 11 on the planet in terms of risk and exposure. A new approach known as "Forecast Based Action" has been developed in reaction to time passing and/or the humanitarian response becoming more successful. This approach has shown a greater potential to reduce suffering and ensure community dignity by acting soon. Being a relatively new initiative, the Forecast Base Action requires the establishment of consensus-based tools and standards as well as the capacity for technical analysis of the Bangladeshi humanitarian community.

The early warning triggers are generated using a robust scientific and analytical approach. They are expected to activate anticipatory actions (AA) that communities and individuals can adopt before the onset of the hazard. In Bangladesh, over the past 50 years, there have been dramatic changes in cyclone frequency, severity, and death toll. Cyclones have both direct and indirect consequences on sociocultural foundations, general public health, livelihoods, infrastructure, and the economy. They can restrict access to food and clean water, and increase the danger of the spread of infectious diseases such as diarrhea, hepatitis, malaria, dengue, pneumonia, eye infections, and other ways. Surface water is the main source of drinking water in Bangladesh's coastal districts, although it is contaminated by saltwater intrusion and poor hygiene standards (Haque et al., 2012).

Inadequate sanitation and open latrines are common in rural and coastal Bangladesh, and cyclones are unquestionably associated with greater rates of crime and suicide. Because of post-traumatic stress disorder and depression, they frequently deteriorate following a tragedy. Additional difficulties following a hurricane are a result of low literacy rates and a lack of awareness of environmental health issues (Haque et al., 2012). There is a significant gap between disaster management policies and programs. To reduce disaster losses, an integrated approach should be adopted (Tran and Shaw, 2007). This study uses a qualitative methodology to understand the underlying causes of a current condition, to provide insight into the context and conditions of existing problems, and, finally, to generate viable solutions and recommendations. The impact curves may play role in suggesting the anticipatory plans by evaluating the recorded data statistically.

The future of living conditions is threatened by the rising environmental threats brought on by accelerated economic expansion (Douglass et al, 2002). As per IPCC 2001 report, "observed changes in regional climate have affected many physical and biological systems, and there are preliminary indications that social and economic systems have been affected. El Nino events have been more frequent, persistent, and intense during the last 20–30 years compared to the previous 100 years." Using data from a 30-year review of satellite records, it was claimed that global warming was to blame for the increase in tropical cyclone strength (Webster et al., 2005). The BoB is also facing the impacts of global climate change by having a high frequency of severe cyclones. Synthesizing meteorological information (such as weather forecasts) with quasi-static information on exposure and vulnerability profiles (such as geodemographic and vital facility maps) to identify the range of hazards faced over a region is the first step in shifting from broadcasting what the weather will be to broadcasting what the weather will do, which is the current plan as part of the anticipatory act (WMO and UN, 2021).

According to (Duncan et al., 2012), anticipating disasters requires them to recognize that past experience is not always indicative of the future and, as a result, that their memories of past tragedies may not be sufficient.

Study Area and Method:

The northern Indian Ocean region, including the Bay of Bengal and the Andaman Sea, has been the subject of this study. This study examines each significant storm that has struck Bangladesh and caused significant structural, environmental, and economic harm. More than a hundred tropical cyclones have hit Bangladesh since it gained its freedom. However, in this study, we only took into account twenty-four cyclones from 1977 to 2021, and we did so based on the damage data that was at our disposal. Based on the time period during which they formed, all of the cyclones have been divided into two groups. 14 of the 24 cyclones are still active (from March to July), and the remaining 16 are still active (from September to December).

The overall approach of this research is mainly divided into the following steps.

Step 1: Cyclone data from 1997 to 2020 and their genesis location those have a landfall or hit the Bangladesh coasts

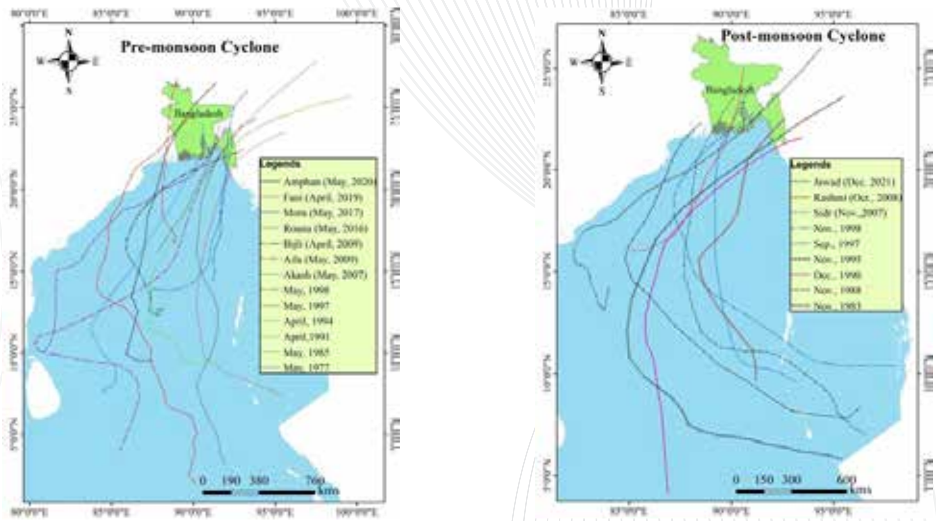


Figure 1: *Study region showing the cyclones that had a landfall on Bangladesh from 1977 to 2021 divided into two groups; the Pre-monsoon cyclones (LEFT) and the Post-monsoon cyclones (RIGHT).*

Step 2: Sea level pressure (SLP) and Sea Surface Temperature (SST) as a Trigger-1 with a 7 to 10 days lead time

Step 3: Wind speed and rainfall of those cyclones as Trigger-2 with a 3 to 5 days lead time

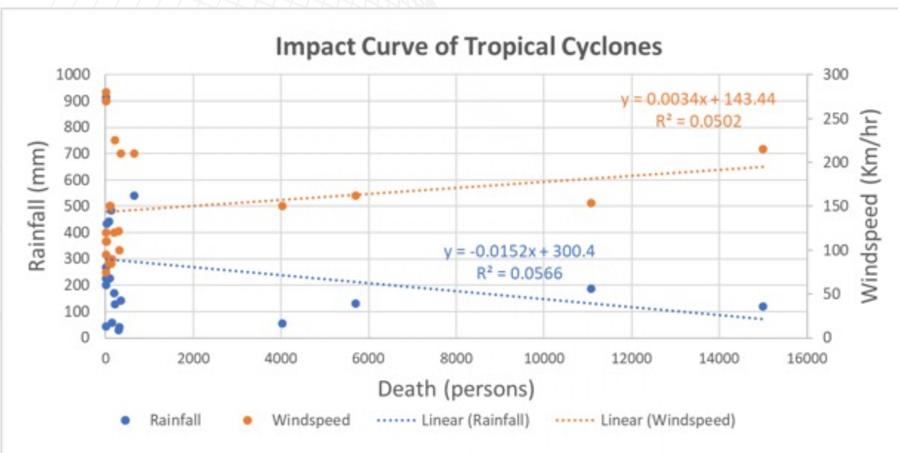
Step 4: Impact Based curve analysis for total damage due to each cyclone

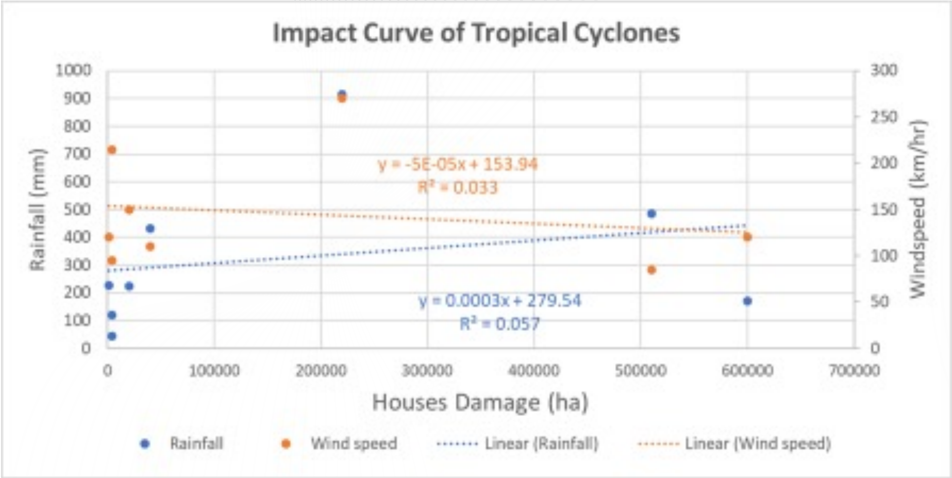
Step 5: Forecast product assessment

Result:

Impact Curve Analysis

In this graph, the cyclones that occurred in the Bay of Bengal were analyzed with the variable of wind speed, rainfall, and deaths of human beings. The orange curve is showing an increasing trend for the relation between wind speed and deaths as per the linear forecast with the R2 value of 0.0823. Whereas the blue curve is presenting decreasing linear forecast with an R2 value of 0.1032. The linear forecast was used as a trendline in the analysis of the impact curve.





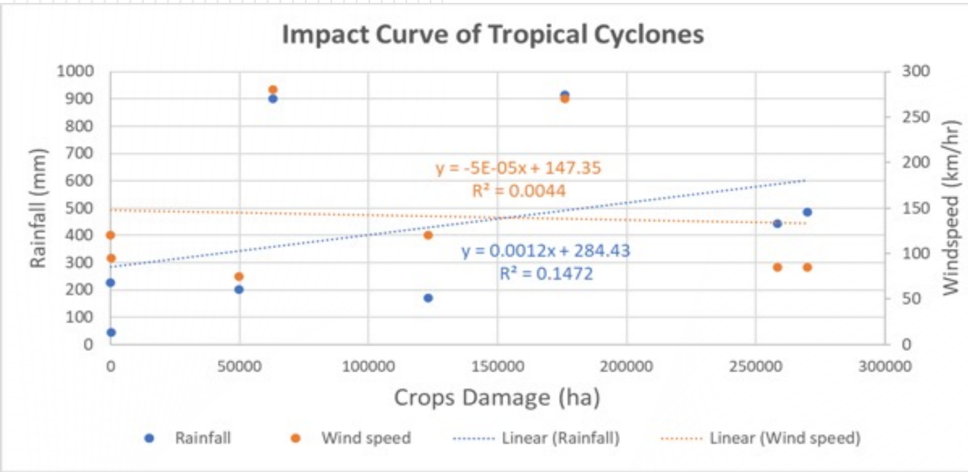


Figure 2 (a-c): *Impact curve analysis*

The variable of wind speed, rainfall, and house damage is shown in this graph. The orange curve is showing a decreasing trend for the relation between wind speed and house damage as per the linear forecast with the R2 value of 0.033. Whereas the blue curve is presenting an increasing linear forecast with an R2 value of 0.057. In the analysis of the impact curve, the linear forecast was used as a trendline. The variable of wind speed, rainfall, and crop damage in hector are shown in this graph. The orange curve is showing an almost static trend for the relation between wind speed and crop loss as per linear forecast with the R2 value of 0.0044. Whereas the blue curve is presenting an increasing linear forecast with an R2 value of 0.1472. In the analysis of the impact curve, the linear forecast was used as a trendline. The variable of wind speed, rainfall, and overall damage in billion US dollars are shown in this graph. The orange curve is showing a decreasing trend for the relation between wind speed and overall damage as per linear forecast. The blue curve is presenting an increasing linear forecast with an R2 value of 0.2675. In the analysis of the impact curve, the linear forecast was used as a trendline. The variable of house damage, crop loss, and overall damage in billion US dollars are shown in this graph. The orange curve is showing an increasing trend for the relation between crop loss and overall damage as per linear forecast with an R2 value of 0.2441. The blue curve is presenting a very static linear forecast with an R2 value of 0.0003 also, indicating a very poor correlation, not to be forecasted because of the randomization in behavior. In the analysis of the impact curve, the linear forecast was used as a trendline.

Correlation analysis

Figure 3 expresses the positive and negative correlation among the variables wind speed, SLP, rainfall., Deaths, House Damage, Crops, and total damage in terms of damage data and wind speed, rainfall, and affected area in terms of physical parameters.

The wind speed is showing the most dominant factor in the losses of crops. Besides, house damage and crop damage are positively correlated with rainfall. The lower the SLP the higher the damage, thus the more negatively correlated with SLP means the worse. The correlation says the SLP has a good correlation with damages. This really indicates that the AA must be taken into consideration with the increasing probability of heavy rainfall, high wind speed, or low SLP. Taking those three as the triggering parameter we model the trigger mechanism for.

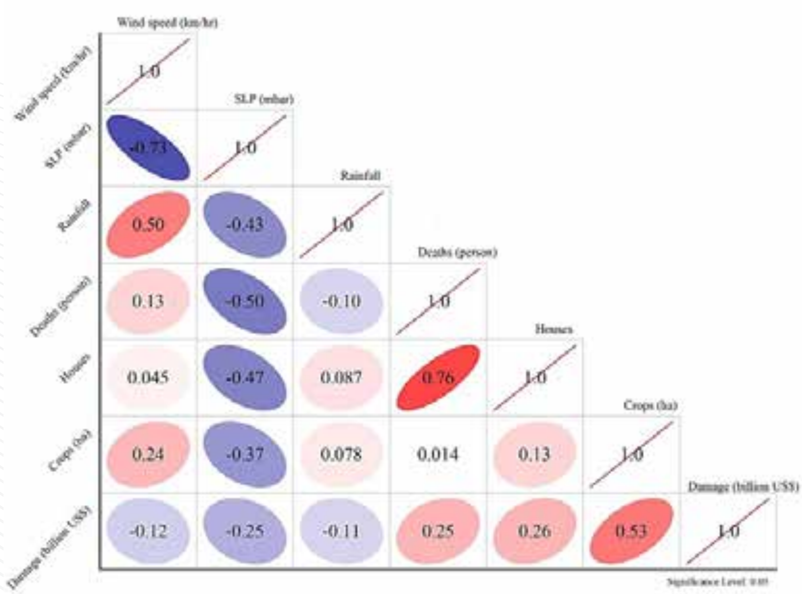


Figure 3: *Correlation Coefficient Matrix of Variables for anticipatory action.*

Triggers for the anticipatory cyclone action:

Table 1: *Cyclone Trigger variables value with ranking for landfall over Bangladesh*

Trigger Variables	Very Low	Low	Medium	High	Very High
SLP (mb)	>997	985	975	945	<935
Rainfall (mm)	<50	120	220	420	>600
Wind speed (Km/h)	<80	100	150	200	>240

Some trigger method has been established for Bangladesh's cyclone anticipatory action plan. Here we have set the probability of 50% to 90% for each parameter, including rainfall, wind speed, SLP, and damage parameters like crop loss, house damage, deaths and overall damage in USD.

When there is less probability of more damage and high rainfall with high wind speed, we have to trigger our anticipatory action faster, at least three days before the cyclone. The less damage and precipitation or wind speed, we need to wait for the trigger until it has a higher probability.

The damage probability part is showing if the AA is not taken even if it triggers as per the table. For example, the 70% probability of 220 mm rainfall indicating for a AA. But if ignored, there is a probability of about 60,000 ha of crop damage, 150000 house damage, around 2000 people death and overall, 2 billion US dollar damages. Fig 4 (b) shows the timeline of what probability when we should trigger. The landfall is the reference or zero, and depending on the probability percentages we should take action. Before taking action, we must take a waiting time or preparedness time of about five to seven days. The more the probability the earlier we must start the AA. At 90% probability, we must activate the AA at least three days prior. The timeline shows stages to comply as the cyclone propagates toward the land.

a

Trigger for Anticipatory Action based on probability

Triggering parameters	SLP (mb)	>997	985	975	945	<935
	Rainfall (mm)	<50	120	220	420	>600
	Wind speed (Km/h)	<80	100	150	200	>240
Probability (%)	90	Trigger				
	80		Trigger			
	70			Trigger		
	60				Trigger	
	50					Trigger
Possible Damage if not Triggered Anticipatory Action	Crop Damage (ha)	<10K	25K	60K	100K	>170K
	House Damage (Count)	<10K	60K	150K	300K	>500K
	Deaths (head count)	<150	500	2K	5K	>10K
	Overall Damage (billion USD)	<0.5	1	1.5	2	>2.5

b

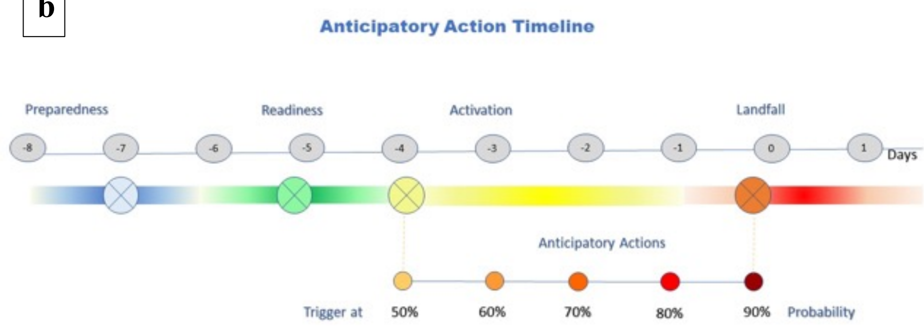


Figure 4: *a) Trigger for anticipatory actions for the cyclone damage mitigation in Bangladesh and b) Anticipatory action plan timeline prepared for cyclone trigger in Bangladesh.*

Discussion:

Bangladesh has shown resilience through institutional and community-level preparedness, and loss and damage have gradually diminished. The Needs Assessment Working Group is developing the conceptual framework and technical guidelines for anticipatory effect analysis. Recent technical developments have elevated early humanitarian action, forecast-based action, and early action to the fore.

The variable rainfall is found to be more correlated with the house damage in between house damage, wind speed, and rainfall. The higher the rainfall, the higher the house damage is. The reason for this is expected to be dependent on cyclones intensity and also the presence of human habitats which is recommended for analysis in further study. So, it can be said that house damage may be dependent on rainfall, but it also may depend on landfall locations land use patterns, and intensity of cyclones as per this analysis.

The variable rainfall is found to be more correlated with crop damage for the analysis of crop damage, wind speed, and rainfall. The higher the rainfall, the higher the crop damage is. The reason for this is expected to be dependent on the intensity of the cyclone and also the presence of crop fields in the impacted area. So, it can be said that crop damage may be dependent on rainfall mostly, but it also may vary upon landfall locations land use patterns, and intensity of cyclones as per this analysis.

The crop loss is found to be dominating the overall damage in the analysis of overall damage, house damage, and crop loss. The higher the crop loss, the higher the overall damage is. The reason for this is expected to be a dependency on overall damage being calculated from crop loss mostly.

The trigger time and criteria are mapped in this figure with the corresponding analysis of the impact curve, data, and probabilistic analysis. The rainfall probability is the main factor for triggering the AA. The losses and damages are correlated with each other. If any three of these criteria (wind speed or rainfall) reach the threshold, the AA should trigger depending on the intensity probability. For example, less than 50 mm of rainfall should trigger AA when the probability is about 90%. But when it is about 420 mm rainfall of probability only 60%, it is the trigger of AA.

Conclusion:

Hydro-meteorological hazards are common in Bangladesh; cyclones and cyclone-induced extreme precipitations are the two main hazards. While both can trigger floods and landslides, strong winds associated with the higher categories of Cyclones can induce storm surges, leading to high destruction of lives and livelihoods. The genesis, landfall, track, and intensity are identified in Bangladesh's Bay of Bengal and coastal area. Usually, June to November is the main Cyclone occurring season, and the exception is only late March. Wind speed >80, Rainfall > 50 mm, and SLP < 997 mb simultaneously with a lead time of 5 to 10 days can be set as Triggers for identifying genesis location based on SST. Cyclone forecasts (track, magnitude, wind speed) can be predicted with an acceptable accuracy with 48 to 72 hours lead time, while extreme rainfalls forecasts need to be accurate enough 48 hours in advance.

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Parallel Technical Session II, Oral Presentation: 010

The Ecological Roles of Coastal Marine and Freshwater Zooplankton: A Perspective on Their Bioindication Capability to Harmful Algal Bloom and Microplastic Pollution in Tropical Delta, Bangladesh

Najmus Sakib Khan

Abstract

Zooplanktons are very majestic invertebrate creatures in both marine and freshwater environments. Basically, they entirely depend on microalgae for their feeding. The aquatic algal community drives the distribution and diversity of zooplankton. The marine copepods were collected from three sampling spots of the lower Meghna River Estuary. Moreover, freshwater cladocerans and rotifers were taken from three different inland canals in the coastal delta of Bangladesh. All types of zooplankton are found very sensitive to environmental stressors (e.g. global warming, harmful algal bloom, and microplastic pollution). Furthermore, zooplanktons are also preferable to larvae or adults of fishes, crustaceans, and mammals over algae due to their palatability, easy digestibility, and high nutritional quality. They contain several digestive enzymes, essential fatty acids, minerals, and vitamins which are very supportive for sustainable freshwater and marine aquaculture. Naturally, copepods are accumulated microplastics (<5 mm – 1mm) mistakenly as food particles. The conducted study has found that marine and estuarine copepods are efficient to indicate microplastic pollution. Moreover, freshwater rotifers and cladocerans are observed as very sensitive to harmful algal bloom. Blue-green algae as the most remarkable harmful algae which are dominated and inhibited cladocerans' assemblages in coastal canals.

Introduction

Zooplankton is a tiny but obvious interconnecting creature between primary producers and higher trophic organisms. Profoundly, zooplankton provides necessary nutrition to the whole food chain by serving themselves. In estuarine and marine environments copepods are mainly dominated by other groups. Marine copepods contain essential proteins, fatty acids, vitamins, and minerals that are supportive of the larval growth of fishes and crustaceans. Therefore, copepods are vulnerable to harmful algal bloom especially dinoflagellate bloom in estuaries. Harmful algal blooms cause oxygen depletion and toxins which consequently affects the growth and living of copepods. Furthermore, freshwater cladocerans are found more convenient as available nutritious foods to the fisheries (e.g. fishes, crustaceans).

Marine litter is a consequence of the careless dumping of waste materials that are either directly or indirectly transported to our seas and oceans. There are a number of sources of plastic waste, and it is discussed how plastic may infiltrate the marine environment both directly and indirectly. The two sorts of sources are primary and secondary sources of microplastic. Eighty percent of the plastics discovered in marine litter come from trash having a terrestrial source.

Microplastic ingestion by Copepods:

Microplastics have the potential to be consumed by a variety of marine biota due to their tiny size and prevalence in both pelagic and benthic habitats. Although it is methodologically difficult to observe microplastic ingestion in the wild, more studies are finding evidence of it occurring throughout the food chain. Uncertainty exists on how much microplastic is consumed and how that may affect zooplankton. Zooplanktons have a crucial biological function in marine environments, serving as both the main consumers in the marine food chain and, in the case of meroplankton, the juvenile life stage of many economically significant species. As exclusive filter feeders cladocerans are very vulnerable to harmful cyanobacteria. They are not selective feeders like copepods so they grossly ingest whatever they found. However, copepods as selective feeders or cladocerans as filter feeders both are ingested microplastics (<0.05 mm) as foods by mistake or unintentionally.

Table 01. Laboratory studies showing uptake of microplastics by Copepods.

Organism(s)	Microplastic	Identification Technique	Publication
Copepods (A. tonsa)	7–70 µm	Microscopy	Wilson (1973)

Microplastic interactions with zooplankton are made possible by the abundance of minute plastic debris in the water column. Due to differences in life stages, species, and prey availability, zooplankton exhibits a variety of feeding strategies. Whereas copepods are selective feeders and cladocerans are filter feeders, all of these animals either actively or inadvertently eat microplastics. Zooplankton may choose their prey by combining chemo- and mechano-receptors, and it has been shown that they can choose one type of algae over others, plastic beads, or debris.

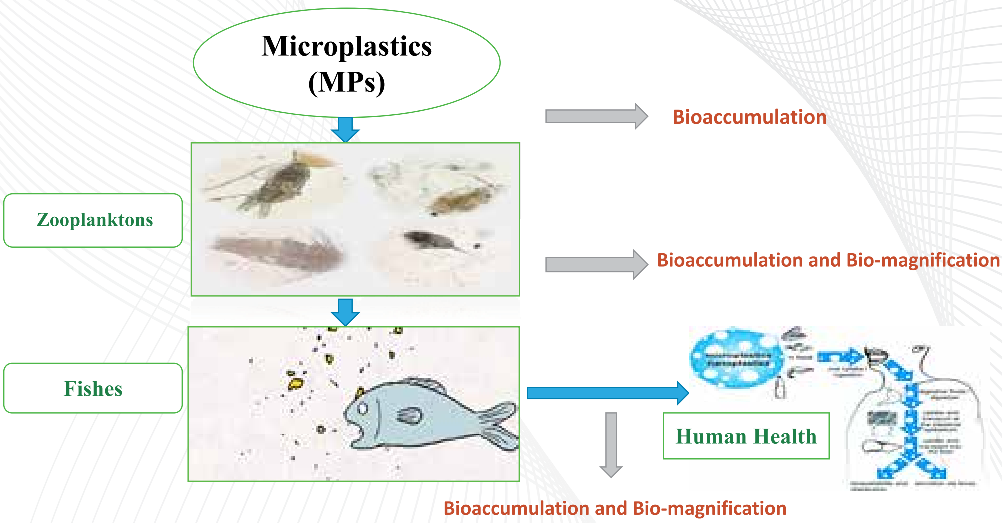

***Fig 01**. Microplastics Enter the Food Chain via Zooplankton Grazing.*

Harmful Algal Groups and Their Effects in Upper Food Web.

The sensitivity of zooplankton's taxonomical groups to the "bloom" of Cyanobacteria and the influence of toxins (according to the increasing proportion of dead organisms in period mass developing Cyanobacteria) increased in line Cyclopoida→Calanoida→Rotifera→Cladocera. At the station where organic pollution, eutrophication, and the biomass of dangerous Cyanobacteria

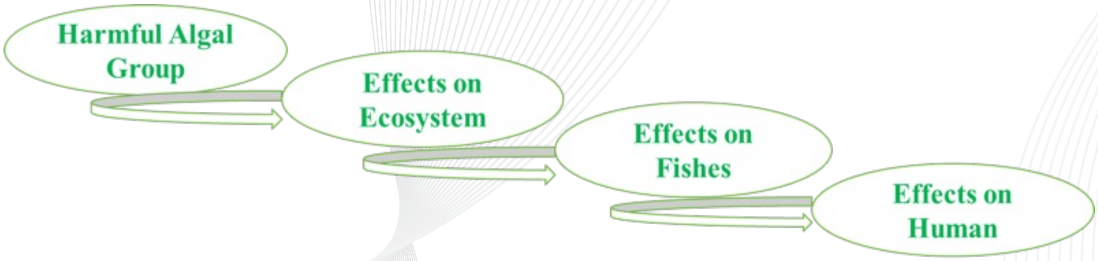

Fig 02. *Harmful Algal Groups and Their Effects in Upper Food Web.*

(particularly Microcystis spp.) were at the lower level, a minimal proportion of dead organisms were detected. The action of the toxin Microcystis spp. is one of the primary potential causes of the rising percentage of dead organisms in zooplankton.

In freshwater bodies, cyanobacteria predominate among the phytoplankton species. These species secrete cyanobacterial toxins such as Microcystin-LR, Cylindrospermopsin, and the Anatoxin-A group, among others that are damaging or poisonous. However, marine ecology is dominated by dinoflagellates. Dinoflagellate blooms are harmful to marine life because they release poisonous substances like PSP (paralytic shellfish poisoning), DSP (diarrheic shellfish poisoning), Ciguatera fish poisoning, NSP (neurotoxic shellfish poisoning), etc. The present study has focused to determine the effects of harmful algal bloom and microplastic pollution on marine copepod and freshwater cladoceran in the Meghna river estuary and coastal freshwater canals.

Study Area

There are two sites are selected for the current study, they are Noakhali Khal and Meghna River Estuary. From each of the sites, there are three (03) sampling stations were selected for primary data collection.

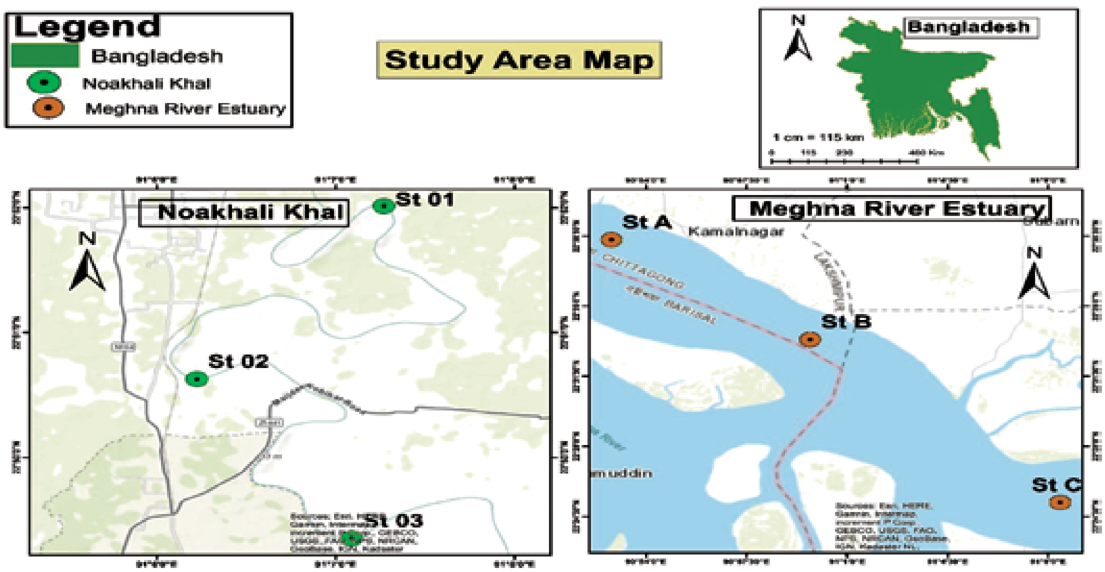

Fig 03. Study Area Map (Noakhali Khal and Meghna River Estuary)

1.1 Noakhali Khal: Noakhali khal is the most ancient canal system in Noakhali district, which is linked with the Feni Choto River.

1.2 Meghna River Estuary: The Meghna River estuary is Bangladesh's biggest and most diverse environment. The capacity of the local community to maintain both a healthy natural system and their way of life is greatly benefited by the services provided by the river basin. Along with some marine species including shrimp, sardines, and hills that have migrated from the Bay of Bengal to tidal rivers, the estuary is home to 62 of the 289 different species of freshwater fish that are known to exist.

Response of Copepods to the Microplastics (MPs) and their Ecological Risks

Microplastics are widely present in terrestrial and aquatic habitats, and their ecological effects have garnered attention on a global scale. They are a top 15 contaminant with global economic and environmental effects. Due to their small size, a wide variety of marine organisms, including zooplankton, may consume them.

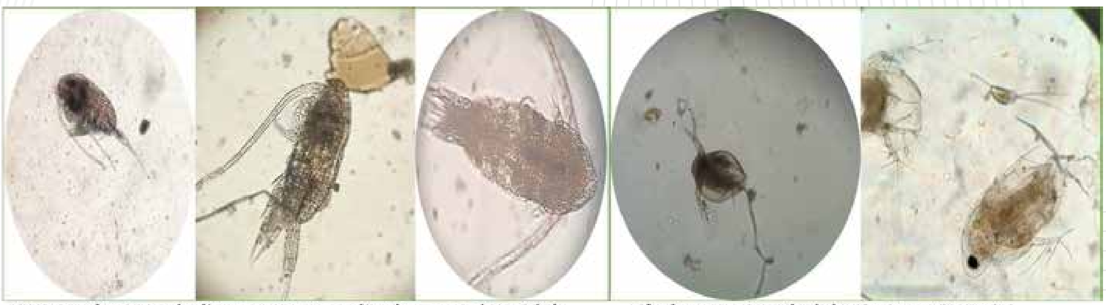

Fig 04. List of some Copepods and Cladocerans species from laboratory analysis.

Several zooplankton species (Specially Copepods) are the primary factors that accumulate microplastics from surrounding aquatic bodies and enter the food chain to the tertiary level. Because zooplankton is an important food source for many secondary consumers, it provides a potential pathway for microplastic to enter the food chain and move up the trophic levels.

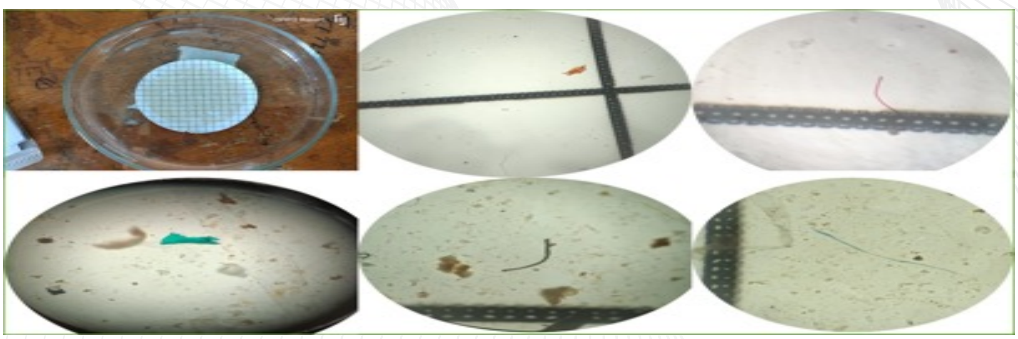

Fig 05. List of Microplastics (MPs) from Zooplankton

A recent study from the "World Health Organization" showed the pervasive presence of microplastics in the environment, raising severe concerns about their exposure and effects on

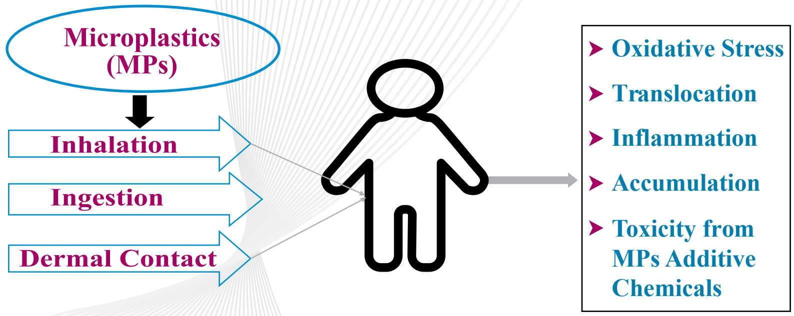

Fig 06. Human Health Risks by Microplastics (MPs)

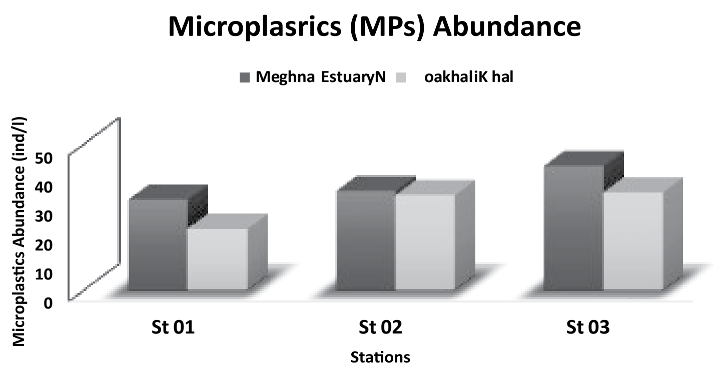

Fig 07. The Bar Chart Showing the Total Microplastics Amount from Meghna River Estuary and Noakhali Khal.

human health. One of the most frequent ways that microplastic enters the human system is via contaminated food. An estimated 80 g of microplastics might possibly be consumed daily by people via plants (fruits and vegetables) that absorb MPs from polluted soil.

Response of Cladoceran to the Harmful Cyanobacteria Bloom and their Ecological Risks

Algal blooms happen when the buildup of biomass outpaces the spread of the organisms via biological and physical mechanisms. Grazer mismatch is crucial for bloom development in

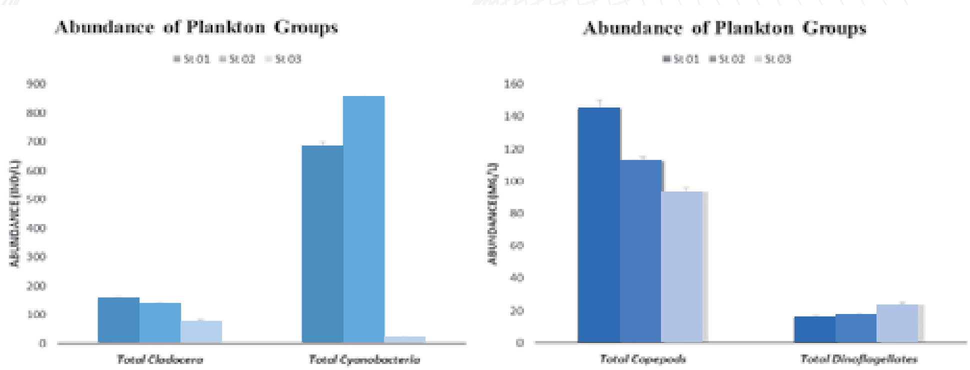

Fig 08. *The Bar Graph Shows the Plankton abundance (ind/l) both in Noakhali Khal and Meghna River Estuary*

developing ecosystems (such as during the spring bloom), but in developed ecosystems, another mechanism is needed for growth to outpace grazing losses. We refer to any bloom that has the potential to damage an ecosystem as a harmful algal bloom (HAB) since many of these blooms inevitably alter how nutrients and energy move through trophic levels.

The interaction between algae and their zooplanktonic predators normally entails nutrient uptake by the algae and grazing by zooplankton, which improves predator biomass, regulates algal development, and replenishes nutrients. Although eutrophication increases nutrient levels, it does not just intensify typical predator-prey interactions; instead, harmful algal bloom (HAB) events often occur, which have significant ecological and aesthetic effects. The majority of HAB species are poor competitors for nutrients on the surface, and their development of grazing deterrents under nutrient stress purportedly happens too late, after the resources have mostly been eaten previously by fast-growing non-HAB species.

Table 02: *Pearson Correlation among Cyanobacteria, C,ladocea and Microplastics (MPs) From Freshwater body in Noakhali Khal.*

Total Cyanobacteria	1.0		
Total Cladocera	-0.9	1.0	
Total MPs	-0.7	-0.4	1.0

Pearson Correlation shows a strong negative correlation between cyanobacteria and cladocerans, and also Cladocea has a negative correlation with Microplastics (MPs) in the Freshwater canal. This indicates that the excess level of harmful cyanobacteria and microplastics can reduce the abundance of cladocerans.

Table 03: *Pearson Correlation among Dinoflagellate, Copepods, and Microplastics (MPs) From Marine Water bodies in Meghna River Estuary.*

Total Copepods	1.0		
Total Dinoflagellates	-0.8	1.0	
Total MPs	-0.9	-0.7	1.0

In the case of the Meghna river estuary, The Pearson Correlation shows a strong negative correlation among copepods, harmful dinoflagellates bloom, and microplastics. This indicates that the excess level of harmful dinoflagellates and microplastics can reduce the abundance of copepods.

Conclution

We need to focus on the bioaccumulation of harmful algal toxins in freshwater cladocerans. We need to identify microplastic content in copepod body itself. Finally, design a flow chart of the cycling process of harmful algal toxins and microplastic from zooplankton to human beings.

Najmus Sakib Khan

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Comments of Session Chair

Dr. Aftab Alam Khan

Oceanography and Energy is the most important and appropriate thematic area in the present global context where 2/3rd of the Earth's oceanic area still remained virgin and unexplored. We know very little about the science of the oceans, its resources, ecosystem, biodiversity, ocean environment and its hazards. This technical session was ornamented by 5 technical papers those have dealt principally the ocean science and ocean energy. The papers presented are:

1. Sea Level Rise and Utilization of Unmanned Aerial Vehicles (UAVs) for Coastal Monitoring in Bangladesh: Prospects, Challenges and Way Forward.
2. Development of a Tropical Cyclone Triggering Mechanism for Anticipatory Actions in the coastal region of Bangladesh.
3. Identification of Potential Productive Zone and Dominant Physical-Biogeochemical Drivers of Seasonal Chlorophyll-a Concentration in the Bay of Bengal.
4. The Ecological Roles of Coastal Marine and Freshwater Zooplankton: A Perspective on Their Bio-indication Capability to Harmful Algal Bloom and Microplastic Pollution in Tropical Delta, Bangladesh.
5. Trends in Oceanic Dissolved Organic Carbon and Acidification.

UN Decade (2021-2030) of Ocean Science proclamation aimed for achieving sustainable development and prosperity in the maritime sectors. However, the papers presented in the thematic session "Oceanography and Energy" lack presentation pertaining to the energy crisis and sustainable economic development. However, the papers presented on "Oceanography" theme have thrown some light for the solution of the problems pertaining to the science of oceanography. Sea level rise and the use of unmanned aerial vehicle have not been properly blended as globally not a single evidence of sea level rise exists. The prediction of sea level rise of 1.5 m by 2100 @ 3 mm/yr is not supported since there is no record of 69 mm sea level rise that should have been in the last 23 years after the claim of IPCC in 1998. Anticipatory actions based on the development of triggering mechanism for early warning of tropical cyclone is encouraging one. Concentration of chlorophyll-a is an indicator for the amount of photosynthetic plankton (phytoplankton) present in the ocean. Identification of Potential Productive Zone in the Bay of Bengal surly would contribute to the blue economy of the country. Coastal Marine and Freshwater Zooplankton and its bioindication capability to harmful algal bloom and microplastic pollution is an important study for ensuring the growth and diversity of zooplankton. This type of study will be able to restore ecologically conducive friendly environment. Study on the oceanic dissolved organic carbon and acidification is an interesting review study although the phenomena are very difficult to understand. However, to protect marine life we must find out the causes of the enrichment of DOC and acidification.

Dr. Aftab Alam Khan

Professor & Head of the Department,
Oceanography and Hydrography, BSMRMU

Parallel Technical Session III, Oral Presentation: 011

Microplastics can reduce the reproductive and morphological traits of male guppy (Poecilia reticulata)

Sheikh Mustafizur Rahman*, Muhammad Abdur Rouf, Shaikh Tareq Arafat, Md. Golam Sarower, Md. Moshiur Rahman

Abstract

The prevalence and availability of plastic wastes, among other pollutants of aquatic ecosystems, have become a severe global concern and may have a substantial impact on fish. A study was carried out with equal sized juvenile male guppy (Poecilia reticulata) exposing to microplastics (< 5 mm), macroplastics (> 5 mm) and no plastics (control) for up to 70 days to explore the effects of microplastics on survival rate, phenotypic traits, mating success and sperm bundle number. This study found that male guppy treated with microplastics had significantly reduced survival rate, shorter standard length, smaller body area, reduced number of sperm bundle, performed lower number of sigmoid displays and sexual interest than those of macroplastics treated and control males. No significant differences in any of the findings were found between macroplastics and control treatments. Tail length and gonopodial thrusts patterns among the treatments were found unchanged. These findings demonstrate the potential effects of microplastics pollution on fish growth, reproduction and survival.

Keywords: *Plastic debris, fish, growth, survival, reproductive success, offspring fitness*

Introduction

The emergence of microplastics (MP) pollution has become an increasingly serious and widespread concern as it has been found to be ubiquitous in ambient aquatic environments, including oceans, lakes, and rivers (Wright and Kelly, 2017). Their small size and relatively low density contribute to their long-range transport (Barboza et al., 2019) and global distribution (Auta et al., 2017). For this reason, MP can remain for many years in the marine and other environments (Barboza et al., 2019), polluting a wide range of organisms, including species widely used in the human diet (Gallo et al., 2018). Many studies have shown adverse impacts of microplastics on aquatic organisms, such as polychaetes, crustaceans, zooplankton and fish larvae (Van Cauwenberghe et al., 2015). Ingestions of microplastics by aquatic animals can cause adverse health effects, including reduction in feeding efficiency, intestinal blockage, alterations in swimming behavior, neurotoxicity and most importantly interference on reproductive success, (Lusher et al., 2017). Most of these information have been derived from marine animals, but studies dealing with fresh water fish are scarce. Nevertheless, most of these studies highlighted some phenotypic traits and, behavior (Lo and Chan, 2018) while the question whether microplastics exposed to water bodies or ingested by fish have any influence on their reproductive success and offspring fitness remain elusive.

Unfortunately, Bangladesh is not immune to the plastic hazard. Because of the ever-increasing use of plastics in different industries, especially packaging, Bangladesh remains one of the top plastic polluted countries. It is estimated that around 73,000 tons of plastic waste ends up in the sea every day through rivers. In addition to the domestic waste, plastic waste from neighbor countries flowing down the Ganges, Yamuna and Brahmaputra also end up in our water bodies, including rivers and canals. Since freshwater fish are mostly preferred in Bangladesh therefore, plastic pollution in Bangladesh's environment continues unabated raising serious threats to human and animal health. For this reason, a scientific understanding about impacts of microplastics on freshwater fish species was carried out by measuring direct and indirect effects of plastic pollution. Thus, the present study was designed to test whether microplastics are consumed by guppy (Poecilia reticulata) and have any effects on their sexually selected traits and growth.

Methods

Almost equal size of juvenile guppies was collected from the local market and stocked in glass aquariums under three different experimental treatments such as 1) control (no plastic), 2) microplastic (< 5 mm) and 3) macroplastic (> 5 mm) for 70 days. The experimental fishes were provided with the commercial dry food every morning at 4% of their body weight. In microplastics treatment, 2% microplastics of their body weight were mixed with the dry food before feeding every time. On the other hand, 40-50 macroplastics were dispersed in the aquarium of macroplastic treatment once a week.

At the end of the study, the standard length, body area, and tail length were analyzed through ImageJ software (v1.46). The male mating behaviours were recorded as the number of sigmoid displays (males arch their body in a characteristic shaped posture and quiver), gonopodial thrusts (forced mating attempts in which males approach females from behind and attempt copulations without prior courtship or female solicitation), and the time (in seconds) spent by the male courting or chasing the female (a measure of the male's overall sexual interest in the female, hereafter "sexual interest") (Houde, 1997) at the end of the study. The sperm bundles from each male were recorded as the methods developed by Evans et al., 2003.

Results and discussion

The findings revealed that microplastic treated males had significantly reduced survival rate (Fig. 1), shorter standard length, smaller body area (Fig. 2), reduced number of sperm bundle (Fig. 3), performed lower number of sigmoid displays and sexual interest (fig. 4) than macroplastic and no plastic male treated males. No significant variation in any findings between macroplastic and no plastic treatment were observed throughout the study. On the other hand, tail length and gonopodial thrusts among the treatments were found insignificant unchanged. Gut content analysis confirmed that male guppy contained at least few microplastics, while no plastic was found in the gut contents of any male from macroplastic and no plastic treatments.

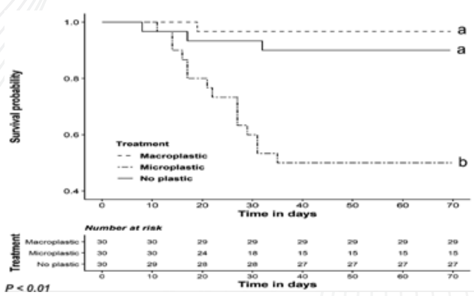

Fig. 1. Survival probability of male guppy reared in control (no plastic), microplastic and macroplastic treatments up to 70 days.

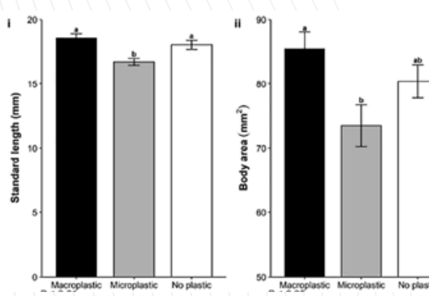

Fig. 2. Effects of microplastics on (i) standard length and (ii) body area of male guppy after 70 days of rearing.

Studies have shown that different organisms are affected by ingesting microplastics directly (as diet: de Stephanis et al., 2013) or indirectly (as secondary feeder: Rochman et al., 2017). The ingested microplastics may affect the organisms by chemical toxicity (Rochman et al., 2013), interrupting feeding (de Stephanis et al., 2013), inducing stress (Rochman et al., 2013), neural dysfunction (Barboza et al., 2018), endocrine disruption (Chen et al., 2019), altering behaviour (Seuront, 2018), reducing growth (Besseling et al., 2014), increasing disease (Jeong et al., 2017) and even decreasing survival (Rist et al., 2016). The findings of current study also contribute a new line to these evidences adding that microplastics ingestion adversely affects some life-history traits in a fish, guppy (P. reticulata).

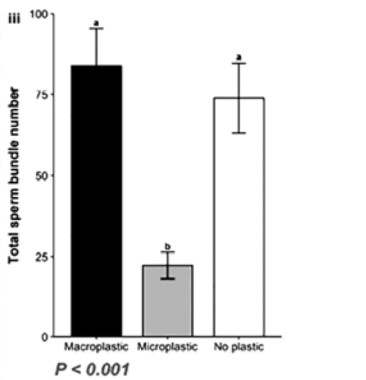

Fig. 3. Effects of microplastics on (iii) sperm bundle number of male guppy after 70 days of rearing.

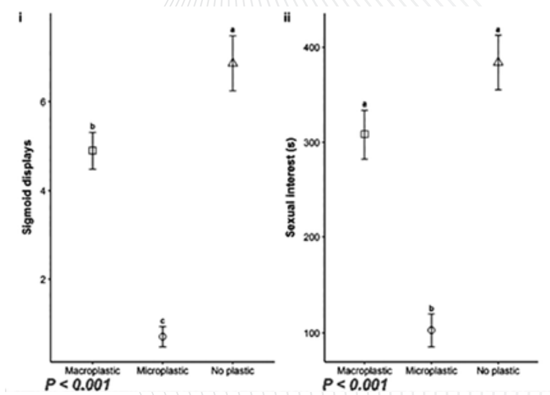

Fig. 4. Effects of microplastics on (i) sigmoid displays and (ii) sexual interest of experimental male guppy after 70 days of rearing. Values are given as mean ± standard error (SE).

Conclusion

Over the last decade, plastic pollution has become as one of the worst anthropogenic activities affecting almost every aquatic ecosystem around the world. It creates a serious risk to the affected ecosystems and their living communities by leaching hazardous chemicals into the environment, bioaccumulating toxic substances from the surrounding water and sediment, making traps for killing species, physically injuring some species, ingesting microplastics as diets, etc. The present study revealed microplastic ingestion can significantly affect survival, growth, reproduction and behaviour of a model fish species. Thus, the findings of this present study warn us about some negative effects of microplastics that are ultimately drained off into the aquatic environments from our daily used plastic products. Considering the future consequences, further studies should be taken to reveal how microplastics can deteriorate aquatic ecosystems, affect the life-history traits of different animals, etc. Necessary policies and rules must be made to reduce the usage, occurrence and distribution of plastic products in our surrounding environments and thereby reduce the adverse effects of microplastics on different ecosystems and the living organisms.

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Parallel Technical Session III, Oral Presentation: 021

Mud Crab farming in Bangladesh: Prospect and sustainability

Zannatul Ferdoushi

Abstract

The mud crab (Scylla serrata) farming and fishing sector are playing a significant role in the national economy of Bangladesh through foreign exchange earnings, increasing employment opportunities, and improving the livelihood of the rural communities in the coastal region. It has been observed that crab fishing and farming in Bangladesh is highly seasonal. Production and benefit are varied with dry and wet season due to the availability of the wild seed and market price fluctuation which ultimately affect the livelihoods of the crab catchers and farmers in Bangladesh. Considering its strong potential aspect in international market, suitable environmental conditions in the southwest part of the country, cheap labour cost and short term technology like fattening could be developed more through proper management. Sufficient and proper market information can encourage the farmers to expand their farming more sustainable level. Well-developed co-operation and partnership between farmers, fishermen, middlemen and wholesaler can also improve this sector for sustainable development. On the other hand, some successful strategies followed by SME's with horizontal and vertical integration could allow individual farms to improve efficiency and competitiveness through enhanced performance.

Key words: *Mud crab, Scylla serrata, sustainability*

Introduction

Crab, a member of phylum Arthropoda belonging to the suborder brachyura of order Decapoda under the class of Crustacea having broad carapace, living in marine, brackish, or freshwaters. They differ from species to species, in size, shape, colour and structure. Among them, Indo-pacific mud crab, Swimming crab, Chinese mitten crab and King crab, Spider crab are become an important source of income both for the export and for local consumption in many countries. In Asian countries capture and culture crab, both Chinese mitten crab and mud crab has been expanding because of the high economic value of the species and its potentiality.

From FAO database there is an increasing trend in production of mud crab in many Asian regions. It's faster growth rate, wider distribution, highly fecundity characteristics contribute it to the resilience of mud crab to harvest. Several species of Scylla are collectively known as mud crab, indo-pacific swamp crab or mangrove crab. Keenan et al. (1998) identified four distinct species of Scylla; S. serrata, S. tranquebarica, S. olivacea and S. paramamosain. It inhabits muddy bottoms, mangrove marshes, and river mouths in estuarine environments (Motoh, 1979) occurs widely throughout the Indo-West Pacific Ocean and Australia, now occurring in Japan, the Philippines, Indonesia, East and South Africa and the Red Sea (Eldredge and Smith, 2001) and sometimes many countries intentionally in attempts to establish populations of this commercially important species.

***Figure 1**. Mud crab (Scylla spp.)*

Mud crab fishery and its role in the economy of Bangladesh

As a food source and exportable fishery, crab plays an important role in the fishery wealth in many nations as well as in Bangladesh. It also has an important acceptance as a poultry and aquaculture food (Zafar and Siddique, 2000). About 628,780 ha of potential mangrove tidal flats where capture and culture of mud crab can be undertaken profitably (Siddiqui and Zafor, 2002). 16 species of crabs have been so far reported from Bangladesh waters, of which the common ones are Scylla sp., Portunas pelagicus, P. sanguinolentus, Charybdis feriata, Charybdis rostrata, Matuta lunaris, M. planipes, Clappa lophos, C. pustulosa, Varuna litterata, Sartorina spinigera, Ocypoda cratopthalma, and Gelasimus annulipes (Khan Gias, 2005). Among them, 6 important genera used as food crabs are Scylla, Portunus, Charybdis, Matuta, Varuna and Sartorina. Scylla spp. or mangrove crab, or mud crab is one of them became most commercially important species due to its high market price in international market.

Bangladesh has extremely favourable conditions for shrimp and mud crab culture. In 1982–1983, there were only 5200 ha of land under shrimp culture; by 1996, 110,000 ha had been brought under shrimp cultivation, 70% being located in the Khulna region. However, with the continued expansion of shrimp culture worldwide, market prices have dropped and profit margins have been squeezed, leading to an upsurge of interest in crab culture. In Bangladesh, conversion of mangrove into shrimp farm and other aquaculture ponds are overestimated destroying the costal region. In addition to this, the mangrove has been under intensive pressure of exploitation for the last few decades (Islam and Wahab, 2005). Government of Bangladesh imposed regulation to stop shrimp seed collection to protect the environment. While, crab can be cultured profitably without destroying the mangrove region (Khatun, 2007). Moreover, recruitment of this species into the fishery takes place throughout the year (Zafar et al. 2006). As an alternative employment opportunity it is important for sustainable development of coastal people . The population density of mud crab in the intertidal zones of the estuaries and coastal backwater swamps of Cox's Bazaar, Chittagong. Khulna, Satkhira and Bagerhat appear to be relatively higher than that of Noakhali. Bhola. Potuakhali and Bonsal (Figure 2).

From Bangladesh exporting of crab have been started from 1987 as a commercial basis and between 1990 to 1991. More than 50,000 people are engaged in fishing, fattening and trading of crabs as well as in export. Bangladesh earned foreign exchange of Tk. 2.7 million. Since then, the farming and exporting of crab has increased to a high level. During 2002, it ranked third in terms of frozen food export items (EPB, 2002). However, the production and earnings from crab fishery were reported to decrease after 2015 (Fig 3, 4). Several causes including the over exploitation, fall in market price etc. were accounted for this.

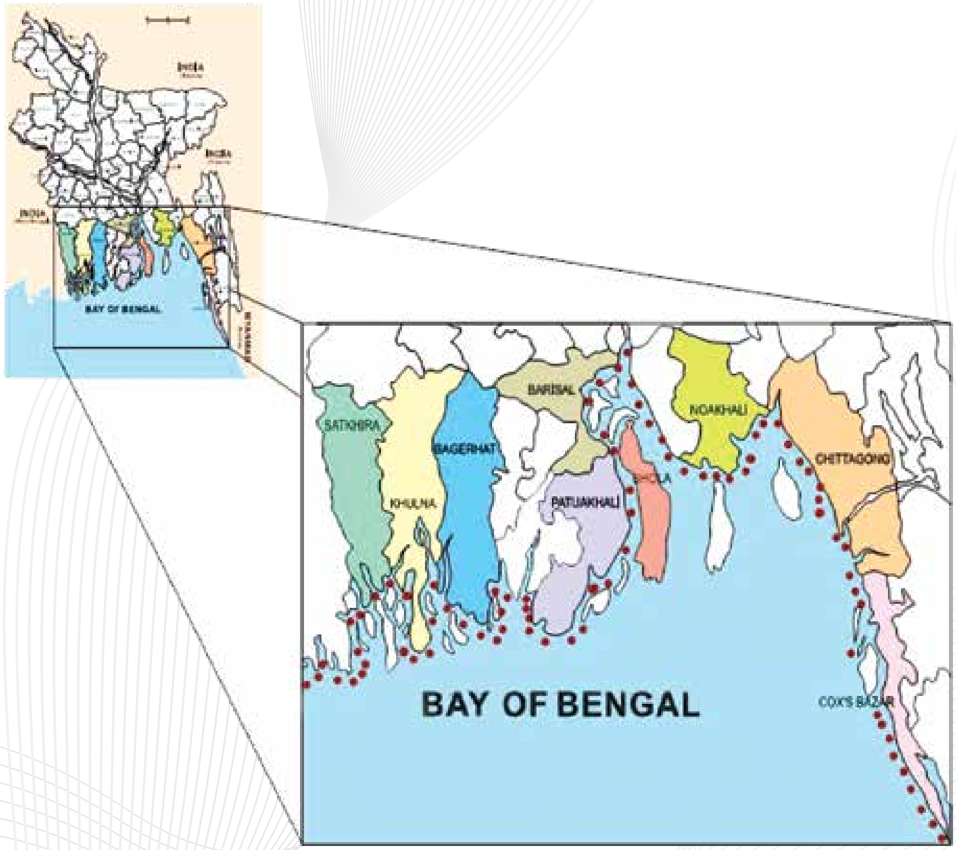


Figure 2 Crab farming and fishing area in Bangladesh.

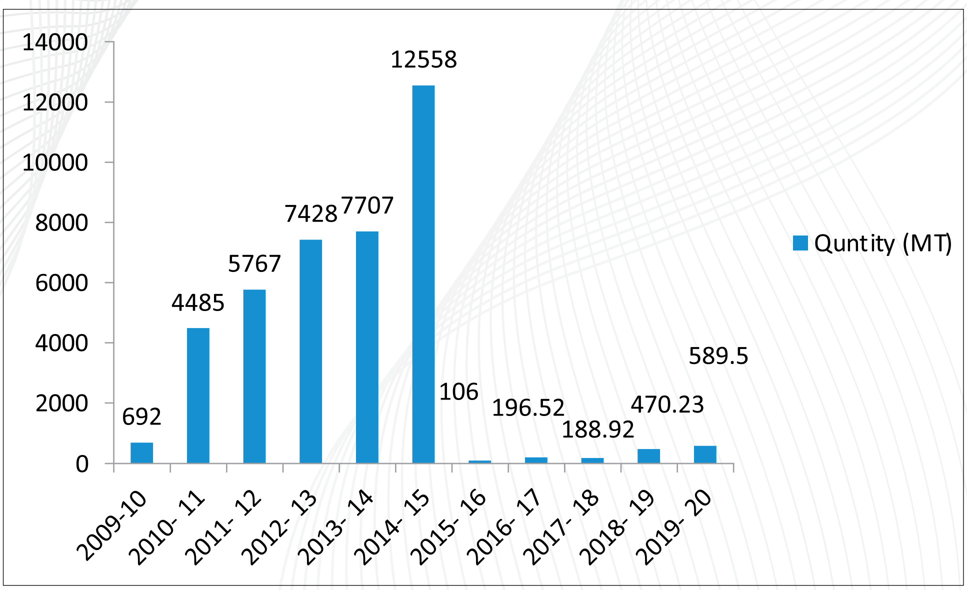


Figure 3: Export quantity of mud crab from 2009 to 2020

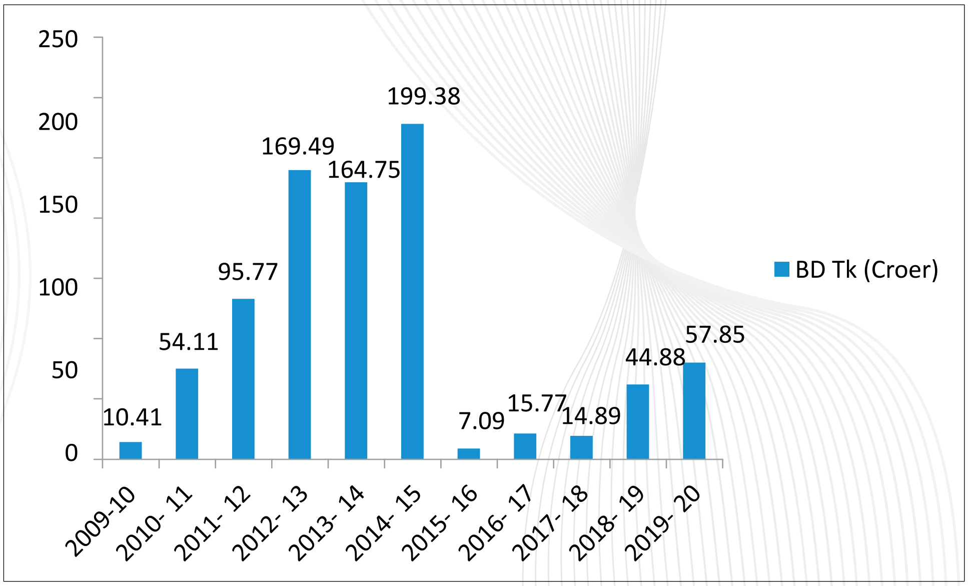


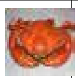
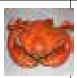
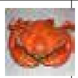
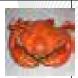
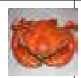
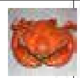
***Figure 4:** Export value of mud crab from 2009 to 2020*

Present crab farming practice in Bangladesh

In Bangladesh, traditional shrimp culture is done simply by "trapping, holding and growing" the wild shrimp fry gathered from tidal waters. During this type of traditional cultivation of shrimp, mud crab larvae also enter into the ponds along with the tidal waters, but the culturists do not take any special care of them. In fact, in past culturists complained about the nuisance caused by the crab; they make holes in the dykes, which drain out the water. Using the experience of shrimp culture, some professional crab catchers became interested in crab culture. However, the situation is changing now. After the falling of market price for shrimp or prawn and as an alternative income sources farmers in coastal region of Bangladesh are getting more interest to mud crab fattening. They are releasing juvenile mud crabs of 2-4 cm into their ponds and are using trash fish as supplementary feed. After few days of culture, the first crop is harvested and the next crop is started. Within a very short period usually 21 to 30 days they are getting more benefit compare to other fish species. Traditionally, the hindus are mostly involved in mud crab farming and trading. In the last few years, Muslims are also entering in this sector. They become interested to take this farming and trading professions as new income opportunities.

Mainly this type of culture practices at first was started in the southern east and southern west part of Bangladesh. Generally, two crab fattening seasons so far have been identified in Bangladesh, one is the dry or peck season (October to May) and another one is lean season or wet season (June to September). Table 1 is showing the availability of crab according to the season and Table 2 is presenting different grades of male and female crabs usually stock for fattening.

Table 1. Availability of crab according to the season.

Season	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
PSM												
PSF												
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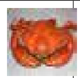
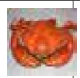
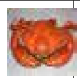
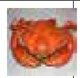
LSF												

Table 2. Different grade of mud crab for fattening.

	Grade	Weight (gm)	Carapace
Male	PD-XXL	>500	Soft
	PD-XL	>400	Soft
	PD-L	>300	Soft
	PD-M	>250	Soft
	PD-SM	<250	Soft
	Grade	**Weight (gm)**	**Hepatopancreas**
Female	KS1	>180	Partially developed
	KS2	>150	Poor
	KS3	<120	Poor

Environmental Impact of mud crab farming

Unfortunately, crab farming resulted several adverse environmental effects on estuarine ecosystems. Figure 5 is showing the direct and indirect environmental impacts of crab farming. Coastal farming could directly or indirectly alter the aquatic and terrestrial environment as well as brought changes in physical environment through its negative environmental impacts. All of those changes can ultimately destruct the local ecosystem including the livelihood of the coastal people.

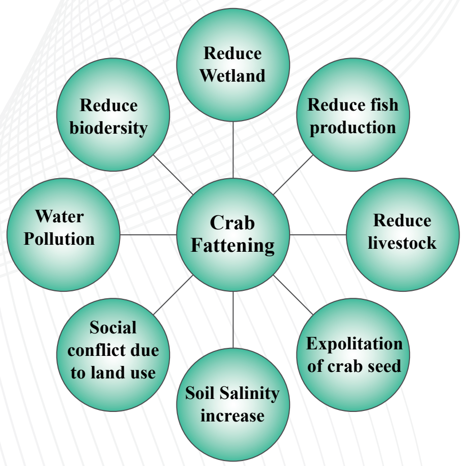


Figure 5. *Direct and indirect environmental impact of mud crab fattening.*

Increasing soil salinity is becoming a major concern in the southwest part of Bangladesh for rice cultivation. Crab farms retain saline waster for long time and the salinity seeps on the adjacent farms and increase the soil salinity. Moreover, due to its higher profit than rice cultivation some the agricultural lands were turned into crab farms or shrimp farms which created some changes in the livelihood for the landless wage labourers, they are loosing their livelihoods and began movements to resist the introduction of shrimp or crab farming in their areas. This often resulted in violence (Firoze, 2003). Moreover, reducing the wetland is also associated with the extension of this farming practice. According to the key informants, the reduction of wetland ultimately reducing the biodiversity, fish production. Loss of local varieties of rice, loss of aquatic plants, increase flood risks are also likely linked with this.

Sustainability of crab farming in Bangladesh

The external environment includes the natural resources used for aquaculture development such as land, water, nutrients and biological diversity. The internal environment of the aquaculture system is considered as husbandry part of the production technology (Edwards, 1998). However, unlike freshwater farming in Bangladesh the current study also showed that brackish water mud crab fattening can contribute some negative impacts on environment. Most important one is the overexploitation of crab in the mangrove region, increasing the soil salinity which could raise the social conflict between agriculture and fisheries. Moreover, unplanned construction of ponds or gher would also reduce the biodiversity. The farming totally depends on the wild seed stock. The harvesting pressure could decrease the wild stock and uncontrolled fishing of brood may threat the natural populations which ultimately affect the livelihoods of fishermen. Moreover social and economic aspects are getting more attention for developing aquaculture and reducing poverty. As the practice is varying with pond size and other social characteristics age, religion, family size etc. and the farmer’s access to vital social service like education, training was found poor. In spite of all negative impacts, mud crab farming in pen in mangrove swamp can enhance the soil quality through increasing the organic carbon (Zafar and Hossian, 2009). The practice has offered an opportunity for increasing farmer’s incomes. However, the overall balance between resource use and impact needs to be more widely assessed.

Conclusion

The mud crab farming and fishing sector are playing significant role in the national economy through foreign exchanged earning, increasing employment opportunities and improving the livelihood of the rural communities in coastal region. However unlike shrimp and prawn, crab farming in Bangladesh has not developed as fast as it could be expected. It is still in primitive stage in Bangladesh. Considering its strong potential aspect in international market, suitable environmental conditions in the southwest part of Bangladesh, cheap labour cost and different advanced technology like soft-shell farming, RAS farming development of canned product from crab could be developed more through proper management.

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Comments of Session Chair

Dr. Maria Zaman

In this session there were three distinguished speakers. 1st speaker was Dr. Mustafizur Rahman, presented paper on microplastic pollution effect of male guppy's morphological and reproductive traits. Session Chair mentioned that this kind of detail research on specific species is very much encouraging. She also requested students to research on Microplastic pollution in fishes specially detection and effects on marine species. 2nd Speaker was Prof. Dr. Zannatul Ferdousi, presented paper on Mud Crab farming prospects and Sustainability in Bangladesh. Dr. Maria appreciated crab farming, as growing demand of Bangladesh Crab fattening can be a good source of protein for our country people.

3rd presenter was Prof. Dr. Imran Parvez, Worked on unexploited shell fish resources of BoB. Dr. Maria said that huge number of molliscano shellfishes are available but very few research were done on their potential use and significance.

In a closing remark, the session chair emphasized that aquaculture and fisheries are the most dynamic sector of Bangladesh. She also focused on the productivity and potentiality aquaculture and fisheries sector. Small scale farming, mariculture, biodiversity study of coastal islands and micro plastic pollution study are encouraged to research. Bangladesh needs to focus on these issues as the country moves forward on the SDGs 2030 goals to achieve a successful Blue Economy.

Dr. Maria Zaman

Assistant Professor & Head of the Department,
Marine Fisheries and Aquaculture, BSMRMU

Vote of Thanks by Registrar, BSMRMU

Cdre Sheikh Firoz Ahmed, (H1), NGP, psc, BN.

Bismillahir Rahmanir Rahim.

The Chief Guest of today's seminar, Barrister Mohibul Hasan Chowdhury, MP Honourable Deputy Minister, Ministry of Education, The keynote Speaker, The Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs, Rear Admiral Khurshed Alam (retd), The Vice Chancellor, Bangabandhu Sheikh Mujibur Rahman Maritime University, Rear Admiral Khaled Iqbal (retd), Distinguished Session Chairs, Learned speakers, Eminent Academicians, Distinguished guests, Faculty Members and Students of Bangabandhu Sheikh Mujibur Rahman Maritime University, Representatives from the Media, Ladies and Gentlemen,

Aassalamu alaiukum and a very good afternoon.

1. It has been indeed a matter of great pleasure and immense satisfaction for Bangabandhu Sheikh Mujibur Rahman Maritime University to successfully host this daylong seminar on "UN Decade of Ocean Science- Imperatives for Bangladesh." It is now my turn to wrap up the seminar and draw curtain on this extensive intellectual pursuit.

Ladies and Gentlemen,

2. We had our key note speaker Rear Admiral Md Khurshed Alam (retd), Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs, who spoke on "Ocean Science- Gateway to Sustainable Development". We are especially honoured to have him as our keynote speaker. He rightly pointed out that the idea of ocean decade is to achieve a major change in the knowledge and management of ocean. He also mentioned that the decade aims to achieve various societal outcome such as clean, healthy, resilient, and safe ocean which is productive, transparent and accessible. Sir, thank you very much for your enlightening deliberations on this key issue.

Ladies and Gentlemen,

3. As you came across, the seminar had two plenary sessions and the session themes were selected in line with the main seminar theme. The first one was "Riding the Waves of Challenges of our weary Ocean" where four eminent speakers from Bangladesh, India, Netherlands and Portugal presented their papers.

4. Speakers identified major challenges and threats facing our ocean today and how these challenges lead to adverse consequences to human society. Riding the waves of these challenges seems to be a daunting task, but the speakers mentioned that things are manageable when powered by scientific knowledge and supported by the committed engagement of stakeholders. From such perspective, we need to identify and fill the critical knowledge gap on the issues.

5. The theme of our 2nd plenary session was "Rethinking Ocean Science for Sustainable Development". In this session also we had four eminent scholars from Bangladesh, India, Netherlands, and United Kingdom who presented their papers on subjects related to the session theme.

6. Speakers mentioned that ocean science has made great progress over the last century in exploring, describing, understanding and enhancing our ability to predict changes in the ocean

system. We shall have even better understanding of the ocean systems in coming decades which will create tremendous opportunity to harness resources from ocean. However, we need to harness ocean using innovative solutions to climate change, ecosystem-based blue food management, nature-based infrastructure development, decarbonization of maritime transport etc. So, we need to rethink ocean science for finding innovative solutions and technologies to support sustainable development.

Ladies and Gentlemen,

7. After the plenary session, we had three parallel technical sessions on "Marine Biotech and Biodiversity", "Oceanography and Energy" and "Marine Aquaculture and Fisheries". In this session, technical papers were presented by the eminent academicians from different universities of the country. The session generated huge interest and enthusiasm among the participants who were mostly academicians and students of related disciplines. As you know, in maritime university, "we strive for maritime excellence" and this was truly reflected during the discussion of this session. Thanks to the participants who made the session very exciting and truly enlightening.

Ladies and Gentlemen,

8. We had another very important element of the seminar; i.e. poster presentation which was participated mostly by the students of maritime disciplines from various universities of Bangladesh. Huge enthusiastic participation made this event extremely vibrant and successful. The posters were truly original and presented with intellectual perceptions. Thanks to the participants who made this event very successful.

9. Before I conclude, I would like to extend my heartfelt thanks to the hon'ble Chief Guest Barrister Mohibul Hasan Chowdhury, MP, Deputy Minister, Ministry of Education, for his kind presence and giving us some valuable words of advice on the development of Ocean science in Bangladesh. This will definitely help us to fulfil the desired out comes of UN Decade of Ocean science.

10. I would also like to extend my heartfelt thanks to our special guest Ms Zuena Aziz, Principal Coordinator, SDG Affairs, in the Prime Minister's Office for her kind presence and words of advice. Her gracious presence and kind words made this program meaningful and encouraged us to work for the ocean science with more vigor and enthusiasm.

11. I would profusely thank eminent speakers, learned session chairs, academicians and distinguished guests from home and abroad for their enthusiastic participation in the seminar. I would also like to thank our officers, faculty members and staffs from BSMRMU who have worked round the clock over past few months to organize this seminar and made it successful. I would also like to thank our friends from the media, for being present at the seminar and covering the program. Thank you very much.

Joi Bangla.

Cdre Sheikh Firoz Ahmed, (H1), NGP, psc, BN,
Registrar, BSMRMU

Poster Presentation

1st

Marine water health assessment in Bangladesh: Prevalence of drug- resistant pathogen

2nd

Driving forces for the annual change in the Chlorophyll-a concentration and nutrients in the SoNG MPA by remote sensing data and how its sustainable

3rd

The Influence of El Nino Southern Oscillation and Indian Ocean Dipole on the Variability of Mesoscale Eddies in the Bay of Bengal

Marine water health assessment in Bangladesh: Prevalence of drug- resistant pathogen

Hazrat Ali[1]*, Kaniz Mehzabin[1], Farida Yesmin[1], Nihad Adnan[1], Dr. Nafisa Azmuda[1], M. Firoz Ahmed[1]# and Salma Akter[1]#

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Abstract

Diversity of marine life is currently a well-explored area of multidisciplinary maritime research due to the enormous involvement of micro- and macro-organisms for ecological balance, biogeochemical cycling, biofouling and impact on climate changes. Anthropogenic pollution has catastrophic effects on marine ecosystems and now it's a global issue. Bangladesh has a massive sea area that is 1.4 times greater than its total land area where many resources are deposited including fisheries. In this study, we collected water samples from 7 distinct points of BoB, from which forty-five presumptive isolates of Vibrio spp. have been collected. After profiling of antimicrobial resistance of these isolates by Disc-Diffusion methods, it was revealed that Ceftazidime and Cefalexin dual-resistance was present in 7 isolates, whereas 5 isolates were resistant to amoxicillin-clavulanic acid. The genomic DNA of the Vibrio isolates were extracted by using the boil DNA extraction method for molecular confirmation using species specific primers and detection of antimicrobial gene diversity. This study will reveal the prevalence of drug-resistant Vibrio spp. in coastal area, which will play crucial role for developing maritime safety policy for human and BoB-aquifers.

Driving forces for the annual change in the Chlorophyll-a concentration and nutrients in the SoNG MPA by remote sensing data and how its sustainable

Mohammad Azharul Islam [1*], Kayes Mahmud[2*]

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[2]Department of Oceanography and Hydrography (Batch-03)

Abstract

After the declaration of Swatch of No Ground (SoNG) as a Marine Protected Area on 26th October 2014, Bangladesh has established an example to conserve the marine biodiversity in the Bay of Bengal on the first place. It was mainly conserved for the whales (2 Species) and Dolphins (5 species), which are endangered species for this region. The unique geography and geology of the underwater canyon, the transportation of the sediments (about 60% of billion tons), and chlorophyll-a concentration and nutrients availability in a certain layer are the major factors which we have found in our analysis. In the SoNG MPA region, the surface is always closed because of the turbid water. The chl-a concentration of the surface waters is maxed up to 0.4544 mg m-3 and the nutrients; Nitrate NO3- is about 7.0913 mmol m-3; PO4- concentration 0.0894 mmol m-3; Si concentration 4.9427 mmol m-3. But while we have reached to the 7-10 m of the surface water, the concentration of the nutrients and Chl-a highly increases and shows a certain layer which nearly looks like a mixed layer. The chl-a concentration thereby 4.8519 mg m-3; NO¬¬3- concentration 30.2182 mmol m-3; PO4- concentration 0.1411 mmol m-3; Si concentration 42.3202 mmol m-3. So, it's preferable to say that, there should be some driving force like wind stress, MLD, temperature, saline layer, density variation which is likely to be responsible for the variation in this MPA region and impacting on the selected mammals.

Keywords: *Chlorophyll-a concentration, Nutrients, MPA, Physical parameters, SoNG*

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The Influence of El Nino Southern Oscillation and Indian Ocean Dipole on the Variability of Mesoscale Eddies in the Bay of Bengal

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Abstract

This study investigates the variability of mesoscale eddies in the Bay of Bengal (BoB) utilizing satellite altimeter throughout a 29-year period. During the study period, cyclonic eddies (CEs) and anticyclonic eddies (ACs) were significantly impacted by El Nino Southern Oscillation (ENSO) or Indian Ocean Dipole (IOD) events. The two strongest summer monsoons—from 1993 to 2021—took place in the years of 1994 and 2019, which occurred concurrently with ENSO and IOD. The second downwelling coastal Kelvin wave (dCKW) was absent during autumn due to the equatorial zonal wind anomalies, which inhibited the EICC dynamics, the monsoon onset, and Rossby waves during the following seasons. Consequently, the combined effect of strong monsoon, El Nino, and positive IOD significantly reduced the eddying in 1995 and 2020, particularly during the spring season of these years. Additionally, the 1995 eddy field was apparently influenced by ENSO, whereas the 2020 eddy field was impacted by IOD event in 2019. Moreover, the properties of ACs are strongly influenced by ENSO and IOD compared to the properties of CEs. The stronger correlation and anti-correlation between mesoscale eddies and climate indices suggest that eddying intensifies following the La Nina and negative IOD years, whereas eddy activity diminishes after the El Nino and positive IOD years because the former event intensifies the second dCKW, whereas the second dCKW weakens or becomes completely absent during the latter episodes. The finding has implications for validating ocean-climate interactions and therefore can be incorporated into forecasting models for the ocean and atmosphere.

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Analysis of Seawater Quality Parameters of (Dublar Char and Teknaf) Mangrove Areas

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Mangroves, biologically one of the richest ecosystems, have long been playing a pivotal role in reducing the impact of cyclones and thus form the best shelterbelt against cyclones and storms. Teknaf Peninsula occurring along the banks and estuarine islands of Naaf river possess mangroves that are both natural and planted. Sundarbans mangrove forest (SMF) is the largest mangrove forest globally, Dublar Char is located on the south side of this mangrove. Seawater qualities and the dependencies of all life processes on these factors make it desirable to take seawater as an environment. Here, a systematic study has been carried out to assess water quality parameters of seawater samples from 11 stations; 6 stations from Teknaf Mangrove Area and 5 stations from Dublarchar Mangrove Area, of the Bay of Bengal. Seawater samples were collected using a water sampler and sampling locations were determined using a GPS. Seawater quality parameters were studied by measuring different physicochemical properties such as pH, conductivity, turbidity, salinity, TDS, density, viscosity, refractive index, DO, COD and BOD using different methods. The obtained results highlight variation in most of the water quality parameters of Teknaf & Dublarchar Areas and have good correlation with each other.

Keywords: Seawater, Teknaf Mangrove Area, Dublarchar Mangrove Area, Seawater quality parameters, Comparative study and correlation

Marine Pollution and its Impacts on Fishes

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Heavy metals are transported to the ocean through surface run-off, acidic rain, and rivers that carry polluted water. Compared to other forms of water pollution, heavy metal contamination in the oceans concerns humans and marine ecosystems. Heavy metal pollution in the ocean or sea is not as severe as reported, but its consequences on humans and marine ecologies are profound. This study identifies the sources of heavy metals (Fe, Mn, Cd, Cr, Cu, Ni, Pb) contamination and their effects on marine natural products. Heavy metals have toxic effects on fish and aquatic invertebrates, including reduced growth, fish body size, fertility, fish larvae and juveniles growing quickly, as well as several diseases of marine aquatic life. The harmful impact on fish larvae is growth inhibition. Fish and other aquatic creatures pick up contaminants directly from contaminated water and indirectly through the food chain.

Keywords: Heavy metal; Human health; Marine life; Pollution; Water

An alternative sustainable fuel solution for Bangladesh: Biofuel”

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This research will carry out a paper review to explore whether seaweeds from the Bay of Bengal are suitable for commercial biofuel production and the viability of biofuel as a sustainable fuel alternative in Bangladesh. Many researchers expressed their perspectives and findings from biofuel research in Bangladesh. Though there are other biofuel sources, the potential of biofuel from seaweed is studied here. According to the physiography of Bangladesh's ocean, seaweed has a significant potential for producing biofuel from the coast and offshore locations. The writers of this study piece discuss the primary and significant hurdles to using biofuel as a fuel, as well as their answers. As a result, a sustainable SWOT analysis was carried out to investigate the availability and potential of seaweed for biofuel production in Bangladesh. We are contemplating biofuel in Bangladesh as an alternative low-cost fuel supply because it has already hit the market. Because biofuel has numerous potentials for enhancing energy security and mitigating climate change.

Occurrence of enteric bacteria in marine water of Bangladesh: a systemic and metagenomic approach

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Marine ecosystem is highly sophisticated and diversified part of our planet. Marine bacteria, unicellular prokaryotic plankton usually (less than 0.5-1 micrometer) relatively unexplored resource. This study focuses on exploring the diversity as well as isolation of pathogenic bacterial strain and their probable impact on ocean ecosystem. In this study, water samples from seven location of Cox’s Bazar and Saint Martin’s Island were collected, followed by detection of physicochemical parameters like temperature, pH, salinity and TDS. Inoculation into selective media revealed presence of presumptive coliform, fecal coliform and Pseudomonas spp in the samples. Further aim for this study is isolation of DNA to perform 16s rRNA metagenomic approach for diversity analysis as well as pathogenic strain identification. The present status of this study indicates our selected locations are contaminated with multiple pathogenic bacteria. Our study may come up with different antibiotic resistant pathogenic bacteria which increase the chances of growing resistance in marine environment. The changes in marine environment may have pernicious effect on marine biome as well as global ecosystem.

Upper Ocean Responses between Oceanic Eddies and Tropical Cyclones in the Bay of Bengal

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Due to the unique geographical location, the Bay of Bengal is often plagued by devastating tropical cyclones every year. Tropical cyclones usually originate in pre-monsoon and post-monsoon season. The present study deals with the role of oceanic eddies in the intensification of the cyclones along the upper surface responses of the ocean during pre-monsoon and post-monsoon from 2015 to 2020 by using satellite and Argo data products. It reveals that chlorophyll-a bloomed during the origination of a cyclone, having an increased rate of 5 times and 8-9 times fold during post and pre-monsoonal period respectively. Since, sea level pressure drops when the cyclones started generating, sea surface temperatures provide favorable conditions for the genesis having impact the amount of upper ocean heat content along oceanic eddies. The role of the oceanic eddies can intensify or weaken the cyclones. The heat content of the water column within the mixed layer depth is also important which has been calculated for the observed cyclones. The average cyclone-induced cooling between the pre-monsoon period and post-monsoon is around 1.5-2.9 °C. The variation in ocean responses occur due to the salinity distribution and stratification during two different monsoonal seasons.

Keywords: eddies, cyclones, chlorophyll-a, sea level pressure, sea surface temperature, sea surface salinity, Bay of Bengal.

Sea weed: A Nutrients for next generation?

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Seaweeds are aquatic plants that contribute our society significantly, economically and environment friendly. Over thousands of global species of seaweeds, only 34 species are suitable for farming. Seaweeds farming areas in the world cover 48 million km2 across 132 countries, although 44 of them are active in production. Global seaweed production estimated approximately 15 billion U.S. dollars in 2021 which is expected to rise 22.13 billion U.S. dollars by 2024. Along the coast of Bangladesh, 32 seaweeds species are abundant, 14 species are commercially important. Due to the increasing world population more food is needed to feed. But the cultivable land and fresh water is decreasing. Researcher tried to find a multifarious food source like farming seaweed. To cultivate seaweed, it requires only sunlight, while it purifies water, and is a sustainable crop. Opportunities for utilization in nutraceuticals, human foods and animal feeds, including aquafeeds, have been identified as offering the most promise in a reasonable time frame. Global seaweed production has increased greatly in recent years, as have the by-products and co-products derived from them. Furthermore, seaweed is a 'superfood', which is easy to process into healthy and tasty food for human and animal consumption.

Inter-annual variation in chlorophyll-a and its relationship with physico-chemical parameters and Indian Ocean Dipole in the northern Bay of Bengal.

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Chlorophyll-a concentration in northern Bay of Bengal (BoB) shows variations from surface to subsurface, zone to zone, and even with time. Chlorophyll-a concentration positively correlates with primary production in the ocean. The variation in oceanic chlorophyll-a has been studied on a geographical, seasonal, and inter-annual basis. Many researchers investigated the inter-relationship between chlorophyll-a and environmental forces (physical or chemical) on a global or regional scale. Only a few studies have looked at the combined effect of physicochemical forcing on chlorophyll-a. Hence, this study investigates a comprehensive basin-wide framework of the inter-annual variations in the chlorophyll-a concentration and their possible physicochemical forcing and Indian Ocean Dipole (IOD). Geospatial mapping and statistical analysis were used to understand the relationship between inter-annual variation in chlorophyll-a and their physicochemical forcing. Temperature, salinity, current velocity, nitrate, phosphate, silicate, dissolved oxygen, and iron data were used in the analysis as probable forcing factors. In 2016, a strong negative IOD was observed, while in 2019, a strong positive IOD occurred. These events have an effect on the inter-annual variation of chlorophyll-a by slowing and speeding up the increase, respectively.

Variability of Chlorophyll-a and Sea Surface Temperature, and Their Relationship with Bathymetry over the Bay of Bengal

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Sea surface temperature (SST) is a fundamental parameter for quantitative studies of the earth, atmosphere, and ocean. SST plays an important role on phytoplankton growth hence the chlorophyll-a (Chl-a) and is closely related to water stratification. Chl-a is the main pigment which phytoplankton uses in photosynthesis to convert nutrients and carbon dioxide, which are dissolved in sea water. The present study was done based on satellite data (MODIS Aqua Product) from 2002-2022. The mean SST of the dataset ranged from 26.46 to 31.17°C, with lowest temperatures between 17.99 and 28.3°C and maximum temperatures between 30.17 and 39.97°C. On the other hand, the mean Chl-a concentration ranged from 0.15 to 0.75 mg/m3, with a minimum range of 0.02 to 0.5 mg/m3 and a maximum range of 6.69 to 86.03 mg/m3. SST has exhibited a progressively rising tendency whilst Chl-a in the Bay of Bengal declined. We found a low positive correlation (0.42086) of Chl-a over bathymetry and a negligible negative correlation (-0.228) between the SST and Chl-a.

Keywords: SST, Chlorophyll-a, Bathymetry, Correlation, Bay of Bengal

Current Status of Microplastic in the Coastal Area of Bangladesh: Spatial Distribution and Future Perspective

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In recent years, scientists have been quite interested in microplastics, a new type of environmental pollutant. These micropollutants are pervasive in both the terrestrial and aquatic ecosystems, endangering biodiversity and the ecosystem. In 2020, almost 367 million tons of plastic products were created globally, and 2 to 5 percent of those products ended up in the oceans. The amount of plastic entering the ocean each year will rise to 16 million tons by 2030 and roughly 32 million tons by 2050 if suitable action is not made to minimize the use of plastic items. By 2050, it is predicted that there will be more plastic in the ocean in terms of weight than there would be fish. The most prevalent polymers for microplastics in Bangladesh's marine and freshwater environments were polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), and polyvinyl chloride (PVC). Extensive and in-depth studies are needed to fill in knowledge gaps and enable comprehensive risk assessments of microplastic pollution on local ecosystems and human health, in addition to the research priorities identified to better understand the ecotoxicological effect and fate of micro-plastics. Effective management of plastic wastes and their recycling are also required to address this issue in the nation.

Keywords: Microplastic, ecosystem, risk, pollution, marine, polymer.

An Overview of Plankton Abundance and Size Class distribution in a water stream near the Payra Port: Support to Ecosystem State Assessment.

Syeda Jasia Firdaws

The study on plankton abundance and size class distribution was studied during the dry season in January 2021. A total of 37 taxa under 33 genera belongings 10 classes, respectively Bacilaariophycea (10 genera), Chlorophyceae (5 genera), Coscinidiscophyceae (3 genera), Cyanophyceae (2 genera), Dynophyceae (1 genera), Fragilariophyceae (3 genera), Zygnematophyceae (2 genera) phytoplankton and 6 genera of Branchiopoda (2 genera), Copepoda (2 genera), Monogononta (3 genera) zooplankton from 4 stations near the Payra Port. The most abundant station with Bacilaariophyceae phytoplankton is A2 with total 6710 Cells/L. On the other side maximum abundant station with Branchiopoda zooplankton is A1 with total 817 Cells/L. Micro-plankton is highly distributed in every station which is ranged from 60% to 50%. The occurrence of aquatic creatures is strongly influenced by the water quality of an environment, hence it is critical to quantify it. In the present study, surface water was recorded mostly natural with low salinity in major part of the channel in dry season. Water temperature, salinity, pH, DO and TDS were shown to be responsible for changes in phytoplankton community structure.

Seasonal and Spatial variability of Chlorophyll-a ((El Niño/La Niña-Southern Oscillation) and it's response with ENSO and Ocean Current in the Northern Bay of Bengal

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Variability of Chlorophyll–a (Chl-a) can be used to assess the primary productivity in the oceans and understand the marine ecosystem responses. This study was conducted to explore the seasonal and spatial variability of Chl-a across BoB and its correlation with ocean current and ENSO events in the Northern Bay of Bengal (BoB) by using satellite data. SST anomalies dataset was used for investigating the climatic ENSO effect on the Chl-a variability. This study revealed that the onshore region has the highest (1.121 mgm-3) abundance of Chl-a whereas the lowest (0.136 mgm-3) was observed in the offshore region. The observed Chl-a was maximum in the onshore region with the corresponding seasonal trends: monsoon >post-monsoon>pre-monsoon. Chl-a fluctuated most in the post-monsoon over the onshore region. Chl-a distribution was found higher during anticyclonic gyre formation. A non-significant relationship ($p > 0.05$; $r = 0.03$) was found between Chl-a and current speed but the relationship was found statistically significant ($p < 0.05$) only at pre-monsoon with a weak positive correlation ($r = 0.28$). The effect of the ENSO event was observed as non-significant in the Northern BoB. Chl-a variability in response to ENSO events across the northern region of BoB requires more investigation.

How regions of higher CO2 levels interact with the populations of plankton, which directly impacts the oxygen levels of the water.

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Since the start of the industrial revolution, CO_2 concentrations in the atmosphere have been growing incessantly. The flux of CO_2 from the atmosphere to the World Ocean has increased in accordance. There is although a limit to the amount of CO_2 the Ocean can absorb. The assertion a general theory or hypothesis. The more important question is whether the flux is the same in different parts of the world? If not, how do the magnitudes vary? It is known that colder water absorbs greater amount of gas. Finally, the question is what impact do each of these fluxes have on their respective phytoplankton communities. It's hard to believe that nowhere these creatures have been utilizing these newer and bigger reserves. And if that's not the case, the reason behind that should be determined as well.

Pervasiveness of Microplastic Contamination in the Gastrointestinal Tract of Fishes from the Western Coast of Bangladesh

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This study aimed to investigate the prevalence of microplastics in the gastrointestinal tract of fishes from the western coast of Bangladesh which possess the world's largest mangrove ecosystem. A total of 8 species (n=8 per species) were investigated for the abundance of microplastics, of which 5 were demersal and 3 were pelagic. Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) were used consecutively for polymer analysis and surface morphology detection of the particles. Microplastics were detected in all the 64 individual fish with an average abundance of 7.1 ± 3.14 particles per specimen. The demersal species were found to ingest more microplastics (7.78+3.51) than the pelagic species (5.92+2.06) Microplastic abundance showed a positive correlation ($r=0.59$; $p<0.0001$) with the body weight of the species. Polypropylene, polyethylene, and polyester were the most abundant polymer types among the extracted particles. Fiber was the most prevalent shape (71.37%) followed by film (14.1%), Fragment (13.22%), Foam (1.1%), and pellet (0.22%). This study will raise a concern about this micropollutant and will help the decision makers to take better actions to sustainably reduce marine plastic pollution to protect and restore marine ecosystems.

Assessment of heavy metals in the Surface Water, Sediment and Some Common Fishes from the Bay of Bengal, Bangladesh

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Heavy metal (Zn, Mn, Fe, Cd, Pb, Cu, Cr and Ni) concentrations were detected in surface water, sediment and some common marine and estuarine fishes of the Bay of Bengal of Bangladesh from July 2021 to June 2022. Samples were collected from Coxes Bazar and Khulna region of Bangladesh and the metals were analyzed by Atomic Absorption Spectrophotometer (AAS). Results showed that heavy metals in water were found below the safe limit of drinking water standards of WHO (1993) and EU (1998) with the exclusion of Mn, Fe, Cu and Cr. In sediment samples, heavy metals were detected at lower values compared to other published results.

The concentration of heavy metals in fish species was detected within the acceptable level, but Cr, Cu and Pb concentrations were close to the maximum allowable limit. Results of the present research indicate that between the two sampling spots, no significant difference in heavy metals concentrations in muscle of fishes was found ($p > 0.05$). More research studies are required to minimize the health risk of the population and the detrimental impacts on the aquatic ecosystem.

Erosion and accretion trends over forty years along the left bank of lower Meghna estuary - implications on coastal economic activities

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The dynamic Ganges-Brahmaputra-Meghna (GBM) delta governs the geomorphological processes shaping the adjacent coastal lands along the lower Meghna estuary located in the central coastal region of Bangladesh. The present study assesses the spatio-temporal dynamics of erosion-accretion trends along the lower Meghna estuary for the past four decades and the implication on the coastal economic activities of this area. Satellite imagery analysis for the year 1980, 1980, 1990, 2000, 2010, and 2020 as well as site survey methods were integrated to quantify the changes and find out the implications on local coastal economy. It is reveals that on an average the lower Meghna river bank experienced mostly erosion. From the year 1980 to 2020, 3252.72m, 2143.42m, 3437.67m, 4626.21m land eroded at Haiderganj, Maju Chaudhury Hat, Ramgati, Chairman ghat respectively. The erosion rate ranged from 81.32m/year to 115.66m/year. However, some accretion trend was observed at a range of 123.454m/year to 364.635m/year in few locations. Overall, fish landing and marketing activities, navigation between Noakhali main land and Hatiya and homesteads of poor people along the river bank are mostly affected due this bank shifting process. Further, an understanding of erosion-accretion dynamics can guide to formulate effective coastal management policies to ensure sustainable economic growth.

Sediment characteristics along with benthic community in the erosion prone area of lower Meghna Estuary

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The estuarine ecosystem is unique in its physic-chemical, morphological dynamics, and biodiversity. The estuarine ecosystem is one of the most productive ecosystems which is isolated from the marine and freshwater ecosystems. The present study was performed to deal with the sediment characteristics and the community structure of benthic organisms inanerosion-prone segment of the left bank of the lower Meghna river estuary. All the physic-chemical parameters were found optimum except total suspended solids (TSS) which are unusually higher.This eroding sediment diversity of benthic organisms was found comparatively poor (H'=1.48). The study revealed that the sub-surface deposit feeders like Polychaeta and surface deposit feeder gastropod are the most dominating groups followed by minor groups like bivalves, decapod, mysids, and fish larvae. The most diversified and abundant station was station-02 and comparatively least was station-01. This indicates that at the finer sediment with favorable physiochemical parameters the macrobenthos density and abundance are high and comparatively lower diversity indicates the unfavorable environment. Overall the Tankir ghat's ecosystem quality is not favorable for the benthic community diversity.

SPATIO-TEMPORAL DISTRIBUTION OF CHLOROPHYLL-A, TOTAL SUSPENDED MATTER, AND COLORED DISSOLVED ORGANIC MATTER IN THE COASTAL AREAS OF SUNDARBAN MANGROVE FOREST USING REMOTE SENSING SATELLITE IMAGERY

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This study evaluates the effectiveness of Sentinel-2 MSI and Landsat-8 OLI multispectral remote sensors to determine the spatial and seasonal fluctuation of Chlorophyll-a (Chl-a), Total Suspended Matter (TSM) and Colored Dissolved Organic Matter (CDOM) in the complex tidal river systems of the Sundarban mangroves. Several algorithms and processors have been applied to retrieve these water quality parameters. For validation, a total of 50 in-situ samples were collected and stored using standard sampling methods and measured in a lab using standard a protocol during winter (December) and pre-monsoon (April). This study also revealed that average monthly wind speeds were higher during the pre-monsoon season. The Case-2 Regional Coast Color (C2RCC) processor in-built into the SNAP software was applied to get the CDOM concentration using Landsat-8 OLI sensor. There was found a strong association with absorption coefficient aCDOM (m-1). On the other hand, R2 for aCDOM is 0.65 during the pre-monsoon season and 0.74 throughout the winter. Finally, to estimate the biological status and productivity of the underwater ecosystem of the coastal water using remote sensing, these water quality parameters should be determined first.

Reduction of Ocean Pollution by Providing Alternative Energy Sources

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Ocean pollution is currently at its peak and ships that discharge sewage wastes and plastic items into the ocean are top contributors to this issue. In brief, our strategy is to collect sewage wastes and plastic products from ships rather than throwing them away and then using sewage wastes, we intend to produce electricity. The objective of this project is to provide a livable environment for the aqua creatures and come up with alternative energy sources and thus protect the environment. The methods to follow, i) Tank Installment: To collect sewage wastes, Arrangement of Bins: To collect plastic wastes. Then these wastes will be collected from some specific ports. Following that Sewage wastes will be sent to 'Microbial Fuel Cell Plant' where by using microbes' electricity will be produced. A 'Pyrolysis Plant' will be established nearby the MFC plant where the sewage electricity will be used to produce biofuel from plastic that will be used later as marine fuel. It is estimated that pyrolysis will have a market value of 8.8 billion. So, this project will also result in economic development but ocean pollution reduction is our first priority.

Microplastics Pollution in Bangladesh: An Investigative Hazard Analysis in South Eastern Coast in Relation to Ecological and Human Health Risks

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Ecological and human health risks due to Microplastic (MP) pollution in the context of Bangladesh is a new dimension of research interest. The purpose of the study was to identify and investigate the MP's influences on coastal ecology and human health by assessing the potential risks on the southeastern coast of Bangladesh. Three types of MPs; Fibers, fragments, and foams have been identified along with the study. There was a predominance of the <1 mm MPs in both water and sediment samples (68.4% and 68%). According to Pollution Load Index (PLI) 20.8 and Polymer Hazard Index (PHI) 1527.0 values, that study area has serious ecological and human health threats. The outcome of this study indicates that Bangladesh has a high risk due to MPs pollution regarding public health concerns because the accumulation of microplastics in the environment causes a potential risk and obvious threats to human health due to transferring capability in aquatic media, uptake by the aquatic organism, plants and above all their subsequent introduction into the food chain.

Keywords: Microplastics, Pollution, Ecological Risks, Human Health Risks.

Population genetic structure and diversity of Paradise threadfin (*Polynemus paradiseus*) in the Bangladesh coast of the northern Bay of Bengal.

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Genetic diversity and population genetic structure of Paradise threadfin, P. paradiseus of different coastal rivers of Bangladesh were investigated using mitochondrial DNA (mtDNA) marker. Fish samples were collected from four coastal rivers namely, Karnofuli (KF), Kirtonkhola (KK), Bishkhali (BK) and Baleshwar (BR). High level of haplotype diversities in contrast with low nucleotide diversity indicates that this fish has experience population expansion after a period of low effective population size. The FST (fixation index) values showed that KK population has significant genetic variation ($P<0.05$) with other populations. Exact test of population differentiation also showed non-panmixia for KK population compared to KF and BS populations. The neutrality tests i.e. Tajima's D tests and Fu's Fs values were significantly negative for all populations suggesting demographic expansion of this fish in the northern Bay of Bengal region.

Keywords: Population structure, genetic diversity, Polynemus paradiseus, Bangladesh.

Genetic diversity and population structure of *Flathead sillago, Sillaginopsis domina* in the northern Bay of Bengal, Bangladesh.

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Genetic diversity and population genetic structure of Flathead sillago, Sillaginopsis domina of different coastal rivers of Bangladesh were investigated using mitochondrial DNA (mtDNA) marker. Fish samples were collected from three coastal rivers viz. the Bishkhali river (BK), Baleshwar river (BR), and Meghna River (MR). All of the mtDNA control region sequences defined 16 haplotypes where BK and BR populations comprised 6 haplotypes of each and MR population comprised 8 haplotypes. The nucleotide diversities (π) were low in each of the population ranged from 0.001 to 0.004 while the haplotype diversities (h) were relatively high which were 0.338 to 0.647. Estimates of pairwise values of fixation index (FST) among the three populations of the Bay Bengal are 0.15 to 0.51 with significant deviation (P=0.0) for each. The exact test of population differentiation also showed significant differentiation between each of the three population pair suggesting non-panmictic populations within Bangladeshi coastal waters in the northern Bay of Bengal.

Keywords: Sillaginopsis domina, Population genetic structure, Mitochondrial DNA, Coastal rivers.

Nutrients dependency of two major fishing grounds (south patches and south of south patches) of Bay of Bengal

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In order to provide a general overview of the nutrients of the fishing grounds south patches (SP) and south of south patches (SSP) of the Bay of Bengal (BoB), this study was conducted. It is essential to know the status of nutrients and their relation with primary productivity. Chlorophyll-a is the pigment of plankton, which concentration can indicate primary productivity where primary productivity is correlated with fish production. The results of the present study indicate that higher concentrations of ammonia, nitrate, nitrite, phosphate and iron are in the eastern side of the fishing grounds but silica and iron are well distributed having average values of 2.77 mg/l and 0.022 mg/l. Ammonia (mean 6.09 mg/l) is dominant over other nutrients. Chlorophyll-a is significantly correlated with ammonia, nitrite and silica. The high values of N:P ratios indicate that phosphate is the limiting factor for phytoplankton growth in the fishing ground of the BoB. Spatial distribution patterns of the studied variables revealed that chlorophyll-a of the fishing grounds waters is dependent on phosphate concentrations.

Keywords: Nutrients, Chlorophyll-a, Primary Production, Fishing Ground.

Quantification, characterization and source identification of microplastic in the gastrointestinal tract of farmed Tilapia

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Plastic debris is widespread in the marine as well as the freshwater environment. The main objective of this study aimed to identify, quantify, and characterize microplastic in the gastrointestinal tract (GT) of a freshwater pelagic fish Tilapia Oreochromis niloticus and to identify the possible sources of ingested microplastic to get a coherent picture of the microplastic pathway in the remote freshwater ecosystem. A total of 120 fish samples were collected from 12 tilapia fish farms in the Noakhali district. In the GT of tilapia, black (25%), blue (24%) and red (23%) were the dominating colour of MPs, while black (33%), blue (22%) and red (23%) was also dominating in the commercial feed. Most of the MPs found in the GT of tilapia and commercial feed were within 45-1500 µm in size and accounted for 81% and 78%, respectively of the total extracted microplastic particles. The nature (based on shape, colour and size) of the MPs extracted from commercial tilapia feeds used in these selected fish ponds were very close to the nature of MPs found in the GT of tilapia, clearly indicating that commercial tilapia feed is the one main source of MPs in these freshwater fish ponds.

Seasonal Variation of Chlorophyll Concentration at various depths in 2021 in the Bay of Bengal

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Chlorophyll plays a crucial part in photosynthesis. Chlorophyll, a green pigment found in plants' chloroplasts, is required for plants to use sunlight to transform carbon dioxide and water into oxygen and glucose. Chlorophyll and other light-harvesting pigments are used by phytoplankton, just like plants on land, to perform photosynthesis, absorbing atmospheric carbon dioxide to create sugars. Phytoplankton, which includes single-celled algae and other creatures that resemble plants, makes up the basis of the ocean's food chain. The purpose of this study is to use R programming to extract chlorophyll concentration for the Bay of Bengal using satellite-based data for the months of January through December in 2021. The research classified the twelve months of 2021 into four seasons: summer (February, March, April); monsoon (May, June, July); autumn (August, September, October); and winter (November, December, January). This study demonstrates seasonal variations in the Bay of Bengal's chlorophyll content from January to December in 2021, ranging from 0.494 to 2874 (m). This study shows that the mean seasonal values of chlorophyll concentration at a total of 43 depths in the Bay of Bengal are 0.1242 mgm-3 in summer; 0.1200 mgm-3 in the monsoon; 0.154 mgm-3 in autumn; and 0.1472 mgm-3 in winter, respectively, from January to December in 2021.

Analysis of Seawater Quality Parameters of Saint Martin

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The only coral island, Saint Martin's Island at the southernmost tip of Bangladesh has significant ecological value for being the most favorite tourism spot along with for acting as nesting site for many internationally vulnerable marine species. Here, a systematic study has been carried out to assess water quality parameters of seawater samples from 9 stations of the northern Bay of Bengal. Seawater samples were collected using a water sampler and sampling locations were determined using a GPS. Seawater quality parameters were studied by measuring different physicochemical properties such as pH, conductivity, turbidity, salinity, TDS, density, viscosity, refractive index, DO, COD and BOD using different methods. Changes in these properties provide information on the seawater quality, source(s) of the variations, and their impacts on aquatic environment. Additionally, concentration of heavy metals: arsenic, lead, chromium, mercury, cadmium, zinc and iron as well as minerals: sodium and magnesium were investigated by Atomic Absorption Spectrophotometer. Seawater quality parameters in this study have been critically analyzed, compared, correlated and important findings were noted. The obtained results highlight variation in most of the water quality parameters of Saint Martin and have good correlation with each other.

Keywords: Seawater, northern Bay of Bengal, seawater quality parameters, comparative study and correlation

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