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Inputs for the Blue Economy Strategy of Bangladesh

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Introduction

Between 2012 and 2014, disputes over maritime boundary with Myanmar and India were favourably settled for Bangladesh, resulting in the expansion of its territorial waters of more than 30% and the country received entitlement to 118,813 km2 in the Bay of Bengal. This achievement offers a wide range of new economic opportunities for jobs & growth around sectors such as marine fisheries, marine aquaculture, tourism, exploitation of natural resources, trade and energy. Yet for these opportunities to truly contribute to the long term development of the country, the marine resources must be managed in a sustainable way. In that regards, the Government of Bangladesh (GoB) has initiated, since 2014, discussions with stakeholders in order to adopt the concept of blue economy across relevant policies and plans. By definition, the blue economy fosters the idea of exploiting untapped potential of the marine environment using smart solutions and innovations for increasing food security, improving nutrition and health, alleviating poverty, creating jobs, lifting trade and industrial profiles while protecting ecosystem health and biodiversity, and improving regional security and peace.

This document addresses the blue economy development in Bangladesh through the analysis of sectorial opportunities and constraints it is facing and will face in a near future. It also provides a wayforward in terms of actions to be carried for the sustainable development of the blue economy sectors. It presents, therefore, inputs for the BE strategy of the country. Their identification has been done from August 2016 to July 2018 under the context of the EU-BGD Joint Collaboration on Blue Economy[1]. During that period, all stakeholders have been met while all available documentation have been consulted, including the one dealing with the development issues of BE activities in other countries, particularly in Asia. Additional discussions made with representatives of administrations, researchers, academics and practitioners during a series of thematic and regional workshops have further contributed to define and analyse major opportunities and constraints that Bangladesh is facing for the implementation of it's BE policy. In that regards, the document brings new elements of thought for the understating of the development of BE in Bangladesh.

The document is structured in 11 chapters covering a wide range of economic sectors considered as important and for which information is readily available[2]. Chapter 1 provides a conceptual framework for the BE development using the SGD context and insists on the need to solve current overfishing problems and mis-uses of marine resources. It also highlights the importance of Research for supporting a sustainable development of any BE activity. Chapter 2 gives an overview of the major stakes that BE will face in a near future: pollution, climate change effects, alongside with food production, shipping and trade, as well as new technologies have been highlighted and presented. Chapter 3 is a projection into the future ((until 2030 and beyond) as it provides a review of the potential importance of the maritimes activities in a few years' time including the highlights of challaanges and constraints. Chapter 4 goes deeper into the marine food production and provides an analysis of the marine fishery management requirement alongside the development of the marine aquaculture. Chapter 5 focuces on the environmental dimension of the BE by analyzing the importance of the Blue Ecological services such as carbon sequestration, costal protection and other key services provided by coastal ecosystems, especialy mangroves. It also reminds the necessity to control pollution coming both from the land and the sea. Chapter 6 looks at marine tourism and more particulary at eco-tourism in the future by highliting the natural assets of Bangladesh but aslo by scrutining the major obstacles to the development of Blue Tourism. Chapter 7 gives a detailed overview of the Blue Biotechnologies, Blue Energies and other

[1] Request for Services Nr. 2016/375947/1, FWC Beneficiaries 2013 – Lot 6 – Environment, EuropeAid/ 132633/C/SER/multi.

[2] Some sectors such as Port development, deep-sea minning for instance, have not been covered due to the lack of information and availability of expertise in these sectors.

Blue initiatives that can emerge rapidely with a sound policy and the development of public-private partnership. Chapter 8 establishes the linkage between BE development, SDG14 and Maritime Secutiry that is a perquisite for any BE implementation. Chapter 9 provides a detailed forecast of the shipping industry in Bangladesh by emphasising the potential of ship building and maintenance of the country while Chapter 10 concentrates on the other major activity arounf shipping: ship breaking and its future in Bangladesh. Chapter 11 gives details on the implementation of the Maritime Spatial Planning as a key tool for avoiding negative externalities between Blue Activities and at the same time for securing the business environment.

1 Exploring the potentials of blue economy for enhancing economic sustainability in Bangladesh

1.1 Abstract

Proper utilization of marine resources towards achieving the sustainable economic development has got worldwide attention in recent years. Likewise, the Bangladesh government has also emphasized on the blue growth after settling the permanent maritime boundary with the neighboring countries. This study aims to identify the blue economy potentials of Bangladesh, evaluate economic values of these potentials, identify challenges for the blue growth and finally develop a management framework. To collect data, consultation with different stakeholders related to the blue growth was conducted. Secondary data were gathered from the review of policy documents, newspaper reports and scholarly articles. Coastal and marine resources i.e. living, non-living and renewable are identified as the main components of blue economy of Bangladesh. Moreover, trades and commerce related to sea and coast, and protections from the natural disasters also have economic returns for enhancing the blue growth. Conversely, sea level rise, climate-driven extreme events, pollution, human interferences and unregulated laws are identified as the major challenges for the development of the blue economy. To achieve the sustainable blue growth in Bangladesh, a strategic planning and management framework is required which should focus on potential sectors, research and ocean governance. Finally, this study submits that enhancing blue growth and achieving Sustainable Development Goals (SDGs) must go together to ensure that balance does not swing too far towards blue growth at the expense of environmental sustainability. Introduction

1.2 Introduction

The blue economy is a concept of economic growth through the sustainable utilization of ocean resources with technological inputs to improve livelihoods and meet the growing demands for jobs without hampering the ocean ecosystem health. The blue economy has great potential for boosting the economic growth and employment. It supports food security, managing and protecting the ocean environment, creating of high value job and has diversification to address new resources for energy, new drugs and value chemicals, protein food, deep sea minerals, security and threats including services to human welfare and measures for resilience climatic changes (Ninawe, 2017). Though “Blue Economy” is an emerging concept, however economic contribution of the ocean and its resources are huge for mankind. The economic activity in the ocean is based on the rapidly expanding ocean industries combined with large industries like maritime and coastal tourism, offshore oil and gas, shipbuilding and maritime equipment (Ninawe, 2017). It is estimated that ocean-based businesses contribute more than 500 billion USD to the world’s economy (Ocean, 2017).Calculations by the OECD’s Ocean Economy Database (OECD, 2016) value the blue economy’s output in 2010 at 1.5 trillion USD in value added, or in other words, approximately 2.5% of world gross value added. The blue economy also contributed some 31 million direct full-time jobs in 2010, around 1% of the global workforce (OECD, 2016).

Oceans are the essence of the planet Earth and cover 70% of its surface, hold 97% of the total water and serve as a reserve of 2.2 million species (Mora et al., 2011). Overall, oceans contribute about 81.5 MT of global fisheries production annually (FAO, 2016).The marine fisheries sector contributes 230 billion USD to the global economy, offering livelihood support directly or indirectly to the 8% of the world’s population (Sumaila et al., 2011). The oceans also provide convenient routes for transportation as about 80% of global trade in goods is transported by sea routes (Corbett and Winebrake, 2017). Coastal tourism is also an essential driver of economic growth for many coastal and island countries. About 161 billion USD revenues come annually from the global marine and coastal tourism (FAO, 2016). Further “ocean energy” (including aquatic biofuels and renewable energies), which is still in its early stage of development, could be an important source of the world’s energy demands. There are a

number of new and potentially valuable industrial products are deriving from the ocean. These include pharmaceuticals, antibiotics, antifreeze and antifouling paints (FAO, 2016). By the mid-century, enough food, jobs, energy, raw materials and economic growth will be required to sustain a likely population level of between 9 and 10 billion people (OECD, 2016). To meet the growing demands for such a huge population, the potentialities of the ocean are huge. However, to make this idea fully functional, it will require substantial expansion of many ocean-based economic activities i.e. shipping, shipbuilding and marine equipment, capture fisheries and fish processing, maritime and coastal tourism, conventional offshore oil and gas exploration and production and port facilities might be the options. These ocean-based economic activities for sustainable economy are termed as "Blue Economy".

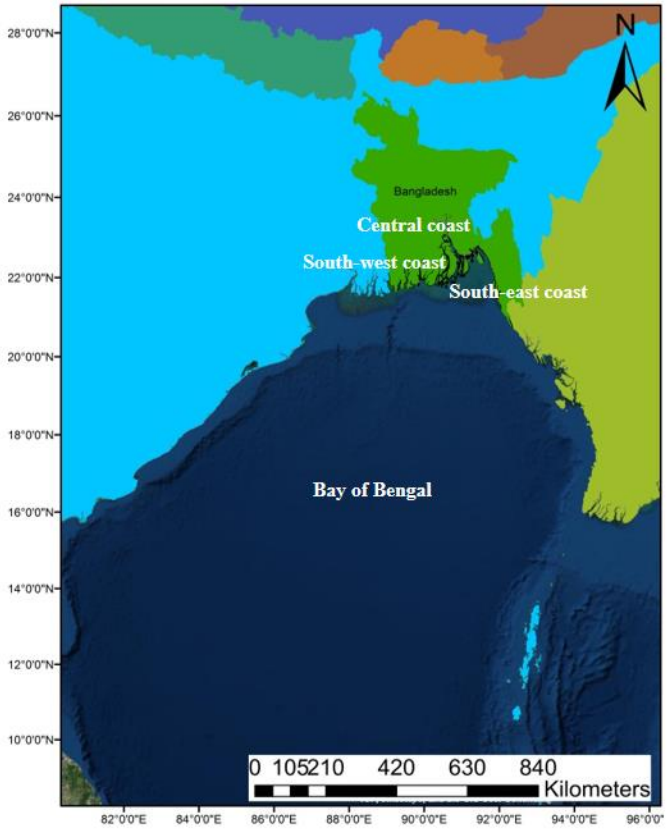

Figure 1: Continental view of south Asian region and geographical location of the Bangladesh coast , showing three coastal zones (i.e. south-west, central and south-east)

Bangladesh is located in the north-east corner of the Bay of Bengal (Fig. 1) and blessed with a large marine ecosystem. Following the international legal verdict on the disputed maritime areas with the neighboring countries India and Myanmar, the permanent coverage of Bangladesh's maritime areas is estimated to 118,813 sq km, with an extended continental shelf about 37,000 sq km having up to 50m depth (MoFA, 2016). Dividing into three major divisions i.e. south-eastern, central and south-western part, Bangladesh coastline extends up to 710 km (Fig. 1). In both coastal and marine systems, Bangladesh endows a wealthy reserve of both living and non-living resources in its long and extended coastal and maritime area (Shamsuddoha and Islam, 2017). United Nations agenda on Sustainable Development (Projected SDG Goal-14 by 2030) is on conservation, sustainability and use of oceans, seas and marine resources for increasing the economic benefits to Small Island developing states and least developed countries for sustainable use of marine resources, including sustainable management of fisheries, aquaculture and tourism (Ninawe, 2017). In the context of the recent development in the maritime boundary, "blue economy" concept recently became a buzzword and attracted much attention from policy makers for sustainable development, particularly in drafting the post-2015 development

goals for Bangladesh (Islam et al., 2017). However, this in turns will require significant progress in innovation and new thinking in many areas of science, technology, manufacturing, infrastructural design, consultation and decision-making processes, institutional co-operation. Last but not least, in the policy mix that government implements to support and encourage innovative capacity in the ocean economy more broadly. Currently a clear overview of blue economy with potentials, challenges and most importantly a management framework integrating all potential sectors are missing in Bangladesh. Therefore, this study attempted to provide a comprehensive view on blue growth potentials towards policy implications in Bangladesh context. Here, we compiled all possible data sources related blue economy of Bangladesh. In this study, we aim to understand the blue economy potentials for Bangladesh to accelerate the "blue growth" for national socio-economic development.

Therefore, this paper aims to answer following questions:

- What are the potentials of blue economy for Bangladesh?
- What are the economic values of different sectors related to blue growth?
- What are the challenges for realizing blue economy potentials in Bangladesh?
- How does enhancing blue growth related to achieving the Sustainable Development Goals (SDGs)?
- What should be the framework for blue economy management in Bangladesh?

1.3 Materials and methods

This work was based on the consultation with stakeholders and synthesis of secondary information. To collect secondary data, an intensive literature reviews related to the coastal and marine resources and their management issues, constraints, potentials in Bangladesh context were conducted through online search. In addition, relevant policy documents and government reports were also collected from the governmental agencies through personal contacts. Consultation with different stakeholders related to coastal and marine management in Bangladesh was conducted at various levels and scales. Stakeholder consultation method involves consulting with a diverse range of stakeholders who are representative of the cross section of issues of interest. Stakeholder consultation provides an opportunity to bring together diverse views and experiences of multiple stakeholders from various backgrounds and groups (Baran, 2004; Borsuk et al., 2001).

This data collection method is particularly helpful in the present study since quantitative data in different sectors related to blue economy are rarely available in Bangladesh and in such case expert knowledge is the best possible resource. In the present study, one to one meetings with pre-selected stakeholders were conducted. Stakeholders were selected based on experiences, knowledge, involvement and interest in the specific issues related to ocean economy. Different stakeholders consulted during 2016 included local people, government officials, academicians; NGOs officials as well as key informant peoples (e.g. fishers, fish trader, port officials, tour operators etc.) in different sectors related to blue growth. At the beginning of the survey, interviewees were given an idea of the blue economy to facilitate a better conversation. During the survey, interviewees were asked about their views on the activities and resources in the coastal and marine water of Bangladesh which has economic returns. In addition, what types of problems they are now facing and what should we do to overcome the stated problems were also asked during the survey.

For data analyses "content analysis" method was used. Content analysis is a research tool for interpreting and coding textual material (e.g., documents, books, oral communication, interviews, and graphics) to elicit meaningful information as different themes. In this process, the textual materials were coded and separated into different themes and then examined through a conceptual lens (Krippendorf, 1980).

1.4 Results and discussion

1.4.1 Overview of living and non-living resources related to the blue economy for Bangladesh

Coastal and marine resources (Table 1) with economic importance are the main components of the blue economy for Bangladesh. These resources are categorized into living, non-living and renewable resources. In addition, trades and commerce related to sea and coast, and protections from the natural disasters also have economic returns. Marine living resources in the maritime zone of Bangladesh include fisheries, mangrove forest, coral ecosystem, plankton, seagrass and seaweeds. Currently, 475 bony fish species belonging to 133 families (Rahman, 1997), 50 cartilaginous fishes, 50 crab species (11 purely marine and 3 commercially important species) (Quader, 1994), 7 turtles species of 6 genera (3 are commercially important), 36 shrimp and 5 lobster species, 3 star fish and 11 dolphin species (Quader, 1994) have been reported from the coastal and marine water of Bangladesh. Total 301 species of marine mollusks (i.e. bivalves, clams, oysters, scallops, snails and slugs, cuttlefish, squids and octopuses) are reported (Islam, 2003) from the marine water of Bangladesh. Among the mollusks, oyster has great economic values and 3 types of oysters (i.e. edible, pearl and windowpane) are reported to occur in the coastal waters of the Bangladesh (Islam, 2003) and the most important group of edible oyster is *Crassostrea*. About 7 species of squids and 2 species of cuttlefish are reported from the Bay of Bengal (Quddus and Shafi, 1983).

Table 1: Coastal and marine resources, and services provided by the maritime portion of Bangladesh

Resource type	Examples	Beneficiary groups
Living resources	Fisheries, mangrove, corals, seagrass, seaweeds, plankton	Common people, fishermen
Non-living resources	Oil, gas, sea salt, fresh water	Common people, government, entrepreneurs
Renewable resources	Wind energy, water current, solar energy	Government, entrepreneurs
Trade and commerce	Transport, tourism, industries, port, shipyard, shipbreaking, agriculture, aquaculture, islands	Common people, government, entrepreneurs, tourists
Protection	Coastal protection, carbon storage, waste disposal	Common people

Source: own conception

After fisheries, mangrove is the second most important living coastal resource in Bangladesh. The Bangladesh coast supports comparatively higher mangrove biomass than any other coastal region of the Bay of Bengal (Fig. 2). The coastal region of Bangladesh supports about 531,000 ha of mangroves of which 99,000 ha are planted mangroves (FAO, 2015). The major continuous natural block of mangroves, known as 'the *Sunderbans*' (Fig. 2), lies in the south-western coastal zone of Bangladesh and covers an area of 6, 01,700 ha (Department of Forest, 2017). Planted mangrove forest is located at the central and south-east coast of Bangladesh. The entire mangrove forest ecosystems support 345 plant species of 245 genera which are economically important (Hussain and Acharya, 1994). In addition, 53 species of pelagic fish belonging to 27 families, 124 species under 49 families of demersal fish, 24 shrimp species, 58 wildlife and 270 bird species are also reported from the mangrove ecosystem of Bangladesh (Hussain and Acharya, 1994). The Saint Martin's Island from the south-eastern coastal

zone with a total area of about 7.5 km^2 is the only coral bearing island of Bangladesh (Hossain et al., 2015). Haider and Mahmood (1992) recorded four coral species of the genus *Acropora* (*A. pulchra, A. horrida, A. humilis and A. variabilis*) and Tomasik (1997) recorded 66 coral species from this island. Islam and Aziz (1992) reported that the major groups of naturally growing seaweeds in Saint Martin Island represent 20–22 species with the most abundant species *Hypnea*. However, information on the existence of seagrass beds is lacking and only the occurrence of *Haloduleuninervis* is reported from the sandy littoral zone (Islam, 1980).

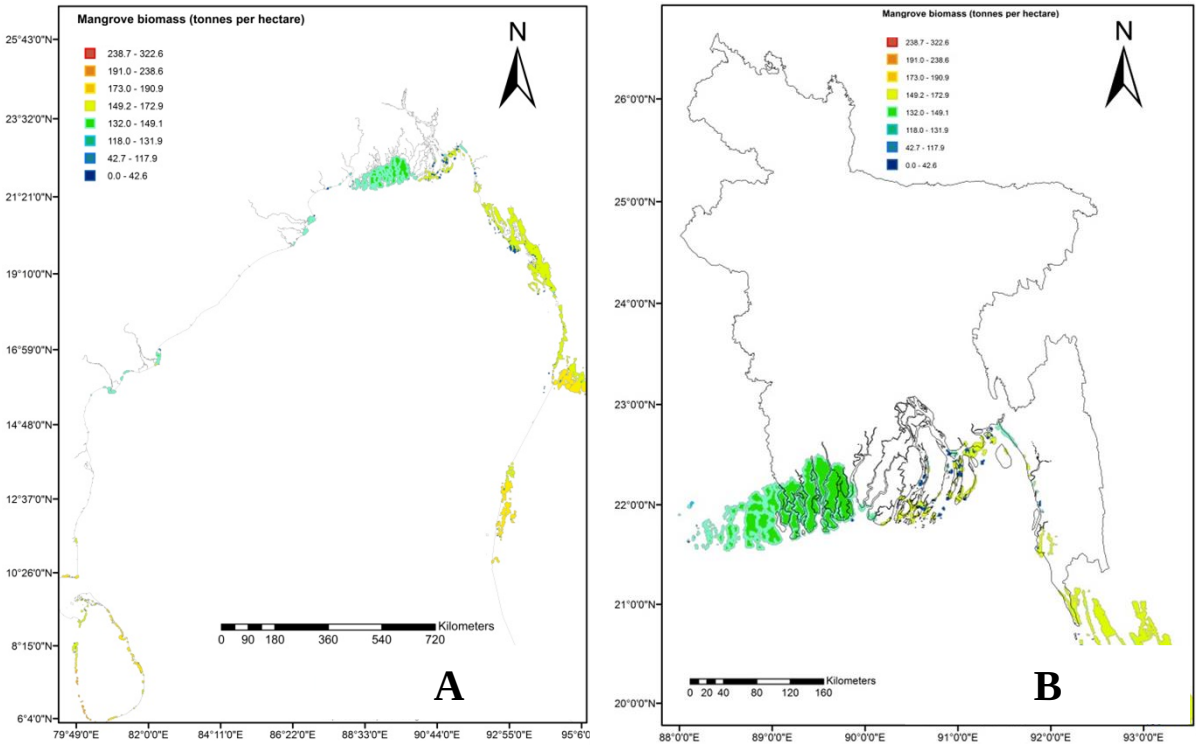

Figure 2: (A) Mangrove biomass distributions in the Bay of Bengal region and (B) the zoom view of mangrove biomass distribution in the coastal area of Bangladesh. Data source: Hutchison et al., (2014)

The river and estuarine ecosystems of Bangladesh covering an area of 660,048 ha with 886,523 ha coastal waters with a depth < 5 m is considered as suitable habitats for seagrass community (Chowdhury et al., 2015). Saltmarshes or tidal marshes are distributed in an area of 111,585 ha along the low-energy coasts and estuaries of Bangladesh (Hasan et al., 2013). The Encyclopedia of Flora and Fauna of Bangladesh reported a total of 156 algal species and 50 of them are brown algae, 82 species are red algae, and 26 species are green algae. Around 34 species of phytoplankton are recorded along the coastal regions of Bangladesh (Kamal, 2009) and Mridha (1995) reported 103 species of phytoplankton in the Bay of Bengal including the north Indian Ocean. IUCN (2015) reported 37 zooplankton species from the marine water of Bangladesh. Due to the presence of diverse phytoplankton groups, the coastal water of Bangladesh is highly productive. Long-term data on the chlorophyll-a concentrations (Fig. 3A) indicates that in the coastal water has a chlorophyll-a concentration > 4 mg m^{-3}. Long-term trend analysis (Fig. 3B) indicates that in recent year's chlorophyll-a concentration has increased which suggests the increase in primary production in this region.

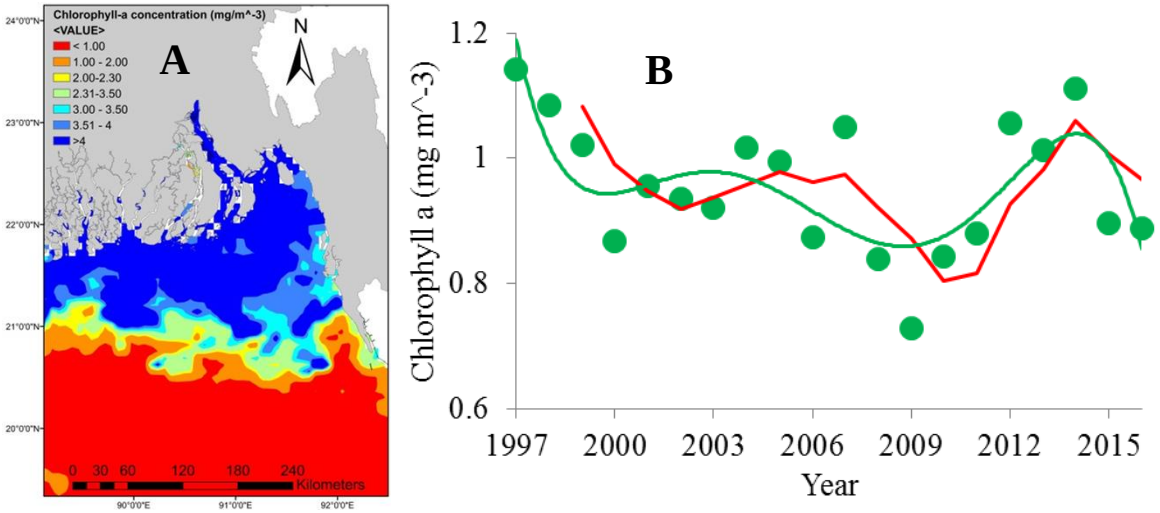

Figure 3: Distribution of chlorophyll-a in the coastal water of Bangladesh (A) Spatial distribution (B) Temporal distribution (1997 - 2016). Each green point indicates annual mean value. The green solid line indicates the smooth trend and red line indicates the two years moving average. Chlorophyll data were collected from the SeaWiFS and AQUA MODIS satellite.

Non-living resources of the Bay of Bengal include crude oil, petroleum, gas and sea salt. Of 26 gas fields discovered in the country so far, only 2 is located in the offshore areas (Badrul, 2015). Kutubdia gas field located about 92 km south-west of Chittagong Port and Sangu gas field located about 50 km south-west of Chittagong city and stands at a depth of 10 m of water in the Bay of Bengal. While the nearshore and offshore areas of Bangladesh's coast offer potential reserve of oil and gas resources, several commercially important heavy minerals are also found intermittently in the beach sands stretching from Patenga to Teknaf (south-east coast). About 17 such deposits have been discovered with potentially valuable minerals i.e. Zircon, Rutile, Ilmenite, Leucoxene, Kyanite, Garnet, Magnetite and Monazite (Hossain et al., 2014). In 1974 the government provided 7 shallow water offshore blocks on the continental shelf of Bangladesh to six international oil companies for exploration (Khan, 2015). After the recent verdict on maritime boundary dispute with Myanmar and India in securing maritime territory in the Bay of Bengal has increased the number of exploratory blocks in the EEZ to 27 (Detsch, 2014). Sea salt has been produced in the coastal area of Bangladesh through solar evaporation technique is another economic potential. About 67757 are cultivated for sea salt production in the coastal area of Bangladesh, still the country needs to import salt, thus there are potential for further increase in salt production to meet domestic demand (Reza, 2015). Bangladesh has a delicate and distinctive attraction of its own with many popular coastal tourist destinations and attractions, including world's longest sea beach (i.e. Cox's Bazar), the largest mangrove forest of the world (the Sundarbans) as well as different national parks, islands etc. However, potential of coastal and marine tourism remains untapped, which is reflected in Bangladesh's overall score in tourism and recreation performance which is only 8% (Ocean Health Index 2016). Apart from these, commercial use of the marine water of Bangladesh involves for international port (i.e. Chittagong and Mongla sea port), and newly established Payra seaport, local transportation, small and large scale industries in the coastal cities, shipyard and shipbreaking industries are also important for economic returns for Bangladesh.

1.4.2 Putting the Blue Economy into practice: Economic evaluation of few marine resources

A complete quantification of all resources related to the blue economy of Bangladesh is not possible due to data deficiency. Therefore, economic quantifications for this study are restricted to fisheries, mangrove, tourism, salt production, shipping industries. In addition, we are offering some theoretical economic calculations for turtle farming, wind power, floating aquaculture and agriculture, "Model Island" concept and desalinization of water.

Table 2: Major fishing grounds of Bangladesh

Fishing ground	Area (km^2)	Depth (m)	Geographical location	Major commercial species
South Patches	6200	60-80	91° 10′ E - 91° 50′ E, 21° 10′ N - 21° 40′ N	Indian salmon, Hilsa, Pomfret, Ribbonfish, Bombay duck, Carangids, Eel, Jew fish, Catfish, Sharks and Rays
Middle Ground Southwest of South Patches East of Swatch of No-ground	4600	80-100	91° 30′ E - 91° 40′ E, 20° 45′ N - 21° 10′ N 90° 00′ E - 90° 40′ E,21° 00′ N - 21° 25′N	Pomfret, Red snappers, Ribbonfish, Silver jew, Carangids, Shrimp Indian mackerel, Snappers, Groupers, Jew fish
Swatch of No-ground	3800	800-1000	89° 00′ E - 90° 00′ E, 21° 00′ N - 21° 40′ N	Shrimps, Hilsa, Pomfret, Ribbonfish, Bombay duck, Jew fish

Source: own conception

With the four major fishing grounds in Bangladesh EEZ (Table 2), fisheries is the main source of income from the marine water. Total marine fish production accounted 0.595 million MT during 2013-2014 (16.78% of the total fish production) (DoF, 2016). River and estuarine ecosystems cover an area of 853863 ha and contribute 174878 MT of fish (FRSS, 2016). Long-term inland, marine and total fish productions in Bangladesh are shown in the Fig. 4. Both inland and marine fish catches have increased over the long-term. Trawl fisheries contributes 84846 MT and artisanal fisheries accounts 599846 MT (DoF, 2013). Over 0.5 million people are directly and indirectly engaged with marine fisheries sector for their livelihood (DoF, 2013). Currently, 225 industrial trawlers of which 24 are mid-water and around 68 thousand mechanized and non-mechanized boats are in operation in the marine water of Bangladesh (DoF, 2013).

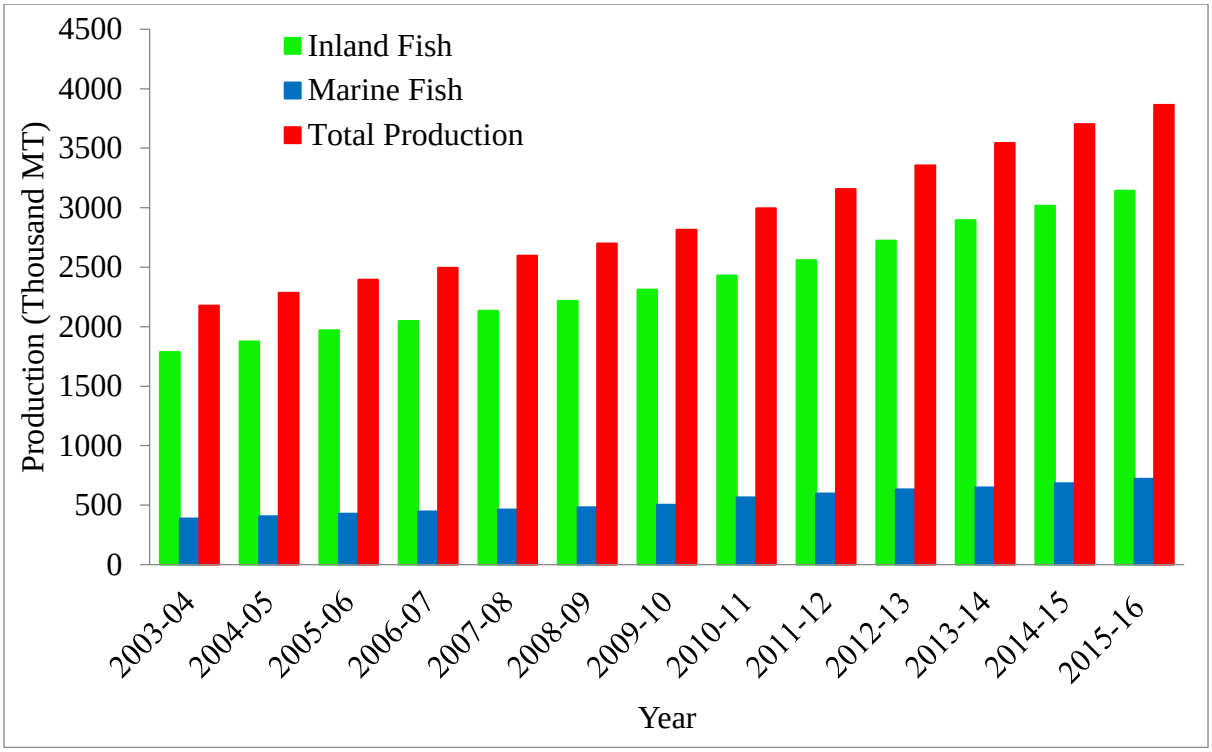

Figure 4: Fish production from inland and marine sectors in Bangladesh. Total production is the sum of production from inland and marine sectors (DoF, 2016)

The *Sundarbans* mangrove forest from the south-western coastal zone offers a venue to economic solvency to the local people and contributes to the national economy. Major economic returns form the *Sundarbans* mangrove forest come from timber, fisheries, honey, wax and tourism. Long-term revenue earned from this forest is shown in Figure 5. Data suggest that in recent years, revenues from this forest are comparatively less than the revenues from the 1980s and the 1990s.

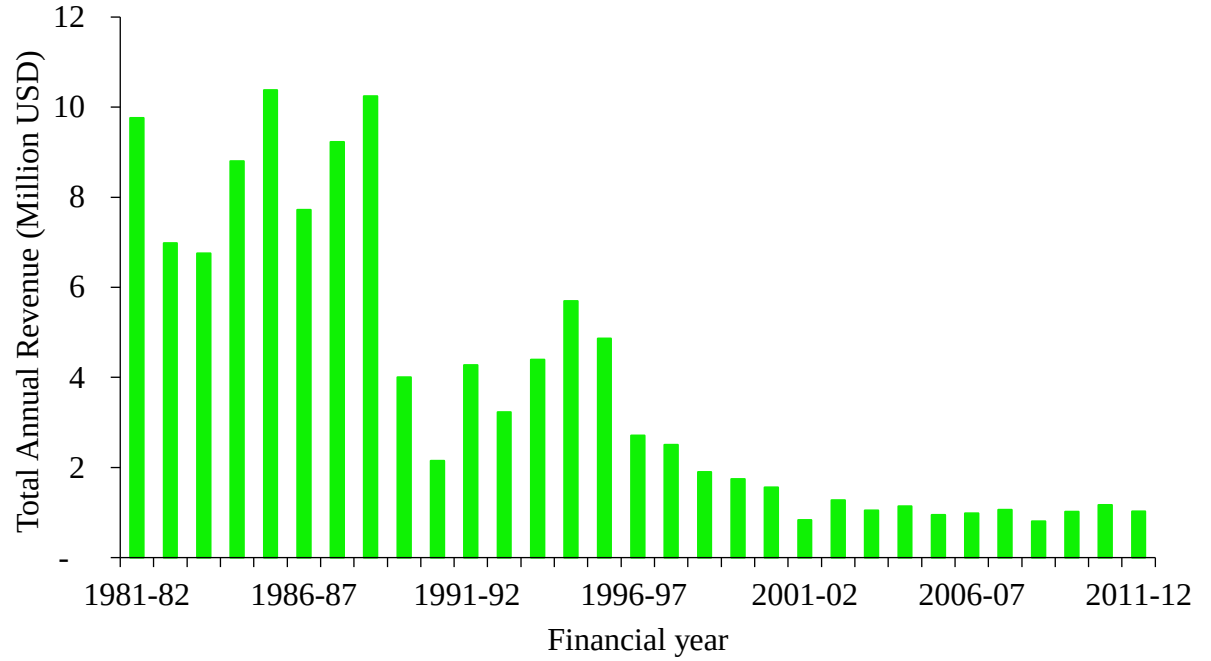

Figure 5: Long-term trends in revenue earned from the Sundarbans mangrove forest of Bangladesh. Data source: Department of Forest.

On average total annual mean revenue from this forest is 4041349.20 USD where timber, fisheries, honey, wax and tourism contribute 3451526.23, 285048.42, 10250.53, 3786.53 and 266260.63 USD, respectively. On the top of that the *Sundarbans* plays a vital role as a wildlife habitat in Bangladesh.

In comparison to neighbouring countries, international tourism is less developed though Bangladesh is blessed with a dense mangrove forest- the *Sundarbans* and the longest sea beach the Cox's Bazar (south-eastern coast). Tourism can provide direct jobs to the community i.e. tour guides and hotel housekeeping. The tourism sector in Bangladesh is now employing over million people and this sector generates a total value of8.4 million USD (Fig. 5).

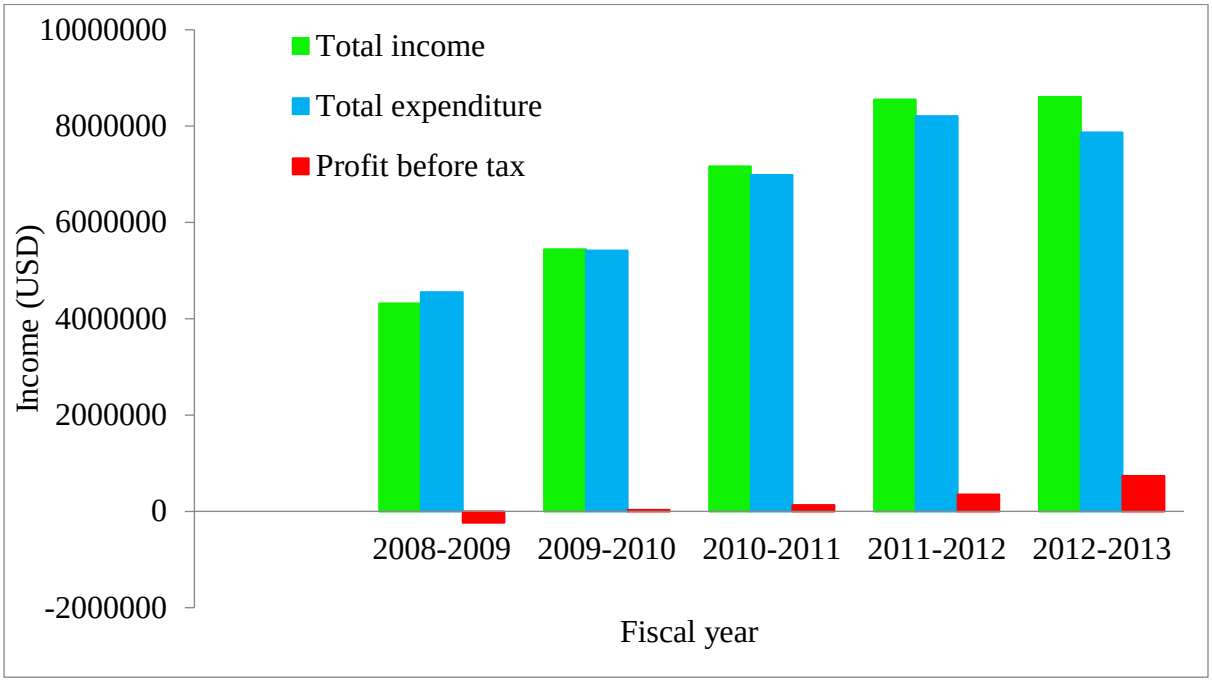

Figure 6: Income, expenditure and profit of Bangladesh Parjatan Corporation for 2008-2013 (Source: Bangladesh Parjatan Corporation, 2014). Bangladesh Parjatan Corporation (BPC) is the National Tourism Organization which regulates and facilitates tourism industry in Bangladesh. The negative value indicates the loss.

In Cox's Bazar about 263 sq kilometer area of land and in Chittagong around 20 sq kilometer area are currently being used for sea salt production. This sector created over 5 million employments (details on sea salt production are shown in Table 3 and 4) and contributes about 35313000to 41198500USD each year in national economy. A target of producing 1.8 million tonnes of salt from 247 sq kilometer area of land in Cox's Bazar has been sat between December 2015 and April 2016 which is enough to meet the domestic demand. In 2011, the government introduced the National Salt Policy 2011, which discouraged the importation of salt. The decision's positive impact had already been seen (Table 3). The number of salt farmers increased in recent years. In addition, actual production is higher than the demand.

The ship building sector also hold promise as a future growth area, with two major shipyards delivering more than 20 vessels to the European customers since 2005. Bangladesh also has the world's largest ship breaking industry which employs over 200,000 (Hossain et al., 2010). At present 10,000 inland and coastal ships and 36 foreign going ships are plying all over the country, which carries more than 90% of total oil product, 70% of cargo and 35% of passengers. Mercantile Marine Department (MMD) of Bangladesh earned revenue 1188960.19 USD in the fiscal year of 2012-13. There are more than 100 shipyards in the country engaged in traditional and domestic shipbuilding, but international standard shipyards capable of building class ships for foreign buyers have also emerged. There are more than 10 shipyards engaged in building ships of international quality. Recently Bangladesh has successfully exported following oceangoing ships and thus the industry has brought revenue of 200 million USD in

foreign currency since 2007. Presently the industry is working on foreign projects worth of 250 million USD.

Table 3: Situation of Salt Production in the coastal area of Bangladesh

Fiscal year	Listed salt farmer	Demand for salt (million MT)	Target (million MT)	Actual production (million MT)	Salt imported (million MT)
1996-97	34170	7.98	8.00	8.98	-
1997-98	33269	8.19	8.50	8.00	-
1998-99	35112	8.53	8.75	11.79	-
1999-00	38194	8.72	9.00	8.24	0.50
2000-01	37293	8.91	9.00	9.90	-
2001-02	36285	8.82	9.00	7.75	1.00
2002-03	38328	9.00	9.20	8.10	1.00
2003-04	40595	9.18	9.50	9.15	0.50
2004-05	42000	11.44	11.50	9.35	0.50
2005-06	44574	11.70	11.70	15.75	-
2006-07	45000	12.20	13.00	10.54	-

Source: Bangladesh Small and Cottage Industries

Table 4: Comparable price of different salt types

Salt type	Market price in USD/MT		
	2006	2007	2008
Black	28 - 48	16 – 26	16 - 26
White	41 - 60	19 – 27	19 - 27
Polyethylene	43 - 61	24 – 32	24 - 32

Source: BSCIC, Cox's Bazar

For centuries humans have hunted sea turtles for meat and other products and therefore, sea turtle farming can be a promising ocean-based economic activity. For example, the Cayman Turtle Farm (CTF) of the Cayman Island was established as Mariculture Ltd in 1968 to commercially raise green turtles which are now became a success (D'Cruze et al., 2015). Currently turtle farming is not commercially practiced in Bangladesh. In Teknaf and Saint Martin Island of south-east coast of Bangladesh, people usually sell turtle eggs (2.4 USD/1000 eggs) to the local Rakhaine people. Therefore, to support a typical family (monthly expenditure of 180 USD) in the coastal village one need to sell 7500 turtle eggs. Thus, it will be a great economic achievement if it is possible to start commercial turtle farming. In the same area, oyster meat and shell are sold at 180 USD/kg and 0,05 USD/shell, respectively. If commercial production of oyster meat is introduced properly, one typical family will need only 125 kg oyster meat per month to sell to maintain their monthly expenditure. In addition, introduction of green mussel culture will be also a commercially beneficial venture. Similar to oyster and mussel, seaweed cultivation in Bangladesh has not started yet commercially.

Seaweed cultivation costs 2.4 USD/m^2 and cultivated sea weed can be sold at 7.8 USD/m^2 with a net profit of 5.4 USD/m^2. Therefore, only 34 m^2 sea weed cultivable area will be required to meet the monthly expenditure of a typical family. Salt production from sea water using solar energy is widely practiced in the Bangladesh coast. When the sea water is concentrated the salinity of salt pans offers a suitable environment for the Artemia culture and cyst production. These cysts can be used in the

hatchery. Currently the price of Artemia cyst is 50-100 USD/kg. Thus, one family will require 2-4 kg cyst to support their monthly expenditure. Non-target marine fish species for example goby fish can be used for poultry feed production. For example, 11185 MT prawn grow out feed can be produced from 3699 MT dried goby fish and can be sold at 0.24 – 0.25 USD/kg. With a wind velocity of 7.34 m/s, possible extractable wind energy through wind mill is equivalent to 0.0279 kWh from 1 m^2 area. Therefore, one family will require around 8853 m^2 area to meet their monthly electricity demand of 247 kWh. In the coastal area of Bangladesh daily sunshine hours varies between 3 to 11 hours. The insolation varies between 3.8 to 6.4 kWh/m^2/day with an average of 5 kWh/m^2/day. Therefore, solar panel from 50 m^2 area would be enough for a family to meet the household demand of electricity. In addition, tidal energy (tidal range: 4 - 5 m) and wave energy (wave height: 0.5 - 2.4 m) can be also used for this purpose in the coastal area.

Floating aquaculture and agriculture: The coastal and marine waters of Bangladesh offer a suitable environment for aquaculture expansion. Particularly, Bangladesh's EEZ has the highest percentage suitable areas in Asia for bivalve's culture (Gentry et al., 2017). Though currently aquaculture is practiced in the coastal area and cage culture is practiced in the river and inland waters, but floating mariculture is not practiced. Introduction of floating aquaculture in the coastal water will create new employment and reduce the on growing pressure on capture fisheries. Further, the marine water of Bangladesh has great potentials for floating aquaculture and agriculture. In theory, land crops should have no problem being grown floating at sea, particularly on tranquil waters, as long as they are provided with all their requirements and not otherwise inhibited. Potted horticultural crops can be grown avoiding contact with salt water on a variety of floating structures, some of which are used for other mariculture activities. To provide freshwater for irrigation, floating seawater distillation and rainwater harvesting devices can be designed. Also, halophyte plants can be grown directly at sea, tying them to floating nets, ropes or other devices, with their roots fully immersed in saltwater as in hydroponics. Similar approaches or modified advanced methods can be followed for Bangladesh.

Conversion of existing island to Model Island: The coastal area of Bangladesh has number of islands which have great economical potentials. Proper management of these islands can make huge economic turnover. One idea of management of these islands is the conversion of existing islands to "Model Island". Model island concept refers the modification of existing islands for maximizing economic returns through diverse utilization strategy of multiple resources with available technological inputs without hampering environmental conditions of islands. Here we take Moheshkhali Island as an example. This island has an area of 362 km^2 with a population of 220000. Salt extraction, agriculture and fisheries are the main activities on the island. This island has mudflats with small patch of mangrove forest. Mangrove forest offers coastal protection and enhances coastal livelihoods by providing goods and services. In addition, islanders can utilize planted mangrove area for crab fattening in cage and seaweed culture. Just after the planted mangrove area islanders can establish oyster and mussel farms. Oyster filters the water and this filtrated water can be pumped into the pond and can be used for aquaculture purpose. This way of integration of different resource use and economic activities in the coastal island can meet the food demand, provide coastal protection and create new employment opportunities.

Desalinization of water: Though it would be more viable to invest in improving and protecting watersheds, however, desalinization of water might be a good option for future. Desalination of water can be done in many ways but we have to consider the cost of the unit production. Desalination by solar energy might be a suitable solution for providing fresh water to remote areas of Bangladesh. This solution becomes competitive, especially for remote and rural areas where small quantities of water for human consumption are needed. For some time, a single-effect basin-type solar still has been the cheapest way to produce drinkable water using solar resources. Daily production is small due to the rejection of the latent heat condensation, less than 4–5 L/m^2, with specific energy consumption around 7000 kJ/kg. But implementation of proper techniques can bring great economic turnover form this

sector. Besides these productions of marine natural products can be extracted from the sea which can be a great economic potential. Marine Park can be developed for tourism purpose which will also bring economic return.

1.4.3 Enhancing the blue economy and achieving Sustainable Development Goals (SDGs)

Several goals of the SDGs, particularly SDG 14 ("Conserve and sustainably use the oceans, seas and marine resources for sustainable development") are explicitly related to blue growth, while its others SDGs may have implications to blue growth. There is concern that enhancing blue growth could lead to degradation of coastal and marine ecosystems which are already under threats due to different anthropogenic pressures. For example, most of the commercial fisheries in the coastal zone of Bangladesh are over-exploited. Thus enhancing blue economy based on fisheries exploitation could further degrade the fisheries resources. As a solution, enhancement of blue growth and achieving SDGs must go together. Hence, Marine resources should be included in development planning at the local and national levels for the blue growth and the achievement of SDGs. The current situation of growing population pressure, demands for jobs and food are raising the concern in the context of achieving SDGs. Of the 17 goals of SDGs, Goal 1 and 2 call for end of poverty and no hunger. To achieve the goal of poverty elevation and reduce hunger, the sustainable use of marine resources is required. Bangladesh has a large number of coastal and marine resources which have great economical values. However, few of the resources we discussed in this study are being used for economic purposes. Therefore, in previous section (section 3.2) we discussed some theoretical economic calculations to see how it would be if Bangladesh can use more marine resources for economic purpose. Conversely, a few stakeholders also cautioned that it should be ensured balance does not swing too far towards the blue growth at the expense of environmental sustainability.

1.4.4 Challenges to the marine economy development in Bangladesh

While the prospects are immense, there are also several challenges ahead towards realizing the potential of blue growth. The major challenges include sea level rise (Fig. 7), land based pollution, human interferences, and unregulated laws. Bangladesh is ranked among the most affected countries in the South Asia in the scenario of 2 °C rise in the world's average temperatures in the next decades, with rising sea levels and more extreme heat and more intense cyclones (Fig. 8). Such changes will threaten food production, livelihoods and infrastructure as well as will slow down the reduction of poverty. In Bangladesh, 40% of productive land is projected to be lost in the southern region of Bangladesh for a 65cm sea level rise by the 2080s (Curry, 2013). About 20 million people in the coastal areas of Bangladesh are already affected by saline water intrusion that affected pure drinking water supply system (Rasheed et al., 2016). Approximately 1 million hectares of land in southern in coastal areas of Bangladesh are at risk from saline water intrusion (Baten et al.). Saline water intrusion (Fig. 9) into upstream region will lead to negative socio-economic impacts through disrupting agriculture, fisheries, forestry and navigation. The largest mangrove forest in the world, The *Sundarbans*, could face devastating impacts in the coming years due to increasing salinity and rising sea level.

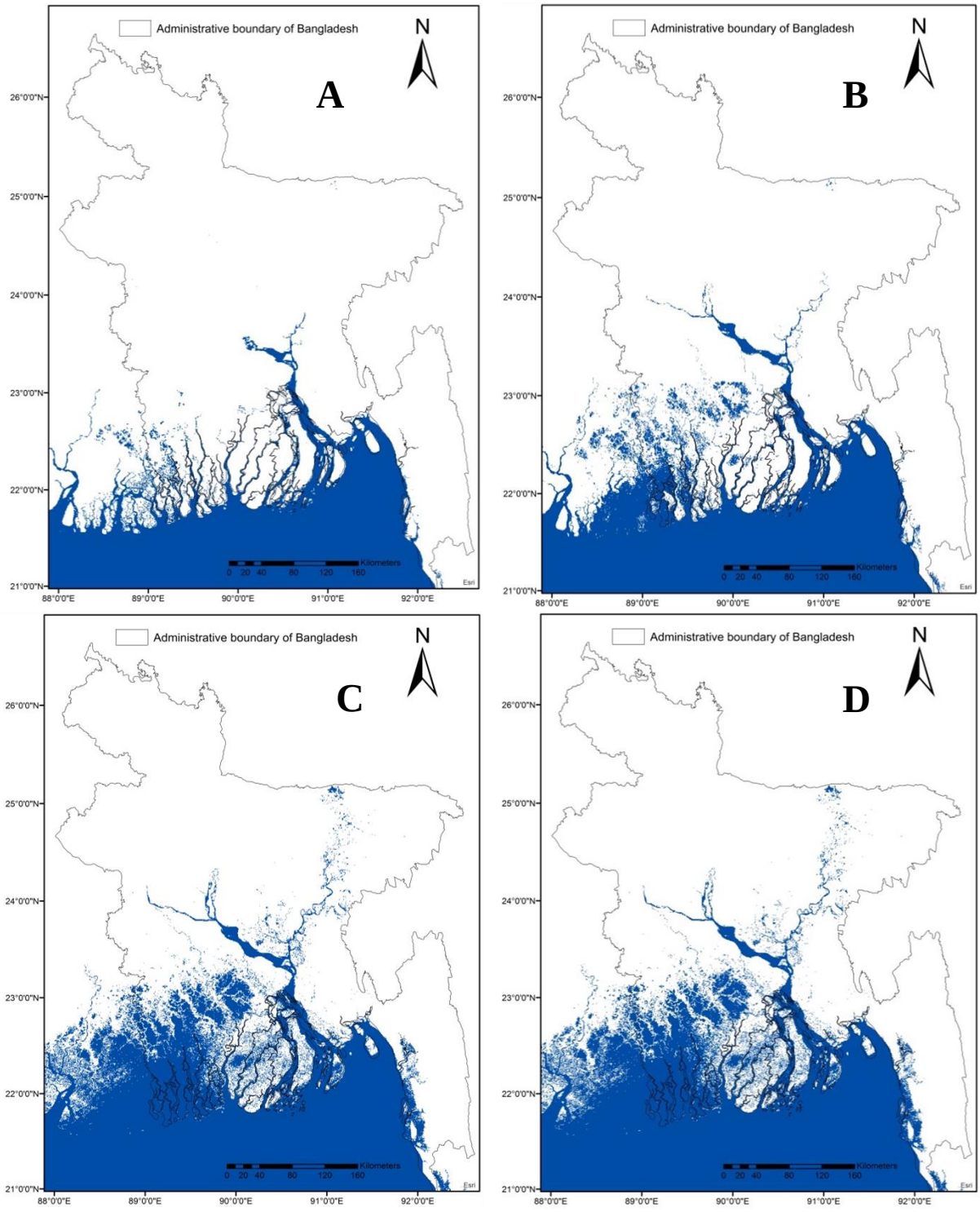

Figure 7: Sea level rise scenarios in Bangladesh (A. Current sea level, B. 1m increase, C. 2 m increase and D. 3 m increase). The illustrations of the different degree of inundation in Bangladesh due to Sea Level Rise (SLR) in the Bay of Bengal are taken from the ArcGIS web map server.

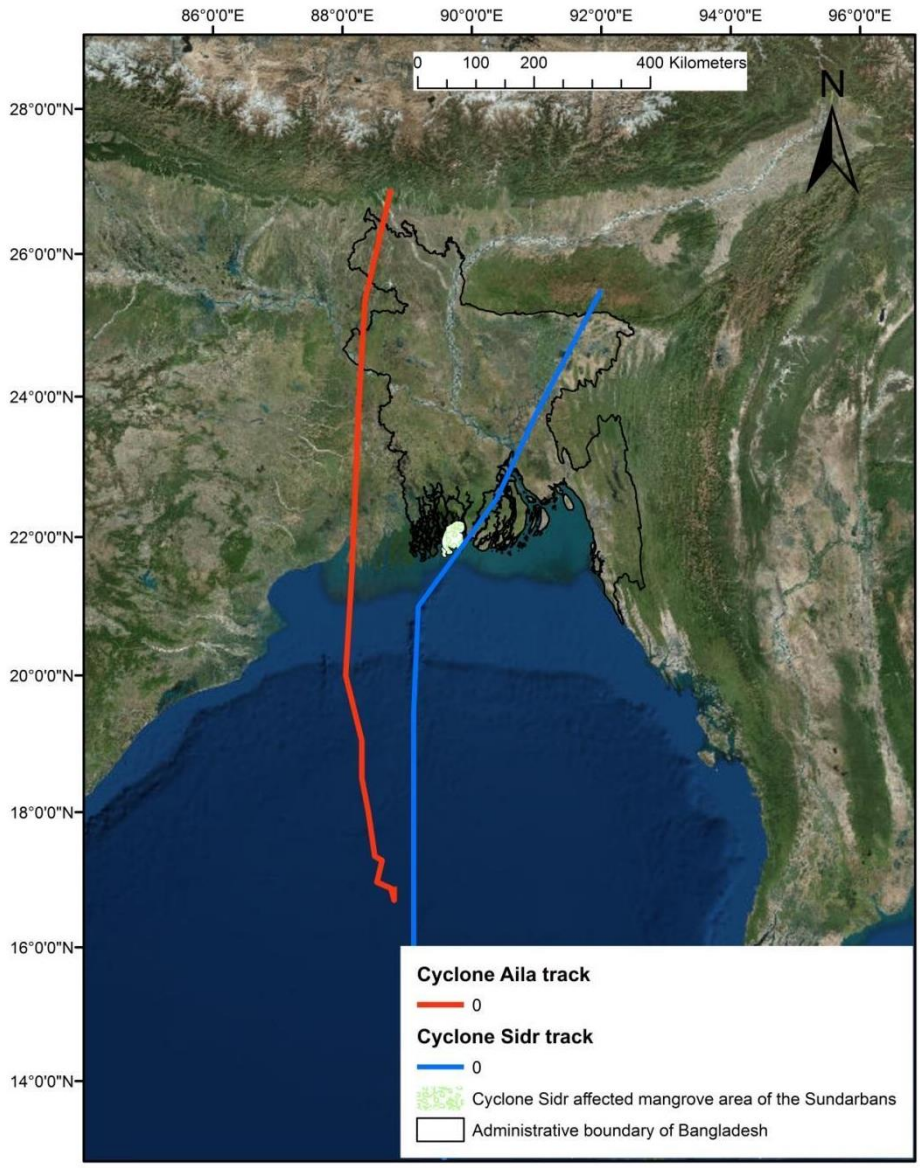

Figure 8: Track of cyclone *Aila* and *Sidr* originated in the Bay of Bengal and passed over Bangladesh. Track of the cyclones are collected from NASA earth observatory.

Rapid industrialization without having any waste treatment plant is responsible for dumping the pollutant in rivers, estuaries and coastal waters. This results a threat to aquatic life and the ecosystem. Aquaculture activities produce high nutrient pollutants, which finds its way to the coastal waters and causes serious problem to the ecosystem health. The Chittagong port handles annually about 1000 ships and 40–50 oil tankers. In addition, the Mongla port handles about 500 ships (Islam and Haider, 2016). Power-driven trawlers and boats engaged in fishing and shrimping in the Bay of Bengal are about 3000 (Hossain, 2001). Ship breaking activities in Chittagong discharge a considerable amount of heavy metals, waste oil and other pollutants during washing and dismantling operations. Oil spilling from ship has drastic effect on biotic community by clogging the breath organ. Mangroves are highly susceptible to oil exposure; oiling may kill them within a few weeks to several months. Oil-impacted mangroves may suffer yellowed leaves, defoliation, and even the death of the tree.

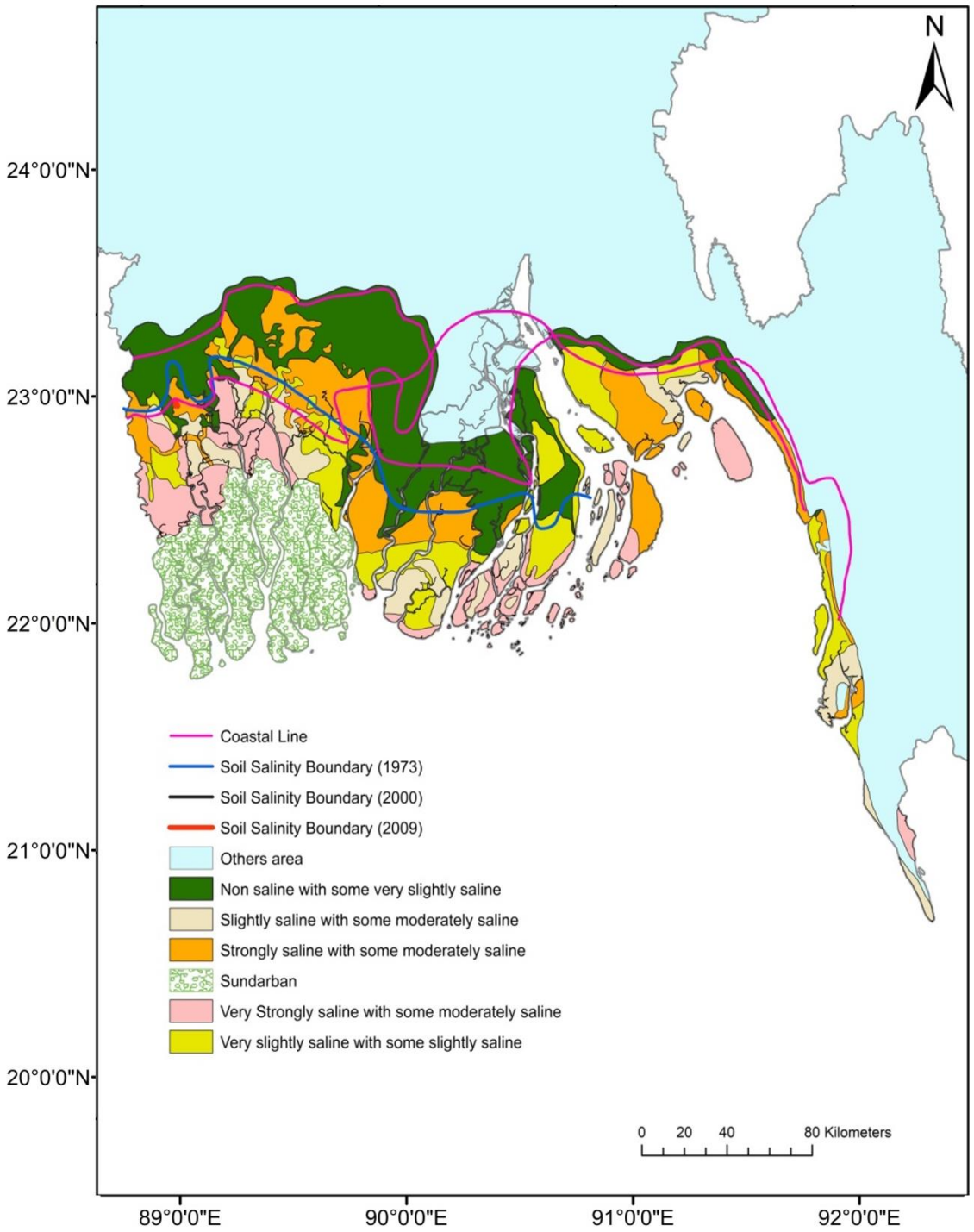

Figure 9 : Salinity intrusions in the coastal area of Bangladesh. Data are gathered from the Soil Resource. Source : Development Research (SRDI), Bangladesh

At present, formal marine resource management legislation is missing in Bangladesh. However, informal forms of coastal area management are existed. However, external forces together with changes in social values, conspicuous consumption, loopholes in regulations, insufficient knowledge and information, and inadequate law enforcement are the major threats to such local management. Land use conflicts in some parts of the coastal zone affects the sustainability of fisheries and aquaculture, shipping, industry, and tourism in the coastal area.

1.5 Blue economy management framework: how to let the vision comes true?

Strengthening the blue economy is a long-term approach to support sustainable economic development and ensuring the livelihood security of Bangladesh. Through proper strategies, it is possible to realize potential of the blue economy in practice to make the marine ecosystem as the main driver for the national economy of Bangladesh. However, to achieve a sustainable blue growth in Bangladesh a strategic planning and management framework are required. In this study, we developed a blue economy management framework for Bangladesh which consists of three components (Fig. 10) i.e. focusing potential sectors, knowledge generation through research and ocean governance.

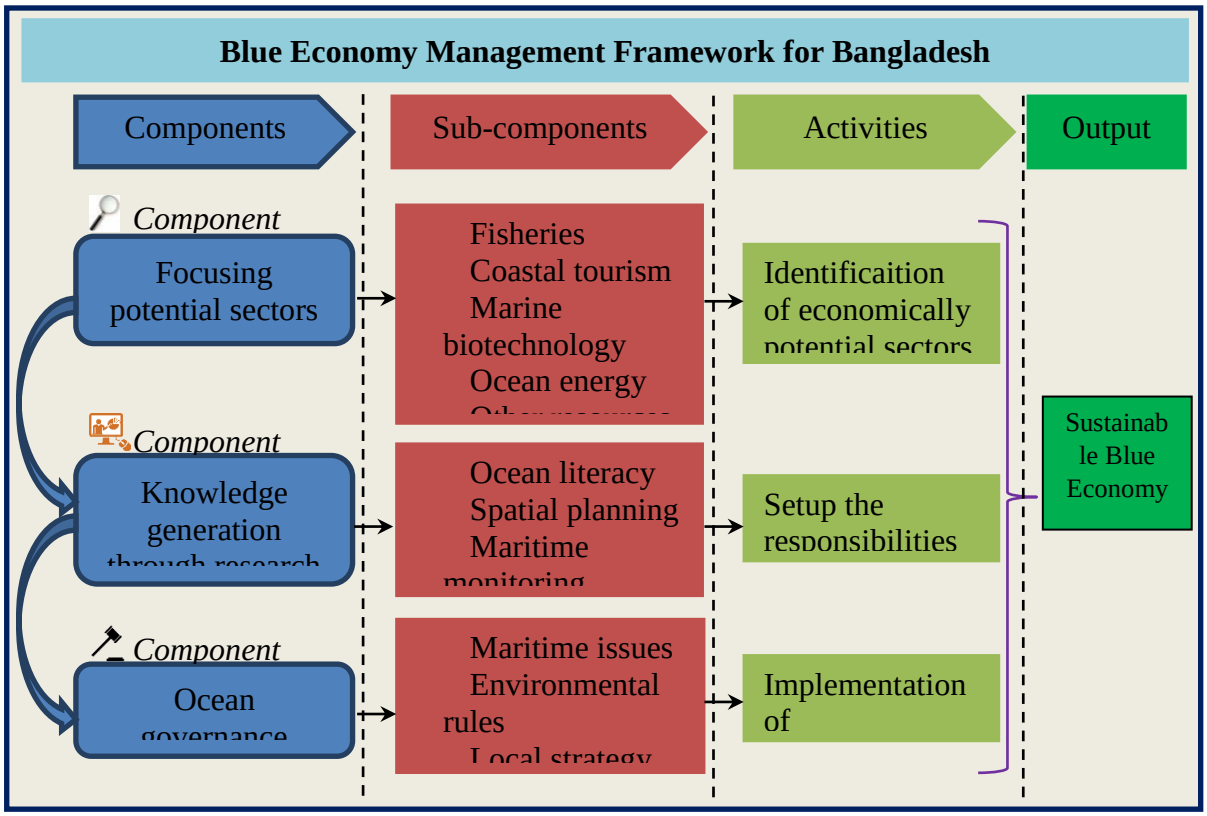

Figure 10: Blue Economy management Framework for Bangladesh

1.5.1.1 Component 01: Focusing potential sectors

Special focus to develop the sectors those have high economic potentials (i.e. fisheries, coastal tourism, marine biotechnology, ocean energy, mangrove forest and other resources) could trigger smooth and sustainable blue growth in the country. Farming finfish, shellfish and aquatic plants is one of the world's fastest growing food sectors; it already provides the planet with about half of all the fish we eat. To boost the fisheries sector, it is important to identify the priority areas through consultation with relevant stakeholders. In addition, identification of bottlenecks will also facilitate cooperation, coordination and exchange of best practices for sustainable fisheries management. The extraordinary beauty and great diversity of coastal areas in Bangladesh have made them the preferred destination for many holidaymakers from the country and also from abroad, and making coastal and maritime tourism an important tourism sector. Therefore, as part of blue growth strategy, the coastal and maritime tourism sector is an aid to foster a smart, sustainable and inclusive economic development for Bangladesh. It is one of the most significant maritime sectors in terms of gross value added and employment. Therefore, to unlock the potential of this promising sector, coastal tourism sector must be paid special attention. Blue biotechnology is concerned with the exploration and exploitation of the resulting diverse marine organisms in order to develop new products (EU, 2017). Research of the sea biodiversity could enable

us to develop new pharmaceuticals or industrial enzymes that can withstand extreme conditions, and which consequently have high economic value. However, in the long term, this sector will offer high-skilled employment. Seas and oceans offer a vast renewable energy resource and technologies are currently being developed to exploit the potential of tides and waves as well as differences in temperature and salinity. Though the development of this emerging sector would not only help us to achieve our renewable energy, but also it could fuel economic growth through innovation and create new, high-quality jobs. The quantity of resources occupying the ocean is potentially massive. Resource extraction (i.e. mangrove, sea salt etc.) is concerned with the retrieval of these resources to ensure security of supply; and fill a gap in the market. Mangroves are the breeding, nursing and feeding grounds for many marine lives including many fishes, mollusc and crustacean population. Considering the role of mangrove, this plays vital support for recruiting of marine life which eventually enriches the sea resources. Our lack of knowledge of the marine resources demands a careful approach. Thus, engagement in a variety of studies and projects aimed at shedding light on the benefits, drawbacks and knowledge gaps associated with this type of resource extraction.

1.5.1.2 Component 02: Knowledge generation through research

Research activities to generate knowledge are essential components for certainty and security of sustainable blue growth. Ocean literacy to improve the understanding the information about the sea, spatial planning for an efficient and sustainable management of activities in sea and maritime monitoring to have a better picture of what is happening in the sea can be achieved through proper research activities. Ocean literacy among the stakeholders will make more effective and sustainable economic use of ocean. Moreover, it will also improve the understanding of how the seas behave. For example, competition for space in sea, space for aquaculture and other uses, demands the management of ocean properly. Therefore, maritime spatial planning (MSP) works across borders and sectors will ensure human activities at sea take place in an efficient, safe and sustainable way. Maritime spatial planning reduces conflicts between sectors and creates synergies between different activities, encourage investment by creating predictability, transparency and explicit rules and protect the environment through early identification of impact and opportunities for multiple uses of space. Monitoring of the maritime area for border control, safety and security, fisheries control, customs, environment or defense will ensure a sustainable blue growth.

1.5.1.3 Component 03: Ocean governance

Ocean governance is about managing and using the ocean and resources in a way that keeps the ocean healthy, productive, safe, secure and resilient. For a good ocean governance practice, it is crucial to adopt a holistic approach integrating all marine and maritime issues in Bangladesh. A robust set of mandatory environmental rules to ensure the use of marine resources sustainably, wherever they operate should put in place. Development of a local level strategy to boost sustainable blue growth is also required under ocean governance. Strategies to address common challenges and opportunities, collaborating closely with stakeholders from civil society and the private sector, marine research for improving cooperation and information-sharing, and making maritime data publicly accessible will be beneficial to achieve to sustainable blue growth. Finally, creating highly qualified and skilled professionals in the blue economy and engagement with international forums will foster the development of ocean economy.

1.5.1.4 Connecting the dots: integrating institutes for implementation of management framework

Existing institutions in Bangladesh related to marine sector include academic institutions (i.e. universities and research institutes), NGOs and other institutions i.e. think tank organizations. To implement the proposed framework, we need to integrate all these institutions. The work should be integrated and multidisciplinary. Bangladesh has national oceanography research institute at the Cox's Bazar which is located on the south-eastern coast of Bangladesh. It is now important to establish coastal

and marine research station in the central and south-western coastal zone of Bangladesh. Existing river research institute should also work on the estuarine area. Fisheries research institute and department of fisheries need to work for domestication of marine fishes which are not yet an aquaculture product. Academic institutions, i.e. universities need to collaborate with each other as well as other government organizations for marine and coastal research in Bangladesh. Proper regulations of economic activities need to monitor through government and NGOs for sustainable utilization of resources. Overall it is important a top-down approach for implement the proposed framework.

1.6 Conclusion

In comparison to other natural resources systems, the potential of coastal and marine ecosystem of Bangladesh, as a driver of economic growth, has long been overlooked by the policy makers. Only recent years, the Bangladesh government has provided priority on exploitation and management of marine resources. The vast potentialities of Bay of Bengal for the national economic development are still not fully realized. However, considering the overexploited and weakly governed marine fisheries, there should be a check and balanced through an appropriate policy and legal framework. Illegal fishing, piracy, climate change, and marine pollution are already at the alarming stage for the Bay of Bengal marine ecosystem. To make the blue economy concept fully functional for the Bangladesh, it is an urgent need to foster research activities to generate knowledge and skilled manpower and then formulate the national plan and policies.

1.7 References

Badrul, I., 2015. Bangladesh falls behind Myanmar in offshore gas exploration. The Daily Star.

Baran, E.J., T, 2004. Stakeholder consultation for Bayesian decision support systems in environmental management. Forest 27, 37.

Baten, M.A., Seal, L., Lisa, K.S., Salinity Intrusion in Interior Coast of Bangladesh: Challenges to Agriculture in South-Central Coastal Zone. scientific Research 4, 248-262.

Borsuk, M., Clemen, R., Maguire, L., Reckhow, K., 2001. Stakeholder Values and Scientific Modeling in the Neuse River Watershed. Group Decision and Negotiation 10, 355-373.

Chowdhury, S.R., Hossain, M.S., Sharifuzzaman, S.M., Sarker, S., 2015. Blue Carbon in the Coastal Ecosystems of Bangladesh. Project Document, Support to Bangladesh on Climate Change Negotiation and Knowledge Management on Various Streams of UNFCCC Process Project, funded by DFID and Danida, implemented by IUCN Bangladesh Country Office.

Corbett, J.J., Winebrake, J., 2017. The impacts of globalisation on international maritime transport activity, OECD/ITF, Mexico, p. 31.

Curry, J., 2013. Bangladesh sea level rise.

D'Cruze, N., Alcock, R., Donnelly, M., 2015. The Cayman Turtle Farm: Why We Can't Have Our Green Turtle and Eat it Too. Journal of Agricultural and Environmental Ethics 28, 57-66.

Detsch, J., 2014. Bangladesh: Asia's New Energy Superpower? The Diplomat.

DoF, 2013. Fishery Statistical Yearbook of Bangladesh (2011-12). Fisheries Resources Service System, Department of Fisheries (DoF). Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF, 2016. National Fish Week, Compendium (In Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Government of Bangladesh, Dhaka.

EU, 2017. Blue biotechnology.

FAO, 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all, Rome, p. 200.

FRSS, 2016. Fisheries statistical report of Bangladesh. Department of Fisheries, Bangladesh, p. 57.

Haider, S.M.B., Mahmood, N., 1992. The Coral Genus Acropora (Scleractinia: Astrocoeniina: Acroporidae) in nearshore waters of the St. Martins Island, Bangladesh Bangladesh. J. Zool. 5, 10.

Hasan, M.N., Hossain, M.S., Bari, M.A., Islam, M.R., 2013. Agricultural land availability in Bangladesh. SRDI, Dhaka, Bangladesh, p. 50.

Hossain, K., K, A.I., Zakaria, S., M, G.N., 2010. Ship Recycling Prospects in Bangladesh. Proceedings of MARTEC, 297–302.

Hossain, M.S., 2001. Biological aspects of the coastal and marine environment of Bangladesh. Ocean & Coastal Management 44, 261-282.

Hossain, M.S., Chowdhury, S.R., Navera, U.K., Hossain, M.A.R., Imam, B., Sharifuzzaman, S.M., 2014. Opportunities and Strategies for Ocean and River Resources Management, Background paper for preparation of the 7th Five Year Plan. FAO, Bangladesh Country Office, Dhaka, Bangladesh.

Hossain, M.S., Chowdhury, S.R., Sharifuzzaman, S.M., Sarker, S., 2015. Vulnerability of the Bay of Bengal to Ocean Acidification. IUCN, International Union for Conservation of Nature, IDhaka, Bangladesh, p. vi+55.

Hussain, Z., Acharya, G., 1994. Mangroves of the Sundarbans. Bangladesh. International Union for Conservation of Nature and Natural Resources IUCN.

Islam, A.K.M.N., 1980. A marine angiosperm from St. Martins Island. Bangladesh Journal of Botany 9, 5.

Islam, A.K.M.N., Aziz, A., 1992. Addition to the list of marine algae of St. Martins Island, Bangladesh II. Brown, red and blue green algae. Nova Hedwigia 34, 7.

Islam, M.A., Haider, M.Z., 2016. Performance Assessment of Mongla Seaport in Bangladesh. International Journal of Transportation Engineering and Technology 2, 15-21.

Islam, M.M., Shamsuzzaman, M.M., Hoque Mozumder, M.M., Xiangmin, X., Ming, Y., Abu Sayed Jewel, M., 2017. Exploitation and conservation of coastal and marine fisheries in Bangladesh: Do the fishery laws matter? Mar. Pol. 76, 143-151.

Islam, M.S., 2003. Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh. Ocean & Coastal Management 46, 763-796.

Kamal, A.H.M., 2009. Coastal and estuarine resources of Bangladesh: management and conservation issues. Maejo University.

Khan, S., 2015. Making IOCs interested in the bidding for hydrocarbon exploration. The Financial Express.

Krippendorf, K., 1980. Content Analysis: An Introduction to its Methodology Beverly Hills. Sage Publications, CA.

Mahmood, N., 1986. On fishery significance of the mangroves of Bangladesh. Institute of Marine Science, University of Chittagong and Marine Fisheries Academy, Fish Harbor, Chittagong, Bangladesh.

MoFA, 2016. Press Release: Press statement of the Hon'ble Foreign Minister on the verdict of the Arbitral Tribunal/PCA, Dhaka.

Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G.B., Worm, B., 2011. How Many Species Are There on Earth and in the Ocean? PLOS Biology 9, e1001127.

Mridha, S., 1995. The Bay of Bengal—biological oceanography and marine resources. Bangla Academy, Dhaka, p. 260.

Ninawe, A.S., 2017. Blue Economy is the Economic Activities that Directly or Indirectly Take Place in the Ocean and Seas, Use Outputs, Goods and Services into Ocean and Land Based Activities. Examines in Marine Biology & Oceanography 1, EMBO.000501. 002017.

Ocean, P.P., 2017. Why are oceans important?

OECD, 2016. The Ocean Economy in 2030. OECD Publishing.

Quader, M.A., 1994. Strategies for proper management utilization of marine resource of the country. A Paper Presented at the Workshop on Sustainable Development of Marine Fisheries Resources in Bangladesh. FRI, Cox's Bazar.

Quddus, M., Shafi, M., 1983. Bangopshagorer matsya shampad (Fisheries Resources of the Bay of Bengal). Bangla Academy, Dhaka.

Rahman, M.M., 1997. Bangladesher upakulia abong samudrik matsha samphad unnayan o babastapana (in Beagali). Department of Fisheries, The People's Republic of Bangladesh, p. 56.

Rasheed, S., Siddique, A.K., Sharmin, T., Hasan, A.M.R., Hanifi, S.M.A., Iqbal, M., Bhuiya, A., 2016. Salt Intake and Health Risk in Climate Change Vulnerable Coastal Bangladesh: What Role Do Beliefs and Practices Play? PloS one 11, e0152783.

Shamsuddoha, M., Islam, M.M., 2017. Bangladesh National Conservation Strategy: Coastal and Marine Resources. Department Forest and International Union for Conservation of Nature

Sumaila, U.R., Cheung, W.W.L., Lam, V.W.Y., Pauly, D., Herrick, S., 2011. Climate change impacts on the biophysics and economics of world fisheries. Nature Clim. Change 1, 449-456.

Tomascik, T., 1997. Management Plan for Resources of Narikel Jinjira (St. Martin's Island) Final Report', Prepared for the National Conservation Implementation Project-1. Ministry of Environment & Forest, Government of the Peoples' Republic of Bangladesh, Bangladesh.

2 Coming stakes in the ocean: Food production, shipping and trade, tourism, ecosystem-biodiversity, new technologies and climate change challenges

2.1 Abstract

Blue economy is an emerging concept in all over the world where Bangladesh is not in exception. The blue economy of Bangladesh is subject to multiple interlinked activities. Among the major activities, food production, shipping and trade, tourism, ecosystem-biodiversity, new technologies and climate change challenges are the most promising sectors which are discussed in this chapter to project the present and future potential, constrains, ways to overcome in the context of the blue economy of Bangladesh following various published literatures. The review has revealed that Bangladesh has enormous resources which have great potential to uplift the existing economy, improving livelihoods, while significantly reducing environmental risks and ecological scarcities. However, there are lot of constrains which hinder to get the ultimate fruit from these potentialities. The major constrains include lack of policy, institutional or organizational structure and coordination, data or information, knowledge in innovating and diversifying marine products and services, marketing strategies, continuous scientific research, skilled manpower with motivation and dedication, public awareness, maritime securityand concern in marine and coastal environment. Initiations to overcome these constrains with long and short term strategic plans and properly implementing the strategic decisions will bring the state more productive and could be a model country with blue economy approach.

2.2 Introduction

The blue economy approach is based on a vision of "improved wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP 2013)..Blue economy is an emerging concept and a frequently discussed issue for strategic planning in all over the world in recent years. It is a revolutionary concept that has opened enumerates number of windows to uplift a national economic functional ecosystem and can act as a milepost from developing to a developed country. Emphasis on this concept and it's potentialities, possibilities, and exploiting untapped marine environment would make the economic backbone more strong as well as improving human welfare, creating opportunities for employment, alleviating poverty, ensuring national food security, protecting environmental balance, a solution for adverse impacts of climate change. Bangladesh, as a part of Indian Ocean Rim countries, is also at the nascent stage of development and assessment of blue economy. The concept of 'blue economy' has got new drive in Bangladesh after the resolution of maritime boundary disputes over Myanmar and India giving her sovereign rights on over 118,000 sq km of maritime territory, 200 nm of exclusive economic zone (EEZ), and 354 nm continental shelves. An international workshop on blue economy was held in 2014 which highlighted that Bangladesh should move ahead with a 'Bay of Bengal (BoB) partnership for Blue Economy' to secure sustainable development among the coastal or littoral states ensuring an inclusive and people-centric blue economy. The workshop raised hopes of extracting "plenty of resources" from the BoB. The concept of blue economy is subject to multiple activities that are interlinked. These activities include twenty-six maritime economic functions (Alam, 2014) following six broad categories mentioned below which can be identified as integral part of blue economy of Bangladesh. The functions include:

- Food and livelihood – fishery (capture and culture), marine aquatic products, marine biotechnology;

- Energy – oil and gas, sea salt production, ocean renewable energy, blue energy (osmosis) and biomass, aggregates mining, marine minerals mining;

- Tourism – coastal tourism, recreational water sports/yachting and marinas, cruise tourism;
- Maritime trade and shipping – shipping, coastal shipping/feeder services, sea ports, passenger ferry services, inland waterway transport, ship building, ship recycling industries;
- Coastal protection/artificial islands/greening coastal belts;
- Human resource/maritime surveillance and spatial planning.

Explaining all these functions are beyond the capacity of this op-ed. The major stakes such as food production, shipping and trade, tourism, ecosystem-biodiversity, new technologies and climate change challenges are discussed below to project the present and future potential, constrains, ways to overcome in the context of the blue economy of Bangladesh following published journal articles, reports and different official web documents.

2.3 Marine food production

2.3.1 Past and current situations

Bangladesh has a total of 284,813 km^2 marine water area, a coastal belt of 710 km long and 118,813 $km^2$the Exclusive Economic Zone (EEZ) which extends from the baseline to 200 nautical miles seaward(DoF, 2017; Hossain *et al.*, 2017; Islam *et al.*, 2017). This vast water body produced about 626,528 MT fish in 2016 (16.15% of total production) of which 105,348 MT was caught by trawling, while 521,180 MT was harvested by artisanal fishing (DoF, 2017; FRSS, 2017). Bangladesh has also 8,538.63 km^2 rivers and estuaries, and 1,777.00 km^2 the Sundarbans water area which produced approximately 178,458 MT (4.6% of total production) and 16,870 MT (0.43% of total production) fish respectively during 2015-16. In addition, shrimp and crab culture areas are around 2,755.09 km^2 which produced approximately 239,798 MT shrimp (6.18% of total production) and 13,160 MT crab (0.34% of total production) respectively (DoF, 2017; FRSS, 2017).

A total of four surveys (1973, 1981, 1983 and 2016) were carried out to assess the stock of marine fisheries resources in Bangladesh (see Table 5). These surveys also identified 149 fish species, 13 shrimp species and 14 different species of other crustaceans and molluscs in marine water areas of Bangladesh (DoF, 2017).

Table 5 : Stock of marine fisheries resources (tonnes) in Bangladesh assessed by four surveys

Demersal fish	Pelagic fish	Shrimp	References
264,000-373,000	-	9,000	West (1973)
160,000	90,000-160,000	-	Saetre (1981)
200,000-250,000	160,000-200,000	4,000-6,000	Penn (1983)
Ongoing	Ongoing	Ongoing	DoF-FAO (2016-17)

Source: Hossain et al., 2017

Bangladesh earns a lot of foreign currencies (US $505.80 million) by exporting a large proportion of these marine fisheries resources which contribute to 3.65% of its GDP(DoF, 2017). It mainly exports ten categories of fishery products (Frozen freshwater fish, frozen marine water fish, frozen shrimp, chilled fish, live fish, dry fish, salted dehydrate, live kusia, live crab, and fish scale/shrimp scull) to more than 55 countries (Ghose, 2014). In 2016, the total exported fishery products (in terms of quantity) from Bangladesh consisted of approximately 53.77% frozen shrimp followed by 16.97% live fish,

14.70% frozen fish and the rest were other fishery products (DoF, 2017). The fisheries export data also revealed that out of 4282.82 crore take (in 2016), 84.03% came from only frozen shrimp export, while 6.39% from frozen fish, 4.30% from live fish and the rest were from other fishery products.

About 5.16 lakhs fishers are working in marine and coastal areas of Bangladesh and 8.33 lakhs farmers are involved in shrimp farming(DoF, 2017). Studies showed that around 67,669 unlicensed fishing boats are engaged in fishing in these areas, of which about 51% are non-motorized boats (Shamsuzzaman *et al.*, 2017), and only 242 trawlers are allowed for fishing by the government (MoFA, 2014). There are about 100 fish processing plants (EU approved) where over 1 million people are working as full time or part-time employees (DoF, 2017).

2.3.2 Future potentialities

Future food security and export earnings of Bangladesh may significantly depend on our coastal and marine resources. Since our natural water systems have limitations, it is unlikely that our future requirements will be met without major change. Therefore, the following issues can be considered to increase the existing marine food production sustainably:

(i) Distance fishing: The majority of fishing boats and vessels in Bangladesh operate in coastal areas within 40 m depth (Hossain *et al.*, 2017) which clearly shows a scope for distance fishing in deep waters and high sea fishing zones.

(ii) Modern fishing technology: In Bangladesh, currently fishing practices are carried out with smaller tonnage vessels and using some selective gears which are unable to harvest deepsea and distant fishery resources (Hossain *et al.*, 2017). So, we can adopt appropriate deep sea fishing technologies, i.e. long line and hook fishing and the utilization of modern gears and vessels to harvest high-valued species, i.e. tuna and other pelagic large fish.

(iii) Mariculture: There are huge opportunities to initiate and introduce both brackish and marine aquaculture in Bangladesh. Breeding and farming of sea bass, mullets, sea bream, etc. could be initiated as important high-valued aquaculture species. Mud crab fattening in ponds and cages, breeding and farming would be the most potential intervention in this sector. In addition, opportunities for breeding, larval rearing and farming of hilsa shad, grouper, oyster, mussel, lobster, etc. also exist as they are species of high interests and demands. Mass culture of different sea weeds could be another valuable option of marine food production Hossain *et al.*, 2017; Hussain *et al.*, 2017). The future growth of mariculture will largely depend on domestication of target species which may ensure better growth, reproduction and minimize the cost of production (Hossain *et al.*, 2017).The existing aquaculture systems in Bangladesh (e.g. shrimp farming) are mostly traditional or extensive methods which follow low stocking density and minimum inputs that produce low yields. Therefore, modern farming techniques (e.g. semi-intensive) should be carried out to boost up the existing production.

(iv) Innovative farming: Coastal and marine (off-shore) 'cage culture' can be introduced in Bangladesh using simple technique with minimum cost to produce some valuable species (e.g. sea bass, mullet, hilsa, sea bream, etc.). 'Aqua silviculture' or 'integrated mangrove-aquaculture' (e.g. mangrove-shrimp/crab) culture can be practised in suitable locations which may strengthen the livelihoods of associated stakeholders without environmental damage. 'Integrated multi-tropic aquaculture' could be another system where wastes from the target species (i.e. fish) can be utilized by other species as food (e.g. organic matters for oysters/mussels and inorganic nutrients for seaweeds). Thus, these innovative farming systems can be introduced to produce more marine foods providing environmental sustainability, economic diversification and social acceptability in some selected suitable areas of Bangladesh (Hossain *et al.*, 2017).

(v) Product diversification and value addition: The Bangladeshis mainly consume different types of marine fish and only some selected varieties of crustaceans (shrimp, crab and lobsters), whereas by-catch and many unconventional species (e.g. sole, ray, molluscs, some crustaceans, aquatic reptiles and mammals, seaweeds, echinoderms, etc.) remain unused for consumption and exportation. Thus, there is an excellent opportunity to harvest these unexploited and locally unconsumed fisheries resources to utilize for various purposes (e.g. making fish cutlets/fingers/cakes/balls/sticks, producing fish oils/sauces, shrimp skewer, squid rings, etc.). On the other hand, the fish processing wastes can be used to produce fish meal, silage and compost, and some value added products such as protein, oil, amino acids, minerals, enzymes, bioactive peptides, collagen and gelatine (Hossain *et al.*, 2017). Thus, producing more diversified and value-added products will create great opportunities to find more international markets for higher export earnings.

(vi) Fish stock assessment: The regularly surveyed stock assessment data (e.g. Table 5) can be utilized to i) estimate the optimal harvesting strategy, ii) monitor the abundance and productivity of exploited fish populations, and iii) support sustainable fisheries conservation and management of the existing fish stocks (Hossain *et al.*, 2017).

(vii) Ecosystem-based fisheries management: This is a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem and recognizes the physical, biological, economic and social interactions. Thus, this management system can (i) balance the needs of fishing communities with species sustainability and (ii) minimize the anthropogenic activities (e.g. pollution) in the selected ecosystem (Hossain *et al.*, 2017).

(viii) Live feed culture and production: *Artemiaspp*. are popularly used to feed different marine fish and crustaceans larvae/juveniles, but the cultivation of live feeds remains to be a bottleneck in Bangladesh. Therefore, it is necessary to produce live feeds following the appropriate technology for sustaining the mariculture industry.

(ix) Disease and health management: Some of the interventions may include developing disease resistant stocks, improvement of husbandry, application of bio-security and eco-friendly health management techniques (e.g. probiotics, immunostimulants), avoid and prevent the irrational use of antibiotics, and embracing organic farming and traceability requirements (Hossain *et al.*, 2017).

(x) Marine biotechnology: This technology can be applied to improve product quality (e.g. lower fat-content, colour, texture of flesh) and growth rates, enhance reproduction and early development success, achieve appropriate stock maturity regimes, control diseases (vaccines, probiotics, SPF and SPR stocks), etc. Since Bangladesh is still lagging far behind in the application of this modern technology, it is necessary to ensure the support facilities in order to enhance the existing marine food production(Hossain *et al.*, 2017; Hussain *et al.*, 2017).

2.3.3 Constraints

The following constraints can be addressed that are needed to solve or improve in order to increase the existing marine food production in a sustainable manner:

(i) Overexploitation: except some mollusc species, major commercial species in coastal and marine waters are overexploited (Islam *et al.*, 2017).

(ii) Lack of rules on by-catch: no regulation and enforcement measures have yet been undertaken on by-catch or trash fish issues. So, the biodiversity is declining which is dangerous for future sustainable management of marine stocks (Hussain *et al.*, 2017).

(iii) Lack of mariculture: very limited numbers of commercially important species are cultured due to various reasons (e.g. domesticated brood and larval availability, hatchery and farming facilities, technological supports, etc.) (Hossain *et al.*, 2017; Hussain *et al.*, 2017).

(iv) Inappropriate knowledge on fish stock: since 1984, there have been no comprehensive fishery surveys in the Bay of Bengal. Hence, the standing stock and maximum sustainable yield values are unknown to policymakers(Islam *et al.*, 2017).

(v) Lack of modern crafts and gears: due to the lack of modern crafts and gears, it is impossible to harvest and catch the larger fish stocks in deeper areas of the BoB (Hussain *et al.*, 2017).

(vi) No specific marine protected area (MPA): in Bangladesh, no straight forward planning has yet been made to declare and establish specific MPAs (Hussain et al., 2017).

(vii) No ecosystems approach to fisheries management (EAFM): lack of planning in the country to implement an EAFM according to FAO Code of Conduct, 1995 (Hossain et al., 2014).

(viii) Lack of application of marine biotechnology: lack of planning to initiate application of marine biotechnology for successful marine food production (Hussain *et al.*, 2017).

(ix) Lack of coordination: a clear lack of coordination between public administrations and research institutions; between administrations and private entrepreneurs/businessmen; between/among public and private sector agencies (Hussain *et al.*, 2017).

(x) Marine pollution: Coastal aquaculture, pollutants from seaports and pollution from ship-breaking activities negatively affect coastal fisheries (Ghose, 2014; Islam *et al.*, 2017).

(xi) Middleman in fish chain: Due to limited access to formal credit, most fishers are entrapped into long-term debt bondage with a middleman, who often forces fishers to resort to destructive fishing for more profit(Islam, 2012).

(xii) Extreme weather conditions: Rough seas, as well as frequent cyclones, often force coastal fishers to stay home or to abandon their incomplete fishing trips (Islam, 2012).

(xiii) Widespread poverty: The majority of the small-scale fishers are poor, socially excluded and politically disempowered (Islam, 2012).

2.3.4 Institutional perspectives

Although some institutions do exist (please find the list in Hossain *et al.*, 2017)to channel stakeholder participation, the enforcement of laws and regulations is sometimes lacking. Therefore, the institutions underlying fisheries and coastal resources management in Bangladesh are important for the following reasons:

(i) Institutions could play a significant role in the management of fisheries and coastal resources in the region to ensure the transfer (or conservation) of the present resource endowments for future generations(Torell and Salamanca, 2001)

(ii) Appropriately crafted formal institutions together with strong political support can enhance the management of common pool resources such as fisheries (Ostrom, 1990).

(iii) Interest in cooperation and interaction between governments, agencies and resource users as well as community involvement in resource management is increasing due to the benefits that accrue from sharing responsibilities and ownership(Pomeroy, 1993).

(iv) Formal institutions provide a structure for cooperation between resource users and government and for participation of local communities and various fisheries organizations as well as other private sector stakeholders in managing natural resources(Torell and Salamanca, 2001).

In Bangladesh, the institutional changes are needed to realize its plans for fisheries recovery and marine ecosystem and therefore, we suggest the following specific measures:

(i) The introduction of regional institutional management councils, whereby all important stakeholder groups are well represented, and the best available science is used in the decision-making process for marine fisheries management. Within such a system, fishing limits would not exceed scientifically determined sustainable levels, and fishermen would need to comply with these limits. Key stakeholder groups would include government, industry, independent scientists, and civil society.

(ii) The introduction of incentives that improve fishing incomes without increasing fishing effort and aggregate fish catch, for example, through the allocation of individual fishing limits or quotas. Funding programs to remove excessive fishing capacity and to promote alternative employment opportunities and workforce training would enhance the success of this initiative, as would the removal of most existing subsidies to the fishing industry.

(iii) The expansion, effective implementation, enforcement, and sustained financing of MPAs throughout EEZ to enhance the recovery of fisheries stocks and the resilience of marine ecosystems.

(iv) The implementation of uniform management and enforcement mechanisms across all water bodies in Bangladesh to ensure that communities and the fishing industry throughout the country are subject to equivalent and effective fisheries regulations.

(v) The promotion of educational opportunities for scientists and fisheries managers to learn from the successes and failures of other nations in marine resource management.

(vi) The establishment of a public process for data sharing and transparency on fisheries practices, catch, stock status, and ecological impacts.

If we are able to carry out these institutional reforms, it will likely experience a true paradigm shift in fisheries management. To be successful, however, the government will need to commit financial resources to cover the transition costs of institutional change. Without adequate funding, efforts to transform fisheries management in Bangladesh will likely be futile.

2.4 Shipping and trade

2.4.1 Importance and present status

Shipping is a well known carrier of trade and is more sustainable than any other career as it is the safest, most secure, most efficient and most environmentally sound means of bulk transportation – with declining rates of accidents, zero terrorist incidents, improving turnaround of ships and significant reductions in discharges to sea or emissions to air. Bangladesh, having long coastline and age old tradition of sea navigation, has a relatively strong development of maritime services that support the sea trade and sea transport functions ranging from shipping agents, freight forwarders, and insurance to classification and inspection, and maritime education in the Marine Academies/Dockyards/Shipyards/ Nautical Institutes etc. According to BSC (2017), net benefit from the sector was 8.66 crore in 2016-17 fiscal year which is 4.31 times higher than the net benefit in 2012-13 and indicates a growing industry in Bangladesh. More than 90% of its external freight trade is seaborne. There are 74 registered merchant ships and 124 registered shipyards in the country. Among the shipyards, most of them can design and fabricate ship up to 3500 DWT and eleven local shipyards of international standard are capable of making ships up to 10000 DWT. Bangladesh has started exporting her ocean going ships to a high-end market like Denmark competing with giant competitor like China, India and Vietnam since 2008.

Shipbuilding has shifted from developed country like Europe, Japan to China, India and now in Bangladesh due to the lower labour cost and overhead. Nearly fifty thousand skilled workers and one lac semi-skilled workers are now working in these industries.

2.4.2 Constraints

Huge investment is the prime requirement for the industry. There is dearth of capital and investment due to high risk for both the entrepreneurs and bankers. In addition, interest rate for the industry (12-16%) is higher than the garments industry (7%). Moreover, the industry required local and foreign banks as guarantee. Bank guarantee for export of ships from Bangladesh is about 16% whereas for other sectors it is around 1 - 2%. On the other hand, it is 0% in other competing countries like Korea, China, Japan, India etc. Commission for opening import L/C at the rate of 0.20% is charged by banks of other competing countries whereas 8% is charged by the Bangladeshi commercial banks. Therefore, additional financial cost of ships built in Bangladesh is about 15 to 25% which is higher than the other competing nations like China, Korea, Japan, India, Vietnam, and Brazil.

Safety health and environment aspects including management cultures are very poor which hinders the employee right and creates or increases pollution. Ancillary industries, research and development (R&D), skilled manpower, model testing facilities, other facilities like electricity, gas etc are insufficient in the country to support the industry for price competitiveness in international ship markets.

2.4.3 Ways to overcome

To acquire the benefit of blue economy to its greatest potential a sustainable and equitable basis, modernization of the port, modern merchant ships, settlement between national and international industry are necessary. The present ocean going vessels in Bangladesh are more than 30 years old which needs high maintenance cost and kills time. To compete with other Asian shipbuilding giants, the ship building industry should be facilitated with a subsidy of at least 20%, sufficient raw materials with ancillary industries need to venture. It is also essential to establish a corporate management culture in this industry with ensuring employee rights, safety and health, and sustaining environment following IMO regulations. At present most of the shipyards located in Narayangonj, Dhaka but international market oriented shipbuilding farms should be shifted in coastal areas (Patuakhali, Bhola, Chittagong).

The World Maritime Day (WMD) – 2017 with the theme of ‘Connecting Ships, Ports and People’ in Bangladesh recognizes the importance of shipping safety, maritime security and marine environment and acknowledge maritime industry. Bangladesh government has been declared the industry as a “Thrust Sector” and initiating various action plans to overcome the aforementioned weaknesses. Government as well as local and private shipping companies need to go some forward and have to have clear concept and knowledge about the benefits of ocean could give us.

2.5 Tourism

2.5.1 Importance and present status

Tourism is an emerging global economic force in the 21st century which creates jobs, drives exports, and generates prosperity across the world. According to the world travel and tourism council, travel and tourism continues to be one of the world’s largest industries in the world and is shown to account for 10.4% of global GDP and 313 million jobs, or 9.9% of total employment, in 2017 (WTTC, 2018a). In Bangladesh, the direct contribution of the sector to GDP was US$5,310.4mn (2.2% of total GDP) and the total contribution was US$10,567.4mn(4.3% of GDP) in 2017. Regarding employment in 2017, the sector directly supported 1,178,500 jobs (1.8% of total employment) and total 2,432,000 jobs (3.8% of total employment) including indirectly supported jobs in Bangladesh (WTTC, 2018b). Tourism

destinations in Bangladesh are mostly nature based and some them are included in the UNESCO Heritage List. The popular tourist destinations and attractions are historical mosques and sites and monuments, archaeological sites, world‟s longest sea beach, hilly areas and forests of Sundarban and wildlife in the Chittagong hilly area, tribes, miles of rolling tea gardens of world famous brands and islands. The sector is in developing stage and the market has both national and international tourist actors competing for the existing marke t(BPC 2015). At present, Bangladesh Parjatan Corporation (BPC) looks after the tourism sector in Bangladesh under the ministry of Civil Aviation and Tourism. Bangladesh government has reformed the national tourism policy in 2010. The aims and goals of this policy are to increase employment, ensure economic development, environmental purity and sustainability (Siraj et al., 2009). The major objective of the policy is to develop Eco-tourism through conservation of natural resources and promote well-being of the community, preservation of cultural values of the local community and their participation and sharing benefits.

Bangladesh Tourism Board established in 2010 to meet the strong demand for private sector and the tourism professionals. It is affiliated with United Nations World Tourism Organizations (UNWTO).

2.5.2 Constraints

Tourism growth in Bangladesh is slower than the pace of growth at world level as well as SAARC countries (WTTC, 2012). The rate of contribution to national GDP is also decreasing.

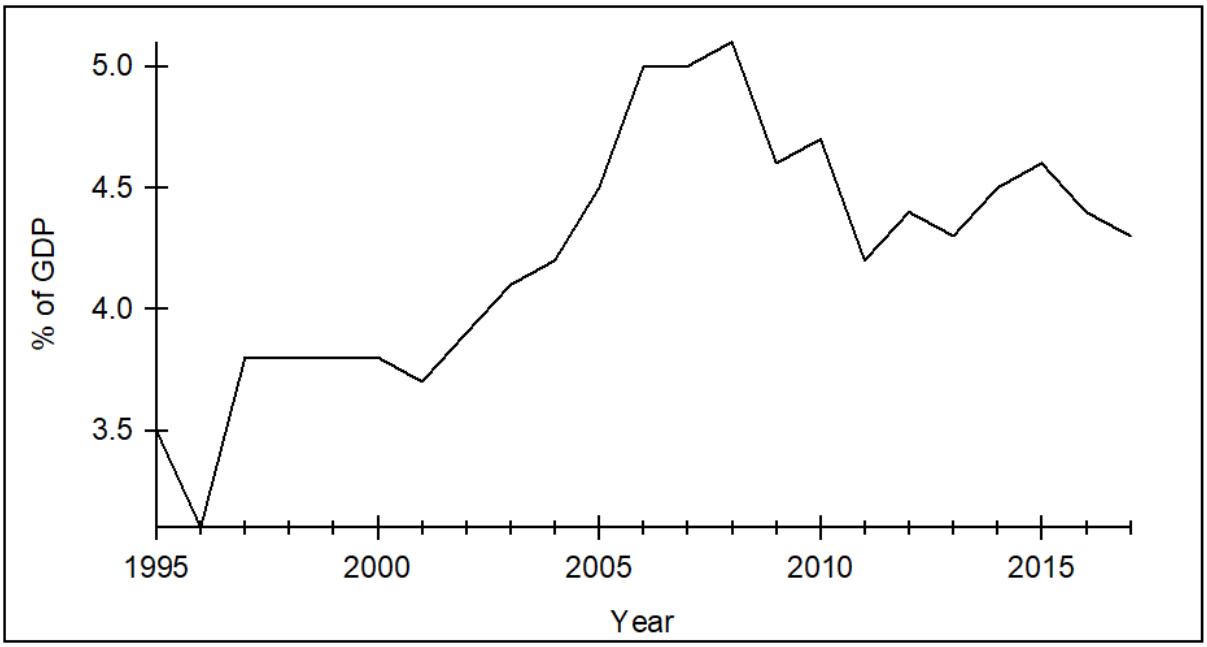

Figure 11 : Trend of the tourism sectors contribution to national GDP in Bangladesh. Source : https://knoema.com/atlas/Bangladesh/topics/Tourism/Travel-and-Tourism-Total-Contribution-to-GDP/Contribution-of-travel-and-tourism-to-GDP-percent-of-GDP

Major constrains in this sector include unplanned development of the industry, lack of adequate knowledge and professionalism, lower level of co-operation and innovation in the sector. The lack of government support has resulted in poor infrastructure such as the poor condition of transport and power. The airline sector of Bangladesh has also negatively affected tourism industry due to limited flights in domestically and internationally, flight delays, inefficiency and mismanagement at the airports. Local travel is hampered by lack of amenities on the highways, poor road conditions as well as frequently road accidents. Political unrest, adverse security situation within Bangladesh deterred both domestic as well as foreign tourists from exploring the country. Natural calamities like devastating floods and cyclone causes extensive damage to the country and negatively effect on tourism. In addition,

availability and access to the right information is not easy and the insufficient safety measures make the tourists worried.

2.5.3 Ways to overcome

A dynamic and supporting ministry of tourism is needed which could focus on ground at gross root level and able to move out to top level. This ministry or responsible government organization needs to determine the issues and strategies for short term and long term to run and develop the product and services, market, infrastructure, human resources and environment associated with the industry. Management, administration and control of the sector without having any bureaucratic process are also a serious concern.

Government needs to create corporate culture in the tourism industry and forthcoming to involve private sector to develop and diversify the marketing aspect. Focus on using social media and information technology, allocating promotional fund and event based promotional activities are also needed for tourism marketing.

It is also essential to take initiatives to develop infrastructural facilities, facilitate easy access to different destination with standard accommodation, liberalize air transportation and visa facilitation, build better image of Bangladesh, ensuring safety and security of tourists, and create social awareness and responsiveness. Thereby the industry will increase the national GDP with employment opportunities as well as disseminate and uphold the culture and customs of the country.

2.6 New technology

2.6.1 Importance and present status

Marine biotechnology is the creation of products and processes from marine organisms through the application of biotechnology, molecular and cell biology, and bioinformatics. There are promising and exciting achievements in biochemistry, genetics, genomics, aquaculture, bioenergy, and other related fields, beginning with genetic recombinant technology as applied to marine algae. Marine biotechnology clearly incorporates enormous social and economic benefits, thus providing a foundation for problems related to food as exemplified by ocean farming.

Marine biotechnology is one of the youngest biotechnology approaches. Modern marine biotechnology has been developing rapidly since the 1980s. The opportunity for application of marine biotechnology in Bangladesh is highly promising but very little is done in this area. The main marine biotechnology industry at present is aquaculture, which concentrates on few marine fish/shrimp farming and breeding. The country up to now has not harnessed the marine resources. Therefore, it is extremely important that efforts are made on research and development in the areas of marine biotechnology.

2.6.2 Constraints

There is the risk of unintended extraction of marine species associated with blue biotechnologies. This field is yet ill defined and poorly regulated. The precautionary principle should be applied to bio-nanotechnology, biomaterials and the introduction of genetically modified fish, shellfish and microorganisms. In Bangladesh due to lack of implementation and enforcement of management measures, many opportunities in marine resources development remain untapped. Obstacles in development potential of marine biotechnology including, lack of funding, lack of infrastructure, lack of available workforce (quantity/quality), deficiency of information, policy landscape, political vision, indigenous skilled capacity, scientific research capacity, scientific research strategy, and so on.

2.6.3 Ways to overcome

The development of blue biotechnology for food, health products and pharmaceuticals presents novel possibilities, and strategies for developing these possibilities are suggested. Where there are opportunities for rationalization of activities under different policy initiatives and between sectors to achieve the overarching objectives of the blue economy, this is strongly supported. To be sustainable, the sectors that are developed need critical mass. This can result in local synergies, sharing of resources and enhanced capacity to add value. Moreover, international interaction will invariably be easier and more equitable. A standard approach, used internationally to facilitate the creation of such a critical mass, is the development of technology incubators, science parks, etc. Listed below are additional recommendations that address the full range of factors that need to be in place to implement a robust, successful blue economy.

- Locally generated or internationally awarded funds could be allocated to specific projects through specific fund for blue economy activities.

- A coordinated research and development strategy is needed to address specific sector requirements and the broader implementation of the blue economy.

- Capacity-building, effective international networking and collaboration, and skills transfer from foreign academic organizations and technology providers, in addition to regional cooperation, are crucial because of limited in-country resources.

- Need a linkage among the policy makers, researchers, GOs and NGOs towards the exploitation or development of blue resources.

2.6.4 Future potential

Marine biotechnology may include techniques such as bioprocessing, bioharvesting, bioprospecting, bioremediation, using bioreactors etc (so called process biotechnology techniques); aquaculture/fisheries; gene, protein, or other molecule based techniques; while applications may include: health, food, cosmetics, aquaculture and agriculture, fisheries, manufacturing, environmental remediation, biofilms and corrosion, biomaterials, research tools etc. Therefore, marine biotechnology has a horizontal scope encompassing very different applications, for all of which the marine environment is providing the resources. The term “marine biotechnology” denotes a potentially wide variety of activities, which may be divided into the following categories.

2.6.4.1 In aquaculture industry

The use of modern biotechnological tools for rearing and enhancing the production of aquatic species can not only help meet the global demands of seafood, but also enhance aquaculture farming per se. These techniques also improve the health, reproduction, development and growth of aquatic organisms, and thus promote the inter-disciplinary development of environmentally sensitive and sustainable systems. This in turn will lead to substantial commercialization of aquaculture. Biotechnology has the potential to offer solutions to several problems in the areas of aquaculture.

Reproduction: Several fishes do not spawn spontaneously when placed under captive conditions. In the past, fish gonadotropin, a group of hormones that stimulate reproduction, were produced in small amounts by extraction and purification from crude preparations of thousands of pituitary glands. At present, large quantities of highly purified gonadotropin can be produced in the laboratory through recombinant DNA technology. Hermaphrodism is a common phenomenon in many coral reef fishes. Some species are male in the early stages of their life cycle, and turn female on the later stages or vice versa. Through genetic engineering, sex of the species can be regulated as it reaches maturity.

Transgenic fish: Conventional fish breeding is based on selecting the fish brood so as to enhance the desirable traits in the fish. However, this process is slow and unpredictable. New molecular tools are much more efficient in identifying, isolating and constructing the genes responsible for desirable traits, and subsequently transferring them to the brood. The production of transgenic fish is in-fact much easier than producing other transgenic mammals. This is because fish produce a large number of eggs (from several dozens to several thousand), which can generate large quantities of genetically uniform material for experimentation. Genetic engineering is also considered to have significant potential to enhance aquaculture through the use of recombinant DNA techniques that would yield faster-growing and/or disease-resistant varieties of fish or mollusks.

Growth promotion: Majority of transgenic research on commercially important fish species are focused on improving growth rates by transfer of growth hormones. This is economically sound because transgenic fish with altered growth traits reach maturity in a shorter span of time than non-transgenic fish and exhibit better feed conversion efficiency. These advantages further translate to shorter production cycle, lower production costs, and reduced pollution in aquaculture facility.

Nutrition: Trash fish or wild fish species for fish meal as protein source for aqua feeds are very limited. Thus, plant-based protein sources are a sustainable option with additional advantage of being cheaper. However, most plants have anti-nutritional characteristics that are not favourable for feed utilization. For instance, carnivorous fishes have limited ability to use up carbohydrates due to the digestibility of polysaccharides. To address this concern, carbohydrate metabolism of salmonid fish was enhanced through genetic engineering. Fish oil is economically important in fish feed production, as well as to human health. The demand for fish oil continued to grow alongside the expansion of aquaculture industry because it is a major lipid source in aqua feeds.

Health management: Traditional disease diagnosis involves analysis of cells and tissues of organisms, which takes a long time to be done. Molecular biology (PCR) provides valuable information about life cycles and mechanisms of pathogenesis, antibiotic resistance and disease transmission. This information can enhance our understanding of host immunity, resistance, susceptibility of diseases and associated pathogens.

Freeze resistant fish: Recombinant techniques can be used to transfer an antifreeze protein (AFP) gene to confer freeze resistance on various species. AFPs are produced by several cold-water marine teleosts (like winter flounder, ocean pout, sea raven, shorthornsculpin). These proteins prevent ice crystal formation in the blood, and hence protect the fish from freezing.

Conservation: Molecular tools can be used to identify and characterize important aquatic germ-plasm including many endangered species. These tools have made it possible to analyze the genomes of many aquatic species. They have also helped us understand the molecular basis of gene regulation, expression and sex determination. This can improve the methodologies for defining species, stocks and populations.

2.6.4.2 In seaweeds industry

Seaweeds are marine algae (macro algae) that exist in the marine environment. These are sea-dwelling plants that lack true stems, roots and leaves. Just like land plants, seaweeds too have photosynthetic machinery and use sunlight to produce food and oxygen from carbon dioxide and water. Seaweeds are a rich source of food, fodder and a host of industrially important chemical compounds. In fact, seaweed is a billion-dollar industry. The most valued seaweed is the red algae Porphyra or nori, which is a major source of human food throughout the world. The other edible seaweeds include *Gracilaria*, *Undaria*, *Laminaria*, and *Caulerpa*.

2.6.4.3 In pharmaceutical industry

Biotechnology researchers have isolated many bioactive substances from the marine environment, which hold great potential for treating various human diseases (anti-bacterial/viral & anti-tumor agents). Particular attention has been paid to a variety of toxins formed by marine organisms. Nutraceuticals constitute a variety of substances used in the food supplement and "natural health" markets.

2.6.4.4 In chemical industry

Marine organisms are the source of a variety of chemicals used in industrial processes. The best-known example is carrageenan, extracted from seaweed and used as a thickener in ice cream and other foods and as a laboratory culture medium. A variety of other chemicals (Agar-agar, alginates, enzymes etc.) used both in food processing and other manufacturing processes have also been developed from marine resources. Oyster shells are providing a new source of synthetic biodegradable polymers with a wide range of useful industrial properties. These polymers are used for water treatment and agricultural applications.

2.6.4.5 In pollution control

Degradation of environmental pollutants is an important concern globally. Studies have shown that marine microorganisms exhibit unique biodegradation pathways for breaking down several organic pollutants. Immobilized cells of bacterium *Pseudomonas chlororaphis* produce pyoverdin, which hastens the breakdown of toxic organotin compounds in seawater. Other studies have also shown that some marine organisms produce eco-friendly chemicals like biopolymers and biosurfactants which can be used in environmental waste management and treatment. Anti-fouling products that can be extracted *e.g.* from marine organisms, including bacteria as well as the mucus of fish and starfish prevent sessile marine organisms such as barnacles from attaching to boats, piers and other submerged manmade structures are examples.

2.6.4.6 In biofuel industry

Biofuels from microalgae is one of the economically viable ways to reduce fossil fuel consumption. Microalgae are considered better sources of biofuels than higher plants because of their high oil content; ease of propagation (can be cultivated in seawater or brackish water, thus do not compete with the resources of conventional agriculture); residual biomass after oil extraction can be used as feed or fertilizer or fermented to produce ethanol or methane; and the biochemical composition can be controlled by modifying growth conditions. Microalgae with superior biomass productivity and lipid content include *Chlorella, Tetraselmis, Chaetoceros, Isochrysis, Skeletonema,* and *Nannochloropsis.*

2.6.4.7 In job market

The enormous biodiversity and growing genetic life in sea are the key driving factors for the growth of marine biotechnology market. Rising cosmetic industry, increasing need for environmental safe feed stocks for sustainable production in display technologies and growing healthcare industry are driving the global marine biotechnology market. Rising support of key players towards providing sustainable products helps in boosting the global marine biotechnology market.

2.7 Biodiversity

2.7.1 Importance and present status

Marine biodiversity includes coastal and marine plant and animal species, their genetic variety, the habitats and ecosystems they form part of, and the ecological processes that support all of these. Marine biodiversity plays a key role through ecosystem services (provisioning and regulation, amongst others). They provide economic wealth and resources that range from active ingredients for pharmaceuticals and medicine to products from fisheries and aquaculture, as well as contributing to cultural well-being and supplying relevant "biological models" for both basic and applied research. Based on the

International Union for Conservation of Nature and National Resources, 2514 species of teleosts are already extinct in the wild or threatened to some degree. Many subspecies, varieties, geographically isolated subpopulations or stocks, which are often of particular interest as fishing resources, are also in danger of extinction.

Bangladesh is ranked 3rd largest in aquatic biodiversity in Asia behind China and India, with approximately 300 species of fresh and brackish water fish species (Hussain and Mazid, 2001). This species diversity has been attributed to one of the world's largest wetland (Bengal Delta) and three large river systems that flow from the Himalayan Mountains into the Bay of Bengal. The Bay of Bengal is blessed with 442 fish species, 36 marine shrimps. About 336 species of mollusks, covering 151 genera have been identified. In addition, 3 lobsters and 7 species of turtles and tortoises, 168species of seaweeds, 3 sponges, 16 crabs, 3 lobsters, 10 frogs, 3crocodiles, 24 snakes, 3 otters, 1 porcupine, 9 dolphins and 3species of whale found in Bangladesh territorial water. Among the marine and migratory species of animals, 4 fishes, 5 reptiles, 6 birds, and 3 mammals are threatened.

2.7.2 Constraints

The loss of marine biodiversity is weakening the ocean ecosystem and its ability to withstand disturbances, to adapt to climate change and to play its role as a global ecological and climate regulator. The ocean is home to millions of species. The health of the oceans is strongly dependent upon this marine biodiversity. Life in the ocean is an essential component of climate regulation.

Fish is a primary source of animal protein for at least one billion people in the world. Apart from overfishing or pollution, climate change alone heavily affects the food resources for human populations, in developing/least developing countries like Bangladesh. Losses in biodiversity also imply a loss of genes and molecules that are potentially valuable for medical research and industry. Though Bangladesh is a small and densely populated country it is rich in biodiversity. Rapid extraction of seed as well as brood fish from natural waters combined with destructive unregulated fishing practices has led to the endangerment and possibility extinction of a number of rather valuable native species. Loss of aquatic habitat due to climate change, temperature raring, acidification, siltation, dam construction, and other anthropogenic activities has been one of the primary causes of species loss. The major constrains for the degradation marine biodiversity in Bangladesh includes high population density; poor integration among the respective departments; policy and information gaps; lack of enforcement or accountability; over exploitation; illegal fishing practices; PL collection, by catch; inadequate and poorly managed system of protected areas; no political vision; lack of awareness; climate change (ice melting due to temperature raise, ocean acidification); lack of alternate livelihoods in sensitive habitats; pollution (effluent, sedimentation, siltation, shipbreaking industry / ship recycling); invasive species; and Corruption.

2.7.3 Ways to overcome

The biodiversity losses in the nature could be overcome with the following activities:

- Establish baselines to study climate change impacts on biodiversity and establish a monitoring program to track changes

- Ensure alternative income for the communities those engaged in shrimp fry collection (to avoid by catch) or fishing (to protect brood fish during breeding season)

- Support rehabilitation of the rare, threatened and endangered native, wild and domesticated species. Develop breeding (in-situ) or preservation techniques (ex-situ) for important aquaculture species or endangered species for future restoration process

- Develop course curricula in University level and provide training of the trainers on biodiversity
- Promote understanding and awareness of the stakeholders of the importance and methods of conservation through developing appropriate communication tools, including materials
- Develop the capacity of different sectors, including the Government, of implementing the necessary tasks in respect of biodiversity conservation, as appropriate
- Conduct village-based inventory of flora and fauna, including their traditional uses.
- Identify the impacts of climate change, desertification, floods and other processes on the integrity of ecosystems and species and develop suitable management plans.
- Develop action plans for reducing levels of pollution
- Encourage co-management activities that include sound representation from local communities, not only the rich and politically connected for the protection of biodiversity
- Strengthen mechanism where international donors and project implementing agencies in the environment field gather regularly to share ongoing project results, data, lessons learned and information on planned projects

2.7.4 Future potential

Biodiversity is important to science because it helps us understand how life evolved and continues to evolve. It also provides an understanding on how ecosystems work and how we can help maintain them for our own benefit. Being a natural resources dependent economy, biodiversity plays very important role to the life and livelihoods of the people here in Bangladesh. The globally important ecosystems, such as the forests, freshwater wetlands, and marine fishing area indeed make up a significant portion of ecosystem services and national economy. Well-functioning ecosystems and human well-being are directly related, where biodiversity contributes significant value to services given by any ecosystem. The economic potentials of marine biodiversity are summarized with the following areas.

- Food resources: agriculture, livestock, fish and seafood, seaweed
- Biomedical research: coral reefs are home to thousands of species that may be developed into pharmaceuticals to maintain human health and to treat and cure disease
- Tourism and recreation: Beaches, forests, parks, ecotourism
- Industry: Textiles, building materials, cosmetics, trash fist for feed industry etc., and
- Conservation: Economical important species

2.8 Climate change challenges

2.8.1 Climate change and marine resources in Bangladesh

Bangladesh has been identified as one of the most climate change affected countries in the world (Kreft *et al.*, 2017). Several evidences have already shown the long-term changes in sea water temperature (Singh, 2012), acidification(Da Silva *et al.*, 2017), deoxygenation (Diaz and Rosenberg, 2008), salinity distribution (Hussain *et al.*, 2012), sea level (Brammer, 2014) and cyclones (Balaguru *et al.*, 2014) in the Bay of Bengal. These multiple stressors are likely to have serious effects, in particular on the BoB ecosystem which is high in productivity and support significant fisheries resources. Thus the productivity, habitats and biological process of this large ecosystem have been affected due to unexpected fluctuations of climate change variables(Jagtap and Nagle, 2007; Vivekanandan *et al.*, 2009a; Hoegh-Guldberg and Bruno, 2010; Vivekanandan *et al.*, 2016; Da Silva *et al.*, 2017).

Distribution (Poloczanska *et al.*, 2013), composition of communities (Perry *et al.*, 2005), physiology (Somero, 2010) of different fish species, increase in frequency and intensity of coral bleaching (Vivekanandan *et al.*, 2016), prevalence, transmission and pathogenicity of parasites and diseases (Britton *et al.*, 2011; Macnab and Barber, 2012), etc. have become evident due to alterations of physicochemical conditions of any ecosystem like the BoB. Some investigations have revealed the impact of climate change variables on different marine fish species of the BoB, for examples: (i) extension of distributional boundary of the oil sardine (*Sardinell alongiceps*) and the Indian mackerel (*Rastrelli gerkanagurta*) (Vivekanandan *et al.*, 2009b); (ii) evidence for a shift in latitudinal distribution and abundance of some catfish species (Vivekanandan *et al.*, 2016); (iii) shift/extension of depth of occurrence of the Indian mackerel (*R. kanagurta*) (CMFRI, 2008); and (iv) phenological changes, such as the occurrence of spawners of the two species of threadfin breams (*Nemipterus japonicus* and *Nemipterus mesoprion*) linearly decreased with increasing temperature during April–September, but increased with rising temperatures during October–March (Vivekanandan and Rajagopalan, 2009).

It has been predicted that fisheries resources of Bangladesh, particularly traditional fisheries, will be the most vulnerable to climate change (Minar *et al.*, 2013; Vivekanandan *et al.*, 2016). Climate warming will also affect the inland and coastal aquaculture sectors of this country(Ahmed and Diana, 2015; Kais and Islam, 2017). Impacts will include changes in hydrology and therefore availability of water, physical threats to aquaculture facilities, and prevalence or spread of known and new diseases of aquatic organisms (Vivekanandan *et al.*, 2016). Prediction also shows that the sundarbans ecosystem will be affected which is one of the major source of marine fisheries resources in Bangladesh (Chowdhury *et al.*, 2010; Minar *et al.*, 2013). Thus the impacts of long-term climate change will decrease the BoB's productivity, alter food web dynamics, reduce abundance of habitat-forming species, shift species distributions, and a greater incidence of diseases (Chowdhury *et al.*, 2010; Hoegh-Guldberg and Bruno, 2010; Fernandes *et al.*, 2013).In addition, when the climate-induced environmental changes will interact with other anthropogenic alterations (pollution, nonnative species, habitat degradation: Staudt *et al.*, 2013), they may have direct or indirect influence on different life-history traits of living organisms (Pörtner *et al.*, 2001; Rijnsdorp *et al.*, 2009; Vivekanandan and Rajagopalan, 2009; Pörtner and Peck, 2010; Anttila *et al.*, 2013). Thus, predicted climate change will seriously affect the coastal and marine ecosystem of Bangladesh and thereby influence the overall future marine fisheries production of this country.

2.8.2 Adaptation strategies

Bangladesh Climate Change Strategy and Action Plan (BCCSAP, 2009) which is built on the following six main pillars has provided the best strategies and plans to tackle the climate change effects in this country (Bhuiyan, 2015):

(i) Food security, social protection and health: To ensure that the poorest and most vulnerable in society, including women and children, are protected from climate change and that all programmes focus on the needs of this group for food security, safe housing, employment and access to basic services, including health.

(ii) Comprehensive disaster management: To further strengthen the country's already proven disaster management systems to deal with increasingly frequent and severe natural calamities.

(iii) Infrastructure: To ensure that existing assets like coastal and river embankments are well maintained and fit-for-purpose and that urgently needed infrastructure, such as cyclone shelters and urban drainage, is put in place.

(iv) Research and knowledge management, which facilitate prediction of likely impacts of climate change on different sectors of the economy and socio-economic groups, to ascertain future investment strategies and to ensure that Bangladesh is networked into the latest global thinking on science and best practice regarding climate change.

(v) Mitigation and low carbon development, used to evolve and implement low carbon development options, as Bangladesh's economy is expected to grow over the coming decades and the demand for energy increases.

(vi) Capacity building and institutional strengthening: To enhance the capacity of government ministries and agencies, civil society and the private sector to meet the challenges of climate change and mainstream them as part of development actions.

In case of marine fisheries, the most important and critical adaptation measures will be to develop human resources capacity to increase understanding of the coastal and marine resources, and implement measures to sustainably manage fisheries. Two main directions can be taken for climate change response (i) contribution to the understanding of large-scale processes and climate change effects, and (ii) contributions to adaptation by addressing habitat degradation, pollution (Srinivas *et al.*, 2015; Ramana and Devi, 2016) and fisheries management, as well as developing capacity and resilience of coastal populations. Recognizing that current problems in weak fisheries management make the sector vulnerable to climate change, different organizations (i.e. government, non-government, national or international) should provide supports for adaptation and increase resilience by strengthening fisheries management and providing assistance to improve fisheries assessments. By strengthening governance, it will be another good strategy for the integration of climate change adaptation into decision-making and response initiatives, e.g. disaster risk management plans (Vivekanandan *et al.*, 2016).

If the above-mentioned strategies and plans are implemented properly, the overall coastal and marine fisheries sector of Bangladesh may able to cope with the climate change impacts and adapt well to keep sustainable production from this sector.

2.8.3 Problems in implementing policies

A number of barriers to climate change adaptation in coastal and marine fisheries sector of Bangladesh include-technologically poor boats, inaccurate weather forecast, poor radio/other signal, lack of access to credit, low incomes, underestimation of cyclone occurrence, coercion of fishermen by the boat owners and captains, lack of education, skills and livelihood alternatives, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets. These local and wider scale factors interact in complex ways and constrain completion of fishing trips, coping with cyclones at sea, safe return of boats from sea, timely responses to cyclones and livelihood diversification (Islam *et al.*, 2014; Islam and Nursey-Bray, 2017).

2.8.4 Role of different organizations:

Formal institutions can play a major role in implementing and resourcing various forms of adaptation and/or interventions, which can take the form of knowledge (training/skill development), information, and support (technological, inputs, financial) (Islam and Nursey-Bray, 2017). In turn these initiatives

could change local perception of risk thus improving the adaptation capabilities of local people through formal and informal institutions (Agrawal *et al.*, 2008).

The Ministry of Fisheries and Livestock (MoFL) and the Ministry of Food and Disaster Management (MoFDM) deliver climate change adaptation programs and have vital roles in shaping climate change adaptation in fisheries in Bangladesh. In addition, coastal afforestation programmes, have been implemented by Ministry of Environment and Forests of Bangladesh to reduce the vulnerability of coastal communities to climate change (Sovacool *et al.*, 2012). Climate adaptive fisheries can be implemented by the development of climate change resilient production technologies, species varieties (adaptive aquaculture species), sustainable fishing, fish breeding technologies, community awareness building and ensuring a flow of climate related information in policy and planning. Thus, different organizations can play very important roles to adapt the climate change challenges in coastal and marine fisheries sector of Bangladesh.

2.9 Conclusion

The peaceful resolution of maritime discords has opened a golden opportunity to explore and exploit the vast valuable resources in the coastal and marine waters of Bangladesh. Sustainable management of these resources can give us the optimal benefits to uplift our existing economic condition. In this chapter, we show how these resources can be properly utilized for food production, shipping and trade, tourism, ecosystem-biodiversity conservation, new technologies and climate change challenges. Considering huge potentialities of these resources and major obstacles to achieve blue economy goals, we also suggest some strategies or policies to exploit these non-renewable resources in sustainable manner. Bangladesh has a very appropriate position to take the advantage of the blue economy, but there should be a sustainable blue economic approach in order to achieve the SDG Goals. Since the economy of Bangladesh is innately affected by natural, cultural, and other societal factors, there is the possibility of transitioning from unsustainable growth approaches to sustainable approaches through blue economy. In order to achieve such a transition, we strongly suggest adopting effective strategies for the sustainable blue economy. Therefore, more collaborative and inclusive patterns of work should be taken for the full potential of these resources. If the sustainable blue economic approach is followed properly, Bangladesh can be a successful benchmark of blue economy for the developing world. Thus, we consider blue economy not only the means of using ocean and marine resources, but also a path of providing secured life for the most vulnerable coastal people of Bangladesh.

2.10 References

Agrawal, A., McSweeney, C. & Perrin, N. (2008). Local Institutions and Climate Change Adaptation. The World Bank. https://openknowledge.worldbank.com/handle/10986/11145 (Accessed 09 June 2015).

Ahmed, N. & Diana, J. S. (2015). Threatening “white gold”: Impacts of climate change on shrimp farming in coastal Bangladesh. *Ocean & Coastal Management* 114: 42-52.

Anttila, K., Dhillon, R. S., Boulding, E. G., Farrell, A. P., Glebe, B. D., Elliott, J. A., Wolters, W. R. & Schulte, P. M. (2013). Variation in temperature tolerance among families of Atlantic salmon (Salmo salar) is associated with hypoxia tolerance, ventricle size and myoglobin level. *Journal of Experimental Biology* 216(Pt 7): 1183-1190.

Balaguru, K., Taraphdar, S., Leung, L. & Foltz, G. (2014). Increase in the intensity of postmonsoon Bay of Bengal tropical cyclones. *Geophysical Research Letters* 41(10): 3594-3601.

BCCSAP (2009). Bangladesh Climate Change Strategy and Action Plan 2009. Government of Bangladesh, Dhaka.

Bhuiyan, S. (2015). Adapting to Climate Change in Bangladesh. *South Asia Research* 35(3): 349-367.

Brammer, H. (2014). Bangladesh's dynamic coastal regions and sea-level rise. *Climate Risk Management* 1: 51-62.

Britton, J. R., Pegg, J. & Williams, C. F. (2011). Pathological and Ecological Host Consequences of Infection by an Introduced Fish Parasite. *PLoS ONE* 6(10): e26365.

Chowdhury, M. T. H., Sukhan, Z. P. & Hannan, M. A. (2010). Climate change and its impact on fisheries resource in Bangladesh. Proceedings of International Conference on Environmental Aspects of Bangladesh (ICEAB10), Japan, Sept. 2010. 95-98pp.

CMFRI (2008). Research Highlights 2007–2008. Central Marine Fisheries Research Institute, Cochin, India36.

Da Silva, R., Mazumdar, A., Mapder, T., Peketi, A., Joshi, R. K., Shaji, A., Mahalakshmi, P., Sawant, B., Naik, B. G., Carvalho, M. A. & Molletti, S. K. (2017). Salinity stratification controlled productivity variation over 300 ky in the Bay of Bengal. *Scientific reports* 7(1): 14439.

Diaz, R. J. & Rosenberg, R. (2008). Spreading Dead Zones and Consequences for Marine Ecosystems. *Science* 321(5891): 926-929.

DoF (2017). National fish week, compendium (In Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Government of Bangladesh, Dhaka.

Fernandes, J., A., Cheung, W., W. L., Jennings, S., Butenschön, M., Mora, L., Fröliche, r. T., L., Barange, M. & Grant, A. (2013). Modelling the effects of climate change on the distribution and production of marine fishes: accounting for trophic interactions in a dynamic bioclimate envelope model. *Global Change Biology* 19(8): 2596-2607.

FRSS (2017). Yearbook of Fisheries Statistics of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh. Vol. 33, pp 1-56.

Ghose, B. (2014). Fisheries and aquaculture in Bangladesh: challenges and opportunities. *Annals of Aquaculture and Research* 1(1): 1001.

Hoegh-Guldberg, O. & Bruno, J. F. (2010). The Impact of Climate Change on the World's Marine Ecosystems. *Science* 328(5985): 1523-1528.

Hossain, M. S., Chowdhury, S., R & Sharifuzzaman, S. M. (2017). Blue economic development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries. University of Chittagong, 32pp.

Hossain, M. S., Chowdhury, S. R., Navera, U. K., Hossain, M. A. R., Imam, B. & Sharifuzzaman, S. M. (2014). Opportunities and strategies for ocean and river resources management (Background paper for preparation of the 7th Five Year Plan). Food and Agricultural Organizations, Dhaka. 61pp.

Hussain, M. A., Islam, A. K. M. S., Hossain, M. A. & Hoque, M. T. (2012). Assessment of Salinity Distributions and Residual Currents at the Northern Bay of Bengal considering Climate Change Impacts. *The International Journal of Ocean and Climate Systems* 3(3): 173-186.

Hussain, M. G., Failler, P., Karim, A. A. & Alam, M. K. (2017). Major opportunities of blue economy development in Bangladesh. *Journal of the Indian Ocean Region* 14(1): 88-99.

Islam, M., M., Sallu, S., Hubacek, K. & Paavola, J. (2014). Limits and barriers to adaptation to climate variability and change in Bangladeshi coastal fishing communities. *Marine Policy* 43: 208-216.

Islam, M. M. (2012). Poverty in small-scale fishing communities in Bangladesh: Context and responses (Ph.D. thesis), University of Bremen, Germany, 2012, pp. 150.

Islam, M. M., Shamsuzzaman, M. M., Hoque Mozumder, M. M., Xiangmin, X., Ming, Y. & Abu Sayed Jewel, M. (2017). Exploitation and conservation of coastal and marine fisheries in Bangladesh: Do the fishery laws matter? *Marine Policy* 76: 143-151.

Islam, M. T. & Nursey-Bray, M. (2017). Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions. *Journal of Environmental Management* 200: 347-358.

Jagtap, T., G. & Nagle, V., L. (2007). Response and adaptability of mangrove habitats from the Indian subcontinent to changing climate. *AMBIO: A Journal of the Human Environment* 36(4): 328-334.

Kais, S. M. & Islam, M. S. (2017). Impacts of and resilience to climate change at the bottom of the shrimp commodity chain in Bangladesh: A preliminary investigation. *Aquaculture*.

Kreft, S., D. Eckstein & Melchior, I. (2017). Global climate risk index 2017. Who suffers most from extreme weather events? Weather-related loss events in 2015 and 1996 to 2015. Germanwatch e.V. URL: www.germanwatch.org/en/cri.

Macnab, V. & Barber, I. (2012). Some (worms) like it hot: fish parasites grow faster in warmer water, and alter host thermal preferences. *Global Change Biology* 18(5): 1540-1548.

Minar, M. H., Hossain, M. B. & Samsuddin, M. (2013). Climate Change and Coastal Zone of Bangladesh: Vulnerability, Resilience and Adaptability.

MoFA (2014). Ministry of foreign affairs, press Release: Press statement of the Hon'ble foreign minister on the verdict of the arbitral tribunal/PCA. Dhaka, 08 July 2014. URL: http://www.mofa.gov.bd/PressRelease/PRDetails.php?TxtUserId¼&PRid¼854/.

Ostrom, E. (1990). Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge.

Perry, A. L., Low, P. J., Ellis, J. R. & Reynolds, J. D. (2005). Climate Change and Distribution Shifts in Marine Fishes. *Science* 308(5730): 1912-1915.

Poloczanska, E. S., Brown, C. J., Sydeman, W. J., Kiessling, W., Schoeman, D. S., Moore, P. J., Brander, K., Bruno, J. F., Buckley, L. B., Burrows, M. T., Duarte, C. M., Halpern, B. S., Holding, J., Kappel, C. V., O'Connor, M. I., Pandolfi, J. M., Parmesan, C., Schwing, F., Thompson, S. A. & Richardson, A. J. (2013). Global imprint of climate change on marine life. *Nature Climate Change* 3: 919.

Pomeroy, R. S. (1993). A research framework for coastal fisheries co-management institutions. NAGA, The ICLARM Quarterly 1.

Pörtner, H. O., Berdal, B., Blust, R., Brix, O., Colosimo, A., De Wachter, B., Giuliani, A., Johansen, T., Fischer, T., Knust, R., Lannig, G., Naevdal, G., Nedenes, A., Nyhammer, G., Sartoris, F. J., Serendero, I., Sirabella, P., Thorkildsen, S. & Zakhartsev, M. (2001). Climate induced temperature effects on growth performance, fecundity and recruitment in marine fish: developing a hypothesis for cause and effect relationships in Atlantic cod (Gadus morhua) and common eelpout (Zoarces viviparus). *Continental Shelf Research* 21(18): 1975-1997.

Pörtner, H. O. & Peck, M. A. (2010). Climate change effects on fishes and fisheries: towards a cause-and-effect understanding. *Journal of Fish Biology* 77(8): 1745-1779.

Rahman, M. A. (2018). Governance matters: climate change, corruption, and livelihoods in Bangladesh. *Climatic Change* 147(1): 313-326.

Ramana, M. V. & Devi, A. (2016). CCN concentrations and BC warming influenced by maritime ship emitted aerosol plumes over southern Bay of Bengal. *Scientific reports* 6: 30416.

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Möllmann, C. & Pinnegar, J. K. (2009). Resolving the effect of climate change on fish populations. *ICES Journal of Marine Science* 66(7): 1570-1583.

Shamsuzzaman, M. M., Xiangmin, X., Ming, Y. & Tania, N. J. (2017). Towards sustainable development of coastal fisheries resources in Bangladesh: An analysis of the legal and institutional framework. *Turkish Journal of Fisheries and Aquatic Sciences* 17(4): 833-841.

Singh, O. P. (2012). Satellite derived sea surface temperature variability in the Bay of Bengal.

Somero, G. N. (2010). The physiology of climate change: how potentials for acclimatization and genetic adaptation will determine 'winners' and 'losers'. *Journal of Experimental Biology* 213(6): 912-920.

Sovacool, B. K., D'Agostino, A. L., Meenawat, H. & Rawlani, A. (2012). Expert views of climate change adaptation in least developed Asia. *Journal of Environmental Management* 97: 78-88.

Srinivas, B., Sarin, M. M. & Sarma, V. V. S. S. (2015). Atmospheric outflow of nutrients to the Bay of Bengal: Impact of anthropogenic sources. *Journal of Marine Systems* 141: 34-44.

Staudt, A., Leidner, A. K., Howard, J., Brauman, K. A., Dukes, J. S., Hansen, L. J., Paukert, C., Sabo, J. & Solórzano, L. A. (2013). The added complications of climate change: understanding and managing biodiversity and ecosystems. *Frontiers in Ecology and the Environment* 11(9): 494-501.

Torell, M. & Salamanca, A. M. (2001). Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. Technical Report 60, pp. 212.

Vivekanandan, E., Hermes, R. & O'Brien, C. (2016). Climate change effects in the Bay of Bengal Large Marine Ecosystem. *Environmental Development* 17: 46-56.

Vivekanandan, E., Hussain, A. M. & Rajagopalan, M. (2009a). Vulnerability of corals to seawater warming. In: Impact, Adaptation and Vulnerability o fIndian agriculture to climatechange (ed. P.K. Aggarwal), Indian Council of Agricultural Research, New Delhi, pp. 97–100.

Vivekanandan, E. & Rajagopalan, M. (2009). Impact of rise in seawater temperature on the spawning of threadfin breams. In: Impact, Adaptation and Vulnerability of Indian agriculture to climate change (ed. P. K. Aggarwal), Indian Council of Agricultural Research, New Delhi, pp. 93–96.

Vivekanandan, E., Rajagopalan, M. & Pillai, N. G. K. (2009b). Recent trends in sea surface temperature and its impac ton oil sardine. In: Impact, Adaptation and Vulnerability o fIndian agriculture to climate change (ed. P. K. Aggarwal), Indian Council of Agricultural Research, New Delhi, pp. 89–92.

WTTC, 2018a. World Travel & Tourism Council: Travel & Tourism: Global Economic Impact & Issues.

WTTC, 2018b. World Travel & Tourism Council: Travel & Tourism Economic Impact 2018 - Bangladesh.

WTTC, 2012. World Travel and Tourism Council: UNWTO Tourism Highlight 2012 edition, .p.8

3 Future importance of maritime activities in Bangladesh

3.1 Abstract

Blue Economy is a concept of economic growth through the sustainable utilization of ocean resources with technological inputs to improve livelihoods and meet the growing demands for jobs without hampering the health of the ocean ecosystem. This paper offers an overview of current maritime key activities, major trends and scenarios, future blue economy development activities with economic and social importance, ecological importance and blue economy policy framework. This paper also focuses on the major constraints and challenges. The current maritime key activities include extraction of living and non-living resources, land based activities, trades and transportation, shipbuilding and ship breaking, tourism and recreation, man-made structures, energy production and, research and survey. The trend data show that the total fish landing and total export income from fisheries has been showed an increasing trend. However, data on mangrove revenue suggest that in recent years, revenues from this forest are comparatively less than the revenues from the 1980s and the 1990s. For further Blue Economy development Bangladesh needs to focus on marine fisheries, non-traditional species, marine biotechnology, oil gas and mineral mining, renewable energy, marine trade and transport, marine tourism and marine spatial planning. However, this paper founds that lack of Implementation and enforcement, management measures, limited planning and coordination are hindering the way of further Blue Economic development in Bangladesh. Thus a strategic management process integrating multiple stakeholders is an urgent need for a sustainable Blue Economy development in the maritime territory of Bangladesh.

3.2 Introduction

The concept of the Blue Economy has become synonymous with the "greening" of the ocean economy or one that more broadly aligns economic growth and job creation with the health of the world's oceans (Monnereau and Failler, 2014). More specifically the Blue Economy is a concept of economic growth through the sustainable utilization of ocean resources with technological inputs to improve livelihoods and meet the growing demands for jobs without hampering the health of the ocean ecosystem (Sarker et al., 2018). Discussions on Blue Economy started in Bangladesh after the settlement of maritime boundary delimitation dispute with Myanmar (2012) and India (2014). So, the Government has recently started dialogues with the stakeholders to adopt the concept of Blue Economy across relevant policies and plans (Hussain et al. 2017a; Hussain et al. 2017b). Blue Economy comprises activities that directly or indirectly take place in the seas, oceans and coasts using oceanic resources and eventually contributing to sustainable, inclusive economic growth, employment, well-being, while preserving the health of ocean. It includes activities such as exploration and development of marine resources, appropriate use of ocean and coastal space, use of ocean products, provision of goods and services to support ocean activities and protection of ocean environment. It is needless to say that for most developing states particularly for Bangladesh, making the transition to a blue economy would entail fundamental and systemic changes in their policy-regulatory–management–governance framework(s) and identification of various maritime economic functions (GED 2015 cited by Patil et al. 2018). The Blue Economy conceptualizes oceans and seas as "development spaces" where spatial planning integrates conservation, sustainable use of living resources, oil and mineral wealth extraction, bio-prospecting, sustainable energy production and marine transport (Alam 2014). Thus Blue Economy requires a balanced approach between conservation, development and utilization of marine and coastal ecosystems, all oceanic resources and services with a view to enhancing their value and generates decent employment, secure productive marine economy and healthy marine ecosystems (GED 2015 cited by Patil et al. 2018).

So far very limited national and international documents are published and available on the detailed concept and implementation of blue economy in Bangladesh. Therefore, this chapter aims to highlight

and describe in detail the future importance of maritime activities in Bangladesh and extend on current maritime key issues and future of sector wise activities including major challenges and constraints. The Chapter 3 consists of a number of sub-sections explaining mainly about overview of current maritime key activities, major trends and scenarios, future blue economy development activities (2030 and beyond), economic and social importance, ecological importance of natural capitals/resources, the way forward to a blue economy in Bangladesh, which also includes blue economy conceptual framework and blue economy policy framework and finally highlighting the major constraints and challenges.

3.3 Overview of current maritime key activities

The current maritime key activities include extraction of living and non-living resources, land based activities, trades and transportation, shipbuilding and ship breaking, tourism and recreation, man-made structures, energy production and, research and survey.

Extraction of living resources: Marine living resources in the maritime zone of Bangladesh consist of fisheries, mangrove forests, coral ecosystems, plankton, seagrass and seaweeds. However, currently fisheries resources and mangrove forests are directly used for economic purposes. Other living resources i.e. coral ecosystem, seagrass and seaweeds are used indirectly and have potentiality for developing further maritime activities in Bangladesh. Major fisheries resources include bony fishes, cartilaginous fishes, shrimps, crabs, lobster, mollusks, starfish, whales/Dolphins and squids (Table 6). Mangrove forest provides foods, honey and wax, thatching materials, medicine and fuel wood and timber for constructions.

Table 6 : Coastal and marine fisheries resources of Bangladesh

Category	Number of species		
	Hossain, 2001	Islam, 2003	Ahmed et al. 2008
Bony fish	475	475	442
Cartilaginous fish	50	-	-
Shrimp	25	24	56
Crab	15	50	16
Lobster	5	-	3
Mollusk (Oyster)	301	301	336
Whale/Dolphin	11	-	-
Squids	-	7	-

Source: FAO (2014)

Extraction of non-living resources: Potential non-living ocean resources in Bangladesh include gas, crude oil and sea salt, which could have a huge positive impact on national economic development. Twenty six gas fields are discovered until now in Bangladesh and 2 of them (i.e. Kutubdia and Sangu gas field; are located in the offshore areas (Badrul, 2015). In addition, several commercially important heavy minerals (i.e. Zircon, Rutile, Ilmenite, Leucoxene, Kyanite, Garnet, Magnetite and Monazite) have also economic importance.

Land based activities: The principal land based activities include urbanization, tourism and seaport development (i.e. Chittagong and Mongla sea port as well as the newly established Payra seaport). Small and large scale industries in the coastal cities (i.e. Chittagong and Khulna industrial zone), shipbuilding (i.e. Khulna shipyard) and shipbreaking (i.e. Sitakunda shipbreaking area in Chittagong) industries also provide important economic returns for Bangladesh.

Man- made structures and energy production: Conventional barrier techniques such as concrete blocks, earthen dike sand sand filled tubes, and wind mill for electricity generation are generally some example of man-made structures seen.

Research and survey: Currently different types of research activities are conducted by different different research organizations, universities and Bangladesh Navy. This research activity includes hydrographic data collection and biodiversity and fish stock assessment.

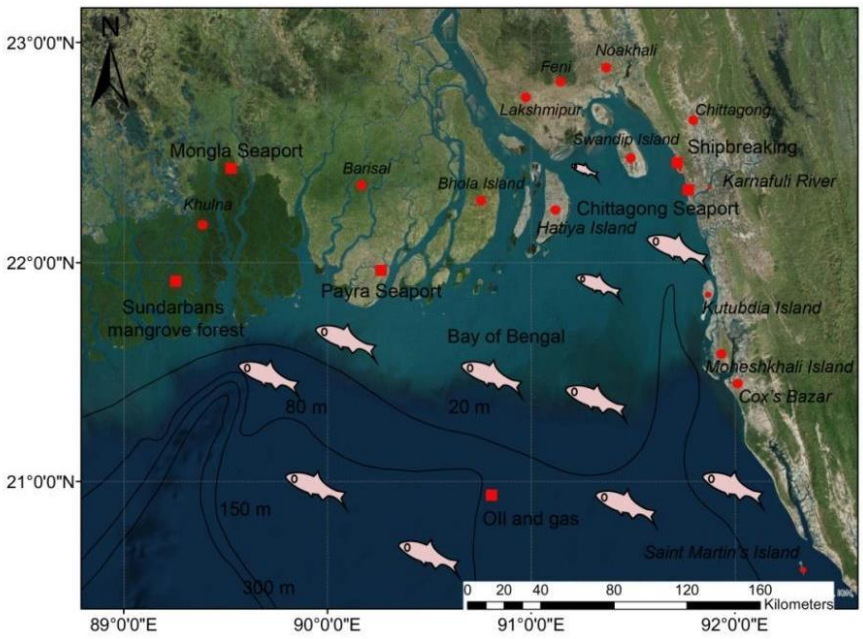

Figure 12 : Geographical location of the coastal area of Bangladesh.

3.4 Major trends and scenarios

Due to data limitation scenarios and trends for this study are restricted to fisheries, mangroves, tourism, salt production and shipping industries. The total fish landing and total export income from fisheries has been showed an increasing trend during the present decade in Bangladesh (Figure 13b). The trend of fish catch, export income, number of fishing trawlers, fishing days and CPUE were gradually increased until 1990s and then the trend was sharply increased. Data on mangrove revenue (Figure 13c) suggest that in recent years revenues from this forest are comparatively less than the revenues from the 1980s and the 1990s. The tourism sector in Bangladesh is now employing over 1 million people and this sector generates a total value of 8.4 million USD. In Cox's Bazar about 263 sq km area of land and in Chittagong around 20 sq km are currently being used for sea salt production. This sector creates over 5 million employments and contributes about 35.5 million to 41.2 million USD each year to the national economy. Bangladesh was the top ship recycling nation from 2004-2009, became the second in 2012, scrapping around 270 ships and by dismantling 210 ships in 2013, became the third largest ship breaking nation in the world. The ship breaking industry in Bangladesh is estimated worth an annual turn-over of around 1.5 billion dollars (Figure 13).

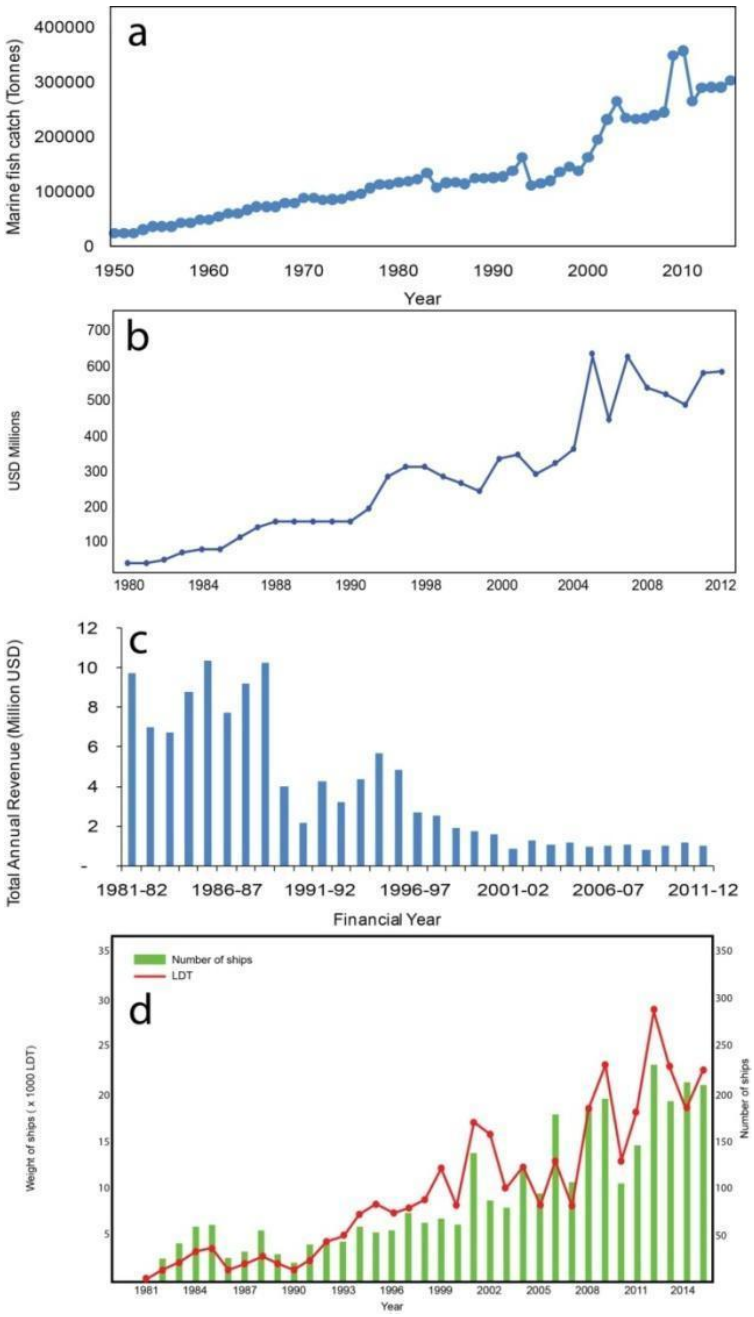

Figure 13 : Long-term marine fish catch (a), export income from fisheries (b), revenue from the Sundarban mangrove forest (c) and LDT (LDT) in Bangladesh (d).

3.5 Future BE development activities (2030 and beyond)

Currently and until 2030 and beyond the following major development and economic activities have emphasized to implement under the concept of ocean or blue economy development in Bangladesh. In this section we are summarizing the future potentials of marine based economic resources (Living, non-living and potential other resources) within the identified sectors.

3.5.1 Marine fisheries and aquaculture

In Bangladesh to harvest and exploit marine fish resources, which is consist of multiple species, various fishing nets and gears are used at different level water depths. Bangladesh must come out of the traditional fishing practices and harness the potentials of moving towards beyond the existing fishing

grounds to harvest large pelagic fishes from deeper zones within 200 nm of EEZ and even up to the high seas (Hussain et al. 2017a). Most essential and important task is to conduct a thorough survey to accomplish stock assessment of marine fishes in BoB area to explore more new fishing ground(s). For harvesting large pelagic fish, the country should have to adopt appropriate deep sea fishing technologies i.e. long line and hook fishing and using supporting crafts, gears and vessels (Hussain et al. 2017a). Rehabilitation of Hilsa fishery is another important task that needs to be intervened as trans-boundary issue. Hilsa as transboundary species of BoB, a joint effort among Bangladesh, India and Myanmar might be effective to prevent the harvest Hilsa juveniles and protect the mature brood stock during the banning period (Hussain et al. 2017a). In respect of indiscriminate harvesting of gravid mother shrimp, P. monodon, similar regulation can be adopted to avoid trawling at the depth of 10 – 40 meters of inshore marine waters.

3.5.2 Marine aquaculture of fin fish and shellfish species

Breeding and farming of sea bass, *Lates calcarifer*, need to be initiated as an important high value aquaculture species. Production of seabass, hilsa, mullet, pompfret etc. in near shore ponds and offshore cages may be an interesting option locally as well as commercially. Soft shell crab farming is an innovative and new technology, which could extensively be practised in other coastal areas.

3.5.3 Marine non-traditional species culture

There are enormous opportunities for maricultire of non-traditional marine species like seaweed, macro algae, shellfish (ie. mussel, oyster etc.), sea urchin and sea cucumber. There are 168 species of sea weed and other macro algae and some of them are commercially important in Bangladesh. Identification of suitable species and development of commercial culture techniques of sea weed might benefit the country. Mussel, Oyster and other shellfish culture could also be included. Sea urchin, sea cucumber etc. living habitat can also be explored in particularly at Inani of Cox's Bazar and St. Martins island as coral basements.

3.5.4 Marine biotechnology

Unlike other countries of the world, no doubt that existing living resources in particularly the marine organisms can be used as a source of new materials/products especially for application in human health care (antibiotics, anti-cancer, bioactive compounds and other pharmaceutical drugs, nutritional supplements, etc.) and nutritionally balanced food (marine fish, shrimps, crabs, molluscs, seaweed etc.).

3.5.5 Oil, gas and minerals mining

Despite significant potential, relatively little oil and gas production has occurred to date within the maritime territory of Bangladesh. After the settlement of maritime boundary disputes in 2012 and 2014 have generated new interest in offshore exploration (Petrobangla 2016). Apart from oil and gas, several studies have found sands containing valuable heavy minerals intermittently over the 250 km of coast from Patenga to Teknaf. If extractable, these minerals could contribute to a range of existing industries such as paper, glass, chemical, ceramic, and welding electrodes (Hossain et al. 2014).

Table 7 : Sectors to develop and way to do it

What to develop?	How to do?
Marine fisheries	Explore pelagic fishery, Explore new fishing grounds, Adopt deep sea fishing techniques, Re-habilitation of hilsa fishery, Adopt mariculture and conservation measures

What to develop?	How to do?
Non-traditional species	Identification of suitable species, Development of culture technique, Identification of site, implementation of culture
Marine biotechnology	Basis research, applied research, implementation of applied research, commercialization
Oil, gas and minerals mining	Intensification of gas, oil and minerals exploration
Renewable energy	Use of wind, wave, tide, current and heat stored in water for energy production
Marine trade and transport	Creation of hub within the Bay of Bengal, Attraction of international market, Reduction of pollution
Marine tourism	Sole tourist spot declaration, attract international tourist, providing facilities
Marine spatial planning	Object identification, object wise zone selection, planning, implementation of plan and monitoring

Source: Own conception

3.5.6 Marine renewable energy

In view of this naturally available energy sources viz. marine wind, wave, solar radiation, tide, water currents, etc. could be utilized through the available and developing technologies to produce renewable energy.

3.5.7 Marine trade, shipping and transport

The country's ports are not located close to main international shipping lanes which is a constraint, however serving as a hub within the Bay of Bengal (along with Kolkata or Chennai) could be an opportunity. Local shipping companies needs to come forward to add more fleets including the expansion of fleet in terms of size and capacity to lift the economic face of the country in a short time (Hossain et al. 2014).

3.5.8 Marine tourism

Bangladesh should process to enter global ocean cruise map for opening a new era in tourism industry. Cruise tourism acts as another valuable travel proposition bringing the people of the world closer together through connection of wishes and waterways.

3.5.9 Marine Spatial Planning (MSP)

MSP is the first step towards ecosystem-based management of the sea and its resources. MSP implementation will facilitate an improved planning and management systems for protecting marine ecosystem heath and services, which will emphasize a balance between economic development and marine environmental conservation (Hassan 2013). The time is extremely crucial to formulate an effective policy and strategy for MSP at national level with the initiative of an authorised body under the auspices of PM's office for sector by sector planning of the blue economy of Bay of Bengal (Hossain et al.2014).

3.6 Economic and social importance

Marine resources are playing an important role in national economy and to the society by providing food and employment opportunities (Figure 14). Fisheries resources are important to the individual for food security, economic security, empowerment, and to society for cultural services, recreational services, human health and well-being, knowledge transfer and capacity building. The Sundarban

mangrove forest in the south-west coastal zone offers diverse livelihood options to the local people and contributes to the national economy. Mangrove wood is resistant to rot and insects, making it extremely valuable. As seaweeds have medicinal and food values, therefore, have the export potentials as seafood to earn substantial foreign revenue. Mollusks species have medicinal values, for example clam are supposed to be the good for heart trouble. Tourism can provide direct jobs to the community i.e. tour guides and hotel housekeeping. Oil and gas sectors are also contributing in national economy through creating job opportunities.

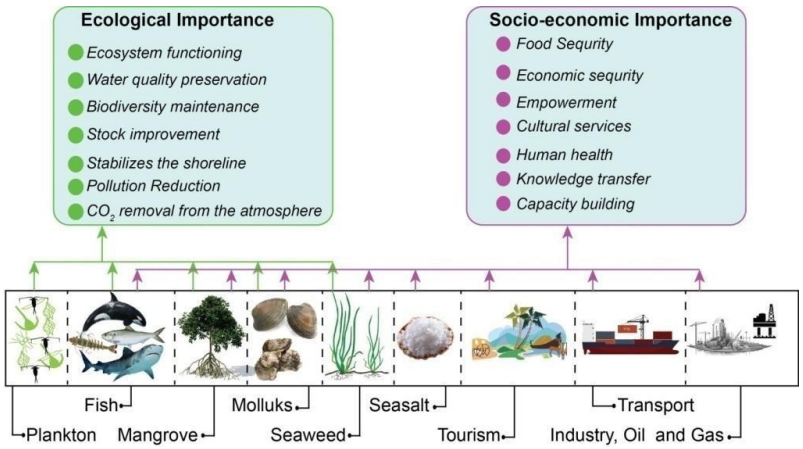

Figure 14 : Socio-economical and ecological importance of marine resources and activities

3.7 Ecological importance of natural resources

Marine natural resources which have ecological importance (Figure 14), especially in Bangladesh coast, include plankton, fish, mangrove, seagrass, seaweeds, mollusk and coral reef. Plankton forms the foundation of food chain by serving as food source for other organisms. Fishes are ecologically important for their role in ecosystem functioning and biodiversity maintenance, and also as indicators of ecosystem change (Allan, 2004). Mangrove forest ecosystem provides irreplaceable habitat for many diverse species of birds, mammals, crustacean and fish (Lee et al., 2014). Seaweeds beds serve as the habitat and shelter ground for many coastal and marine organisms for their whole life span or for a part of their life cycle. Oysters and other suspension-feeding bivalves help estuaries and coastal oceans against developing and sustaining excessive phytoplankton blooms (Officer et al., 1982). Coral reefs are important for many different reasons aside from supposedly containing the most diverse ecosystems on the planet (Komyakova et al., 2013).

3.8 Way forward to apply the Blue Economy Concept in Bangladesh

3.8.1 Blue Economy conceptual framework

The Blue Economy concept defines a pathway over time: for an ocean economy that transitions towards a “Blue Economy” where ecosystem service flows are sustainable inputs to ocean-based industries and the impacts from these industries upon the ecosystems are reduced – via policy reforms. Patil et al. (2016) suggested and proposed an updated conceptual framework for the blue economy in Figure 15, in order to help illustrate the circularity of the ocean economy system, and transition of this system towards a “blue economy” via the introduction of policy instruments that enhance the sustainability of natural capital inputs and reduce the impacts of ocean industries on the underlying ecosystems. The

intention is to provide an organizing framework for policies that simultaneously promote economic development and environmental management (Colgan CS. 2017).

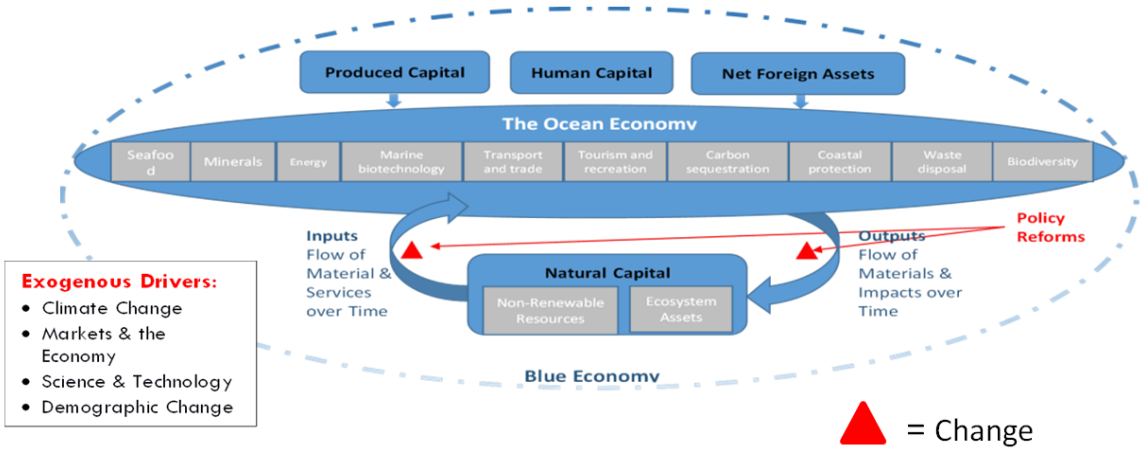

Figure 15 : Blue Economy Conceptual Framework. Source: Adapted from Patil et al. (2016)

The conceptual framework supports consideration of the ocean economy and ecological systems together as the blue economy, recognizing the relationship between the natural capital and the economic activity, as well as produced capital, human capital and net foreign assets (Patil et al. 2016; Patil et al. 2018). The framework also includes drivers of change external to the blue economy, such as climate change, larger markets and the economy, science and technology and demographic change. In essence, Figure 15 provides a conceptual framework for the Government of Bangladesh (Patil et al. 2018) to: a) think about economic activity in the ocean as a discrete and unique segment of the larger economy, with shared risks and opportunities (including cluster opportunities within the ocean space); and b) measure and incorporate natural capital into accounting and supporting policies for this ocean economy.

3.8.2 Blue Economy policy framework

The growth in the country's ocean economy is contingent upon the status of ocean ecosystems has been emphasized in the Seventh Five Year Plan, which also suggested thatwhile "there are some prospects for oil and gas resources, the potential is most promising for marine fishing, transportation and tourism (GED, 2015). The plan is centered around three themes, of which aims to implement "a sustainable development pathway that is resilient to disaster and climate change; entails sustainable use of natural resources; and successfully manages the inevitable urbanization transition" – consistent with the definition of the blue economy concept (GED, 2015).The Plan suggests articulation of an integrated Coastal and Ocean Management Policy under this concept and describes the following actions/programs (among others) to promote the transition to a blue economy during the FY2016 – 2020 period in Bangladesh (recently stated by Patil et al. 2018):

- Protecting and managing the fisheries for the present and future generations,
- Developing a strong renewable energy sector using ocean and atmospheric forces,
- Maintaining existing (e.g. ship building) and developing new maritime industries,
- Extending fishing areas using new technologies and methods even beyond EEZ in the international waters,

- Developing a strong human resource base for domestic utilization, and export to foreign job markets,

- Substantially increasing fisheries production and export earnings through improved inland aquaculture and introduction of marine aquaculture,

- Creating a competitive tourism industry, including ecotourism and marine cruises,

- Further increasing revenue from shipping and commerce by the expansion of domestic fleet and destinations, transshipment and transit provisions, linking neighboring states to the sea-ports, etc.,

- Give special priority to anticipated Climate Change impacts on all relevant matters, and adjust policies and plans,

- Maintain the inland river systems and ecosystems for fishery, sediment transport, and inland shipping,

- Building a solid science, research and education base, and

- Along with other coastal areas, establishment of marine academy in Khulna may be considered (GED 2015)."

In summary, the Government of Bangladesh has articulated a clear policy objective to apply the blue economy concept to the ocean economy in the Bay of Bengal, as well as identified a number of initial activities and programs to start down this pathway (Patil. et al. 2018).

3.9 Challenges and constraints

3.9.1 Lack of Implementation and Enforcement Management Measures

In Bangladesh, many opportunities in marine resources development remain untapped due to lack of implementation and enforcement of management measures. To minimize these issues by the respective ministry/departments, no regulation and enforcement measures have yet been implemented. Until today another management issue remains an obstacle in the country that marine fish stocks are being assessed on fragmented and less reliable catch data from commercial vessels. Due to lack of modern crafts and gears, incapability in regard to harvesting and catching of large pelagic fish stocks in deep sea areas already exists in the country.

3.9.2 Lack of planning

In Bangladesh, Marine Spatial Planning (MSP) has not been designed and implemented in coordination of various stakeholders. MSP should be integrated and multi-objective, strategic and future oriented, and continuous and adaptive to use all marine resources for sustainable blue growth (Hossain et al., 2014; Alam, 2016). No straight forward planning has yet been made to declare and establish specific Marine Protected Areas (MPA) in the country. To implement Ecosystem Approach to Fisheries Management (EAFM) planning has not yet been made in the country according to FAO Code of Conduct, 1995 laid out as broad principles and approaches for effective and responsible fisheries management, which embody the concept of EAF (FAO, 2003).

3.9.3 Lack of coordination

The lack of coordination between and among the partners is presently considered as one of the most important gaps for development of marine based economic sectors in the country. In that case public private partnership is seriously hampering the development in particularly in the sectors like trade, shipping, tourism, oil and gas field exploration, fish preservation and marketing, ecosystem services, social welfare related to coastal dwellers etc. (Husain et al. 2017a; Husain et al. 2017b).

3.10 Conclusion

It is attempted in this chapter to highlight and describe in detail the future importance of maritime in Bangladesh and deepen on current maritime key issues and future of sector wise blue economy activities including the major challenges and constraints. In this process, a coordinated approach with concerned stakeholder's groups is required to determine the extent to which these constraints can be turned into opportunities, and to ensure that development of the blue economy does not result in unsustainable and damaging practices for the benefit of short term economic gains over longer terms sustainable economic and social benefits. In particular, for Bangladesh, this involves developing a maritime/marine spatial planning directive to detail coordination between blue economy sectors and stakeholders to ensure sustainable development. Better linking research activities and sectoral development is required to provide a coordinated approach to development of the blue economy in Bangladesh, which is currently lacking. Lessons can be learnt from developments in marine spatial planning, which are currently ongoing in developed nations such as the EU to ensure that developments in the blue economy lead to sustainable outcomes in line with the country's current and future development objectives (Hussain et al. 2017a; Hussain et al. 2017b).

3.11 References

Abdullah, A.N.M., Stacey, N., Garnett, S.T., Myers, B., 2016. Economic dependence on mangrove forest resources for livelihoods in the Sundarbans, Bangladesh. Forest Policy and Economics 64, 15-24.

Ahammad, H., Sujauddin, M., 2017. Contributions of Ship Recycling in Bangladesh: An Economic Assessment, IMO-NORAD SENSREC Project, London, UK, p. 78.

Ahmed, N. and M. Glaser. 2016. Can "Integrated Multi-Trophic Aquaculture" adapt to climate change in Coastal Bangladesh. Ocean and Coastal Management 132:120-131

Allan, J.D., 2004. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. Annual Review of Ecology, Evolution, and Systematics 35, 257-284.

Alam, M. K. 1997. Regional maritime cooperation under the auspices of SAARC. BIISS Journal 19-41.

Alam MK. 2014. Ocean/Blue economy for Bangladesh. In: Proceedings of International Workshop on Blue Economy. Dhaka, Bangladesh: Bangladesh Ministry of Foreign Affairs. [accessed 2017 Dec 18]. http://www.mofa.gov.bd/content/about-blue-economy.

Alam, M.A. 2016. Marine spatial planning: Bangladesh perspective. Asia Pacific Journal of Energy and Environment 3: 21-28. http://journals.abc.us.org/index.php/apjee/article/view/870

Al Mamun MA, Raquib M, Tania TC, Rahman SMK. 2014. Salt Industry of Bangladesh: A Study in the Cox's Bazar. Banglavision 14:7–17.

Andreae, M.O., Crutzen, P.J., 1997. Atmospheric aerosols: Biogeochemical sources and role in atmospheric chemistry. Science 276, 1052-1058.

Asia-Pacific Fishery Commission (APFIC). 2014. Regional overview of aquaculture trends in the Asia-Pacific Region 2014, RAP Publication 2014/26, 45 p.

Badrul, I., 2015. Bangladesh falls behind Myanmar in offshore gas exploration. The Daily Star.

Banerjee, S. 2013. Vanishing Islands of Bangladesh. Retrieved from Down to Earth: http://www.downtoearth.org.in/content/vanishing-islands-bangladesh.

Barua, S., Karim, E., Humayun, N.M., 2014. Present Status and Species Composition of Commercially Important Finfish in Landed Trawl Catch from Bangladesh Marine Waters. International Journal of Pure and Applied Zoology 2, 10.

bdnews24.com. 2017. Bangladesh discovers new gas field in southern district of Bhola. bdnews24.com. [accessed 2017 Dec 18]. https://bdnews24.com/bangladesh/2017/10/23/bangladesh-discovers-new-gas-field-in-southern-district-of-bhola.

BOBLME. 2012. Transboundary Diagnostic Analysis (TDA).

Charlson, R.J., Lovelock, J.E., Andreae, M.O., Warren, S.G., 1987. Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate. Nature 326, 655-661.

Chowdhury, S. R., M. S. Hossain, S. M. Sharifuzzaman and S. Sarker. 2015. Blue Carbon in the Coastal Ecosystems of Bangladesh. Project Document, Support to Bangladesh on Climate Change Negotiation and Knowledge Management on Various Streams of UNFCCC Process Project, funded by DFID and Danida, implemented by IUCN Bangladesh Country Office.

Colgan CS. 2017. Climate Change and the Blue Economy of the Indian Ocean.

Detsch, J., 2014. Bangladesh: Asia's New Energy Superpower? The Diplomat.

DoF, 2013. Fishery Statistical Yearbook of Bangladesh (2011-12). Fisheries Resources Service System, Department of Fisheries (DoF). Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF, 2016. National Fish Week 2016 Compendium. Department of Fisheries, Ministry of Fisheries and Livestock in Bangladesh. 148pp.

Duarte, C.M., Wu, J., Xiao, X., Bruhn, A., Krause-Jensen, D., 2017. Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation? Frontiers in Marine Science 4.

El Gamal, A.A., 2010. Biological importance of marine algae. Saudi Pharmaceutical Journal 18, 1-25.

Failler P, Hussain MG, Karim AA, Alam MK, Drakeford B. 2017.Opportunities and Constraints of Blue Economy Development in Bangladesh. Paper presented at International Workshop on Blue Economy Dialogue, 22– 23 November 2017; Hotel Pan Pacific Sonargaon, Dhaka, Bangladesh

Falkowski, P.G., Barber, R.T., Smetacek, V., 1998. Biogeochemical controls and feedbacks on ocean primary production. Science 281, 200-206.

Follows, M.J., Dutkiewicz, S., Grant, S., Chisholm, S.W., 2007. Emergent biogeography of microbial communities in a model ocean. Science 315, 1843-1846.

FAO 2014. The state of world fisheries and aquaculture (opportunities and challenges) Food and Agricultural Organization of the United Nations, Rome.

FAO 2016. Global aquaculture production dataset 1950-2014 (Fishstat), Fisheries and Aquaculture Department. Rome, Italy..Available at: www.fao.org/fishery/statistics/software/fishstatj/en

FRSS, 2017. Yearbook of Fisheries Statistics of Bangladesh. Fisheries Resources

Survey System (FRSS), Department of Fisheries, Bangladesh. Volume 33: 124 p.

General Economics Division (GED). 2015. Seventh Five Year Plan (FY2016 – 2020): Accelerating Growth, Empowering Citizens. Dhaka, Bangladesh: Planning Commission, Government of the People's Republic of Bangladesh.

Golder, M.I., Failler, Pierre., Hussain, M.G., Sen, A. and Alim, M.A.. 2017. Fisheries and Aquaculture Trends in Bangladesh: Potentials and Challenges of Marine Fisheries and Mariculture under the Concept of Blue Economy Development, organized by Maritime Affairs Unit, Ministry of Foreign Affairs, Government of Bangladesh with the support of the European Union in association with Depatment of Fisheries, Cox's Bazar, Bangladesh. 26 pp.

Haamer, J., 1996. Improving Water Quality in a Eutrophied Fjord System with Mussel Farming. Ambio 25, 356-362.

Hassan, D. 2013. "The Great Barrier Reef: Maritime spatial planning", Environment Policy and Law, 43:4-5.

Hassan, D. and Haque, E. 2015. Marine spatial planning in the Bay of Bengal sub-region in South Asia. In: D. Hassan, T. Kuokkanen and N. Soininen (eds), Transboundary marine spatial planning and international law. Abingdon, Oxon ; New York, NY : Routledge/Taylor and Francis Group, 2015. pp. 203 – 218.

He, X., Kitchell, J.F., 1990. Direct and Indirect Effects of Predation on a Fish Community: A Whole-Lake Experiment. Transactions of the American Fisheries Society 119, 825-835.

Hossain, K., K, A.I., Zakaria, S., M, G.N., 2010. Ship Recycling Prospects in Bangladesh. Proceedings of MARTEC, 297–302.

Hossain, M.S., Chowdhury, S.R., Navera, U.K., Hossain, M.A.R., Imam, B., Sharifuzzaman, S.M., 2014. Opportunities and Strategies for Ocean and River Resources Management, Background paper for preparation of the 7th Five Year Plan. FAO, Bangladesh Country Office, Dhaka, Bangladesh.

Hossain, M.S., Lin, C.K., Tokunaga, M., Demaine, H., Hussain, M.Z., 2003. Land use zoning for salt production in Cox's Bazar coast of Bangladesh: A remote sensing and GIS analysis. Asian Journal of Geoinformatics 3, 9.

Hoq, M. E., Haroon, A. K. Y., & Chakraborty, S. C. 2013. Technical outcomes of the BOBLME project in Bangladesh. Support to sustainable management of the BOBLME project (SBOBLME Pub./Rep. 09). Bangladesh Fisheries Research Institute. 32pp.

Hussain, M.G. and M.J. Rahman. 2010. Marine fisheries resources of Bangladesh: Stock status and management issues. pp 37-51. In Sustainable Management of Fisheries Resources of the Bay of Bengal (eds. M.G. Hussain and M.E. Hoq.). Support to BOBLME Project, Bangladesh Fisheries Research Institute, Bangladesh.

Hussain, M.G., Failler, P, Karim, A.A. and Alam, M.K. 2017a. Review on opportunities, constraints and challenges of blue economy development in Bangladesh. Journal of Fisheries and Life Sciences, 2(1): 45-57.

Hussain, M.G., Failler, P, Karim, A. A. and Alam, M.K. 2017b. Major Opportunities of Blue Economy Development in Bangladesh. Journal of Indian Ocean Region: DOI: 10.1080/19480881.2017.1368250.

Islam, M.M., Shamsuzzaman, M.M., Hoque Mozumder, M.M., Xiangmin, X., Ming, Y., Abu Sayed Jewel, M., 2017. Exploitation and conservation of coastal and marine fisheries in Bangladesh: Do the fishery laws matter? Mar. Pol. 76, 143-151.

Islam, M.M., Sunny, A.R., Hossain, M.M., Friess, D.A., 2018. Drivers of mangrove ecosystem service change in the Sundarbans of Bangladesh. Singapore Journal of Tropical Geography, n/a-n/a.

Khan, M.G., 2008. The status of coastal and marine fishing fleet in Bangladesh and preparedness for a monitoring, control and surveillance regime, National workshop on monitoring, control and surveillance in marine fisheries-Bangladesh in Cox'sbazar, Bangladesh. GoB/DANIDA/BOBP-IGO, Cox'sbazar, Bangladesh, pp. 77-79.

Khan, S., 2015. Making IOCs interested in the bidding for hydrocarbon exploration. The Financial Express.

Komyakova, V., Munday, P.L., Jones, G.P., 2013. Relative Importance of Coral Cover, Habitat Complexity and Diversity in Determining the Structure of Reef Fish Communities. PloS one 8, e83178.

Lee, S.Y., Primavera, J.H., Dahdouh-Guebas, F., McKee, K., Bosire, J.O., Cannicci, S., Diele, K., Fromard, F., Koedam, N., Marchand, C., Mendelssohn, I., Mukherjee, N., Record, S., 2014. Ecological role and services of tropical mangrove ecosystems: a reassessment. Global Ecology and Biogeography 23, 726-743.

Lynch, A.J., Cooke, S.J., Deines, A.M., Bower, S.D., Bunnell, D.B., Cowx, I.G., Nguyen, V.M., Nohner, J., Phouthavong, K., Riley, B., Rogers, M.W., Taylor, W.W., Woelmer, W., Youn, S.-J., Beard, T.D., 2016. The social, economic, and environmental importance of inland fish and fisheries. Environmental Reviews 24, 115-121.

10.1080/19480881.2017.1368250.

Ministry of External Affairs (MEA). 2015a. Joint Declaration between Bangladesh and India during Visit of Prime Minister of India to Bangladesh. [accessed 2017 Dec 18]. http://www.mea.gov.in/bilateral-documents.htm?dtl/25346/Joint_Declaration_between_Bangladesh_and_India_during_Visit_of_Prime_Minister_of_India_to_Bangladesh_quot_N.

Ministry of External Affairs (MEA). 2015b. Memorandum of Understanding between the Government of the Republic of India and the Government of the People's Republic of Bangladesh in the field of Blue Economy and Maritime Co-operation in the Bay of Bengal and the Indian Ocean Region.

MoFA, 2016. Press Release: Press statement of the Hon'ble Foreign Minister on the verdict of the Arbitral Tribunal/PCA, Dhaka.

Monnereau, I. and. Failler, P. (2014). Unlocking the full potential of the blue economy: Are African Small Island Developing States ready to embrace the opportunities? African Climate Policy Center and Economic Commission for Africa, http://www.climdev-africa.org/sites/default/files/DocumentAttachments/Blue%20Economy_19Sept14.pdf

Muller-Karger, F.E., Varela, R., Thunell, R., Luerssen, R., Hu, C., Walsh, J.J., 2005. The importance of continental margins in the global carbon cycle. Geophysical Research Letters 32, 1-4.

Nellemann. C., E. Corcoran, C.M. Duarte, L. Valdés, C. De Young, L. Fonseca and G. Grimsditch. 2009. Blue Carbon. A Rapid Response Assessment. United Nations Environment Programme, GRIDArendal, www.grida.no

Ocean, P.P., 2017. Why are oceans important?

OECD, 2016. The Ocean Economy in 2030. OECD Publishing.

Officer, C.B., Smayda, T.J., Mann, R., 1982. Benthic Filter Feeding: A Natural Eutrophication Control. Marine Ecology Progress Series 9, 203-210.

Orr, S., Pittock, J., Chapagain, A., Dumaresq, D., 2012. Dams on the Mekong River: Lost fish protein and the implications for land and water resources. Global Environmental Change 22, 925-932.

Parvez, M. S. 2012. Bay of Bengal prospects towards national flourishment. Retrieved from BD Fish: http://en.bdfish.org/2012/03/bay-of-bengalprospects-towards-national-flourishment/

Patil, P.G., Virdin, J., Colgan, C.S., Hussain, M.G., Failler, P., and Vegh, T. (2018). Toward a Blue Economy: A Pathway for Bangladesh's Sustainable Growth. Washington, D.C., The World Bank Group.

Patil PG, Virdin J, Diez SM, Roberts J, Singh A. 2016. Toward a Blue Economy: A Promise for Sustainable Growth in the Caribbean. Washington, DC: The World Bank.

Petrobangla. 2016. Annual Report: 2015.

Premarathne, D.M.U., 2010. Non-living ocean resources. Vidurava 27, 4.

Rahman M. M. 2006. A study on coastal water pollution of Bangladesh in the Bay of Bengal. [Dhaka, Bangladesh]: BRAC University.

Rahman, M. R. 2013. Regional cooperation in maritime security: A view from the Bay of Bengal. Annual International Studies Convention 2013, organized by Jawaharlal Nehru University (JNU), New Delhi, India, 10-12 December, 2013. https://ssrn.com/abstract=2369076

Sarker, S., Bhuyan, A.A.H., Rahman, M.M., Islam, M.A., Hossain, M.S., Basak, S.C., Islam, M.M., 2018. From science to action: Exploring the potentials of Blue Economy for enhancing economic sustainability in Bangladesh. Ocean & Coastal Management 157, 13.

Shamsuzzaman, M.M., Islam, M.M., Tania, N.J., Abdullah Al-Mamun, M., Barman, P.P., Xu, X., 2017. Fisheries resources of Bangladesh: Present status and future direction. Aquaculture and Fisheries 2, 145-156.

Sujauddin, M., Koide, R., Komatsu, T., Hossain, M.M., Tokoro, C., Murakami, S., 2015. Characterization of ship breaking industry in Bangladesh. Journal of Material Cycles and Waste Management 17, 72-83.

Tedesco, K., Thunell, R., 2003. High resolution tropical climate record for the last 6,000 years. Geophysical Research Letters 30, 17.

Thakur, N.L. and A.N. Thakur. 2006. Marine biotechnology: An overview. Indian Journal of Biotechnology 5:263-268.

Thilsted, S.H., Roos, N., Hassan, N., 1997. The role of small indigenous fish species in food and nutrition security in Bangladesh. Naga 20.

Trumper, K., M. Bertzky, B. Dickson, G. van der Heijden, M. Jenkins and P. Manning. 2009. The Natural Fix? The role of ecosystems in climate mitigation. A UNEP rapid response assessment. UNEP, UNEPWCMC, Cambridge, UK, 65pp. http://www. unep.org/pdf/ BioseqRRA_scr.pdf.

Valiela, I., J.L. Bowen and J..K York. 2001. Mangrove forests: One of the worlds threatened major tropical environments. BioScience 51:807-815.

WFO, 2008. Towards sustainable coastal and marine capture fisheries in Bangladesh: initiating a precautionary approach. Ministry of Fisheries and livestock, p. 86.

Wipfli, M.S., Baxter, C.V., 2010. Linking Ecosystems, Food Webs, and Fish Production: Subsidies in Salmonid Watersheds. Fisheries 35, 373-387.

World Bank. 2017. Bangladesh Trade Summary: WITS Data. [accessed 2017 Dec 19]. https://wits.worldbank.org/CountryProfile/en/Country/BGD/Year/LTST/Summary.

World Bank, United Nations Department of Economic and Social Affairs (UNDESA). 2017. The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine

Resources for Small Island Developing States and Coastal Least Developed Countries. Washington, DC: The World Bank.

World Commission on Environment and Development (WCED). 1987. Our Common Future. New York, NY: United Nations.

Zilinskas, R.A., R.R. Colwell, D.W. Lipton and R.T. Hill. 1995. The Global Challenge of Marine Biotechnology: A Status Report on the United States, Japan, Australia and Norway. University of Maryland Sea Grant. UM-SG-TS-95-01. 372p

4 Augmenting marine Food Production through fisheries management and mariculture

4.1 Abstract

There is new aspiration of sustainable exploitation of marine resources and to achieve sustainable development goals (SDG 14) in recent years. In this context, this document delineates new scope of venturing into the blue economy relative to marine fisheries and mariculture. Potential interventions in marine fisheries include – (i) expansion of the commercial fishing area (beyond the 80 m depth) for harvesting high value fish species (such as tuna, lakkha), (ii) exploration for new fishing grounds and fisheries, (iii) value addition and reducing post-harvest losses, and (iv) assessment of fisheries stocks for estimation of potential yields and optimum sizes of harvest. Food production through mariculture mostly relies on – (i) domestication of new species (such as finfish: seabass, mullet, hilsa, grouper; crustaceans: mud crab; plants: seaweeds) for product diversification and risk reduction towards economic stability, (ii) production intensification (such as semi-intensive farming) and adoption of innovative fish/shellfish farming (such as marine cage culture, aquasilviculture, integrated multi-trophic aquaculture) to create new business opportunities, and (iii) live feeds (such as rotifers, artemia biomass) production for hatchery for sustaining the mariculture industry. Nevertheless, investments, knowledge, innovations, new technologies, new breeds and newly domesticated mariculture species can promise a blue revolution in Bangladesh.

4.2 Introduction

More than half (56%) of the total fisheries product produced in Bangladesh comes from freshwater aquaculture, while inland capture fisheries and marine capture fisheries provide 28% and 16%, respectively (DoF 2017). Marine aquaculture, which is limited to coastal and brackishwater farming, is dedicated to shrimp culture only. Therefore, it is clearly evident that contribution of marine waters to aquaculture production of the country is very low (Figure 16). Although there is still a marginal increasing trend in marine capture fisheries production, which is mostly shared by the hilsa fishery and may be the outcome of increasing fishing effort and efficiency, there are signs of depletion of some fishery stocks too. For example, changes in catch composition, decreased availability of high value fish species (such as lakkha/threadfin) and increased exploitation of low value species (such as sardine) clearly indicate that some of the fisheries are depleting in the marine territory of Bangladesh. In response to the declining capture fisheries, rising demand of fish protein by the growing population and shrinking land based resources, an increasing marine food production through expansion of mariculture and management of marine fisheries is inevitable. Importantly, after the settlement of maritime border disputes with neighboring states, Bangladesh now has a statutory right on 118,813 km^2 marine area in the Bay of Bengal and this has initiated a new aspiration of sustainable marine resource exploitation termed as ‘blue economy’. In this context, the aim of this document is to identify new opportunities for venturing into the blue economy related to marine fisheries and mariculture. This information would be useful for formulating a national policy for ocean governance and for developing the blue economy in Bangladesh.

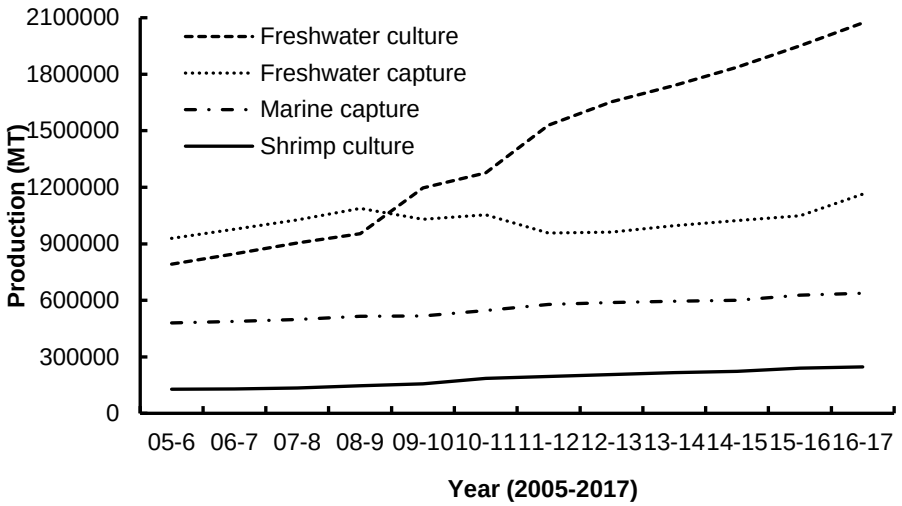

Figure 16 : Culture and capture fisheries production from 2005-06 to 2016-17. Source : DoF 2017.

4.3 Unlocking the blue fisheries economy

4.3.1 Present status and major characteristics

Bangladesh has an extraordinary shallow continental shelf, extending more than 185 km which is much bigger than the global average of 65 km (Hossain et al. 2017). It offers a great opportunity of fishing for the boats with limited capacity and thus, artisanal fisheries (= small-scale fisheries) bloomed in the past decades and contributing a large share to the country's total marine fisheries production (Figure 17).

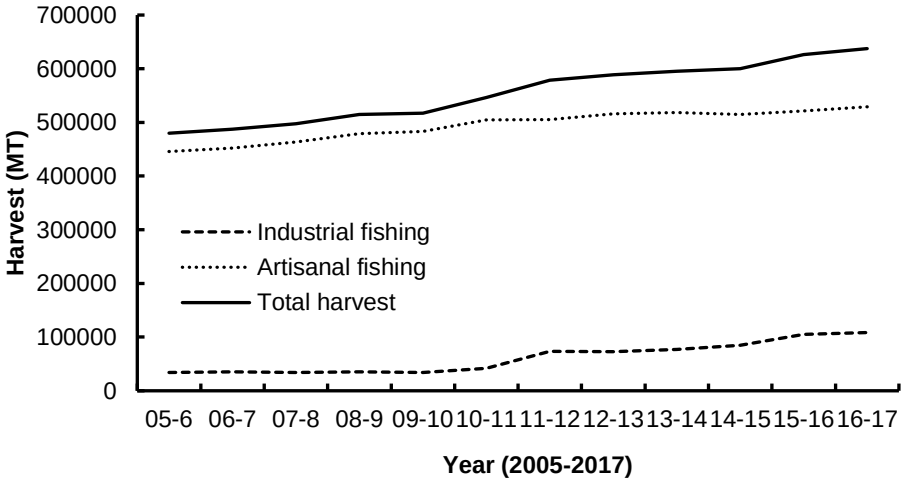

Figure 17 : Trends in sector-wise marine fisheries production (data DoF 2017)

At present more than 67,000 mechanised and non-mechanised boats are involved in this type of fishery. On the contrary, due to lack of appropriate fishing technologies and high capacity fishing vessels for deep sea fishing, industrial fishery (= trawl fishing) remain underdeveloped. In 2017, industrial fishery contributed only 2.62% to total fish production of the country, while artisanal fishery contributed 12.79% (DoF 2017). Industrial exploitation of marine finfish resources started in 1972 with 11 trawlers introduced by Bangladesh Fisheries Development Corporation (BFDC). Subsequently, in 1978, shrimp trawling was started after an encouraging report of penaeid shrimp stocks by the Mitsui Tayo survey in

1976-1977 (Islam 2003). Currently, 37 shrimp trawlers and 211 fish trawlers are operating in the marine waters of Bangladesh (DoF 2017).

4.3.2 Extending the fishing horizon

As mentioned above, due to the limited capacity, fishing in the high sea area is very limited and therefore, there is a chance of additional marine fisheries harvest by adopting appropriate fishing vessels (= high-tonnage vessels of >50 m length, >2000 HP, >500 GT) and gears for the deep sea fishery (Figure 18).. Using long-line method, hook fishing and other suitable gears, there is a possibility to harvest the unexploited pelagic fishery, including high valued tuna!

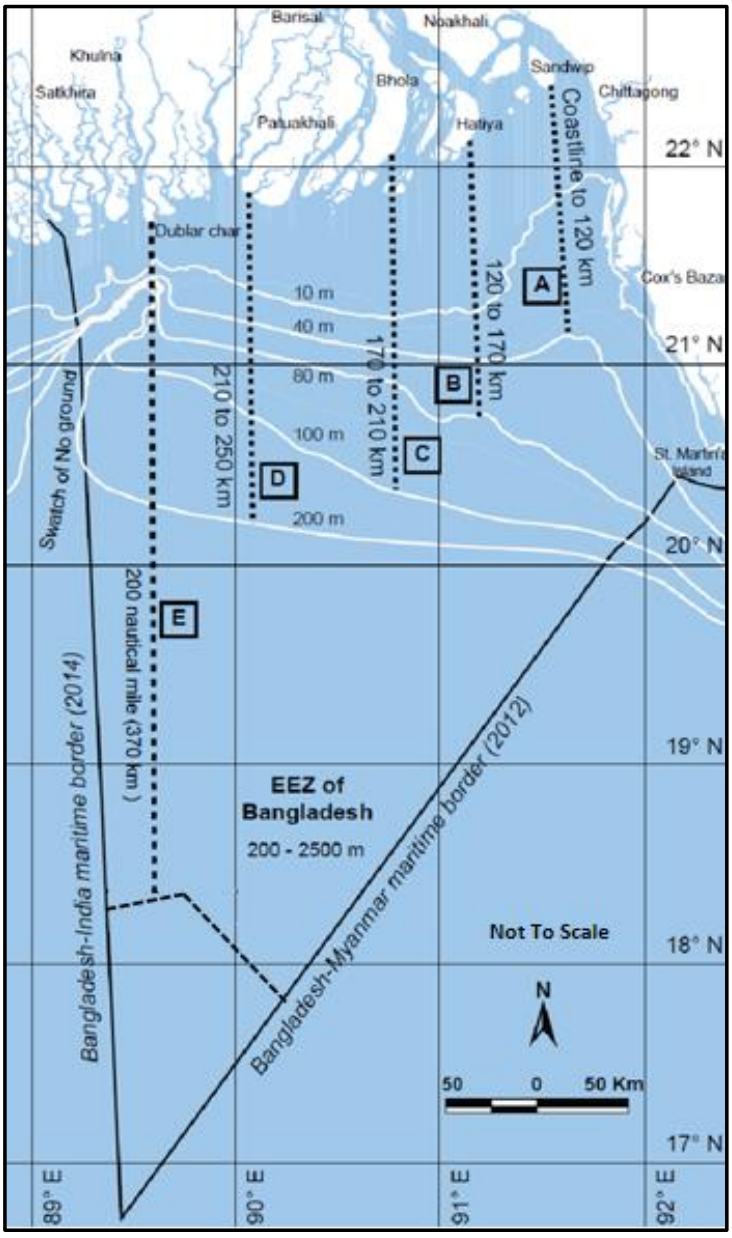

Figure 18 : Marine fishing grounds of Bangladesh (source: Hossain et al. 2017). Zone A (depth: 0-40 m; distance: coastline to 120 km; artisanal fishing), B (depth: 40-80 m; distance: 120-170 km; trawl fishing), C (depth: 80-100 m; distance: 170-210 km; lightly fished zone), D (depth: 100-200 m; distance: 210-250 km; no fishing), and E (depth: >200 m; distance: >250 km; no fishing)

According to experts, bluefin tuna long-line fishing may not be a viable option as the habitat of high sea area (>200 m depth) is assumed to be less suitable (= turbid water) for bluefin tuna – this hypothesis needs to be verified through survey or feasibility study. But, there are some species of tuna caught as by-catch of industrial, mechanised and non-mechanised trawlers, and comprised ~2% of the industrial catch. Among the five marine fishing grounds (A-E), only zone A and B (depth 0–80 m) are regarded as active fishing area Therefore, fishing efforts in under or unexploited zones (C-E; depth 80 to >200 m) can be an option for enhancing capture fishery production.

4.3.3 Discovering new fisheries

Certain high value fish species, such as pelagic tuna (Scombridae), swordfish (Xiphidae), and lakkha (Polynemidae) are rarely appear in catches despite their presence in deep water areas. Moreover, there is evidence of increased exploitation of low value sardines by the industrial fishing which is less attractive as commercial fishery (Figure 19). Therefore, it is necessary to identify the habitats across the lifecycle of valuable species for choosing the right fishing season of the target species.

Figure 19 : A high value fish species, lakkha (left) and bulk of sardines in trawl fishing (right)

4.3.4 Value addition and reducing post-harvest losses

By-catch or nonconventional species (such as sole, ray, squid, cuttlefish, small pelagic species) remain unused due to unattractive appearance, color, texture, bones and small size. Although some species are used industrially for fishmeal manufacturing, utilization of other species for human consumption is essential to prevent post-harvest fishery losses. The possible means of using low-cost fishery resources include preparations of fish cutlets, fish fingers, canning of fish and fish products, dried and salted fish/shrimp, breaded prawns and fish sticks, fish cakes, shrimp skewer, coated squid rings, coated fish balls, fish oils, liver oils, fish sauces, surimi and surimi-based products, sausages, fermented products, and protein concentrates.

Besides, seafood processing discards (20–80% depending upon the level of processing and type of fish/shellfish) is a rich source of proteins and xanthophylls, but these valuable components in discards remain a neglected issue. This waste can be used for production of fishmeal, silage and compost, including various value added products such as proteins, oil, amino acids, minerals, enzymes, bioactive peptides, collagen and gelatin.

4.3.5 Fisheries stock assessment

The stock assessment of fishery resources was carried out in 1973, 1981 and 1983, and the current survey (DoF-FAO 2016-17) is ongoing with the research vessel ‘RV Meen Sandhani’ (Table 8). However, recent declining trends of the catch-per-unit-effort by the commercial trawlers indicate an alarmingly dwindling stocks, despite the overall total catch seems to be increasing in the short run that might be correlated to increased number of vessels in operation and use of underwater fish finder technology. However, stock assessment reports can provide updated life histories, biology and fishery

information for a particular species as well as additional fisheries statistical information. On the basis of data obtained from stock assessment analyses, it is possible to:

(i) estimate the optimal harvesting strategy,

(ii) monitor the abundance and productivity of exploited fish populations, and

(iii) support sustainable fisheries by providing fisheries managers with the scientific information necessary for the conservation and management of stocks.

Table 8 : Standing stock (tonnes) of marine fisheries of Bangladesh

Demersal fish	Pelagic fish	Shrimp	Reference
264,000–373,000	–	9,000	West (1973)
160,000	90,000-160,000	–	Saetre (1981)
200,000–250,000	160,000–200,000	4,000–6,000	Penn (1983)
Ongoing	Ongoing	Ongoing	Dof-FAO (2016-17)

4.4 Unlocking Blue mariculture Economy

4.4.1 Present status

Bangladesh has 272,717 ha (DoF 2017) suitable area for coastal aquaculture where farming is mostly carried out in tide-fed ponds. Black tiger shrimp (*Penaeus monodon*), locally known as 'bagda', is the only species farmed in the coastal districts of Satkhira, Khulna, Bagerhat and Cox's Bazar. Shrimp culture expanded rapidly between 1970 and 1990, mostly in ghers (i.e. piece of land protected from the sea by polders) under extensive production systems. There are also very limited scale production of seabass (*Lates calcarifer*), mullet (*Mugil* sp.), crab (*Scylla* spp.) and seaweeds. Mariculture is significant to our national economy, earning a sizeable foreign exchange for the country, about BDT 42,876 million by exporting ~68 thousand MT of shrimp/prawn and other fisheries products (DoF 2017). Bangladesh exports frozen shrimp and fisheries products to over 50 countries, including Belgium UK, Netherlands, Germany, USA, China, France, Russian Federation, Japan and Saudi Arabia. Despite the immense potential for further growth, coastal aquaculture is facing multiple challenges related to disease outbreaks, technological barriers, unscientific use of inputs, poor compliance with quality standards, sourcing of seed, etc. By selectively overcoming these bottlenecks, the production of coastal and marine aquaculture can be improved considerably.

4.4.2 Domestication and farming diversification

The domestication process of marine species in Bangladesh has been extremely slow, and is limited to a few fish and crustaceans. As of now, only the entire lifecycle of tiger shrimp has been closed under captive condition, but with inputs of wild brood (i.e. third level domestication). Captive rearing of wild fry/seed is achieved for mud crab, seabass, mullet and seaweeds (i.e. second level domestication). While the 'first level' domestication corresponds to the initial trials of acclimatization of about fifteen species of fishes, including threadfin, seabream, terapon, spotted scat, goby, croaker, mugil, and silver biddy in tide-fed coastal ponds and hilsa in freshwater pond with significant bottlenecks of closing the lifecycle in captivity (Figure 20). Therefore, future growth of mariculture will largely depend on the ability to successfully domesticate of both currently farmed and new species. For example, mud crab fattening (i.e. rearing of wild small crabs up to marketable size) in pens or cages, which gained attention recently, holds great promise if hatchery technology for artificial propagation and fry production can be guaranteed. This is also applicable to seabass, mullet and seaweeds in order to realize their commercial production. Importantly, domestication of new aquaculture species can play a vital role in diversified

farming, for example to bring in alternative species to tiger shrimp farming which is no more profitable due to disease problems (= WSSV, EMS/AHPND, luminous Vibrio, etc). In the long run, domestication can help improve the productivity and sustainability of our aquaculture industry.

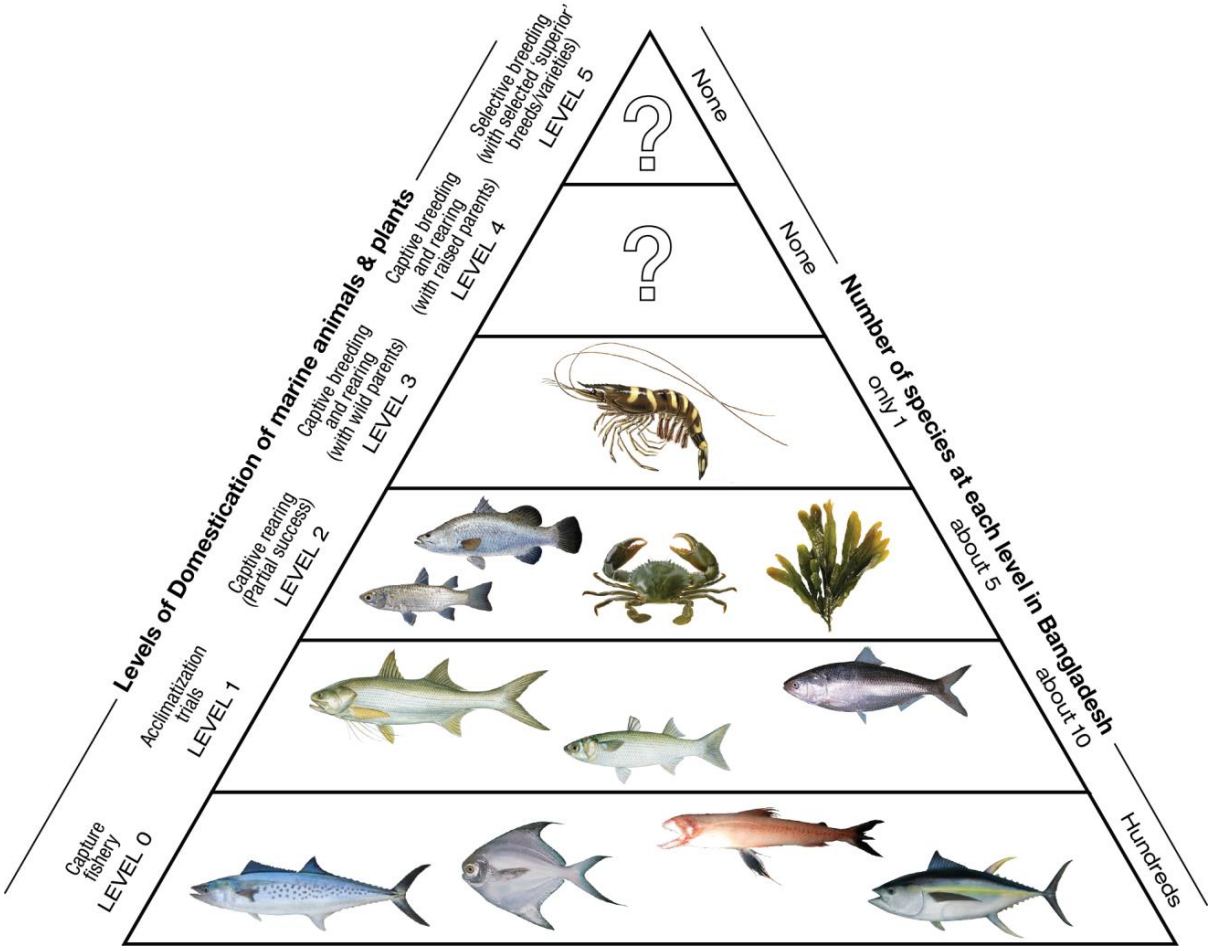

Figure 20 : Domestication levels of marine species in Bangladesh. Source: Hossain et al. 2017.

4.4.3 Adopting new farming techniques

Marine cage farming (Figure 21), not in practice at present, can be done at artisanal level with simple design and small size. Fish farming cages can be made using locally available materials including bamboo, wooden boards, steel/PVC pipe, and nylon nets. Cages can be inshore coastal, open sea or offshore types, installed either individually or connected together to form floating raft. Potential farming species includes seabass, mullet, grouper (*Epinephelus* sp.) and seabream (*Acanthopagrus* sp.) provided that artificial breeding, hatchery-produced fry and manufacturing of pelleted feed is successful. The collective knowledge and experience of Southeast Asian countries such as Thailand, Malaysia, the Philippines, Indonesia and Viet Nam would be extremely useful to fruitfully introduce cage farming in Bangladesh.

Figure 21 : Potential cage farming site at the Moheshkhali Channel (source: Hossain et al. 2017)

4.4.4 Intensification of mariculture production

Shrimp farming is mostly carried out following traditional or extensive cultivation methods featuring low-stocking density and zero to minimum inputs that result in low yields, 60–230 kg/ha (Table 9). This outdated mode of production need to be upgraded to semi-intensive system with the introduction of healthy and quality seed, nutritious feed, good husbandry practices, and improved health management techniques (i.e. probiotics, bio-security), reaching a plausible boost in production up to 2,000–3,000 kg/ha. It should be noted that intensification comes with its own risks and challenges, therefore, measures and techniques must be learnt to reduce and avert the risks (Hossain et al. 2014).

Table 9 : Shrimp farming systems and level of production in Bangladesh (after Belton et al. 2011)

Production system	Characteristics			
	Management	Stocking (PL/m^2)	Yield (kg/ha)	Remarks
Extensive	Natural feeding, little or no management	0.2–1.5	60–230	Followed by >90% farms
Improved extensive	Supplemental feeding, little management	1–2.5	350–500	Followed by some farms only
Semi-intensive	Artificial feeding, aeration, waste control	5–10	Avg. 2,000	Investment intensive & remains very rare

4.4.5 Developing the promise of mariculture

Aquaculture activities are often blamed for the degradation of water quality of aquatic ecosystem. Therefore, it is necessary to promote environmental sustainability and social acceptability of

aquaculture practices. For this, aquasilviculture (= integrated mangrove-aquaculture) and integrated multi-trophic aquaculture (IMTA) system are promising eco-friendly options. Aquasilviculture is a low-input farming system that maintains harmonious co-existence between aquaculture and mangrove forests as well as supports income, food security, coastal defense, community resilience, and restoration and/or conservation of the mangroves. Thus, for example, suitable locations for the 'integrated' mangrove-shrimp, 'separate' mangrove-shrimp (i.e. mangroves as biofilter for shrimp pond effluents; Figure 22), mangrove-crab, and nipa-shrimp systems include the Chakaria Sunderbans and adjacent Cox's Bazar coasts. The area of an aquasilviculture farm needs to be at least 4 ha to provide a decent livelihood to farmers.

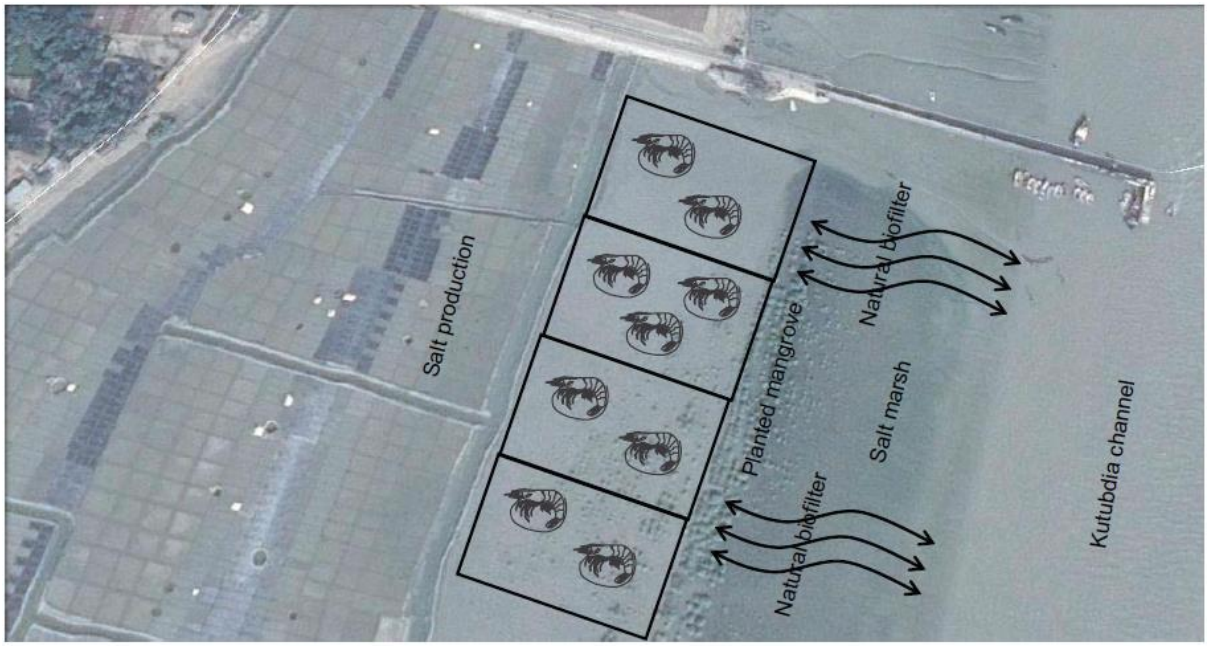

Figure 22 : A potential mangrove-shrimp system at the Kutubdia Island. Source: Hossain et al. 2017.

In IMTA system, wastes generated by target species (i.e. fish) could become food for other species having different feeding habits in different trophic levels, for example, organic wastes for suspension feeders (i.e. oyster, mussel) and dissolved inorganic nutrients (such as nitrogen and phosphorus) for seaweeds. No attempts have been made to develop and test the IMTA system in Bangladesh, although area such as Cox's Bazar-Teknaf coast and the Islands of St. Martin's, Moheshkhali and Sonadia can be considered suitable.

4.4.6 Live feeds production for larviculture

Feeding of the most commercial aquaculture species still relies on live feeds during the early life stages. Three groups of live diets are commonly used in larviculture:

(i) several species of microalgae (*Isochrysis* sp., *Chlorella* sp.) ranging 5–50 µm in size for bivalves, penaeid shrimps, rotifers, copepods and fish,

(ii) rotifers *Brachionus plicatilis* and *B. rotundiformis* (50–200 µm in size) for crustaceans and marine fish, and

(iii) nauplii of brine shrimp *Artemia* sp. (400–800 µm in size) for crustaceans and fish.

Artemia biomass is used for shrimp broodstock and fish juveniles. Unfortunately, the cultivation of live feeds remains to be a bottleneck in Bangladesh because of no local sources (laboratories and institutions) to obtain pure strains of rotifers and algae. But, saltpans in the southeast coastal areas can

be used for *Artemia* cyst and biomass production (Figure 23). Therefore, it is necessary to acquire technology for the production of live feeds for sustaining the marine aquaculture industry.

Figure 23 : Harvesting of *Artemia* cysts (left) and biomass (right) from a saltpond. Source: Lavens and Sorgeloos 1996.

4.4.7 Promoting aquatic animal health/disease management

Diseases caused by WSSV (White spot syndrome virus) and luminous bacteria (*Vibrio harveyi*) are significant bottlenecks to economic and production sustainability of shrimp farming in Bangladesh. Typically, chemical disinfectants and antibiotics are used to control diseases, despite their serious effects on product quality (= compliance issue with quality standards) and human health (= antibiotic-resistant pathogens). As an alternative, interventions may include developing specific pathogen free (SPF) and specific pathogen resistant (SPR) stocks, improvement of husbandry and hygiene practices, application of bio-security and eco-friendly health management techniques (i.e. probiotics, immunostimulants), avoid the irrational use of antibiotics, and embracing the traceability requirements (Sharifuzzaman and Adhikari 2013; Sharifuzzaman and Austin 2017).

4.5 Challenges along the path

Venturing into the blue economy related to marine fisheries and mariculture is not straightforward and simple. Importantly, implementation of some of the identified opportunities above is time-consuming and investment intensive. For example,

(i) it can take years of research (5–12 years) to domesticate a new species and bring it to market,

(ii) any genetic improvement and selective breeding program, such as developing SPF stocks can take 5–10 years, and

(iii) a comprehensive stock assessment of marine fishery resources can take 5–10 years and requires a reassessment in every 2-3 years depending on the level of depletion of stocks, and an expensive process too.

4.6 Conclusion

It is the scientific and technical knowledge, innovation and investment that can help raising marine food production under the blue economy initiative. The ultimate success of the activities will rely largely on the developments in research pipeline and new results, and to translate these results into viable commercial use. Effective stakeholder engagement (farmers, industry, academia, extension service,

etc.), and the regional and global cooperation are also equally important for the sustainability of blue economy in Bangladesh.

4.7 References

Belton B, Karim M, Thilsted S, Murshed-E-Jahan K, Collis W, Phillips M (2011) Review of aquaculture and fish consumption in Bangladesh. Studies and Reviews 2011-53. The WorldFish Center, Dhaka.

DoF (2017) Yearbook of fisheries statistics of Bangladesh 2016-17. Fisheries Resources Survey System, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Vol. 34, 129 p.

Hossain MS, Chowdhury SR, Navera UK, Hossain MAR, Imam B, Sharifuzzaman SM (2014) Opportunities and strategies for ocean and river resources management. Background paper for preparation of the 7th Five Year Plan 2016-2020, Ministry of Planning, The Government of Bangladesh, 67 p.

Hossain MS, Chowdhury SR, Sharifuzzaman SM (2017) Blue economic development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 p.

Islam MS (2003) Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh. Ocean and Coastal Management 46(8): 763-796.

Lavens P, Sorgeloos P (1996) Manual on the production and use of live food for aquaculture. FAO Fisheries Technical Paper 361, 295 p.

Penn JW (1983) An assessment of potential yield from the offshore demersal shrimp and fish stock in Bangladesh water (including comments on the trawl fishery 1981-1982). FE:DP/BGD/81/034, Field Doc. 22 p. Fishery Advisory Service (Phase II) Project, FAO, Rome, Italy.

Saetre R (1981) Survey of the marine fish resources of Bangladesh Nov.-Dec. 1979 and May 1980. Report on surveys in the R.V. Dr. Fridtjof Nansen. Institute of Marine Research, Bergen, 67 p.

Sharifuzzaman SM, Adhikari S (2013) An assessment of biosecurity and hazard management practices in the larviculture of shrimp (*Penaeus monodon*), Bangladesh. Communications in agricultural and applied biological sciences 78(4): 417-420.

Sharifuzzaman SM, Austin B (2017) Probiotics for disease control in aquaculture, pp. 189–222. In: Diagnosis and Control of Diseases of Fish and Shellfish (1st edition), Austin B, Newaj-Fyzul A (Eds.). John Wiley & Sons Ltd., Oxford.

West WQB (1973) Fishery Resources of the upper Bay of Bengal. Indian Ocean Programme, Indian Ocean Fisheries Commission, Rome, FAO, IOFC/DEV/73/28, 28 p.

5 Future importance of healthy oceans: Ecosystem functions and biodiversity, marine pollution, carbon sequestration, ecosystem goods and services

5.1 Abstract

The chapter provides a review the current status of ecosystem and resource extraction to provide a series of thoughts related to the future challenges in maintaining the health of the Marine and coastal ecosystems at the Bay of Bengal. The chapter highlighted the challenges current efforts and future interventions necessary to keep the Bay of Bengal large marine ecosystem healthy. They are mainly linked to climate change, environmental pollution from different sources, biodiversity conservation, sediment movement. marine spatial planning and adoption of protected area concept to design marine reserve, fish sanctuary and ecological critical areas in the coastal zone were highlighted. The importance and means of monitoring of the marine and coastal ecosystem at the Bay of Bengal required local and international collaboration in order to ensure adoption and management of an objective monitoring system.

5.2 Introduction

The earth has got its title 'blue planet' as oceans occupy two-thirds of the surface of earth. Oceans - the relatively less explored among the natural resources - provides ecosystem services which are seminal to the very existence of both terrestrial and aquatic biospheres on planet earth. Oceans act as a buffer to the changes in the composition of the atmosphere (Catling and Kasting, 2017; Gregor, 1985; Jickells, 2002; Sukumaran, 2000; Voss and Montoya, 2009) of global thermal equilibrium (Faizal and Rafiuddin Ahmed, 2011; Wang et al., 2012), regulator of the hydrological cycle (Gröger et al., 2007), sync of all forms of wastes from the anthrosphere (Goldberg, 1985; Holdgate and McIntosh, 1986; Peterson and Teal, 1986), mediator in the formation of different kinds of sedimentary and metamorphic rocks, world's largest pool of flora and fauna (Armbrust and Palumbi, 2015; Farrow, n.d.). Recently, we have started to understand the value of oceans as a sink of carbon dioxide (Ibánhez et al., 2016; Landschützer et al., 2016; Orr and Sarmiento, 1992; Quéré et al., 2003) and its importance in global warming. Also, oceans are importance of oceans are emphasized as never before due to fishery and seaweeds (Bouwman et al., 2011; Hehre and Meeuwig, 2016; Sweatman et al., 2016), salt and minerals (Loganathan et al., 2017; Shahmansouri et al., 2015), drinking water (Elimelech and Phillip, 2011; Ghaffour et al., 2013; Shannon et al., 2008), navigation (Fransoo and Lee, 2013; Lee and Song, 2017), petroleum resources including oils and gases under the sea bed and methane hydrate in the sea floor. In all, the sustainable future of mankind is largely dependent on healthy reduction of influx of pollutants into them and to maintain the biodiversity therein for sustenance of ecosystem services from them ("Classification of marine ecosystem services," 2016; Palumbi et al., 2009; Sultan, n.d.; United Nations, 2017). This importance is manifested from the declaration of sustainable development goals (SDGs) as Goal 14 explicitly call to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" and outlined 7 main and 3 associated targets in order to attain the goal (Neumann et al., 2017; Vierros, 2017).

The Bay of Bengal large Marine ecosystem is the largest among the 66 large Marine ecosystems in the world (Coleman, 2008; NOAA et al., 2007; Sherman, 1991). This ecosystem provides food and nutrition to more than half a billion people while supporting the livelihood of several hundred million coastal population living along and in the vicinity of coastal zone of the marine ecosystem of the Bay of Bengal spreading over 8 countries including India, Bangladesh, Sri Lanka, Myanmar, Indonesia, Malaysia, Thailand and Maldives. The future development of these countries depend largely on the blue economy development in the region which again is dependent on the conservation of the marine and coastal ecosystem in the Bay of Bengal large marine ecosystem area. Accordingly, while all the countries need to take local initiatives to ensure the future health of this crucial ecosystem, regional

cooperation and joining forces to work together is the only way to ensure the conservation of this ecosystem for the sustenance of ecosystem services to avail the potential offered by blue economy under threat of climate change (Verlaan, 2005; Vivekanandan et al., 2016).

This chapter aims to review the current status of ecosystem and resource extraction in brief in order to come up with thoughts related to the future challenges in maintaining the health of the Marine and coastal ecosystems at the Bay of Bengal. In the beginning, a discussion has been included to contextualize the concept of healthy ocean in relation to Blue economy development and the importance as well as global and local challenges in keeping the Bay of Bengal healthy has been briefly introduced. Since the importance of any ecosystem is, in recent time, popularly expressed in terms of ecosystem services - a complete section has been dedicated to outline the ecosystem goods and services from the Bay of Bengal specifically by using the popular classification of ecosystem services under four categories - provisioning regulating, support and cultural services. The thematic section of this chapter highlighted the challenges current efforts and future interventions necessary to keep the Bay of Bengal large marine ecosystem healthy. In this section, future challenges related to the health of the Bay of Bengal including climate change, environmental pollution from different sources, biodiversity conservation, sediment movement. marine spatial planning and adoption of protected area concept to design marine reserve, fish sanctuary and ecological critical areas in the coastal zone were highlighted. This section included a schematic discussion on the importance and means of monitoring the help of the marine and coastal ecosystem at the Bay of Bengal which outlined the need for local and international collaboration in order to ensure adoption and management of an objective monitoring system for generation storage and analysis of data by devising a shared common platform under the leadership of Bangladesh to assist informed decision making regarding the Bay.

5.3 Healthy Oceans

5.3.1 Context

The health of oceans in the world are under the serious threat from a multitude of stressors including climate change environmental pollution, over exploitation of resources, enhanced marine transportation, reduction in the river discharges and changes in the sediment dynamics in rivers etc (Halpern et al., 2008). Climate change and related sea level rise along with the changed climatic extremes are posing the greatest threat to the ocean ecosystem especially in the Bay of Bengal large Marine ecosystem area (Bosello and De Cian, 2014; Greenberg et al., 2012; Weissenberger and Chouinard, 2015). Oceans are the largest sink of all the different types of wastes and pollutants which are entering into our environment from natural and anthropogenic sources (Bates and Peters, 2007; Heimburger et al., 2013; Krishnamurthy et al., 2007; Okubo et al., 2013; Zhang et al., 2004). These pollutants are entering into the oceanic system through transportation by and deposition from the atmosphere; with river discharges carrying contaminants from natural, municipal, industrial and agricultural sources; from the large number of marine vessels operating globally for different purposes; and from the exploration of resources from oceans and other activities like setting up of wind turbines, installation of underwater energy harvesting systems and laying out of global submarine internet communication network. Recently, for example, we became quite concerned about the entry of plastics into the ocean which are subsequently break down into microplastics and finally enter into the food chain creating a lot of issues related to the overall marine ecosystem. In this backdrop, it became quite important to act concertedly to ensure and healthy ecosystem in our oceans not only to conserve the biodiversity in the oceans but also to sustain the ecosystem services rendered by oceans which is very much crucial to the sustenance of our environment and the terrestrial life sustaining systems.

5.3.2 Importance

Healthy oceans are seminal to the very existence of human civilization as they play crucial role to maintain the global climate, the water cycle, atmospheric gases cycles including oxygen nitrogen and carbon dioxide cycles, in regulating global heat budget (Cullen, 1999; Gröger et al., 2007; Monteiro et al., 2010; Reed and Harrison, 2016). Besides, oceans are also linked to the sustainable flow of different consumable and economic resources including fishes, seaweeds, crabs, molluscs, algae, salt, petroleum, pearl etc (Baturin, 2000; Csirke and Garcia, 2009; Gonzalez, 2016; Seibold and Berger, 1996). Moreover, oceans are the main pathway for the global movement of merchandize which fuel world economy (Hoffmann et al., 2017). Conserving the oceans and its resources are fundamental to attain the lofty goal of converting the global economy into ocean and water based blue economy (Cressey, 2011). In addition, it is imperative to keep in mind that there are more resources in the oceans than we currently are aware of and without keeping the oceans healthy we shall miss exploring them (Cater and Cater, 2007; Gupta, 2017; Leary et al., 2009; Rajagopalan and Nihous, 2013). As the EEZ of Bangladesh is about the size of the country (KAŁDUŃSKI, 2015; Qiu and Gullett, 2017), the long term GDP growth of the country and equitable development depend on the productivity of BoB which in terms depends on maintaining the BoB in a healthy condition (Hussain et al., 2018; Rahman, 2017; Sarker et al., 2018). Maintaining the health of BoB largely depends on understanding the threats to the ecosystem and biodiversity of BoB including climate change, overexploitation of resources, pollution and flow of pollutant containing sediments from municipal, industrial and agricultural sources. Special emphasis is needed to specially address the plastic pollution as Bangladesh is among the major contributor of (Fisner et al., 2017; Vince and Hardesty, 2017; Yu et al., 2018) plastic wastes to the Bay of Bengal.

5.3.3 Challenges of Healthy ocean for Blue economy for – global and local

Oceans are the only repository of global natural resource pool which is yet to be discerned and explored to its fullest. The lack of technology to explore oceans and seas are the main barriers which has shielded the oceans from destructive and unsustainable human explorations to some extent. However, the situation is changing quite rapidly due to the rapid progress in the technological frontier which are evident from (Candeloro et al., 2015; Greenemeier, 2014; Moore, 2007; Pai, 2015). In contrary to worries, there is a glimmer of hope since the exploration of oceans and seas will commence at a time when there is a global consensus on exploring resources sustainably and we, as humans, are becoming more capable of ensuring sustainable resource exploration and utilization. Nations are becoming more interested in the concept of circular economy, sustainable development, low carbon growth, environmental conservation.

The challenges associated with keeping the oceans healthy are both global and local since the oceans are all connected and any problem caused locally has global implications. Gulfs, Bays and Seas have economic zone marked for adjoining countries and are sources of disputes as exemplified by the recent resolution of dispute between Bangladesh, India and Myanmar (Alam, 2018; Qiu and Gullett, 2017) which has culminated in a verdict n favour of Bangladesh. The major challenges in maintaining healthy oceans include checking the flow of pollutants and contaminants through river discharges, atmospheric transportation and This is one example of internationalization of local dispute over seas. This has created an immense opportunity for Bangladesh to take steps in making its portion of the Bay of Bengal healthier and conserve the ecology and biodiversity therein to attain the SDGs of the country (Shamsuzzaman and Islam, 2018).

5.3.4 Blue economy vs. Healthy ocean – Bangladesh context

Blue economy, a term first used by Belgian economist Gunter Pauli, denotes effective and planned utilization of resources from blue ocean water strategically for sustainable economic development through generation of new jobs and social capital while conserving the existing (Rahman, 2017). It can be envisaged as a framework for sustainable ocean governance for development based on marine and

coastal resources (Gamage, 2016) without aggravating environmental degradation. The origin of this concept has linkage to technological advancements which has enhanced the interest in sustainable exploration of ocean resources. Also, blue economy can be considered as an integration of activities related to coastal ecosystem marine ecosystem, marine and coastal resource extraction and livelihood, maritime trade under one umbrella due to our increased understanding of the intricate relationships among these activities (Smith-Godfrey, 2016). Blue Economy aims to achieve a sustainable ocean economy Show the balanced uses of ocean and coastal resources without jeopardizing their health and resiliency (Patil et al., 2016).

Bangladesh has taken the opportunity offered by the concept of blue economy very seriously especially after it has won the maritime boundary dispute with India and Myanmar and established legal right over a large tract of the Bay of Bengal as he its exclusive economic zone. Bangladesh has established a blue economy cell under the ministry of power energy and mineral resources in the beginning of 2017 in order to coordinate the related activities. A number of projects has already been launched under the banner of blue economy in Bangladesh which includes projects on coastal aquaculture on the exploration of economically important Maritime flora, decide organising a number of seminar, conferences and dialogues. Different Ministries associated with the management of marine and coastal resources have taken programs to develop projects on the theme of blue economy. however, he is this project are not coordinated and implemented concertedly; these projects will result in bad outcome. Therefore, the urgent need for Bangladesh to take a lead in the development of blue economy in the Bay of Bengal, used to establish an umbrella organisation in order to streamline the formulation of policy and programmes and their implementation by line Ministries efficiently with desired outcomes.

Due to the action of a large number of Mega development projects near the coastal zone of Bangladesh including the establishment of exclusive economic zones in Mangla, Bhola, Mirsarai, Sitakunda, Anwara, MaheshkhalI, Teknaf areas may go against the blue economy development, if proper infrastructure development along with waste and effluent management systems are not put in place to save the coastal and Marine environment from the pollution which will be created from these economic zones.

5.4 Ecosystem goods and services from Ocean – the case of Bay of Bengal

Bangladesh is dependent on the Bay of Bengal since its geographical origin is the largest delta in the world formed show the deposition of sediments carried by the Ganges-Brahmaputra river system at the foothills of the Himalayan mountain range. Major aspects of life in Bangladesh are shaped by the Bay of Bengal due to the wide range of ecosystem goods and services which the country receives from it. An exhaustive list of ecosystem goods and services from the Bay of Bengal is still to be enumerated. A map of ecosystem services is shown in Figure 24.

5.4.1 Provisioning services

The countries' 710 km coastline has created a large community of people dependent on coastal and Marine resources for their food and livelihood. People of Bangladesh are very much dependent on fish catches from the Bay of Bengal to meet their dietary protein needs. The coastal and Marine fishery and its related industries are a very big employment sector of the country providing livelihood for millions of people. A large population in coastal districts are dependent on shrimp farming and salt production - two industries which are completely dependent on the Bay of Bengal. The coastal sand and the sediment at the Bay of Bengal has high concentration of rare Earth elements for which the Limited efforts has this far been employed. Marine and coastal roads of the country are very busy transportation routes which acts as a blood stream by regulating the supply chain of the country. The mangroves and coastal plantations are also substantial sources of of ecosystem goods wheat economic values. In addition, Bangladesh has started to get gas and petroleum from beneath the seafloor at the Bay of Bengal.

Unfortunately, Bangladesh has so far failed event explore the full potential of provisioning services that the Bay of Bengal can render to its economy. Due to the concentration of entire fishery industry to shallow water fisheries in the coastal region, and due to the lack of survey data font the availability and stock of deep sea fishes - the provisioning services in terms of fishery is yet to be realised. Hilsa fishery alone contributes about 1% of the GDP of Bangladesh which is adequate to exhibit the role that blue economy can play in pushing the GDP growth of Bangladesh they are on the magical 10% figure.

There is no visible Seaweed industry in the country, mariculture, cage culture of fishes, pearl farming, utilisation of the energy potential in the tide and wave of the Bay of Bengal as well as the wind energy potential in the coastal region has not been seriously investigated. on the other hand, the huge discharge of Methane containing sediment into the Bay of Bengal has made the Bay a potential stockpile of Methane hydrate which is considered as source of abundant energy for the future growth of this planet.

Due to the population growth in the urban centres coupled with serious pollution in the freshwater carrying rivers, the country is approaching towards a situation when it will face shortage in fresh water supply for its population. The country has to rely on desalination of water from the Bay of Bengal to meet freshwater demand and planning to that and needs to be started now.

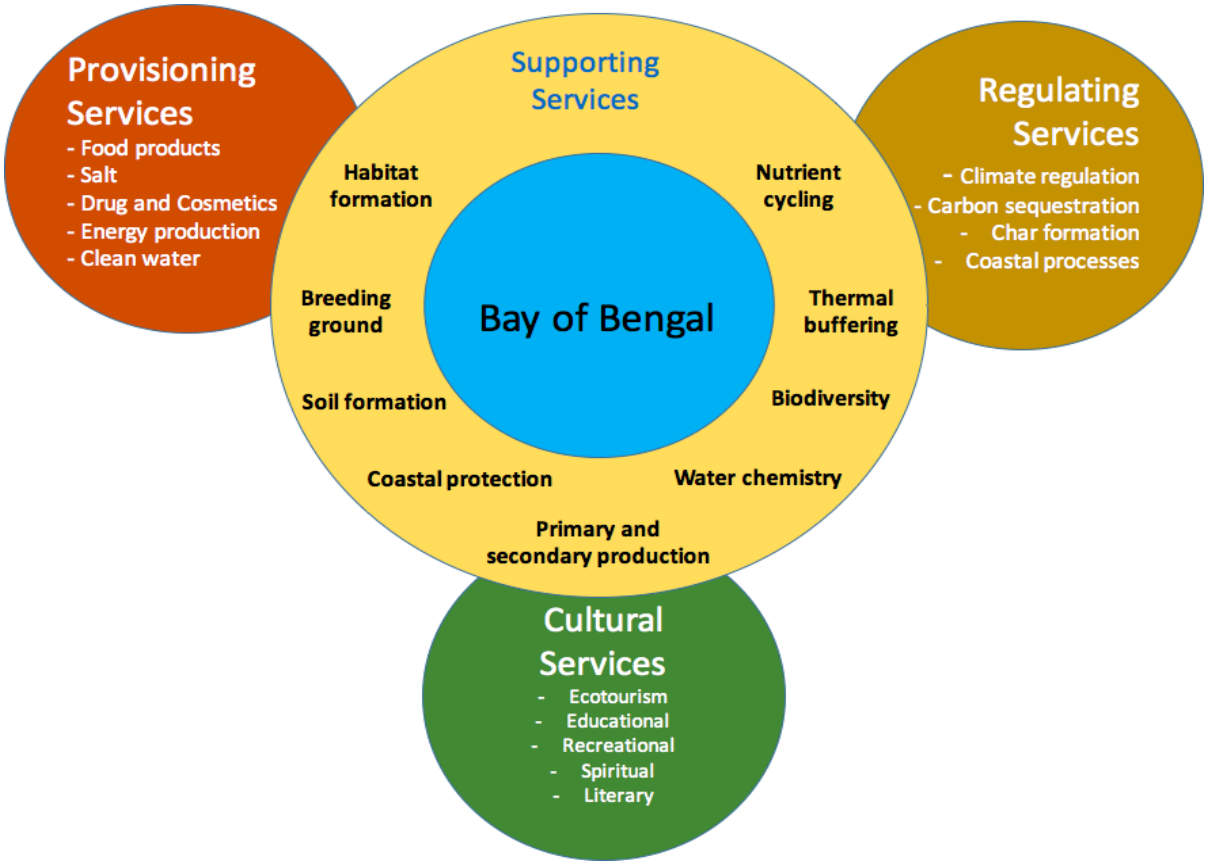

Figure 24: Map of ecosystem services at the Bay of Bengal

5.4.2 Regulating services

The Bay of Bengal regulates the pattern of climate and weather of Bangladesh. The temperature, humidity, rainfall and all the related phenomena are totally dependent on the behaviour of the Bay of Bengal. Bangladesh is a country of Six Seasons and the division of seasons are basically dictated by

regulation of thermal and hydrological cycles in the region by the Bay. Bangladesh is also known as a country of flood caused by torrential rainfall during the rainy season from clouds originated in the Bay of Bengal and moved to the north by the monsoon wind. Though the floods a devastating, it's regulate the formation of land by changing the river and Canal courses, by recharging the in law what is including groundwater table, buy distribution of fertile sediments on the arable land throughout the country. In a sense, most of the major infrastructure projects of Bangladesh are associated with the management of hydrological resources and floods as well as with the construction of dams and bridges to cross barrier among different parts of the country created by the extensive River system. Therefore, the future adoption of different development projects in the country should and buy shares its relationship with the Bay of Bengal and its bearing on the development of blue economy be it in the coastal region of the country or in the deep Northern region - far away from the coast in order to enhance the regulatory services provided by the Bay of Bengal and to reduce the impacts of negative regulatory ecosystem services.

5.4.3 Supporting services

The Bay of Bengal is rich in biodiversity is rich in biodiversity of of fishes, crabs, shrimps, birds, marine turtles and other aquatic flora and fauna. The Bay of Bengal large Marine ecosystem provides the habitats, supplies nutrients and acts as the breeding ground for all these species. the Bay acts as a reservoir a huge volume of sediments and by using the sediments the currents in the Bay create new offshore Islands and controls the dynamics of coastal land accretion and erosion. The newly formed coastal lands known as Chars and the of your Islands, forms vibrant ecosystem to support a rich assemblage of terrestrial flora and fauna through the process of succession. A great example is Nijhum Dwip - a recently formed offshore Island that now supports a vibrant Island mangrove ecosystem. Most of the industrial and municipal wastes generated by 150 million people of Bangladesh ultimately find their way into the Bay of Bengal. Hence, the day can be considered as the final sink and ultimate treatment facility of wastes.

On the majority of the inhabitants of Bangladesh are dependent on agriculture and their farming is in turn completely reliant on the rainwater from the Bay of Bengal through the unique weather phenomena related to the Bay of Bengal known as the monsoon.

5.4.4 Cultural services

The Bay of Bengal controls all the major aspects of life and livelihood in Bangladesh. it is therefore inevitable that all forms of cultural activities in the country has a strong correlation with the Bay and it's changes throughout the year. There are unique forms of songs, crafts, craftsmanship related to boat building and net making related to lifestyles in the coastal region based on its dependency on the Bay of Bengal. All these has created a unique heritage for the country and a rich source of interest among people for the development of tourism. In Bangladesh, the cost of Cox's Bazar is the most popular tourist destination followed by the Saint Martin Island, the Kwakata sea beach and the Sundarban mangrove forest which is the only Coral island of the country located at the fringe of the Bay of Bengal. However due to the lack of facilities for tourists in terms of transportation, accommodation and amusement has hindered the growth of coastal and Marine tourism in Bangladesh. If proper attention is given, infrastructural and industrial development are taken cautiously, security in transportation at movement are assured and promotions to attract International tourists taken care of - the traditional tourism and eco-tourism in the coastal and marine regions at joining the Bay of Bengal will be able to add substantially to the GDP growth of the country.

5.5 Keeping BoB healthy: challenges, current efforts and future needs

5.5.1 Challenges

5.5.1.1 Climate change

There are 66 Large Marine Ecosystems (LMEs) in the world which produces more than 80% of the total fish catches in the world and contributes about $12 trillion per annum in ecosystem services goods and services (Sherman, 2001; Sherman and Hamukuaya, 2016). Bay of Bengal Large Marine Ecosystems (BOBLME) is the largest among the LMEs supporting about half billion people by food, livelihood and security through its coastal and marine resources. Climate change is threatening to bring forth sweeping changes to the BOBLME in terms of water pH, salinity, dissolve oxygen, temperature etc (Vivekanandan et al., 2016) which will increase water column stratification and inhibit primary production. The ultimate outcome will be declining fish stock and diminishing sustainable levels of fisheries yields. The ultimate outcome will stress on food security of billions of people and livelihood of hundreds of millions of BOBLME depended coastal communities (Sherman and Hamukuaya, 2016). On the other hand, the pattern of cyclones and climate change induced sea-level rise at the Bay will be inevitable. The ultimate outcome of changes in ecosystem will result in the Impaired ecosystem productivity due to the modification of living environment and associated biological and nutrition cycles leading to modified distribution and phenological traits of marine and coastal flora and fauna. These will impact the fish catch in quantity and composition especially for the traditional fishermen. [(Carson et al., 2015). On the other hand, sea level rise due to climate change in the Bay of Bengal region may displace as many as 100 million people living in the coastal districts of Bangladesh by resulting in the loss of home, agricultural land, industries, the entire belt of shrimp farming and salt producing area in the coastal zone (Ahmed and Diana, 2015). The climate change will also affect Sundarban mangrove forest and the coastal vegetation which is very crucial to the food chain of the Bay of Bengal. Sea level rise will also hamper the sediment movement dynamics in the way of Bangalore and the pattern of accretion and erosion of land in the coastal Islands and the entire post of Bangladesh (De, 2013). On the other hand, climate change induced climatic events and sea level rise will also impact the budding tourism industry of the country (Hassan and Rahimi, 2018). Therefore, a large scale mitigation and adaptation activities are needed in order to come back and the ecological and economic disaster created to the coastal communities and to the coastal ecosystem.

5.5.2 Environmental pollution

5.5.2.1 Pollution from ship breaking

Ship breaking and recycling industry (SBRI), due to its open-beach dismantling of scrap ships in Sitakunda-Bhatiary region on the coast of Bay of Bengal, is blamed for pollution to water and sediments by heavy metals, asbestos, paints, oil spills, and different persistent organic pollutants including dioxin. Some reports attributed the occurrence of higher than natural level of trace metals in fishes from the nearby coastal areas.

5.5.2.2 Pollution from municipal, industrial and agricultural runoff

Bangladesh is the largest delta which has formed due to the deposition of sediments carried by every active river system consisting of the Padma, the Yamuna, The Brahmaputra besides the Karnaphully, Sangu and Matamuhuri river system. In the past most of these rivers wear flowing through Christian landscapes hands the sedimentary carried away free from anthropogenic contaminants of pollutants. However due to the rapid population growth in Indian sub-continent most of this rivers and now flowing through different Municipal, agricultural and industrial areas and walls of the rivers has very high load of water pollution by pollutants including heavy metals, hazardous industrial wastes, pesticides and other active chemicals, I level of organic and nutrient loads. Hence, the sediments which is carried to the Bay of Bengal by this way active river system laden with pollutants of all descriptions which ultimately contaminates the nearest area of Bay of Bengal which is the main fishing region of the Bay of Bengal. This is difficult to separate the pollution from ship breaking industry and the pollution from pollution carrying sediments. However, the high level of heavy metals, persistent organic pollutants, microplastics etc., in different fishes the occurrence of trace elements are clearly indicating a gloomy

future in getting pollutant free catches of fish and other biomass from the Bay of Bengal. It becomes urgent for the policy makers and all other stakeholders to take immediate and pragmatic actions to stop the flow of pollutants into the rivers from Industries, Municipal sources, and hazardous coastal activities including ship breaking.

5.5.3 Atmospheric deposition

During the dry season, air containing different kinds of contaminants including reticulate matters of wearing nature from households, industrial sources, power generation units close to the Bay of Bengal beside marine transportation by engine boats and other marine vessels. The airborne pollutants are ultimately deposited into the Bay of Bengal and contaminates the water. Do the severity of pollution from this source vary seasonally and spatially, due to the establishment of a large number of big coal based power plants in in the coastal belt of Bangladesh and its neighbouring countries, the possibility of enhanced load of atmospheric deposition is becoming worry. It becomes very important to show the policy makers and planners to take the sources of pollution of Bay of Bengal very seriously and then the development intervention in a way to minimise atmospheric deposition to the Bay of Bengal instead of enhancing the possibility of more pollution from this source since unlike water pollution atmospheric deposition is very difficult to control.

5.5.4 Transboundary pollution

BOBLME Project includes 8 countries joining the Bay of Bengal which is indicative of the very international nature of the Bay of Bengal. Rivers are quite dynamic and hence the pollutants released into the Bay of Bengal it become dispersed and effect the whole of the Bay and its ecosystem including the economic resources. Therefore, formation of a stronger cooperation in order to ensure the closure of flow of pollutants from any of these countries is very crucial to the health of the Bay of Bengal. Formation of a joint pollution control and monitoring initiative should be immediately organised among the nine countries of BOBLME in order to ensure good health of the Bay of Bengal in the future and to ensure the sustainable flow of ecosystem services and economic benefits to ensure proper utilisation of blue economy opportunities offered by the Bay of Bengal. All trans-boundary rivers should be kept clean of pollutants in the respective parts of these rivers introspective the countries and the joint monitoring system should monitor the adherence of respective countries to the scheme. In addition, transponder movement of pollutants through atmospheric circulation needs to be monitored in order to check atmospheric deposition of pollutants into the Bay beyond it's natural assimilative potential.

5.5.5 Microplastics

The BOBLME covers eight countries including Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand. Among these countries Indonesia, Sri Lanka, Thailand, Malaysia and Bangladesh among the top 20 Countries which are adding substantial amount of unmanaged plastic wastes into global water. The respective contribution of these countries 3.2 million, 1.6 million come 0.9 million 0.8 million metric tons of unmanaged plastic wastes (Figure 25). Therefore, the total amount of plastic wastes sent to the BOBLME region by 20 countries is 7.5 million MT. Since it is expected that the plastic pollutants in the ocean will become one third of the total Ocean biomass in near future, the situation will be greater in the case of Bay of Bengal since the countries in this region are amongst the largest release year of plastic pollutants into BOBLME ecosystem. Therefore, it becomes inevitable to to check the flow of unmanaged plastics into the Bay of Bengal to ensure the future health of the Bay of Bengal. On the other hand, if the plastic pollution is controlled from the rivers carrying lots of plastics from urban centres in the densely populated Indian sub-continent and its neighbouring countries, this single source of pollution is adequate to jeopardize the total health of the ecosystem of the Bay of Bengal and bring down the biomass production at the bay to a halt.

5.5.6 Oil spills and waste disposal from marine vessels

Bay of Bengal is amongst the busiest roots of marine transportation since most of the countries along the coast of the bay amongst the rapidly developing countries in the world. In the future, with this establishment of new posts, expansion of the exploration of ocean resources due to the enhanced emphasis on blue economy, the number of ocean going classes are going to increase at a faster rate. Wearing amount of pollution is caused by all ocean going vessels and with the increase in the number of main industries in the bay region, the solution from this source is going to aggregate. On the other hand, this country is in the coastal region of the Bay of Bengal are becoming increasingly reliant on imported petroleum through the ocean route which is increasing the chance of largest oil spills from accidents associated with crude carriers. This type of accidents has happened in different parts of the world in the past. However, as the countries in the coast of the Bay of Bengal doesn't have the technological and economic preparation to combat if largest oil spill or similar marine pollution occurs in the Bay of Bengal. It becomes a big responsibility these countries to initiate process of transporting petroleum through pipelines in order to reduce the risk of jeopardizing the help of the ecosystem and the biosphere at the Bay of Bengal severely.

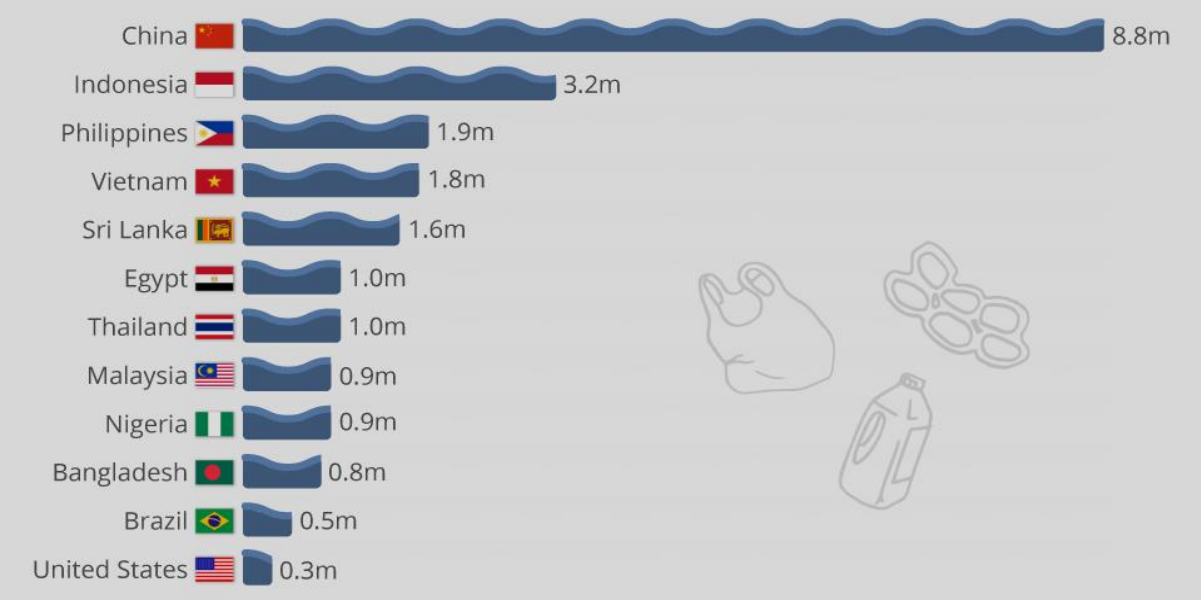

Figure 25: The countries polluting the oceans the most in terms of annual metric tons of mismanaged plastic wastes in global waters. Source: The Wall Street Journal, 2010.

5.5.7 Tourism related contaminations

Most of the countries on the coast of the Bay of Bengal are the most densely populated countries in the world. As these countries are in a trajectory of development, the people are becoming more solvent and interested in in-country and regional tourism. In Bangladesh, the enhancement in the flow of tourists to the coastal region is exemplified by the following figure which shows the increase in the number of tourists visiting the Cox's Bazar sea beach and the Saint Martin Island over the past 5 years. The number of tourists visiting this places are already beyond the carrying capacity of these places. Seems that residents of these countries are most educated and unaware, the regulatory and infrastructural facilities at the tourist spots are inadequate, the vigilance by the regulatory authorities are inadequate and poor, each tourist is creating more or less contamination to the places they are visiting in the coastal region. Accordingly, the pollutants they are releasing are getting into the water of the Bay of Bengal. If this continues to grow undeterred, the tourism industry will become one of the biggest contributor of pollutants to the Bay of Bengal and hence want to the biggest threat to the future health. It is therefore crucial to take immediate measures to calculate the carrying capacity of coastal tourism spots along the

coast of the Bay of Bengal to put regulatory and infrastructural projects in place and to make the tourists every year to behave environmentally friendly way to sustain the growth of tourism without affecting the health of the Bay of Bengal.

5.5.8 Biodiversity conservation

The conservation of biodiversity at the Bay of Bengal is crucial to sustaining the flow of ecosystem services and goods. There are a number of initiatives in different forms which has been adopted over the decades for the conservation of different Marine and coastal species. For example, there are ongoing projects for the conservation of marine Turtle in the Saint Martin Island, at Cox's Bazar sea beach and at Sonadia Island. A prominent example large scale effort of biodiversity conservation is the ban on harvesting all kind of fishes and crustaceans in the Exclusive Economic Zone of the Bay of Bengal for 65 days starting from May 20 till July 23 every year to support the breeding of fishes and crustaceans in order to maintain their stock at sustainable level. Bangladesh has already enjoying the benefit of measures taken for the conservation of Hilsa fish from October 1 to October 22 every year in order to stop unnecessary killing of Hilsha fries. Due to this conservation scheme, in 2017, Hilsa contributed more than 1% of the country's GDP. the department of environment has declared the Cox's Bazar sea beach as the ecological critical area and has taken a number of steps, with poor implementation, to safeguard different Marine species including Turtles which are dependent on coastal ecosystem at some point of their life cycle. This kind of initiative has to be replicated in the other coastal areas which are important for breeding of marine species. The fishing ban alike that of Hilsa fish can also be replicated for other economically important and popular fish species with proper scientific investigation to increase the size of the stock and subsequently the volume of catch. Many people in the coastal region are dependent on catching shrimp fries and crabs for their livelihood by using zero mesh fishing nets. This dangerous practice catches all other small marine organisms besides shrimp fries which are usually discarded at the sea beach to die. The campaign to raise awareness among people associated with this destructive activity next to be strengthened hundred folds to stop indiscriminate killing of marine organisms and fries of non-commercial fish species in masses.

5.5.9 Coastal vegetation

Bangladesh has a 710 km long coastline boarding the Bay of Bengal besides the coastline for offshore islands numbering. In addition, to continue changes to the shoreline due to the accretion and erosion of land, there are continuous formation and erosion of offshore charland. Since all of these landforms are lucrative sites for natural succession for mangrove species in forming a coastal mangrove ecosystem and a very promising site for coastal plantation. Bangladesh has a great success story in creating a dense coastal vegetation belt specifically after the devastating cyclone in 1991 that killed hundreds of thousands of people and destroyed properties worth billions. On the other hand, natural succession has created mangrove vegetation and in some places enhanced the man made vegetation cover along the coast and in islands and chars. Bangladesh is fortunate to have Sundarban Natural Mangrove Forest (area) on the southwestern part and unfortunate to destroy the Chakaria Natural Mangrove Forest on the North eastern corner between 1980 - 1995. Ownership of these coastal chars is with he Forest Department and after the land is stabilized, the ownership goes to the Land Ministry and managed by public administration of the local government. There are numerous examples of destruction of coastal natural and planted coastal vegetation in the name of development by the government in one hand, local power brokers and private sector on the other hand. For example, the state sponsored destruction of coastal vegetation in Maheskhali for recent developments in the area, the complete destruction of the Chakaria Sundarban for shrimp farming, the large scale destruction of coastal Forest by Mirsarai Economic Zone Project under implementation.

The coastal mangroves provide a long list of ecosystem services for which Sundarban has gained the status of world heritage site from UNESCO. They provide food and livelihood, provides habitats for

many keystone species that can not occur elsewhere and play a key role in the flow of nutrient for the coastal and marine fisheries. There are different stressors which are affecting the coastal vegetation and the natural mangroves mainly related to man made changes in the upper watershed, climate change and the reckless development intervention due to the lack of understanding on the critical roles this vegetation plays in mitigating climate change, enhancing climate change adaptation, safeguarding from climate change induced devastating cyclones and tidal surges. The future of blue economy development of the Bay of Bengal depends on action oriented scientific understanding of these stressors as they regulate the food chain and nutritional level along with water quality while directly supporting numerous terrestrial, coastal and Marine species of economic importance by functioning as a habitat.

Therefore, safeguarding the future health of the Bay of Bengal instead of making the health of the bay to wane, a critical evaluation of the existing mangrove cover and coastal plantation should be done to find means not only to check their further deterioration but also to take all out measures for the enhancement of activities and programs to create and conserve coastal vegetation in yet-to-be planted areas and newly accreted charland. In order to ensure the sustainability, the programs are need to be adopted for diversification of value-added economic use of products and services from the coastal vegetation and mangroves. There had been some assessment on the possibility of revival and restoration of Chakaria Sundarban which needs to the put together to come up with projects for actually doing it following the shrimp farming model in Thailand and Vietnam where shrimp farms' productivity has-been enhanced by mangroves.

5.5.10 Sediment movement and deposition

The Bay of Bengal receives water discharges from a number of river systems as listed in Table 10 below as adapted from (Kumar et al, 2005) and as shown in Figure 26. The Bay of Bengal receives water discharges from Ganzes river system, Irrawati river system and Godawari rivers system (Yaremchuk et al., 2005). 3-D Princeton Ocean Model (POM) based calculation showed the seasonal circulation and mixed layer depths in Bay of Bengal which indicated increased fresh-water flow affecting only the western parts of the BoB. Due to the opposing northward ocean currents created by monsoon winds and southward current due to fresh-water discharge that results in strong vertical salinity stratification, the monsoon induced turbulence is subdued (Chamarthi et al., 2008). Decreasing sediment flow (Rahman et al., 2011) has been reported and linked to the decreased productivity of the marine ecosystem. Marine sediments along the Chennai coast of the Bay of Bengal contained 1.88 to 39.76 ppm petroleum hydrocarbons (PHC) with higher concentrations in in the northern part receiving wastes from shipping activities and polluted sediments through the rivers like Kuvam (5.5–39.72 ppm) and Adayar (7.26–16.83 ppm) and the vertical distribution of PHCs in the sea bed clearly indicated anthropogenic origin of PHCs (Veerasingam et al., 2011; Venkatachalapathy et al., 2010)

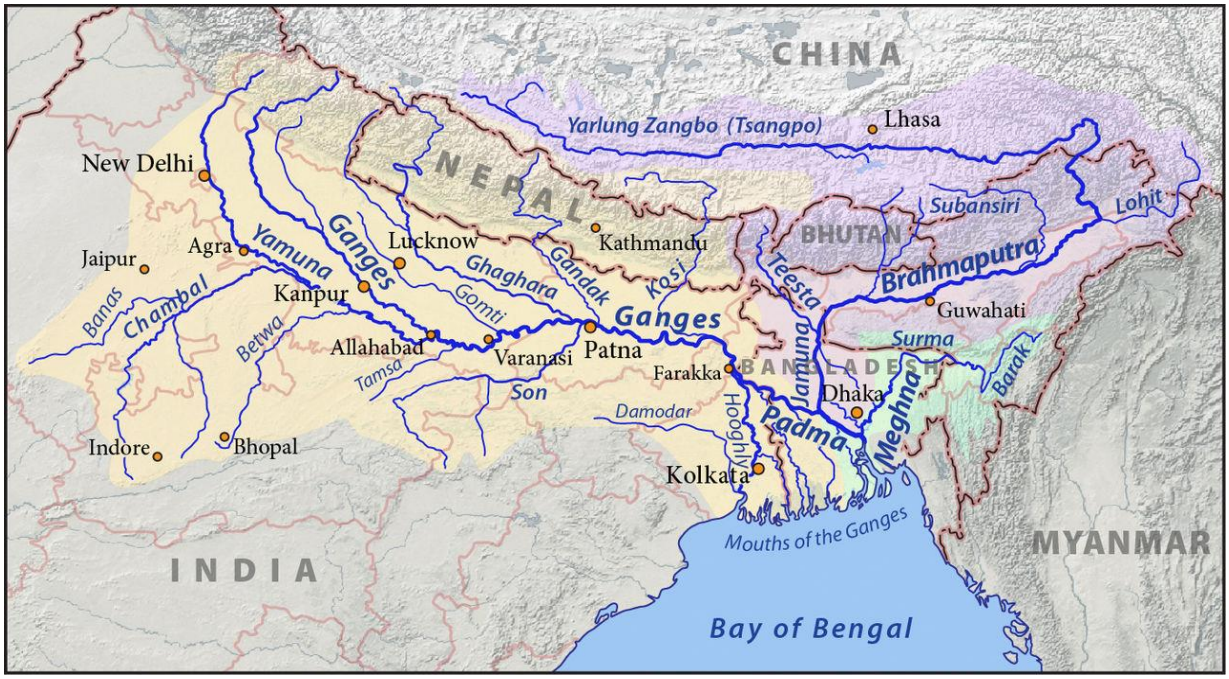

Figure 26: The river system contributing water and sediment discharges to the Bay of Bengal. Source: Pfly - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=15068725

Rivers are a big sources of methane (CH4) Methane to oceans. Atmospheric depositions and coastal swamps are other sources. The huge volume of discharge from active river systems containing increasing methane loads will enhance methane concentration at the Bay of Bengal. Southwest coast region of the Bay of Bengal showed higher methane concentration (4.4 ± 0.9 nM) with super-saturation (208 ± 37%) compared to Northwest region (2.5 ± 0.1 nM and 116 ± 2.6% respectively). Evidently, Indo-Bangla coasts send a total of 21.9×109 g CH4 yr−1 (Rao and Sarma, 2017).

Table 10 : The river system contributing water and sediment discharges to the Bay of Bengal. Source: Kumar et al, 2005

Region	River	Length (km)	Drainage area (km²)	Average discharge (m³/s)
Indo-Bangladesh	Ganges - Brahmaputra - Meghna	2948	1,635,000	38,129 (Trans-boundary, 3rd largest discharge in the world)
Indian-Deccan	Godavari	1465	312,812	3505
Indian-Deccan	Krishna	1400	258,948	2213
Indian East Coast	Mahanadi	858	141,600	2119
Indian East Coast	Brahmi-Baitarani	480	39033	903
South India	Cauvery	765	81,155	677
Indian East Coast	East flowing rivers between Mahanadi and Godavari	-	-	561
Indian East Coast	Subarnarekha	470	19300	392
Central India	Mahi	580	34842	383
South India	Penner	597	55213	200.4
India-Myanmar	Kaladan	450	-	3468
Myanmar	Irrawaddy	2170	411000	13000

The water and sediment in the Bay of Bengal is getting contaminated with heavy metals such as Fe, Cd, Mn, Ni, Pb, U, Zn, Co, Cr, As, Cu, Rb, Sr, and Zr etc. from riverine inflows carrying industrial and urban wastes besides pollution from ship breaking yard and other coastal activities including shipping (Khan et al., 2017; Siddiquee et al., 2012). There are many instances of the occurrence of heavy metals in fishes and other food from the Bay of Bengal indicating bioaccumulation and bio-magnification of these contaminants into the food chain. and if not properly regulated through constant monitoring of water and sediment qualities, the health of the Bay and the people dependent on its fisheries and other food resources will be affected.

5.5.11 Marine spatial planning

For Bangladesh, the conservation of the future health of the Bay of Bengal in order to avail the opportunities offered by the prospects of blue economy, marine spatial planning is utmost important. MSP will provide a framework for the monitoring of the health of the Bay based on the spatial challenges to its health. The formulation of the MSP should take into consideration the spatio-temporal pattern of water and sediment qualities, the geographic distribution and characteristics of the habitats of different species in the bay of bengal, the life cycle of different species in context of their spatial, water and sediment quality needs. The flow of water and sediments and maintaining their qualities should also be a part of MSP. Based on the background data, MSP should create and outline the management of proper zoning of activities, resource conservation, resource extraction and utilization should propose TO-DOs and NOT-TO-DOs for respective zones by promulgating the means of implementing them through the liaison among the public and private sector stakeholders. The MSP should contain a strong monitoring and evaluation plan in order to check the efficacy of its directives and make improvements where the proposed intervention falls short in ensuring the health of the Bay. An organizational framework to ensure the guardianship of the plan and its follow through also need to be sought by outlining its structure, roles, coordination needs both locally, regionally and internationally to safeguard the marine ecosystem and its productivity for the future generations.

5.5.12 Marine protected areas

Among different tools that MSP can adopt are the creation of marine protected areas in the forms of marine reserve, species sanctuary, banning catches of single or multiple species for specific period time under strong scientific basis with consideration of the livelihood of people dependent on those sources (already in place), formation of captive breeding centres to ensure the conservation and reintroduction of endangered and threatened species. The coastal and marine areas are to be brought under the scheme of ECAs in order to arrest further degradation and take measures to restore the degraded aspects of such areas Chakaria Sundarban. This scheme should be designed in such a manner that not only the designated areas are under the protection but also the threats from outside sources including pollution flow are properly regulated for the success of such schemes. Declaration of such designated areas are quite inadequate in the absence of proper

5.5.13 Regional collaboration and cooperation

Eight countries are associated with the Bay of Bengal large Marine ecosystem. Many rivers and river systems flowing through these countries are contributing water sediment and pollutants to the ecosystem at the Bay of Bengal which has further been complicated by the fact that some of the rivers flowing through these countries trans-boundary in nature. on the other hand, there are instances of past disputes over the boundary of marine territory which is taken some of these countries to International court, for example Bangladesh solved Maritime boundary disputes with India and Myanmar through International Court. Moreover, no single country among the eight is technologically, economically and logistically capable enough to handle the management of the Bay of Bengal large Marine ecosystem by itself while any harm caused by any of these countries will affect all other countries by affecting the

health of the Bay of Bengal ecosystem. Therefore regional collaboration and cooperation are essential and Bangladesh should put motion in place to take the lead in the formation of regional framework for the joint management of the Bay of Bengal large Marine ecosystem by using shared pool of resources, sharing pertinent research and monitoring data and taking all policy plans and programs in consultation with the others to conserve the ecosystem and its resources to ensure sustainable health of the Bay of Bengal large Marine ecosystem in the future.

5.5.14 Monitoring health of BoB

5.5.14.1 Importance

Action with science is many-a-time more harmful than no action. It is essential to gather science about different aspects of health of the Bay of Bengal in order to launch and maintain a successful program to harness the potential of blue economy be keeping the ecosystem healthy and productive. Only then focused planning and strategy can be formulated to ensure adoption of effective projects and programs for exploitation of resources without jeopardizing the base of productivity - the valuable LME of the Bay of Bengal. The continuous flow of the full range of ecosystem services that the bay is capable to deliver can only be obtained by keeping it healthy through continuous vigilance on its health and rapid action based on monitoring data to correct any wrongdoing. There are sources of problems causing harm to the health of BoB and identification of the source and measuring the extent of such harm is needed in advance to ensure justice against the agents of damage.

5.5.14.2 Indicators and tools

A proper set of indicators should be identified or designed specific to the Bay of Bengal needs to be readied and refined which will be able to reflect the health and dynamic changes in the ecosystem. The tools to measure those indicators are to be designed and put in place. There are already some research done in the area (Borja et al., 2008; Knap et al., 2002; Wells, 2003) but none is available in context of the Bay of Bengal. It is urgent to adopt large scale research activities by including all pertinent academic and research organizations in the country to meet this shortfall.

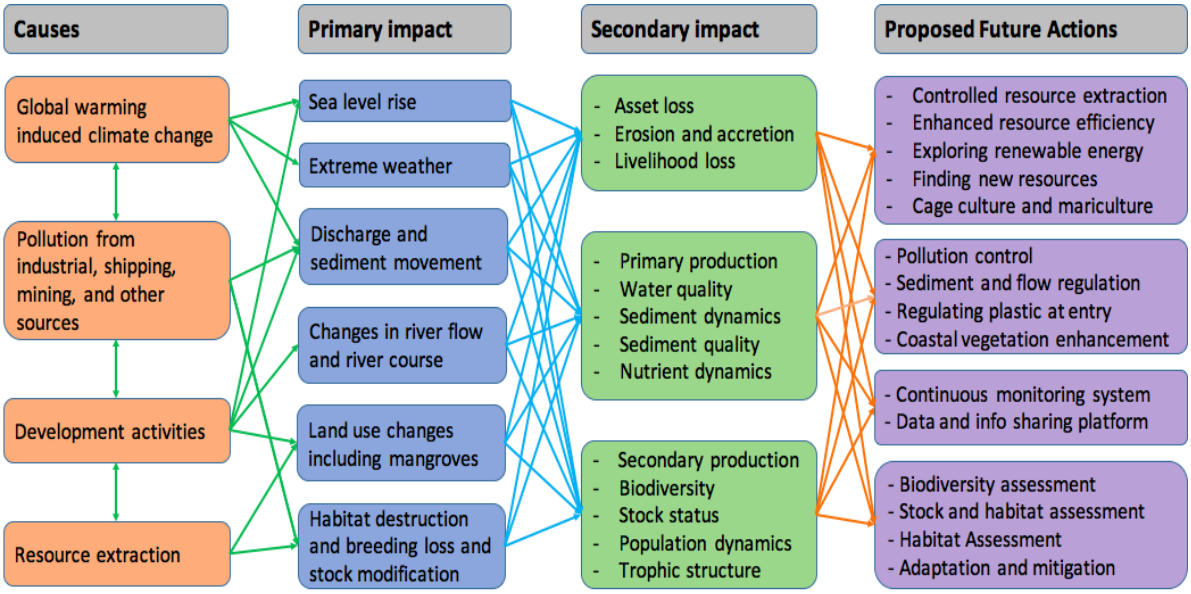

Figure 27: The decision matrix for future health of the Bay of Bengal

5.5.14.3 Means

Physicochemical monitoring: There are existing sensor systems to measure different physico-chemical parameters related to marine environment as part of the global monitoring initiatives related to ocean. However, accessing the state how are not a straight forward for the scientists and practitioner. However, accessing this data are not straightforward for the scientists and practitioner for Bangladesh from Bangladesh which delays important decision making related to the management of the health outerwear Bangalore. Therefore, Bangladeshi take immediate step on its own and kickstart collaboration with the beneficiary countries of the day of Bengal large Marine ecosystem in order to put a network of sensors in place at the Bay of Bengal for real time gathering of data on the physico-chemical properties of water and sediment. The recently launched to Bangabandhu satellite can have a very good use in this pursuit which needs to be explored.

Biological monitoring: Bio-monitoring of marine environment is an emerging field of science which depends on the behaviour of ocean dwelling flora and fauna to assess the changes in the marine environment (Wells, 1999), (Chaumot et al., 2014). There are many species in the ocean which are indicative of the different aspects of ocean water (Cunha et al., 2008) and sediment quality, pollutants such as trace heavy metals (Lafabrie et al., 2007; Rainbow, 1995), PAH (Baumard et al., 1998), organic pollutants, benthic environment (Chakraborty et al., 2014) etc. In Bangladesh, the science of bio-monitoring of ecosystem health of the Bay of Bengal is still at its infancy and this gap needs to be addressed quickly by adopting research programs on the use of locally available indicator species for the monitoring of the health of BOB.

Remote monitoring: GIS and remote sensing has been extensively used in different parts of the world to monitor different aspects of the ocean health including primary productivity. Already there are some global monitoring system in place under international collaboration (Harnayak, 2016). However, the availability of data is always an issue for which there should be alternative local remote sensor based monitoring system should be established.

Artisanal monitoring: The local fishermen and the other people whose livelihood are dependent on the availability of resources for extraction usually develop insights from their day to day exposure to the ocean and marine environment regarding the health of it. There are examples of the use of traditional and indigenous knowledge in the monitoring and management of ecosystem health in marine and coastal environment. The accumulated experience of this artisans can be accumulated through a project

for gathering indigenous knowledge and technology (ITK) for ocean health monitoring. This can then be used in Combination with other indicators and tools to get a better picture of the changes in water and sediment qualities as well as the ecosystem health in terms of the changes in the availability of fishes and other catches which the extract from the coastal and marine ecosystem.

Resource output based monitoring: Health index: Based on the multitude of data different, different ocean health indices for quantitative assessment of the health of the Bay of Bengal should be constructed through research initiatives. There are already some models of ocean health indices (Anon, 2018). Based on which new indices for different aspects of health and indices based on different indicators of health can be constructed. Quantitative indices are helpful not only in getting a clear understanding on the health of the marine or coastal ecosystem, it also help to analyze the factors and different management options. Immediate research initiatives is necessary to meet this gap.

Monitoring Framework: Monitoring the ecosystem health the outer way of Bangalore in near future and in long term is basically a continuous process that requires Collection of data by different means from different sources and analysing the data to come up with qualitative and quantitative indicator values depicting the health of marine and coastal environment and the resources therein. Consequently, a well-designed framework is needed for a successful monitoring program which will include different stakeholders as providers and consumers of data, a mechanism of exchanging data and outcomes combined with a system of conveying the results relevant authority is for quick response. Planning for designing a monitoring Framework through local and regional collaboration should be set forward immediately if we want to measure the impact of different interventions at the Bay of Bengal for all forms of conservation, assessment and utilisation to meet the ends of blue economy.

Data hub and sharing: Data is the cornerstone of informed decision making in any kind of management and making sense of data through different kind of analysis is very crucial for making policy decisions and subsequent program designs. Information and Communication Technology has created immense opportunity of generating, storing, sharing and making sense of huge volume of data known as big data through analysis at convenient time points or in real time. Since Bay of Bengal is the largest among the large Marine ecosystems of the world that provides services to billions and if its health is affected, millions of people in 8 countries dependent on this ecosystem will be affected, there should be a robust, open, versatile and strong data hub and data sharing system in place so that all the stakeholders can share their data and insights with the others to make sure collaborative conservation of the Bay of Bengal large Marine ecosystem. Bangladesh should take immediate steps in creating this platform in order to assert leadership and the benefits of being a host of such hub with international collaboration. Figure 27 shows a decision support system based on the the discussions and ideas added into this chapter.

5.6 Potential new uses from BE perspective

5.6.1 Wave energy

(Basu, 2018) Proposed the use of already available sensor network in the Bay of Bengal as wave power generators beside their use in the disaster warning system.

Table 11: Stations Summary

Serial No	Station Name	Latitude	Longitude	Tidal Range, H (m)	Basin Area, A (km^2)	Annual Average Power Generation (MW)
L1	Saint Martin	20.59583	92.331388	2.22	38.13	18.1
L2	Cox's Bazar	21.439464	92.007732	2.54	90.26	55.04
L3	Jahaizzer Char West	22.37436	91.449405	2.94	103.66	80.73
L4	Jahaizzer Char East	22.37436	91.449405	2.94	60.5	47.06
L5	Charchanga	22.03662	90.92496	2.41	159.2	84.65
L6	Khepupara	21.81791	90.279263	2.05	68.3	28.2
L7	Hiron Point	21.72046	82.432934	2.04	35.8	13.78

5.6.1.1 Rare earth metals

The beach sand of Cox's Bazar in Bangladesh is known to contain very high concentration of rare Earth metals including zirconium. This indicates a great potential for Bangladesh since the demand for rare earth metals increasing Global it due to their demand in making high value electronic equipment. Bangladesh is established a reset installation at Cox's Bazar in support with the Australian government to study the concentration of rare Earth metals in the beach sand and to find out optimum path for separating it from sand matrix. keeping the quality of ocean water in Pristine condition will also dictate the cost of separating these minerals from their matrices.

5.6.1.2 Pure water

The technology for converting seawater into potable water are becoming economically viable and technologically stronger (Bharadwaj et al., 2008; Hocking, 2013; Hsu et al., 2002; Kamal, 2005). As the population of Bangladesh is rising and the sources for collecting treatable water to meet the demand of rapidly growing population in urban centers, the country will need to evaluate the possibility of purifying water from the Bay of Bengal to meet the demand of water in the coastal regions. Besides drinking water, low cost conversion of saline water can also provide for irrigation (Martínez-Alvarez et al., 2016) and industrial water use (Pais and Ferreira, 2007). Under the climate change scenario, as Bangladesh is worried about the submersion of the low lying coastal land under water, it is inevitable for the country to initiate programs on seawater desalination through promotion of technology to do so. It can be coupled with the salt production (Tanaka et al., 2003; Turek, 2003) to make the process more sustainable. However, the success of any such scheme will largely depend on keeping the water in the oceans free from pollutants which are very difficult to remove during water desalination (https://www.climate-policy-watcher.org/reverse-osmosis/global-desalination-situation.html).

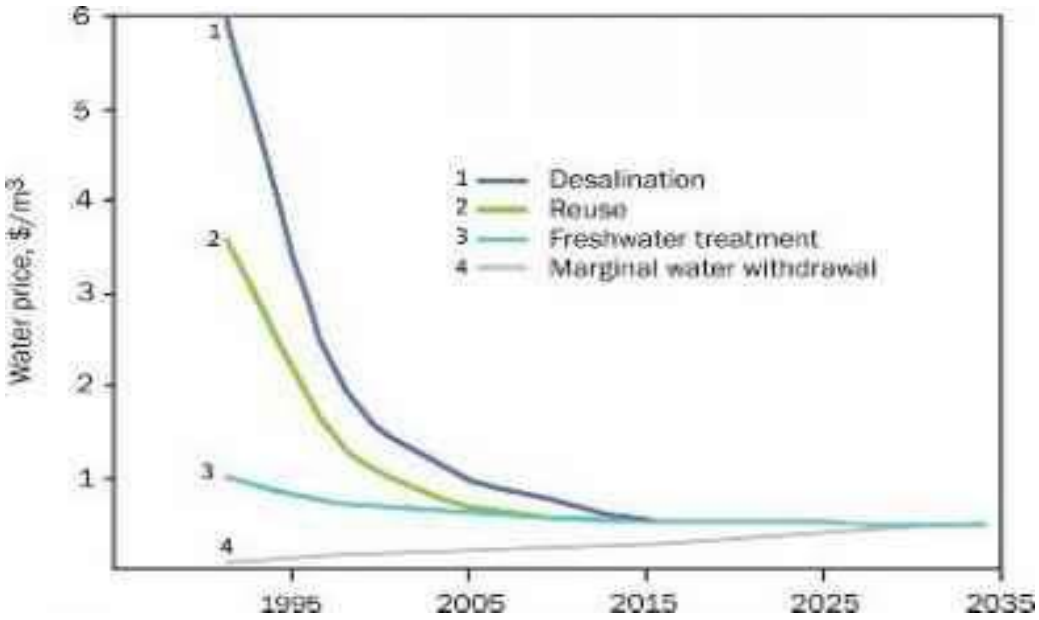

Figure 28: Evolution of water price depending on sources

5.7 Conclusions

Blue economy development is crucial for this world in order to sustainably explore and utilise the largest part of the earth's surface covered by blue oceans. It is more so for the countries like Bangladesh which are heavily dependent on coastal and marine environment for food, livelihood, supporting and regulatory ecosystem services provided by the coastal and marine ecosystems. In this context, meaningful schemes of conservation of marine ecosystem and its resources has to be adopted by Bangladesh on a priority basis to maintain the future health of the Bay of Bengal if it wants to sustain and add to the GDP growth other country. This chapter outlines the challenges associated with the future health of the large Marine ecosystem at the Bay of Bengal and has proposed a number of interventions necessary to overcome those challenges. Specifically, the issues related to climate change and it's impacts, development induced pollution management, aspects of water and sediment discharge, status of biodiversity and extraction of marine and coastal resources were highlighted.

5.8 References

Ahmed, N., Diana, J.S., 2015. Threatening “white gold”: Impacts of climate change on shrimp farming in coastal Bangladesh. Ocean. & Coast. Manag. 114.

Alam, M.K., 2018. Resolution of Maritime Boundary Disputes among Bangladesh, Myanmar and India in the Bay of Bengal, in: Maritime Governance and South Asia: Trade, Security and Sustainable Development in the Indian Ocean. WORLD SCIENTIFIC, pp. 23–33.

Anon. 2018. FAQ. Ocean Health Index. Accessed June 29 2018. http://www.oceanhealthindex.org/about/ faq.

Armbrust, E., Palumbi, S., 2015. Uncovering hidden worlds of ocean biodiversity. Science.

Basu, R., 2018. Use of Ocean Sensors as Wave Power Generators, in: 8th International Conference on Engineering, Project, and Product Management (EPPM 2017). Springer International Publishing, pp. 23–29.

Bates, N.R., Peters, A.J., 2007. The contribution of atmospheric acid deposition to ocean acidification in the subtropical North Atlantic Ocean. Mar. Chem. 107.

Baturin, G.N., 2000. Mineral resources of the ocean. Lithology and Mineral Resources 35.

Baumard, P., Budzinski, H., Garrigues, P., 1998. PAHs in Arcachon Bay, France: Origin and biomonitoring with caged organisms. Mar. Pollut. Bull. 36.

Bharadwaj, R., Singh, D., Mahapatra, A., 2008. Seawater desalination technologies. Int. J. Nucl. Desalination 3.

Borja, A., Bricker, S.B., Dauer, D.M., Demetriades, N.T., Ferreira, J.G., Forbes, A.T., Hutchings, P., Jia, X., Kenchington, R., Carlos Marques, J., Zhu, C., 2008. Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide. Mar. Pollut. Bull. 56, 1519–1537.

Bosello, F., De Cian, E., 2014. Climate change, sea level rise, and coastal disasters. A review of modeling practices. Energy Economics 46, 593–605.

Bouwman, A.F., Pawłowski, M., Liu, C., Beusen, A.H.W., Shumway, S.E., Glibert, P.M., Overbeek, C.C., 2011. Global Hindcasts and Future Projections of Coastal Nitrogen and Phosphorus Loads Due to Shellfish and Seaweed Aquaculture. Rev. Fish. Sci. 19, 331–357.

Candeloro, M., Mosciaro, F., J. Sørensen, A., Ippoliti, G., Ludvigsen, M., 2015. Sensor-based Autonomous Path-Planner for Sea-Bottom Exploration and Mosaicking∗∗This work has been carried out at the Centre for Autonomous Marine Operations and Systems (AMOS). The Norwegian Research Council is acknowledged as the main sponsor of AMOS through the Centres of Excellence funding scheme, Project number 223254. IFAC-PapersOnLine 48.

Carson, M., Köhl, A., Stammer, D., A. Slangen, A.B., Katsman, C.A., W. van de Wal, R.S., Church, J., White, N., 2015. Coastal sea level changes, observed and projected during the 20th and 21st century. Climatic Change 134.

Cater, C., Cater, E., 2007. Marine ecotourism resources., in: Marine Ecotourism: Between the Devil and the Deep Blue Sea. CABI, pp. 46–76.

Catling, D.C., Kasting, J.F., 2017. Formation of Earth's Atmosphere and Oceans, in: Atmospheric Evolution on Inhabited and Lifeless Worlds. Cambridge University Press, pp. 171–197.

Chakraborty, S., Bhattacharya, T., Singh, G., Maity, J.P., 2014. Benthic macroalgae as biological indicators of heavy metal pollution in the marine environments: a biomonitoring approach for pollution assessment. Ecotoxicology and environmental safety 100, 61–68.

Chamarthi, S., Ram, P.S., Josyula, L., 2008. Effect of River Discharge on Bay of Bengal Circulation. Mar. Geod. 31, 160–168.

Chaumot, A., Ferrari, B., Geffard, O., Garric, J., 2014. Ecotoxicology, Aquatic Invertebrates, in: Encyclopedia of Toxicology. Elsevier, pp. 284–288.

Classification of marine ecosystem services, 2016. , in: Marine Ecosystem Services. Nordic Council of Ministers, pp. 23–38.

Coleman, K., 2008. Research Review of Collaborative Ecosystem-Based Management in the California Current Large Marine Ecosystem. Coastal Management 36, 484–494.

Cressey, D., 2011. Ocean conservation: Uncertain sanctuary. Nature 480, 166–167.

Csirke, J., Garcia, S.M., 2009. Marine Fishery Resources, Global State of, in: Encyclopedia of Ocean Sciences. Elsevier, pp. 576–581.

Cullen, J.J., 1999. Iron, nitrogen and phosphorus in the ocean: Oceanography. Nature 402. doi:10.1038/46469

Cunha, S.R., Gonçalves, R., Silva, S.R., Correia, A.D., 2008. An automated marine biomonitoring system for assessing water quality in real-time. Ecotoxicology (London, England) 17, 558–564. doi:10.1007/s10646-008-0216-y

De, U., 2013. Environmental and Socio-Economic Impacts of Climate Change in the Sundarban Delta and the Need for Green Management, in: Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change. Springer Berlin Heidelberg, pp. 601–633. doi:10.1007/978-3-642-36143-2_34

Elimelech, M., Phillip, W.A., 2011. The future of seawater desalination: energy, technology, and the environment. Sci. 333, 712–717. doi:10.1126/science.1200488

Faizal, M., Rafiuddin Ahmed, M., 2011. On the ocean heat budget and ocean thermal energy conversion: Ocean heat budget and OTEC. Int. J. Energy Res. 35. doi:10.1002/er.1885

Farrow, S., n.d. Modeling The Importance Of Oceans And Estuaries, in: Proceedings OCEANS. IEEE, pp. 130–132. doi:10.1109/OCEANS.1989.592836

Fisner, M., Majer, A.P., Balthazar-Silva, D., Gorman, D., Turra, A., 2017. Quantifying microplastic pollution on sandy beaches: the conundrum of large sample variability and spatial heterogeneity. Environmental science and pollution research international 24, 13732–13740. doi:10.1007/s11356-017-8883-y

Fransoo, J.C., Lee, C.-Y., 2013. The Critical Role of Ocean Container Transport in Global Supply Chain Performance. Prod. Oper. Manag. 22. doi:10.1111/j.1937-5956.2011.01310.x

Gamage, R.N., 2016. Blue economy in Southeast Asia: Oceans as the new frontier of economic development. Maritime Affairs: Journal of the National Maritime Foundation of India 12, 1–15. doi:10.1080/09733159.2016.1244361

Ghaffour, N., Missimer, T.M., Amy, G.L., 2013. Technical review and evaluation of the economics of water desalination: Current and future challenges for better water supply sustainability. Desalination 309. doi:10.1016/j.desal.2012.10.015

Goldberg, E.D., 1985. The Oceans as Waste Space*. Ocean. Yearb. Online 5. doi:10.1163/221160085X00113

Gonzalez, J.-A., 2016. Sustainability of Marine Food Resources-An Ecological and Fishery Approach. Journal of Environment and Health Science 2. doi:10.15436/2378-6841.16.1027

Greenberg, D.A., Blanchard, W., Smith, B., Barrow, E., 2012. Climate Change, Mean Sea Level and High Tides in the Bay of Fundy. Atmosphere-Ocean 50, 261–276. doi:10.1080/07055900.2012.668670

Greenemeier, L., 2014. Iron Man-like exosuit could expand ocean exploration. Nature. doi:10.1038/nature.2014.14822

Gregor, B., 1985. The chemical evolution of the atmosphere and oceans. Geochim. et Cosmochim. Acta 49. doi:10.1016/0016-7037(85)90154-1

Gröger, M., Maier-Reimer, E., Mikolajewicz, U., Schurgers, G., Vizcaíno, M., Winguth, A., 2007. Changes in the hydrological cycle, ocean circulation, and carbon/nutrient cycling during the last interglacial and glacial transition: CHANGES IN THE HYDROLOGICAL CYCLE. Paleoceanography 22. doi:10.1029/2006PA001375

Gupta, P., 2017. Marine Ecosystem: A Majorly Unexplored Domain for Drug Discovery. Natural Products Chemistry & Research 05. doi:10.4172/2329-6836.1000e123

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig,

E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Sci. 319, 948–952. doi:10.1126/science.1149345

Harnayak, T. 2016. New sensors promise better picture of world ocean health. Science | AAAS. Accessed June 29 2018. http://www.sciencemag.org/news/2016/01/new-sensors-promise-better-picture-world -ocean-health.

Hassan, A., Rahimi, R., 2018. Case Study Bangladesh: Addressing climate change effects on coastal tourism in St Martin's Island of Bangladesh., in: Global Climate Change and Coastal Tourism: Recognizing Problems, Managing Solutions and Future Expectations. CABI, pp. 212–220. doi:10.1079/9781780648439.0212

Hehre, E.J., Meeuwig, J.J., 2016. A Global Analysis of the Relationship between Farmed Seaweed Production and Herbivorous Fish Catch. PloS one 11, e0148250. doi:10.1371/journal.pone.0148250

Heimburger, A., Losno, R., Triquet, S., Nguyen, E.B., 2013. Atmospheric deposition fluxes of 26 elements over the Southern Indian Ocean: Time series on Kerguelen and Crozet Islands: DEPOSITION FLUXES OVER SOUTHERN OCEAN. Glob. Biogeochem. Cycles 27. doi:10.1002/gbc.20043

Hocking, G., 2013. Seawater desalination: an environmental regulator's perspective. Desalination Water Treat. 51, 273–279. doi:10.1080/19443994.2012.714733

Hoffmann, J., Wilmsmeier, G., Lun, Y.H.V., 2017. Connecting the world through global shipping networks. Journal of Shipping and Trade 2. doi:10.1186/s41072-017-0020-z

Holdgate, M.W., McIntosh, P.T., 1986. The Oceans as a Waste Disposal Option - Management, Decision Making and Policy, in: The Role of the Oceans as a Waste Disposal Option. Springer Netherlands, pp. 1–18. doi:10.1007/978-94-009-4628-6_1

Hsu, S.., Cheng, K.., Chiou, J.., 2002. Seawater desalination by direct contact membrane distillation. Desalination 143. doi:10.1016/S0011-9164(02)00266-7

Hussain, M.G., Failler, P., Karim, A.A., Alam, M.K., 2018. Major opportunities of blue economy development in Bangladesh. J. Indian Ocean. Reg. 14. doi:10.1080/19480881.2017.1368250

Ibánhez, J.S.P., Araujo, M., Lefèvre, N., 2016. The overlooked tropical oceanic CO2 sink: Overlooked Tropical Oceanic CO2 Sink. Geophys. Res. Lett. 43. doi:10.1002/2016GL068020

Japan Agency for Marine-earth Science and Technology (JAMSTEC), Research and Development Center for Marine Biosciences, Marine Bioresource Exploration Research Group, 2016. . JAPAN TAPPI JOURNAL 70. doi:10.2524/jtappij.70.1290

Jickells, T., 2002. Emissions from the Oceans to the Atmosphere, Deposition from the Atmosphere to the Oceans and the Interactions Between Them, in: Challenges of a Changing Earth. Springer Berlin Heidelberg, pp. 93–96. doi:10.1007/978-3-642-19016-2_15

KAŁDUŃSKI, M., 2015. A Commentary on Maritime Boundary Arbitration between Bangladesh and India Concerning the Bay of Bengal. Leiden Journal of International Law 28. doi:10.1017/S0922156515000436

Kamal, I., 2005. Integration of seawater desalination with power generation. Desalination 180. doi:10.1016/j.desal.2005.02.007

Khan, M.Z.H., Hasan, M.R., Khan, M., Aktar, S., Fatema, K., 2017. Distribution of Heavy Metals in Surface Sediments of the Bay of Bengal Coast. Journal of toxicology 2017, 9235764. doi:10.1155/2017/9235764

Knap, A., Dewailly, E., Furgal, C., Galvin, J., Baden, D., Bowen, R.E., Depledge, M., Duguay, L., Fleming, L.E., Ford, T., Moser, F., Owen, R., Suk, W.A., Unluata, U., 2002. Indicators of ocean health

and human health: Developing a research and monitoring framework. Environ. Health Perspect. 110, 839–845.

Krishnamurthy, A., Moore, J.K., Zender, C.S., Luo, C., 2007. Effects of atmospheric inorganic nitrogen deposition on ocean biogeochemistry. J. Geophys. Res. 112. doi:10.1029/2006JG000334

Kumar, R., Singh, R. D. and Sharma, K. D. 2005.Water resources of India. Current Science, 89(5):794-811 p

Lafabrie, C., Pergent, G., Kantin, R., Pergent-Martini, C., Gonzalez, J.-L., 2007. Trace metals assessment in water, sediment, mussel and seagrass species--validation of the use of Posidonia oceanica as a metal biomonitor. Chemosphere 68, 2033–2039. doi:10.1016/j.chemosphere.2007.02.039

Landschützer, P., Gruber, N., Bakker, D.C.E., 2016. Decadal variations and trends of the global ocean carbon sink: DECADAL AIR-SEA CO2 FLUX VARIABILITY. Glob. Biogeochem. Cycles 30. doi:10.1002/2015GB005359

Leary, D., Vierros, M., Hamon, G., Arico, S., Monagle, C., 2009. Marine genetic resources: A review of scientific and commercial interest. Mar. Policy 33. doi:10.1016/j.marpol.2008.05.010

Lee, C.-Y., Song, D.-P., 2017. Ocean container transport in global supply chains: Overview and research opportunities. Transp. Res. Part B: Methodol. 95. doi:10.1016/j.trb.2016.05.001

Limpet (Patella sp) as a biomonitor for organic pollutants. A proxy for mussel?, n.d.

Loganathan, P., Naidu, G., Vigneswaran, S., 2017. Mining valuable minerals from seawater: a critical review. Environ. Sci.: Water Res. Technol. 3. doi:10.1039/C6EW00268D

Martínez-Alvarez, V., Martin-Gorriz, B., Soto-García, M., 2016. Seawater desalination for crop irrigation — A review of current experiences and revealed key issues. Desalination 381. doi:10.1016/j.desal.2015.11.032

Monteiro, F.M., Follows, M.J., Dutkiewicz, S., 2010. Distribution of diverse nitrogen fixers in the global ocean: DIVERSE NITROGEN FIXERS IN GLOBAL OCEAN. Glob. Biogeochem. Cycles 24. doi:10.1029/2009GB003731

Moore, B., 2007. Ocean Exploration: Introductory Remarks, in: Law, Science & Ocean Management. Martinus Nijhoff Publishers, pp. 219–224. doi:10.1163/ej.9789004162556.i-850.58

Neumann, B., Ott, K., Kenchington, R., 2017. Strong sustainability in coastal areas: a conceptual interpretation of SDG 14. Sustainability Science 12. doi:10.1007/s11625-017-0472-y

NOAA, NMFS, NEFSC, Sherman, K., Aquarone, M.-C., Adams, S., 2007. Global Application of the Large Marine Ecosystem Concept 2007-2010, NOAA Technical Memorandum NMFS-NE-208.

Okubo, A., Takeda, S., Obata, H., 2013. Atmospheric deposition of trace metals to the western North Pacific Ocean observed at coastal station in Japan. Atmospheric Res. 129–130. doi:10.1016/j.atmosres.2013.03.014

Orr, J.C., Sarmiento, J.L., 1992. Potential of Marine Macroalgae as a Sink for CO2: Constraints from a 3-D General Circulation Model of the Global Ocean, in: Natural Sinks of CO2. Springer Netherlands, pp. 405–421. doi:10.1007/978-94-011-2793-6_22

Pai, S., 2015. Autonomous Marine Vehicle: A Cost Effective Technology to Manage Risk in Exploration and Production, in: SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers. doi:10.2118/174924-MS

Pais, J.A.G.C.., Ferreira, L.M.G.., 2007. Performance study of an industrial RO plant for seawater desalination. Desalination 208. doi:10.1016/j.desal.2006.06.017

Palumbi, S.R., Sandifer, P.A., Allan, J.D., Beck, M.W., Fautin, D.G., Fogarty, M.J., Halpern, B.S., Incze, L.S., Leong, J.-A., Norse, E., Stachowicz, J.J., Wall, D.H., 2009. Managing for ocean biodiversity to sustain marine ecosystem services. Front. Ecol. Environ. 7. doi:10.1890/070135

Patil, P.G., Virdin, J., Diez, S.M., Roberts, J., Singh, A., 2016. Toward a Blue Economy: A Promise for Sustainable Growth in the Caribbean. World Bank. doi:10.1596/25061

Peterson, S., Teal, J., 1986. Scientific basis for the role of the oceans as a waste disposal option. Mar. Policy 10. doi:10.1016/0308-597X(86)90037-0

Qiu, W., Gullett, W., 2017. Quantitative analysis for maritime delimitation: Reassessing the Bay of Bengal delimitation between Bangladesh and Myanmar. Mar. Policy 78. doi:10.1016/j.marpol.2017.01.011

Quéré, C.L., Aumont, O., Bopp, L., Bousquet, P., Ciais, P., Francey, R., Heimann, M., Keeling, C.D., Keeling, R.F., Kheshgi, H., Peylin, P., Piper, S.C., Prentice, I.C., Rayner, P.J., 2003. Two decades of ocean CO2 sink and variability. Tellus B: Chem. Phys. Meteorol. 55. doi:10.3402/tellusb.v55i2.16719

Rahman, A.F., Dragoni, D., El-Masri, B., 2011. Response of the Sundarbans coastline to sea level rise and decreased sediment flow: A remote sensing assessment. Remote Sensing of Environment 115.

Rahman, M.R., 2017. Blue Economy and Maritime Cooperation in the Bay of Bengal: Role of Bangladesh. Procedia Eng. 194.

Rainbow, P.S., 1995. Biomonitoring of heavy metal availability in the marine environment. Mar. Pollut. Bull. 31.

Rajagopalan, K., Nihous, G.C., 2013. An Assessment of Global Ocean Thermal Energy Conversion Resources With a High-Resolution Ocean General Circulation Model. Journal of Energy Resources Technology 135. doi:10.1115/1.4023868

Rao, G.D., Sarma, V.V.S.S., 2017. Influence of river discharge on the distribution and flux of methane in the coastal Bay of Bengal. Mar. Chem. 197. doi:10.1016/j.marchem.2017.11.002

Reed, D.C., Harrison, J.A., 2016. Linking nutrient loading and oxygen in the coastal ocean: A new global scale model: NUTRIENTS AND OXYGEN IN THE COASTAL OCEAN. Glob. Biogeochem. Cycles 30. doi:10.1002/2015GB005303

Sarker, S., Bhuyan, M.A.H., Rahman, M.M., Islam, M.A., Hossain, M.S., Basak, S.C., Islam, M.M., 2018. From science to action: Exploring the potentials of Blue Economy for enhancing economic sustainability in Bangladesh. Ocean. & Coast. Manag. 157. doi:10.1016/j.ocecoaman.2018.03.001

Seibold, E., Berger, W.H., 1996. Resources from the Ocean Floor, in: The Sea Floor. Springer Berlin Heidelberg, pp. 277–302. doi:10.1007/978-3-662-03317-3_11

Shahmansouri, A., Min, J., Jin, L., Bellona, C., 2015. Feasibility of extracting valuable minerals from desalination concentrate: a comprehensive literature review. J. Clean. Prod. 100. doi:10.1016/j.jclepro.2015.03.031

Shamsuzzaman, M.M., Islam, M.M., 2018. Analysing the legal framework of marine living resources management in Bangladesh: Towards achieving Sustainable Development Goal 14. Mar. Policy 87. doi:10.1016/j.marpol.2017.10.026

Shannon, M.., Bohn, P.., Elimelech, M., Georgiadis, J.., Mariñas, B.., Mayes, A.., 2008. Science and technology for water purification in the coming decades. Nature 452, 301–310–301–310.

Sherman, K., 2001. Large Marine Ecosystems, in: Encyclopedia of Ocean Sciences. Elsevier, pp. 413–419. doi:10.1016/B978-012374473-9.00292-7

Sherman, K., 1991. The Large Marine Ecosystem Concept: Research and Management Strategy for Living Marine Resources. Ecological applications : a publication of the Ecological Society of America 1, 349–360. doi:10.2307/1941896

Sherman, K., Hamukuaya, H., 2016. Sustainable development of the world's Large Marine Ecosystems. Environ. Dev. 17. doi:10.1016/j.envdev.2015.12.002

Siddiquee, N.A., Parween, S., Quddus, M.M.A., Barua, P., 2012. Heavy Metal Pollution in Sediments at Ship Breaking Area of Bangladesh 78–87.

Smith-Godfrey, S., 2016. Defining the Blue Economy. Maritime Affairs: Journal of the National Maritime Foundation of India 12, 58–64. doi:10.1080/09733159.2016.1175131

Sukumaran, P.V., 2000. Evolution of the atmosphere and oceans: Evidence from geological records: 2. Enhancement of oxygen in the atmosphere. Resonance 5. doi:10.1007/BF02834667

Sultan, R., n.d. Economic value of marine ecosystem services for sustainable ocean management: the case of Mauritius, in: Handbook on the Economics and Management of Sustainable Oceans. Edward Elgar Publishing, pp. 152–173. doi:10.4337/9781786430724.00016

Sweatman, W., Mercer, G., Boland, J., Cusimano, N., Greenwood, A., Harley, K., Van Heijster, P., Kim, P., Maisano, J., Nelson, M., Pettet, G., 2016. Seaweed cultivation and the remediation of by-products from ethanol production: a glorious green growth. ANZIAM J. 56. doi:10.21914/anziamj.v56i0.9402

Tanaka, Y., Ehara, R., Itoi, S., Goto, T., 2003. Ion-exchange membrane electrodialytic salt production using brine discharged from a reverse osmosis seawater desalination plant. J. Membr. Sci. 222. doi:10.1016/S0376-7388(03)00217-5

The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries, 2017. . World Bank. doi:10.1596/26843

Turek, M., 2003. Seawater desalination and salt production in a hybrid membrane-thermal process. Desalination 153. doi:10.1016/S0011-9164(02)01123-2

United Nations (Ed.), 2017. Aesthetic, Cultural, Religious and Spiritual Ecosystem Services Derived from the Marine Environment, in: The First Global Integrated Marine Assessment: World Ocean Assessment I. Cambridge University Press, pp. 159–170. doi:10.1017/9781108186148.011

Urabe, T., Ura, T., Tsujimoto, T., Hotta, H., n.d. Next-generation technology for ocean resources exploration (Zipangu-in-the-Ocean) project in Japan, in: OCEANS 2015 - Genova. IEEE, pp. 1–5. doi:10.1109/OCEANS-Genova.2015.7271762

Veerasingam, S., Venkatachalapathy, R., Sudhakar, S., Raja, P., Rajeswari, V., 2011. Petroleum hydrocarbon concentrations in eight mollusc species along Tamilnadu coast, Bay of Bengal, India. Journal of environmental sciences (China) 23, 1129–1134. doi:10.1016/S1001-0742(10)60524-4

Venkatachalapathy, R., Veerasingam, S., Ramkumar, T., 2010. Petroleum hydrocarbon concentrations in marine sediments along Chennai Coast, Bay of Bengal, India. Bull. Environ. Contam. Toxicol. 85, 397–401. doi:10.1007/s00128-010-0097-7

Verlaan, P., 2005. Second Letter from Madras: Progress in the Bay of Bengal Large Marine Ecosystem (BOBLME) Programme. Underw. Technol. 26. doi:10.3723/175605405784426628

Vierros, M., 2017. Global marine governance and oceans management for Achievement of SDG 14. UN Chronicle 54.

Vince, J., Hardesty, B.D., 2017. Plastic pollution challenges in marine and coastal environments: from local to global governance: Plastic pollution governance. Restoration Ecology 25.

Vivekanandan, E., Hermes, R., O'Brien, C., 2016. Climate change effects in the Bay of Bengal Large Marine Ecosystem. Environ. Dev. 17.

Voss, M., Montoya, J.P., 2009. Nitrogen cycle: Oceans apart. Nature 461, 49–50.

Wang, J.-W., Han, W., Sriver, R.L., 2012. Impact of tropical cyclones on the ocean heat budget in the Bay of Bengal during 1999: 1. Model configuration and evaluation: TROPICAL CYCLONES AND OCEAN HEAT BUDGET, 1. J. Geophys. Res. Ocean. 117.

Weissenberger, S., Chouinard, O., 2015. The Vulnerability of Coastal Zones Towards Climate Change and Sea Level Rise, in: Adaptation to Climate Change and Sea Level Rise. Springer Netherlands, pp. 7–31.

Wells, P.G., 2003. Assessing health of the Bay of Fundy - concepts and framework. Mar. Pollut. Bull. 46, 1059–1077.

Wells, P.G., 1999. Biomonitoring the Health of Coastal Marine Ecosystems – The Roles and Challenges of Microscale Toxicity Tests. Mar. Pollut. Bull. 39. doi:10.1016/S0025-326X(99)00120-4

Yu, Y., Zhou, D., Li, Z., Zhu, C., 2018. Advancement and Challenges of Microplastic Pollution in the Aquatic Environment: a Review. Water, Air, & Soil Pollut. 229.

Zhang, J., Zou, L., Wu, Y., Lin, Y.A., 2004. Atmospheric Wet Deposition and Changes in Phytoplankton Biomass in the Surface Ocean: ATMOSPHERIC WET DEPOSITION AND CHANGE. Geophys. Res. Lett. 31.

6 Coastal and marine tourism/eco-tourism in the future

6.1 Abstract

Having the world's largest unbroken sea-beach and vast coastline, Bangladesh has an immense potentiality to develop sustainable coastal and marine tourism. In Bangladesh, coastal and marine tourism is already in operation, though on a limited scale. But the growth of tourism in this country is lagging behind compared to the world as a whole. The contribution of this sector in the economy of Bangladesh is still below the mark. Therefore, the economy can be benefited by harnessing opportunities pertinent to the country's coastal and marine tourism. To attract the local and foreign tourists, the country can improve the existing tourist sites. It can also develop new tourist spots in the coastal and marine areas. Introduction of new tourism products such as cruise to Swatch of no ground from Chittagong and Khulna, exclusive tourist zones for foreigners, surfing zones, community-based ecotourism, underwater tourism, and sports tourism in the coastal and marine areas can be thought of. In the process of developing tourism, proper planning, budgetary allocation, community participation, awareness building, coordination between agencies and proper marketing strategies are among the important factors. By developing the proposed tourism in marine and coastal areas, Bangladesh can increase GDP, generate more jobs, reduce poverty, earn foreign currencies, gain socio-cultural benefits, conserve environment, and protect coastal areas. In addition, development of coastal and marine tourism can create the opportunity to promote local culture and heritage by integrating local communities into the development process. Finally, government can play a vital role in promoting coastal and marine tourism by providing some special services including on arrival visa and one stop service to the foreign tourists.

6.2 Introduction

Bangladesh has the world's longest-unbroken sea beach of 580 km of coastline, 200 nm exclusive economic zone and 12 nm terrestrial zones. So far, relatively limited tourism is developed in a couple of spots including Cox's Bazar, Teknaf and St. Martin's Island. In addition, in the western part, Sundarbans-based tourism has been flourished for last few decades. Although a little success has been achieved in coastal tourism, marine tourism has remained largely ignored. Moreover, most of the tourist activities are of mass nature.

While Travel & Tourism sector accounted for 10.4% of global GDP and 9.9% of global employment in 2017, the contributions of this sector in Bangladesh in terms of GDP and employment are 4.3% of GDP and 3.8% of total employment (World Travel and Tourism Council [WTTC], 2018). Although this scenario is a positive development compared to the past, global scenario suggests that the country is yet to realize its full potential. Particularly, given the large coastal and marine area the country owns, a large scale developmentof coastal and marine tourism in this country is possible.

This chapter aims at analysing the status quo and proposing suggestions to be implemented in the ongoing and future development processes. In particular, it discusses the existing facilities and how further improvement can be achieved so that Bangladesh can use its vast coastal area and marine water body in economic development through enhancing ecotourism.

The remainder of this chapter is organised as follows. Section 6.2 sheds some light on a couple of tourist spots which are less familiar and relatively immature but potentially can be developed. This section also proposes some development ideas. Barriers to and benefits of developing sustainable coastal and marine tourism in Bangladesh are discussed in Sections 6.3 and 6.4, respectively. The Free-rider problem in tourism: Bangladesh perspective is discussed in 6.5. Some policy suggestions are proposed in Section 6.6. Finally, Section 6.7 offers concluding remarks.

6.3 Development of sustainable coastal and marine Tourism

6.3.1 Expansion of coastal tourism (new, safe and secure)

Among the tourist destinations in Bangladesh, many are in coastal and marine environments. Accordingly, they are termed as coastal and marine tourist spots. Some of them are relatively well-established and recognized by Bangladesh Parjatan Corporation. They are located mainly in Chittagong, Cox's Bazar, Khulna and Patuakhali districts. The existing tourist spots in Chittagong District are Patenga sea beach and Parki sea beach. Cox's Bazar District has an unbroken 120 km long sandy sea beach with gentle slope. Many consider it as the longest sea beach in the world ("Cox's Bazar sea beach," n.d.). This district is the home of quite a few tourist spots like Laboni point, Himchori, Inani beach, Sonadia Island, Teknaf sea beach, St. Martin Island and Cherawip. Khulna is one of the southwestern districts in Bangladesh. It is considered as the gateway to the Sundarbans, one of the UNESCO world heritage sites. Bordering the Bay of Bengal, Khulna has two important coastal and marine tourist spots; Katka and Dublar Char. Finally, Patuakhali District, located in the south-central region of the country. Adjacent to the Bay of Bengal, this district has become attractive due to Kuakata sea beach which is locally known as ShagorKonnya (Daughter of Ocean).

Apart from that, there are a good number of beaches that are not as developed as the ones discussed in the previous section. They seem to have huge untapped potentials. Those potentials need to be unfolded in order to attract more tourists from home and abroad. To this end, proper initiatives should be taken.

Kutubdia: Kutubdia is a relatively small island under the district of Cox's Bazar. There is a sea beach adjacent to boroghop bazar which seems to be as wonderful as Cox's Bazar sea beach. But because of the lack of supporting facilities and necessary publicity, many even do not know the existence of such a lovely place.

Kattoli: Kattoli beach, located at South Kattoli beside Zohur Ahmed Chowdhury Stadium in Chittagong city, is one of the most attractive beaches that have grossly failed to draw tourists' attention. This is perhaps because of the fact that this beach has come into existence relatively recently compared to other familiar beaches like those in Cox's Bazar and Kuakata. Thanks to the Forest Department, there is a mangrove forest that beautifies the beach andacts as a protection against tidal wave. That is why local people call it the "Sundarbans of Chittagong" (Ara, 2017).

Bashbaria: Fifteen minutes distant from Bashbaria bazar in ShitakundoUpazila of Chittagong, this beach is largely muddy. A Jhauban and a newly emerged sandy field are among the main attractions of the beach.

Figure 29 : Guliakhali Sea beach. Source: Google Image

Figure 30 : Sun sets at Kattoli Sea beach (Photo by MNN)

Guliakhali: This beach is 5 km west of Shitakundo bazar in ShitakundoUpazila of Chittagong. One amazing attraction of the beach is thatit is green and grassy. This distinguishes the beach from other traditional sandy beaches. The scope of development ofthis beach is huge.

Bashkhali: It is one of the wonderful beaches that remain largely unexplored. This 35 km long sandy beach belongs to points including Khankhanabad, Kathariya, Gondamara, Kadamrasul, Baharchara and

Ratnapura. It is the home of some fascinating species including oysters, corals and embellished snail shells (Islam et al., 2016).

6.3.2 Improvement of the existing spots in the coastal zones

The tourist spots in coastal and marine zones in Bangladesh have remained utterly unexploited. Many of the tourism and recreational activities that are supposed to be in place in a typical coastal/marine spot are yet to be introduced in those spots. Table 12 lists such potential recreational activities as well as existing ones in important coast/marine-based tourist places in Bangladesh. An activity is listed as existing if at least one spot offers the activity. That means many of the activities listed as existing are potential for one or more spots. Thus it is clearly evident from the table that the area of improvement is huge. Tapping this potential would be instrumental in ensuring sustainable expansion of the tourism industry in this country.

Table 12 : Potential Marine and Coastal Tourism Activities in Bangladesh

Different coast/marine-based tourist spots in Bangladesh	Coastal tourism activities		Marine tourism activities	
	Existing	**Potential**	**Existing**	**Potential**
	beach volleyball, kite-flying, walking, horse-riding, sand-castle building or sand sculpting, wildlife watching, shell-fish gathering, beach-combing, sun-bathing (baking), picnic and barbecues	tidal-pool exploration, land-yachting, fishing, skim-boarding, radio-controlled boating, crabbing, hang gliding, parasailing	SCUBA diving, snorkeling, scenic boat cruising, surfing, swimming	yachting, water-skiing, wake-boarding, boat based fishing, wildlife watching, sea kayaking, surf-ski paddling, kite-surfing, board-sailing (windsurfing), dragon-boat paddling, stand-up-paddle boarding

Source: Authors' own observations

6.3.3 Cruise to Swatch of no ground from Chittagong and Khulna

Located in the southern side of Dublar Char Island in the Bay of Bengal, the Swatch of No Ground (SONG) is a trough-shaped submarine canyon spanning about 1738 square kilometres area with an average depth of 900 metres. On October 27, 2014 a part of it was announced as the first marine protected area (MPA) of Bangladesh by the government ("World leaders can," 2016). It is reported to be a safe breeding and spawning ground for such endangered species as dolphins, whales, sharks, turtles, and a myriad of other marine wildlife ("World leaders can," 2016, Khan, 2017).As far as tourism is concerned, the SONG is enormously valuable. However, the opportunity to use it as a tourist spot has long been unrealized. One important way to generate values from this mysterious place may be to initiate cruises to it from Chittagong and Khulna.As a marine wildlife tourist spot, SONG will be an exciting place to the tourists for observation of wildlife. Whales and Dolphins, which are commonly appeared wildlife in SONG, have gradually become ones among the most attractive touristic amenities. As Gibson et. al., 2007 reveals, for watching Whales and Dolphins, New Zealanders and international visitors made more than 425,000 visits in 2004. This is an outcome of the growth of number of visits at the annual rate of11% since 1998.

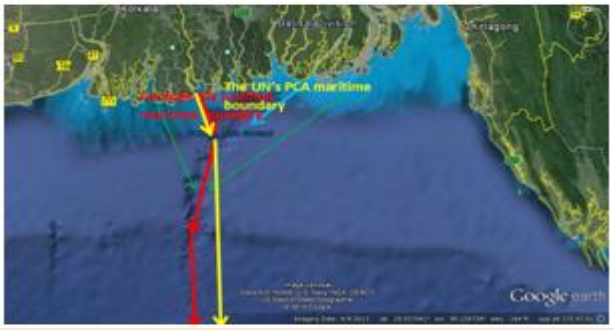

Figure 31 : Swatch of No Ground. Source: newsg24.com

Figure 32 : Dolphine Swimming in Swatch of No Ground. Source: bdnews24.com

6.3.4 Cruise on seaside tour

A seaside route from St. Martin to Chittagong via Teknaf and Cox's Bazar (Blue colored in Figure 33) and another route from Chittagong to the Sundarbans (Khulna) and Kuakata (Potuakhali) can be envisaged. Cruising on these potential routes would likely to generate a substantial commercial value as well as a significant amenity value. Tourists would be able to explore and enjoy the natural beauty offered by coastal landscapes. It is important to mention that currently going from Chittagong to Khulna through land route (marked by purple color in Figure 33) requires travelling via Dhaka entailing a 12.30-hour journey of 445 km distance. If the proposed marine route is introduced (Red marked in Figure 33), traveling from Chittagong to Khulna would significantly reduce time and cost. Additionally, it would help reduce ever-growing traffic jam on Dhaka-Chittagong highway.

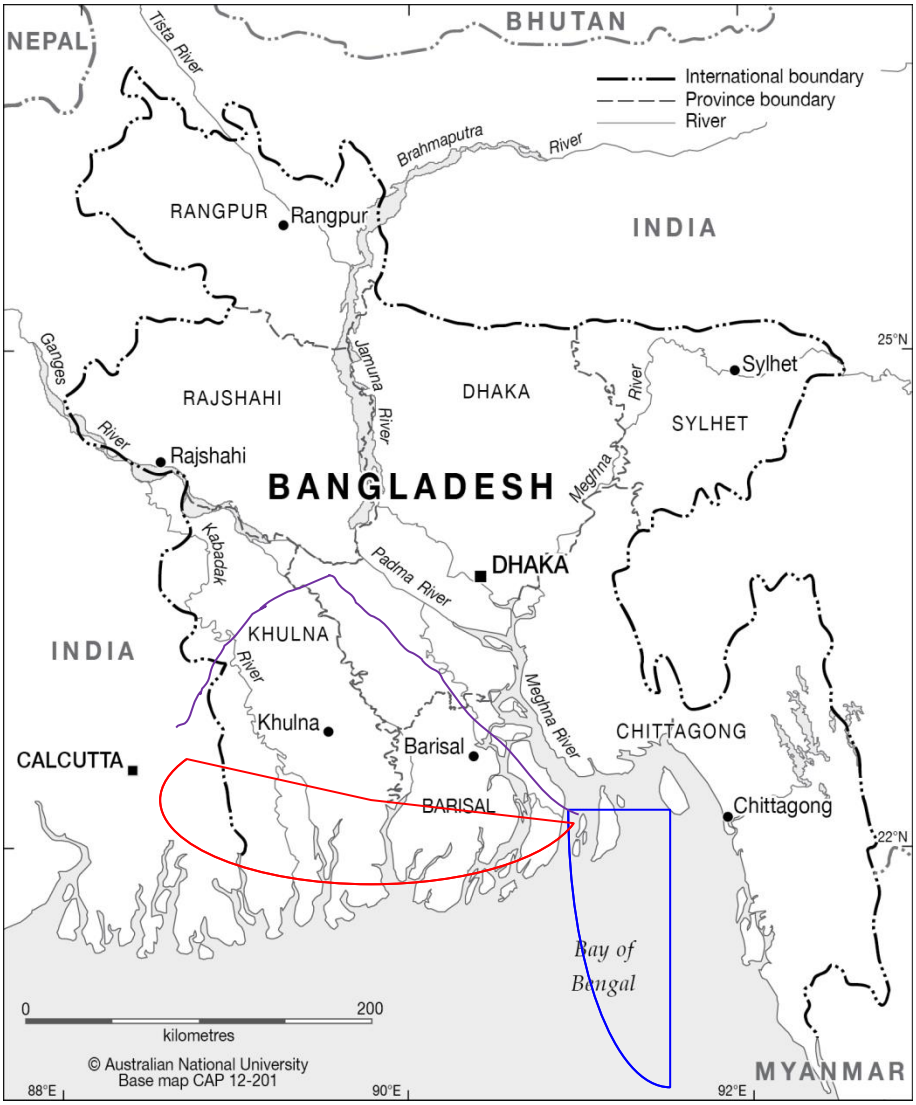

Figure 33: Seaside Routes

6.3.5 Exclusive tourism zones in the coastal areas for foreigners

With a view to attracting foreign tourists, Bangladesh Economic Zone Authority (BEZA) has taken an initiative to build up an exclusive tourism zone encompassing an area of 1027 acres in Sabrang under TeknafUpazila of Cox's Bazar. The geography of Sabrang allows development of a wide range of tourism and entertainment. On completion of the zone, the authority would be able to allure many foreign as well as local tourists.BEZA should examine the possibility of setting up such zones in other spots such as St. Martin and Kuakata.

6.3.6 Surfing zone

Surfing is one of the interesting components of tourism.Although Bangladesh has the world's longest sea beach,surfing activities are available on a very small scale and only in Cox's Bazar. Our nighboring countries, especially, India, Sri Lanka and the Maldives are far ahead of us in this respect. Initiatives should be taken to establish surfing zones in different beach areas such as Cox's Bazar, St. Martin, Teknaf, and Kuakata. Government, however, has a plan to establish one in Cox's Bazar. Tapping the potential for surf tourism is likely to positively affect our domestic economy. This is empirically evident. For example, Pettina (2016) examines the influence of surf tourism on coastal Bali and finds that there is a correlation between the influx of surf tourist and the acceleration of development.

6.3.7 Community-based ecotourism

As defined by Denman (2001), community-based ecotourism is a form of ecotourism where the local community plays a major role in its development and management, and a substantial portion of the benefits is received by the community. Since the community is proactively involved and the livelihoods of a host of the community's residents hinge on the intactness of the nature and the environment, the residents of the community have incentive to collectively conserve the tourist area. If proper initiatives are taken, Bangladesh can generate huge benefits by developing community-based ecotourism in the coastal regions. Wood (2009) suggests that Teknaf peninsula offers a great potential for community-based ecotourism.

6.3.8 Underwater tourism

Underwater tourism is an exciting form of tourist attraction. It opens a new frontier in tourism. Providing direct access to aquatic lives and ecosystem in underwater world, it creates immense pleasure for tourists. Underwater tourism has been developed in many countries.

Figure 34: Underwater Tourism. Source: Mismach.com

Figure 35: Underwater Tourism Facility. Source: Business insider

The benefit of underwater tourism is impressive in terms of monetary value. Pascal &Seidl (2013) estimated the economic benefit of underwater tourism in Vanuatu and Fiji.They showed that around 12000 visitors participated in underwater tourism in Vanuatu in a year contributing benefits for 10 businesses.

Figure 36: St. Martin Island. Source: solarpowerportal.co.uk

Figure 37: CheraDwip. Source: Mapio.net

Two Bangladeshi coral islands—St. Martin's main island and CheraDwip—offer ample opportunity for developing underwater facilities. The water that surrounds these two islands is so blue and clear that the living aquatic animals and plants can be watched with bare eyes. One other potentially suitable spot is Kuakata sea beach, which fronts water of comparable quality. Introduction of underwater tourism in these places would potentially attract huge number of tourists from home and abroad. However, while

developing the underwater facilities government should consider the carrying capacity of the spots. Carrying capacity sets a limit beyond which development activities are not consistent with ecological and social sustainability (Pascal & Seidl, 2013).

6.3.9 Marine and coastal based sport tourism

As a tourist attraction popularity of marine and coastal based sport tourism increases globally (Lagarense and Walansendow, 2016). Introduction of marine and coastal based sport tourism in Bangladesh could be another exciting event for tourism development. Lagarense and Walansendow (2016) advocated sport tourism at the Manado waterfront in Indonesia. To promote it as a tourist attraction, they recommended that it be included in the calendar events with proper planning and facilities. In Cox's Bazar, bodybuilding competition has already become a popular event. In 2017, the 3rd Walton bodybuilding competition started at Laboni sea beach at Cox's Bazar and about one hundred participants from 35 clubs took part in that competition. Bangladesh Bodybuilding Federation organizes this competition with the sponsorship of Walton Bangladesh ("Bodybuilding competition," 2017). This type of sport induces organizers, participants and sport lovers to make tour for sport purpose during their leisure (Herstein and Jaffe, 2008; cited from Lagarense andWalansendow, 2016). Being the world's largest, Cox's Bazar sea beach offers a great opportunity to introduce more sport events. Such attempt would certainly promote the country's marine and coastal tourism.

Figure 38: Bodybuilding Competition at Cox's Bazar Sea Beach. Source: AllEvents.in

6.4 Barrier and Constraints in developing coastal and marine tourism in Bangadesh

6.4.1 Lack of proper planning

Planning is instrumental in the process of any sort of development. Tourism industry is no exception. Although Bangladesh has several entities that wereestablished for the betterment of tourism industry, a proper planning is yet to be designed and implemented for the specific purpose of developing the country's coastal and marine tourism.

6.4.2 Lack of sufficient budgetary allocation

Since development of tourism essentially requires provision of some goods which are of public or quasi-public nature, market failure is inevitable. Hence, budgetary allocation is necessary to achieve optimal level of development in tourism sector. Traditionally every year Bangladesh government proposes an allocation for Civil Aviation and Tourism Ministry in the national budget. But the size of the allocation appears very scanty. For example, in the recent budget (2017-18) Tk. 687 crore was proposed which is 0.17% of the budget. It is quite impossible to develop a sustainable coastal and marine tourism with this scanty allocation.

6.4.3 Short term focus

Developing a sustainable coastal and marine tourism is a long-term phenomenon. Because government has incentive to focus on short-term objectives ignoring long-term ones, such development agendum is left mostly unattended. Short term focus induces government to give priority to economic achievements over social and environmental concerns creating a strong barrier to sustainable development of tourism (Dudds and Butler, 2009).

6.4.4 Absence of community participation

If the residents of the local community are not made involved in the process of development of the tourist spot, they will be reluctant in playing any role to conserve the nature and the environment. This is a great impediment to the development in question.As mentioned before, community-based ecotourism is an approach to getting around such impediment. Bangladesh is yet to embrace community-based ecotourism. That means the impediment is in place.

6.4.5 Lack of awareness among local residents

If local residents are not aware of the issue of sustainability and the environment and the value that their neighbourhood generates as a tourist spot, they will neither realize the importance of conserving the neighbourhood nor demand government contribution in developing the spot. Thus lack of awareness is one of the major impediments to sustainable development of tourism.

6.4.6 Lack of coordination between agencies

There must be coordination between different agencies involved in a process in order for the process to succeed. As far as development of coastal and marine tourismis concerned, several government agencies such as Civil Aviation and Tourism Ministry, Bangladesh Tourism Board and Bangladesh Parjatan Corporation are involved. Some degree of coordination among them must prevail. Besides, local administration, local community, NGOs working for the conservation of environment, potential private investors etc. are relevant entities. These non-government entities also must have coordination among themselves and with the government agencies. However, in countries like Bangladesh, it is the government bureaucracy that inherently stands in the way of necessary coordination.

6.4.7 Lack of publicity and marketing activities

Bangladesh lags far behind the nations in its peer group in taking proper marketing strategy to promote and publicize even its mature tourist destinations. Some of its tourist spots, such as Kattoli sea beach and Banshkhali sea beach, are not mature. The immaturity of those spots can largely be attributed to the lack of necessary publicity.

6.5 Benefits of Tourism development

6.5.1 Contribution to GDP

Coastal and marine tourism in Bangladesh contributes to GDP in many ways. Tourism activities in coastal and marine spots involve direct production of numerous goods (e.g. foods, entertainment equipment, and recreational equipment) and services (e.g. accommodation, transport, retail trade, recreation). Indirect contributions to GDP take place through investment and government spending in this sub-sector. Additionally, there are induced contributions due to spending of those who are directly or indirectly employed by this sub-sector. While no particular estimation of how much coastal and marine tourism contributes available, World Travel & Tourism Council (WTTC) regularly publishes global and country-specific economic impact of travel& tourism on a yearly basis. According to WTTC (2018), the total contribution of travel & tourism to GDP in Bangladesh was $10,567.4mn (4.3% of GDP) in 2017.

6.5.2 Employment generation

Being largely labor-intensive, tourism industries provide jobs for many. WTTC (2018) quotes President & CEO of WTTC as saying "Travel & Tourism, which already supports one in every 10 jobs on the planet, is a dynamic engine of employment opportunity". Although Bangladesh is not on a par with the world in this respect the contribution of Travel & Tourism in general and coastal and marine tourism in particular to employment generation is not ignorable.Many hotels, restaurants, retailers, and street vendors are serving tourists in the country's tourist attractions along the seashore, creating extensive employment opportunity.Others employment generators in this sub-sector include travel agents, airlines and other passenger transportation services, leisure industries etc. WTTC (2018) estimates that in Bangladesh Travel & Tourism created 2,432,000 jobs (3.8% of total employment) in 2017.

6.5.3 Poverty alleviation

Many of the jobs created in tourism sector are accessible to the poor due to low requirement in terms of skill and investment. Many tourism activitiesparticularly in the coastal region of Bangladesh are suited to the people of disadvantaged groups. Meanwhile, the incidence of poverty in the coastal region of Bangladesh is significant. According to estimation, this region is the home of 12 million poor (World Bank, 2016). That means there is adequate supply of labor as against demand for labor, which gives rise to a potential for poverty alleviation. There are evidences that this potential is at least partially, if not fully, realized; out of the pool of poor people many find opportunity to work in respective tourism spots. For example, Farzana (2014) reveals that in Kuakata sea beach area 77.12% of the poor are employed in tourism related occupations, whereas this ratio for local people as whole is 74.05%. The study, however, suggests that there is still ample untapped opportunity for poverty reduction.

6.5.4 Foreign exchange earnings

One of the great benefits of coastal and marine tourism in Bangladesh is earning foreign exchange. Thanks to international tourists spending within Bangladesh, the country earns a good amount foreign currency each year. In 2017, it earned $228.5mn from visitor exports which was 0.6% of total exports (WTTC, 2018). A significant portion of this is due to tourism in the costal and marine zones. According a newspaper report, Bangladesh earned Tk.3.5mn in foreign currency from a single recent cruise tour in the coastal belt ("Bangladesh enters," 2017). Similar amount of foreign currency earnings from another upcoming trip was predicted by the same report. This is just an indication of how much crucial role coastal and marine tourism in Bangladesh can play in earning foreign currency.

6.5.5 Socio-cultural benefits

Sustainable tourism brings diverse socio-cultural benefits. It promotes peace by fostering understanding between local residents and tourists. It facilitates the preservation and transmission of cultural and

historical traditions. It raises awareness among local people about the socio-economic value of the tourist sites. Above all, it makes them take pride in heritages and realize the importance of conserving those ("Socio-cultural benefits," n.d.). To the extent that coastal and marine tourism in Bangladesh is sustainable, it gives rise to the benefits just mentioned.

6.5.6 Environmental benefits

Multiple environmental benefits may emerge from sustainable tourism. When environmental sitesare allocated for tourism keeping them presentable to the tourists in a sustainable mannerbecomes an important duty of the concerned authorities. Thus the authorities have incentives totake necessary steps in order to adequately protect and preservethe sites. Since sustainable tourism is often community-based, it makes the local people actively participate in the management and thereby stimulates public awareness of the value of environment and nature. So the residents of the local community lend support to the conservation of the tourist site. Moreover, various fees and taxes collected from tourists form a handsome government fund which can be spent for offsetting environmental degradations, if any. Although Bangladesh cannot claim that its coastal and marine tourism is fully sustainable, it seems to be on the way to that goal. Gradually it would be able to reap all of these benefits.

6.5.7 Protecting coastal areas

Development of sustainable coastal and marine tourism in Bangladesh might have double dividend: huge influx of tourists and protection of coastal areas from natural disasters. A proper tourism plan will precipitate enormous development activities including building dams and embankments, and establishing mangrove plantations in the coastal zones. Such activities will create amenity services with facilities and will protect the coastal zones from sea waves, wave surges and cyclones. Because of multiple factors including funnel shape of the Bay and shallowness of the water body, Bangladesh is most likely to be hit by cyclones formed in the Indian Ocean (Shaji et al. 2014). However, properly developed sustainable coastal and marine tourism will reduce the intensity of the damages during the natural disasters in the coastal areas.

6.6 Free-rider problem in tourism: Bangladesh scenario

Free-rider problem is said to exist if economic agents can use resources without making any payment. Many goods and services related to tourism are exposed to such problem due to their non-excludable nature. Ability to free-ride induces people to over-consume. As far as tourism is concerned, such overconsumption leads to numerous negatives consequences including environmental degradation and extinction of valuable resources. Since market is inherently unable to solve free-rider problem, appropriate government intervention is necessary. However, in the absence of public intervention, the only guard against this problem is the level of consciousness which in turn vitally depends on education and the level of development.

Insufficient government intervention coupled with poor levels of education and development has given rise to high prevalence of free-riding tendency among the tourists visiting various tourist attractions in Bangladesh including those in coastal and marine areas. Besides tourists, other actors in the tourism industry such as private entrepreneurs and street vendors are driven by the same tendency. Tourism in this country has thus become a giant source of environmental pollutions.

Despite the presence of a great number of coastal and marine-based tourist spots, Bangladesh is unable reap the whole range of benefits from them due to the presence of free-rider problems. For example, Cox's Bazar sea beach would have been far more productive in terms of generating pleasures to tourist and sustainably contributing to the economy if free-rider problem could be properly addressed. Water of this beach is seriously polluted due mainly to tourism activities. And so is air. Unplanned construction of hotels and other infrastructures has destroyed the aesthetic value of the beach and its adjacent areas.

Lack of proper regulatory measures provides people incentives to discharge garbage and trashes wherever they want.

One important factor that reinforces free-rider problem is lack of adequate and convenient toilet infrastructure. Such infrastructure is a pressing need because of the fact that among hundreds of tourists many (especially children and sick adults) are not physically fit enough to postpone defecation and urination for long. Hardly any coastal tourist destination in this country has well-equipped public toilet facilities. Thus instances of open defecation and open urination are not very uncommon in beach areas which severely damage the amenity of the beaches.

6.7 Policy suggestions for sustainable tourism in coastal and marine areas

Prior to 2013, Bangladesh had no effective tourism plan. In 2013, Government has prepared a national tourism plan for the Sundarbans Forest Reserve. The aim of that national tourism plan was to promote ecotourism in the Sundarbans mangroves; the world largest mangrove forest. Along with the Sundarbans tourism plan, government can declare a new tourism plan for coastal and marine tourism. The new tourism plan may be a driving factor to attract both local and international tourists to the coastal and marine tourist spots. The proposed tourism plan should emphasize on the following issues.

6.7.1 Encouraging private entrepreneur to invest under PPP initiatives

It is clearly evident both in the global and local contexts that tourism can be a crucial tool for economic development. Therefore, investment in this sector is extensively important. Due to big minimum required investment and the existence of public goods and quasi-public goods, market failure is most likely to exist in tourism sector. As a result, optimal level of investment will not be achieved through only private sector initiatives. Hence, there must be government intervention in the form of government investment. This statement is more applicable to countries like Bangladesh where market failure is pervasive. Bangladesh government can invest in infrastructural development of coastal and marine tourism and/or can invite private sector to invest along with the government through Public Private Partnership (PPP) scheme. In fact, Bangladesh government enacted a law named Bangladesh Public-Private Partnership Law, 2015 with a view to facilitating the development of core sector public infrastructure and services ("Enactment of the Bangladesh," 2015). Under this initiative, private entrepreneurs are encouraged to invest along with the government on a profit-sharing basis. This law allows the government to finance for equity and loan and finance for the linked component. Besides, government can invite foreign finance under the foreign portfolio investment. In the foreign portfolio investment, foreigners purchase bonds, equity or cash equivalent and this initiative could be effective in developing infrastructure in the proposed new tourists' spots. Government can also collect money from local financial market by issuing mutual funds for the development of coastal and marine tourism.

6.7.2 Promoting local heritage and culture

Promoting local heritage, festive and culture could be interesting events to the local and foreign tourists to marine tourism. One good example of local culture and festive in existing tourism is in Dublar Char in the Sundarbans. During the November, people from the Hindu community gather in Dublar Char to celebrate an occasion called Rashmela. Now, every year many local and foreign tourists go there to enjoy the occasion. In an attempt to develop sustainable coastal and marine tourism, government can take initiatives to promote local heritage and culture.

Figure 39: Worship at Rashmela. Photo by authors

Figure 40: Worship at Beach in Dublar Char. Photo by authors

6.7.3 Inclusion of local communities

Community involvement is one important factor in developing coastal and marine tourism. Inclusion of local communities in the process of tourism development makes the tourism sustainable and everlasting by promoting conservation through income generation for the local people. At first, community people will provide the various services like transports, accommodations and tourists guide to the tourists. But, the literacy rate in the coastal areas is low since coastal communities are mostly poor and dependent on nature. As a result, Awareness should be created among local residents and domestic tourists, so that they understand the importance of the seaside tourism in the economy (Sakib et al., 2016). It is mentionable that inclusion of local communities can lead to better management of natural resources. If local communities are involved, then their livelihood and living standard will increase which will enable them to actively participate in the tourism activities as suppliers of different tourism products. In such a setting, some portion of earnings from tourism activities can be used for the wellbeing of the local communities. Therefore, government should design development plan in such a way that local people get involved and gain a sense of ownership. To reap better outcome from community involvement, government should provide proper training on tourism management and hospitality to the local people.

6.7.4 On arrival visa service for foreign tourists

Many countries are promoting tourism through on arrival visa. Thailand is a good example which provides on arrival visa to the tourists. By providing this facility Thailand has been able to attract a good number of tourists every year. On an average, 1.4 m tourists visited Thailand from 1997 to 2018 (“Thailand tourist arrivals,” n.d.). Such a huge influx of tourists can be attributed to flexible visa procedure. Thus, to promote tourism Bangladesh could implement on arrival visa service to the foreign tourists.

6.7.5 One-stop service for tourists

One-stop service is another flexible and easy visa policy that government can adopt for developing tourism in Bangladesh. Like many other sectors, tourism in Bangladesh requires approval from many stakeholders. Those intending to visit the Sundarbans for tourism purpose need approval from Forest Department, Inland Water and Transport Department and Police Department. The procedure of taking approval is same for both local and foreign visitors. People want to avoid administrative hazards. One-stop service, by significantly reducing tourists’ anxiety that arises from administrative complications, can lead to increased flow of tourists to coastal and marine destinations. It is worth mentioning that one-

stop service will be very effective for foreign tourists who come directly to Bangladesh maritime zone through cruise ship. Recently, Journey Plus, a Bangladeshi tour operator, organized a trip for foreign tourists. In that trip, Silver Discoverer, a world-famous cruise ship, arrived in Maheshkhali carrying 95 foreign tourists (Mahmud, 2017). The tourists had to stay longer time than usual in the ship as they required administrative permission from various offices including The Chittagong Port Authority, Custom and Visa Division. This created a negative image of Bangladesh tourism. Thus, offering one-stop service for tourists will reduce the hassles leading to increased arrival of foreign tourists.

6.7.6 Pollution control measures

Given the widespread prevalence of pollutions arising from free-rider problem, enactment of specific pollution control policies is urgently needed. Some kind of incentive scheme can be devised that deters actors in the tourism industry from freeriding. For example, provision of adequate well-equipped toilet facilities in different points of a beach can completely eliminate the possibility of the incidents of open defecation and open urination. Littering can be drastically reduced by keeping well-designed dustbins in appropriates places in beaches and their adjacent areas. Ineligible discharges of garbage must be subject to severe punishment. Existing regulation pertinent to construction of buildings and other infrastructures must be enforced. If need be in changed circumstances, the existing regulation should be changed and modified. More importantly, sound pollution must be strictly controlled. Sound creation must remain confined in sufficiently narrow space so that tourists can enjoy a calm and noise-free ambiance.

6.8 Conclusion

Coastal and marine tourism in Bangladesh is evidently expanding. With the increase in the countries per capita GDP, the leisure and recreational activities are gradually becoming very popular. People visit tourist spots during their holydays. Moreover, foreign tourists are also interested to visit various coastal and marine tourist spots such as the Sundarbans, St. Martin's Island and Cox's Bazar sea-beach. But still the extent of foreign tourist arrival in those fascinating spots does not appear to be satisfactory. By improving the existing spots and developing new ones, the country can attract significant number of local and international tourists. However, to make that happen the country should design appropriate tourism related policies. Initiating proper policies is crucial for transforming mass tourism into sustainable coastal and marine tourism in this country. One good example of such transformation is the case of Mauritius. Because of offering eco-tourism, Mauritius successfully attracted the world tourists. FAO reported (TravelMauritius.net) that on average tourists spend 10 days in Mauritius. Thus, experiencing from Mauritius Bangladesh can move forward to offer eco-tourism in marine and coastal tourism sector.

6.9 References

Ara, F. (2017, June 17). Authorities lack attention to Kattolibeach.*New Age*. Retrieved from http://www.newagebd.net/article/17941/authorities-lack-attention-to-kattali-beach

Bangladesh enters cruise tourism. (2017, March 01). *The Daily Star*. Retrieved from https://www.thedailystar.net/business/bangladesh-enters-cruise-tourism-1368913

Bodybuilding competition begins in Cox's Bazar. (2017, July 26).*The Asian Age*.Retrieved fromhttps://dailyasianage.com/news/76041/bodybuilding--competition-begins-in-coxs-bazar

Cox's Bazar sea beach. (n.d.). Retrieved from http://www.parjatan.gov.bd/site/page/6ee6072e-bf5b-4078-82d9-df007e92e93b/Cox's-Bazar

Denman, R. (2001). Guidelines for community-based ecotourism development.WWF International. Retrieved from http://www.widecast.org/Resources/Docs/WWF_2001_Community_Based_Ecotourism_Develop.pdf

Dodds, R. & Butler, R. (2009).Barriers to implementing sustainable tourism policy in mass tourism destinations. Munich Personal RePEc Archive (MPRA). Retrieved from https://mpra.ub.uni-muenchen.de/25162/1/MPRA_paper_25162.pdf

Enactment of the Bangladesh public-private partnership (PPP) act, 2015 (2015, September 20). Retrieved from https://www.pppo.gov.bd/events2015_enactment-of-the-bangladesh-public-private-partnership-ppp-act-2015.php

Farzana, F. (2014). Pro-poor tourism: unlocking the opportunity for the pooroKuakata sea beach. *Journal of Bangladesh Institute of Planners,7,* 1-13.

Gibson, L., O'Connor, S., &Duratovic, T. (2007). The growth of Whale and Dolphin watching tourism in Oceania. In M. Luck, M. L. Miller, A. Graupl, M. Orams& J. Auyong (Eds.), *Proceedings of the 5th international coastal & marine tourism congress: Balancing marine tourism, development and sustainability* (pp. 68-72). Auckland: The School of Hospitality & Tourism and The New Zealand Tourism Research Institute.

Herstein, R. & Jaffe, E. D. (2008).Sport hospitality as a business strategy. *Journal of Business Strategy,29*(6), 36-43. https://doi.org/10.1108/02756660810917228

Islam, M. L., Zakia, Bushrat, Pantha&Shomir (2016, September 27). Unexplored beauty of Banskhali.*Daily Sun*. Retrieved from http://www.daily-sun.com/arcprint/details/170129/Unexplored-beauty-of-Banshkhali/2016-09-27

Khan, A. (2017, May 19). Swatch of No-ground: A treasure trove of marine lives. *The Daily Star*. Retrieved from https://www.thedailystar.net/backpage/swatch-no-ground-treasure-trove-marine-lives-1407508

Lagarense, B. E. S, &Walansendow, A. (2016). Developing marine and coastal-based sport tourism on the waterfront: The case of Manado waterfront, Indonesia.*Journal of Indonesian Tourism and Development Studies, 4*(3), 107-114.

Mahmud, T. (2017, February 22). International cruise ship arrives in Cox's Bazar. *Dhaka Tribune*. Retrieved from https://www.dhakatribune.com/bangladesh/2017/02/22/silver-discoverer-arrives-75-tourists/

Pascal N. &Seidl A. (2013).Economic benefits of marine protected areas: case studies in Vanuatu and Fiji, South Pacific.Mooréa, French Polynesia: AFD/IUCN.

Pettina, K. (2016). *Waves of development: the influence of surf tourism on coastal Bali* (Doctoral dissertation). Retrieved from https://scholarspace.manoa.hawaii.edu/bitstream/10125/45574/1/Pettina_Kristin_Spring%202016.pdf

Sakib, B. A., Hafiz, N., & Chowdhury S. T. (2016, July 04). *Daily Sun*. Retrieved from http://www.daily-sun.com/home/printnews/149303

Shaji, C., Kar, S.K., and Vishal, T. (2014). Storm surge studies in the North Indian Ocean: A review. *Indian Journal of Geo-Marine Science, 43*(2), 125-147.

Socio-cultural benefits (n.d.). Retrieved from http://www.coastlearn.org/tourism/why_sociobenefits.html

Sonadia Island (n.d.). Retrieved from https://bn.wikipedia.org/s/2cjy

Thailand tourist arrivals 1997-2018 (n.d.). Retrieved fromhttps://tradingeconomics.com/thailand/tourist-arrivals

Travel Mauritius. Available at http://www.travelmauritius.net/eco-tourism.html. Date accessed on 30 June, 2018.

Wood, M. E. (2009). Teknaf peninsula community-based ecotourism strategy. USAID Bangladesh.

World Bank (2016). *Development Research Group Monthly Research Highlights*.Issue 96. Retrieved from http://pubdocs.worldbank.org/en/918011470775944412/DECRG-climate-change-research-highlights-Aug2016.pdf

World leaders can learn from Bangladesh's 'Swatch of No Ground', says US ambassador (2016, June 5). Retrieved from https://bdnews24.com/bangladesh/2016/06/05/world-leaders-can-learn-from-bangladeshs-swatch-of-no-ground-says-us-ambassador

World Travel and Tourism Council (2018). *Travel & tourism economic impact 2018: Bangladesh*.London, United Kingdom: Author.

7 Blue biotechnology, renewable energy, unconventional resources and products as emerging frontiers at sea

7.1 Abstract

Blue biotechnology, renewable energy and unconventional marine living resources are considered as emerging frontiers for enhancing ocean-based blue economy in Bangladesh. Blue biotechnology can help both fisheries and aquaculture industry by producing fish varieties that can become quicker, more beneficial, and greater with tastier flesh, by developing gene transfer technology to be used to develop the growth of fish or by using of monoclonal antibodies and DNA probes to new diagnostic strategies for pathogens. Transformation of marine bioresources (main, co-product and by-products) into food, medicine, animal feed and related bio-based items i.e. cosmetics, nutritional supplements, enzymes, agrichemicals etc could help in meet the Bangladesh future challenges for the 21st century. Given that majority of conventional living resources is facing over-exploitation, non-conventional marine living resources, specifically mollusk (squids, oyster, mussel), seaweeds, marine echinoderms, marine micro algae and others can be utilized as a source of new fishery products that could straightforwardly consumed as nutritionally balanced marine food. In terms of non-living resource, renewable energy comes from hydro power, solar, biogas and wind, however, tide and wave energy have good potential. Towards sustainable utilization of these sector-specific resources there are several challenges, such as little knowledge about their current status, limited focus by policy makers. To escape this situation, marine policy relatives must have to include the marine fisheries, mariculture, marine food, health, natural resources and industrial application. Research activities can create information to advise the policy and strategy, which thus stimulates future development by informing how the marine environment can be monitored and managed reasonably and realize its role in giving ecological facilities to the country as well as the world.

7.2 Introduction

Marine Biotechnology', mean diverse things to different people. Simply, marine biotechnology, is the utilization of marine bioresources as the objective or source of biotechnological applications; marine resources are utilized to develop products or services; however, the marine environment can likewise be the beneficiary of biotechnology applications developed using terrestrial resources. As indicated by the Smithers Group (2015), global market for marine biotechnology can possibly reach $4.8 billion by 2020, rising to $6.4 billion by 2025. The United States leads the market with biggest share for marine biotechnology. Healthcare services or biotechnology constitutes biggest end-utilize section for marine bioresources. Europe is dominating one of the main areas adding to the development of this market. In Asia Pacific, China, India, South Korea and Japan, Thailand and Vietnam and Australia are expected to become significant markets for marine biotechnology within a reasonable time-frame, unfortunately Bangladesh is quite behind.

7.3 Emerging blue activities in Bangladesh

Emerging sea-based activities creating and applying a scope of science and technological advancements to explore the sea's all resources more securely and sustainably, or to make the seas cleaner and more secure and to ensure the abundance of their resources. The activities contrast extensively in their phase of improvement: some are generally cutting-edge while others are still in their initial stages (Table 13).

Table 13: Established and emerging sea-based sectors in Bangladesh.

Established	Emerging
Capture fisheries	Mariculture
Seafood processing	Marine Biotechnology
Marine trade, shipping and transportation	Sea renewable energy
Sea ports infrastructure & services	Offshore wind energy
Shipbuilding and repairing	Marine and seabed mining
Offshore oil and gas (shallow water)	Deep- water oil and gas
Marine manufacturing and construction	Maritime safety and surveillance
Maritime and coastal tourism	Marine unconventional products and services
Marine business services	Marine R&D and education
Sea salt production	Others

7.3.1 Evolving opportunities and present challenges in Biotechnology, Renewable Energy and Unconventional products

7.3.1.1 Marine Biotechnology

With regards to a worldwide financial downturn, Bangladesh is presently confronting intricate and troublesome difficulties, for example, the sustainable supply of food and energy, climate change and natural disaster, human health and wellbeing, high unemployment rate and old populaces. Marine Biotechnology can make an inexorably imperative commitment towards addressing these societal challenges and in supporting monetary recuperation and development in Bangladesh (Figure 41).

7.3.1.2 Renewable energy

Despite the financial status, developing or developed, it is the worldwide pattern to advance renewable energy source, as a major aspect of energy security and additionally greenhouse gas emission reduction. Right now, renewable energy sources including solar energy have a low offer of the aggregate energy production (<2%) in Bangladesh (Islam and Khan 2017). The production of renewable energy from tides and waves, wind turbines situated in offshore regions, submarine geothermal assets and marine biomass could be suitable options for contributing to energy needs and environmental change mitigation goals. For Bangladesh, such renewable sources could help extend their energy portfolios and secure larger amounts of energy security.

7.3.1.3 Unconventional fishery products

Unlike other countries of the world, the unconventional fishery products in Bangladesh is profoundly encouraging. There is most likely that existing living resources, specifically mollusk (squids, oyster, mussel), seaweeds, marine echinoderms, marine micro algae and others can be utilized as a source of new fishery products that could straightforwardly consumed as nutritionally balanced marine food.

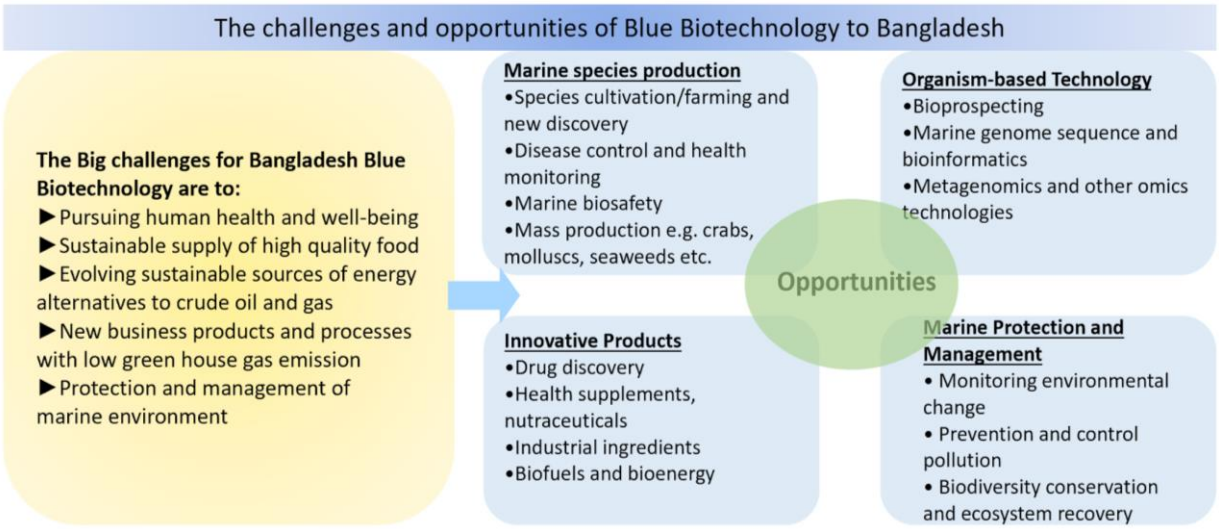

Figure 41: The grand challenges and evolving opportunities of blue biotechnology to Bangladesh.

7.3.2 Key role of the government and private sectors

The government of Bangladesh has a grand responsibility and a dynamic part in the blue economy, tending to existing issues and boundaries to enhance the overall blue development potential and research center around its needs. The Initiative aims to encourage empowering crosscutting advancements;

- to make the best empowering condition for augmenting the improvement of marine biotechnology, renewable energy sources and unconventional fishery items;
- to create and maintain infrastructure to help a coordinated information and data base empowering industrial development and backup maritime governance;
- to build up a research to-approach system, specifically to help the marine strategy framework directive (MSFD) and marine spatial planning and administration;
- and to promote the interdisciplinary human capacities important to achieve the SDG 2030 goals and objectives.

The private sector has the duty to recognize and express the real statistical surveying needs. The government of Bangladesh looks for help and works together with several private sector stakeholders for the research and innovation (R&I) program.

7.3.3 International cooperation:

There are huge challenges with respect to blue development explore, the greater part of which are worldwide (e.g. ocean acidification) and should be tended to by joint activity attempted at a worldwide level. Global collaboration in R&I for practical improvement and development of the marine and sea parts should be upgraded.

7.4 Blue Biotechnology and the blue economy

7.4.1 The Blue biotechnology — an empowering technology

Blue is the shade of the seas and of the oceans and that is just why it defines the world of biotechnology that utilizes molecules and substances of marine origin, while other specific sectors defined by colors for example red for pharmaceuticals, white for industrial biotechnology, green for agricultural, yellow for environmental (Greco and Cinquegrani, 2016).

One of the significant uses of biotechnology in marine science is with respect to aquaculture. In any aquaculture industry the main point has dependably been to produce fish varieties that can become quicker, more beneficial, and greater with tastier flesh. Biotechnology in sustainable aquaculture and fisheries is profoundly effective to help the food security of Bangladesh (Figure 42). For instance, gene transfer technology was used to develop the growth of fish. In China, Zhang et al (1998), developed a gene containing promoter gene of antifreeze protein (AFP) and salmon growth hormone cDNA and was introduced into the red sea bream fish genome by electroporation technique and found good result. Another case of the utilization of biotechnology in aquaculture is the progress of DNA immunizations for aquaculture. Heppell et al. (1998) described that DNA vaccines are harmless, modest and proficient to be utilized as a part of aquaculture industry.

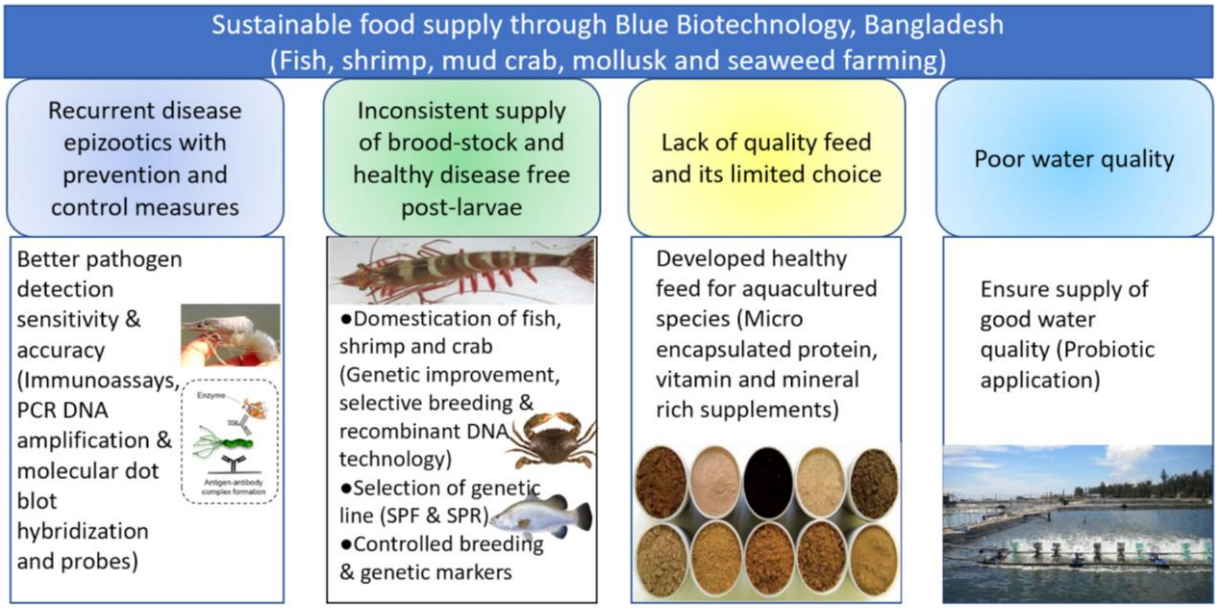

Figure 42: Sustainable food supply through blue biotechnology, Bangladesh.

A noteworthy issue in aquaculture is disease control. In many shrimps producing countries, *Vibrio* and *Aeromonas* are considered as the most well-known and significant infectious pathogens and causing mass mortality of penaeid shrimp larval stages (Lightner, 1996; Vaseeharan et al., 2005; AftabUddin et al., 2008). Use of monoclonal antibodies and DNA probes to new diagnostic strategies for pathogens has turned out to be extremely encouraging.

Another valuable utilization of molecular techniques is for stock assessment, genetic variation and evolutionary processes of aquaculture and wild fish and species recognizable proof which remain uncertain issues in fishery management. To resolve those issues several molecular techniques such as mitochondrial DNA (mtDNA), Nuclear DNA (nDNA), DNA chips (microarrays), microsatellite DNA markers has become very promising (Olsen et al., 2000; Miller 2003; Liu and Cordes 2004; Hemmer-Hansen et al. 2014; Komoroske et al., 2017).

Another rising part in marine biotechnology is marine natural products (marine medication revelation). Trabectedin, a marine-derived anticancer medication was likewise endorsed to be utilized in Europe in 2007 (Molinski et al., 2009). A variety of bio-active compounds has been acquired from various marine organisms and are right now under investigation and in cutting edge phases of clinical trials (Montaser and Luesch, 2011; Blunt et al., 2014).

So, the blue biotechnology is a key empowering technology that backings the growth of nations blue economy. It is a multi-disciplinary, information and capital-intensive innovation that is applicable all through the value chain and navigate diverse segments. The initial steps of the chain depend on the discovery of new marine living beings, the isolation and characterization of interesting bioactive molecules and proteins, and to establishing protocols that developing potential business utilizations of these molecules. Until now the Bangladesh Blue Biotechnology sector is not existing compared to India, Japan, Malaysia, Thailand, EU and other developed country but have a good growth potentiality (Figure 43).

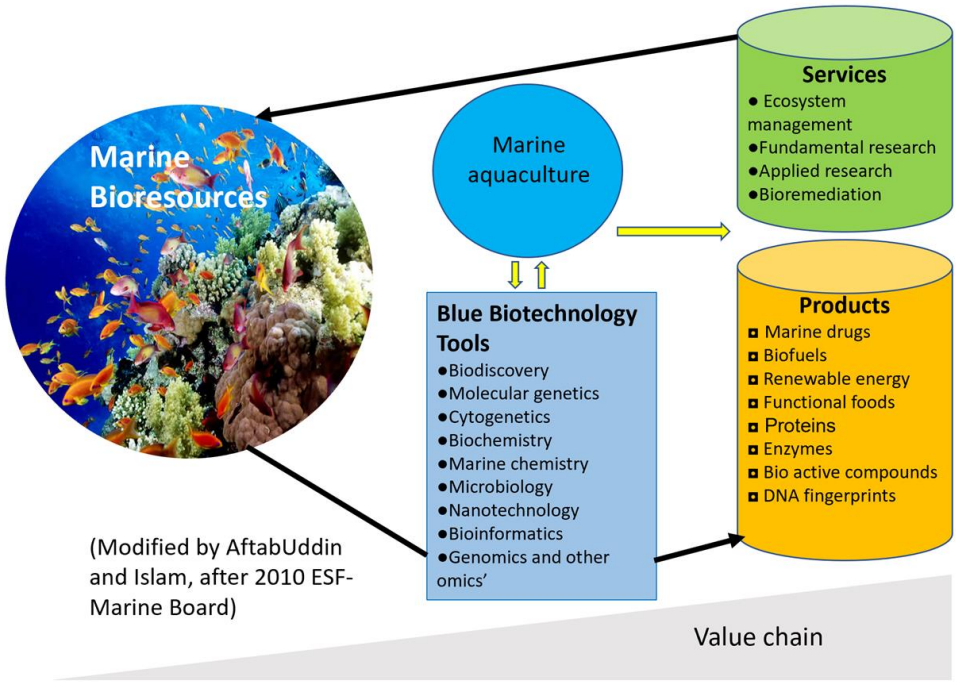

Figure 43: Possibility of blue biotechnology (resource-infrastructure-innovation) and the sorts of tools and technologies applied, resulting products and services. Source: slightly modified after 2010, ESF-European Science Foundation-Marine Board.

7.4.2 Blue biomass and its role of biosciences and contribution to the blue economy:

Marine biomass starts from the wide-ranging marine biodiversity of the seas and contains numerous forms, e.g. entire fish, discards from open sea catching or processing, aquaculture items, macro and micro algae — both wild and developed, marine invertebrates and marine microbes. The production and harvesting of available marine biomass is the beginning stage of extracting value from marine bioresources. The growth of Bangladesh's blue economy could be enhanced on the transformation of marine bioresources into food, medicine, animal feed and related bio-based items i.e. cosmetics, nutritional supplements, enzymes, agrichemicals etc. and is perceived as addressing to meet the Bangladesh future challenges for the 21st century (Figure 44).

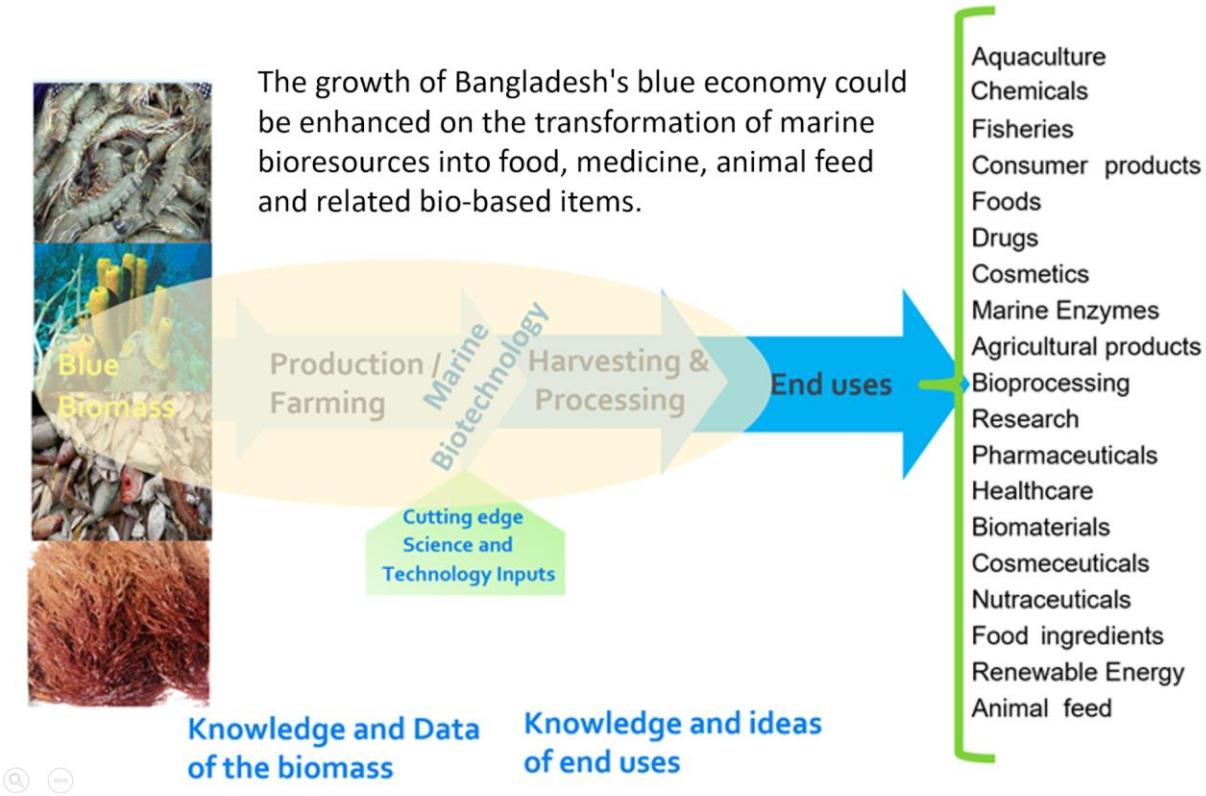

Figure 44: Transformation of Blue biomass into industry or process sectors.

7.4.3 Business activity and global markets for marine bioresources:

The major opportunities to utilization of marine bioresources in business sectors are modern chemical compounds or enzymes, pharmaceuticals, foods, beautifiers, farming items etc. However, the emerging applications includes bioprocessing, ecological remediation and monitoring, genetics, marine bioactive substances, marine biomaterials, mariculture, fermentation engineering and enzyme engineering. Marine fish, sponges, tunicates, molluscs and bacteria are the main sources of potent bioactive compounds that shows various anti-tumor, anti-inflammatory, analgesia, immunomodulation, allergy, and anti-viral properties (Ebel and Jaspars 2015). As of March 2018, the US FDA has approved seven marine derived drugs for clinical use and a further 22 at various stages of pharmaceutical clinical trials (Mayer 2018).

Another growing business is nutraceutical products which is expected to be worth USD $578.23 billion by 2025 (Research and Markets, 2018). This market mainly constitutes functional foods and beverages, dietary supplements, sports drinks and medically formulated foods. The nutraceutical ingredients include pre-biotic and pro-biotic vitamins, minerals, fibers, proteins, omega 3 and structured lipids, amino acids and various other constituents. The global Omega-3 PUFA market is valued at 12.3 billion US$ in 2017 and will reach 19.00 billion US$ by the end of 2025, growing at a CAGR of 5.6% during 2018-2025 (QY Research 2018). The Global Cephalosporin Market was valued at US $77,764 million in 2016 and is estimated to reach US $1,99,754 million by 2023 (Kaul & Srivastava 2017). The Cephalosporin was derived from microscopic fungus *Cephalosporium acremonium* in 1945 and first sold in 1964 (Torok et al., 2009).

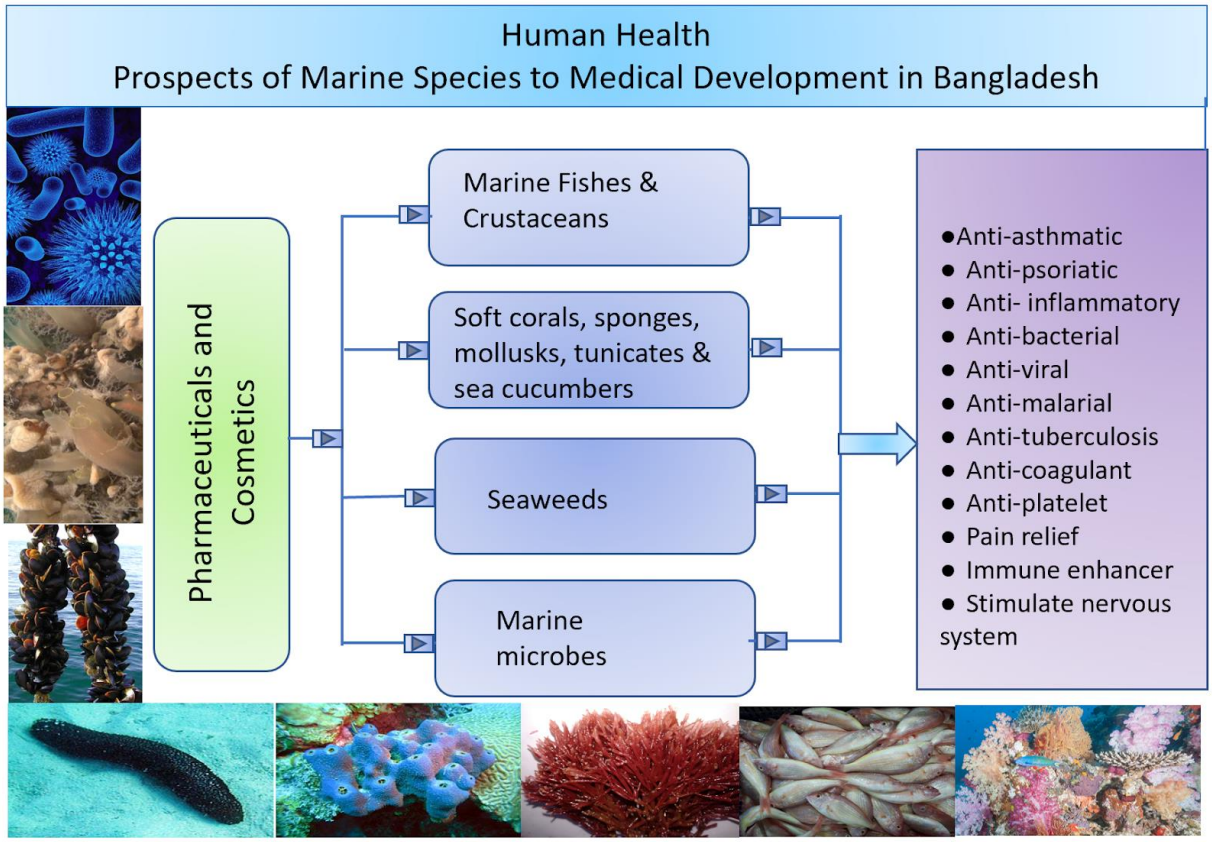

Figure 45: Prospects of marine bioresources to clinical development in Bangladesh.

Though, the anticipated high-development prospects for human wellbeing, food and biomaterials-related applications offer significant extension to make high-esteem products from Bangladesh marine bioresources. Marine biotechnology or blue biotechnology related research and innovation is not familiar by Bangladesh policy makers and the private entrepreneurs. The challenge of developing marine biotechnology capabilities has just been grasped by India and other neighboring countries, they have built up some intends to enhance their blue economy by expanding the utilization of their sea resources, unfortunately we are very behind it.

7.4.4 Exploration of the ocean environment:

Even with the potential of the seas, the expenses of deep water exploration beyond the shallow coastal zone of the Bay of Bengal, is the main challenge of accessing those areas that remain undiscovered. Bangladesh's extensive coastal regions are home to numerous types of organisms, algae, fish, crustaceans and invertebrates, all of which offer convenience to marine bioresources for discovery type research. Seaweeds and fish are the vital sources of marine biomass as of now utilized as a part of business applications, essentially as food and food ingredients. The consequences of different bioprospecting and discovery activities show the conceivable outcomes for a more extensive scope of utilizations for compounds derived from marine species.

Materials discarded during catching, harvesting, production and processing of marine species are exploited as human and animal food ingredients, composts, dietary supplements, biochemicals, proteins and lipids. More exploration and examination of known sources of bioproducts is expected to grow the conceivable scope of uses for such materials. However, marine exploration is largely dependent on collaborative research activity and technologies. To explore the Bangladesh marine environment, policy must be taken to i) targeting the sources of marine biomass; ii) accessing marine habitats; and iii) characterizing marine species, including their chemical and biological composition (Figure 46).

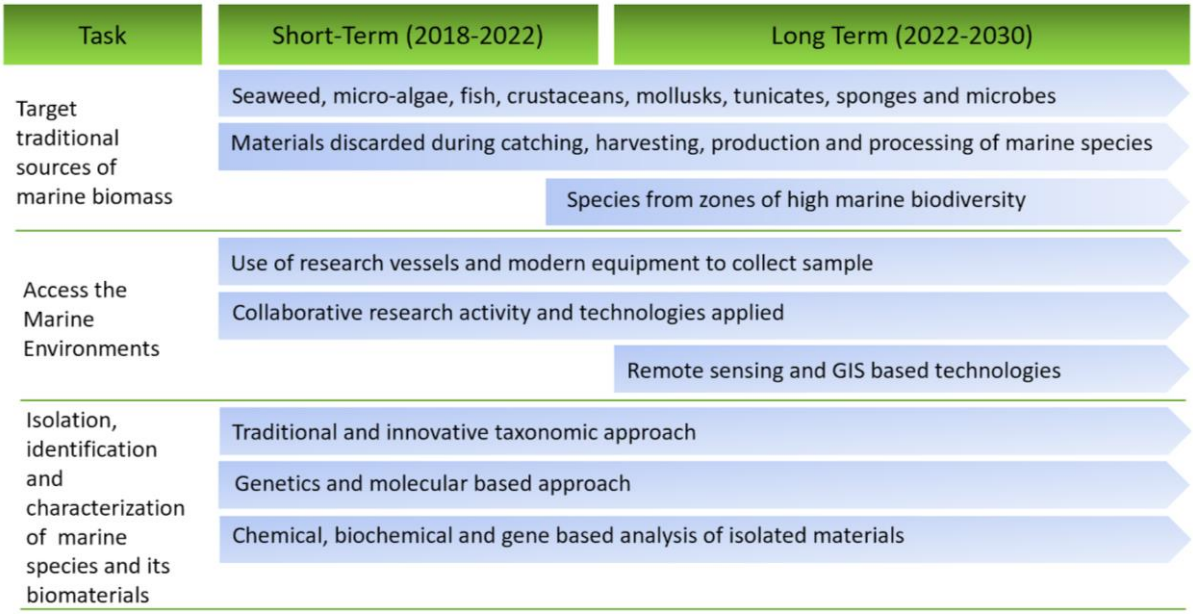

Figure 46: Marine exploration strategy for Bangladesh.

7.4.5 Marine Biomass production and processing:

In Bangladesh, the culture of marine species is restricted to the production of finfish and shellfish, currently lesser extent to seaweed in coastal aquaculture activities. Offshore and deep-water aquaculture and integrated multi-trophic aquaculture (IMTA) are dynamic research themes. Changes in culturing processes are probably going to extend the utilization cultured biomass from food to take in non-food use and additionally develop new sources of feed. Marine biotechnology, including new breeding technology and genetics, is set to help more diverse and beneficial culturing of marine species. For instance, the global demand for marine lipids for use in functional foods, ingredients and in nutraceutical products, is growing and uses marine biotechnology to extract Omega-3 from fish, seaweeds and microalgal sources. The important components of the marine biomass production and processing in Bangladesh involve various tasks (Figure 47):

- Expanding the culture of biomass from marine resources, together with investigating the possibility to grow on coastal land and offshore aquaculture.

- Building up the controlled culture of marine biomass at sea and coast and creating strategies to culture marine living organisms which have not at present in culture.

- Decreasing the intricacy of the inventory network by incorporating biomass generation and refining, reducing energy demand and waste in processing marine biomass.

- Taking part in research to help the extension of cultured biomass production including measures to limit and relieve ecological effects; tending to waste management; upgrade biosecurity and the start of new production approaches like breeding, rearing, genetic manipulation, food and health status etc.

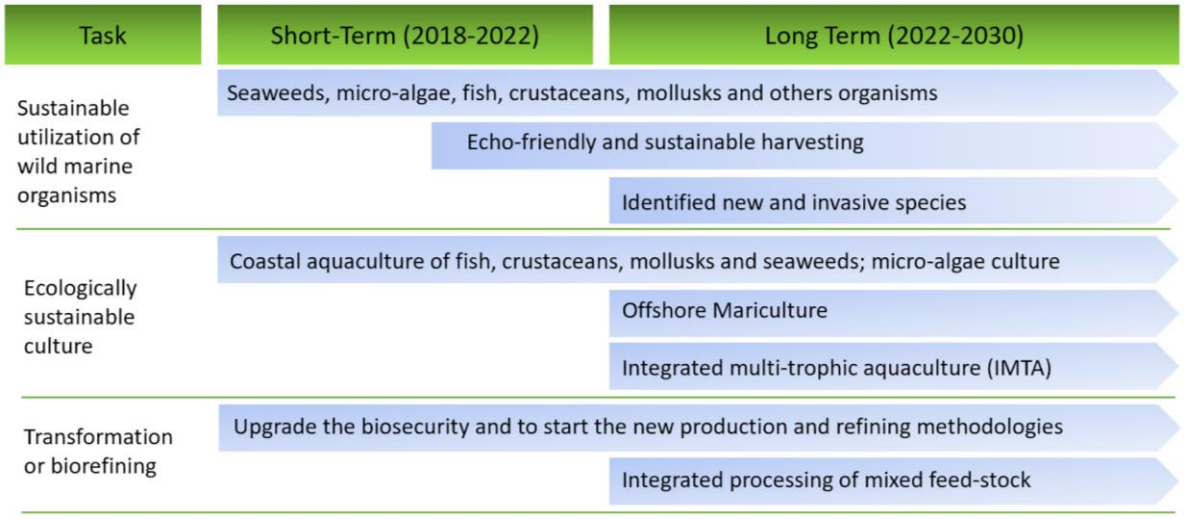

Figure 47: Policy can be taken for biomass production and process in Bangladesh.

7.4.6 Emerging market opportunities and challenges for product innovation and development:

Currently, marine biomass is used as food and feed sectors in Bangladesh and none of them are used in the alternative sectors like pharmaceuticals and others. But there is a good prospect of application of novel marine derived compounds and its emerging market in the country like the health sector (new drug discovery). Even though the making new products from novel marine materials is often consideration, current accessible marine resources should not be ignored. With the growths in aquaculture sector in Bangladesh, the fish processing activities are going to increase. While processors plan to augment the recovery of the eatable segment of fish, absolutely, not all materials are completely utilized. The discarded portion can be termed as 'co-product' and this marine biomass is a ridiculous source of polysaccharides, lipids, proteins, pigments, flavors, polymers and other various chemical compounds. All of which can be used as product and process applications and the target markets for these materials are human and animal food, chemical substances, beauty care products, pharmaceuticals, public health and nourishment ingredients. For example, collagen and gelatin extracted from fish; algin, carrageenan and agars from seaweeds and algae; are generally utilized by the food industry (Figure 48). Developing customized diets, integrated food production and processes Bangladesh could be taken various novel short term and long-term approaches (Figure 49).

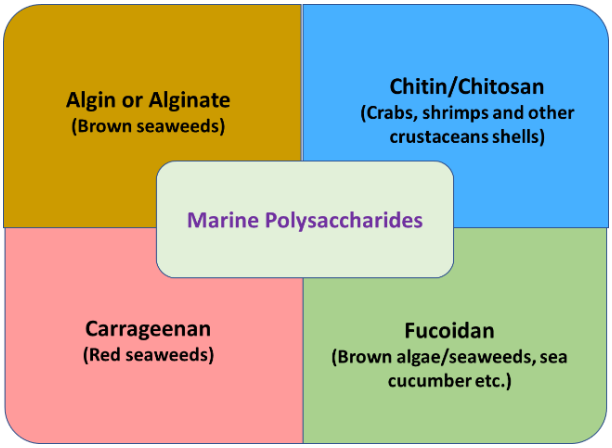

Figure 48: Various sources of marine polysaccharides for cosmeceutical, nutraceutical and pharmacological applications has been used.

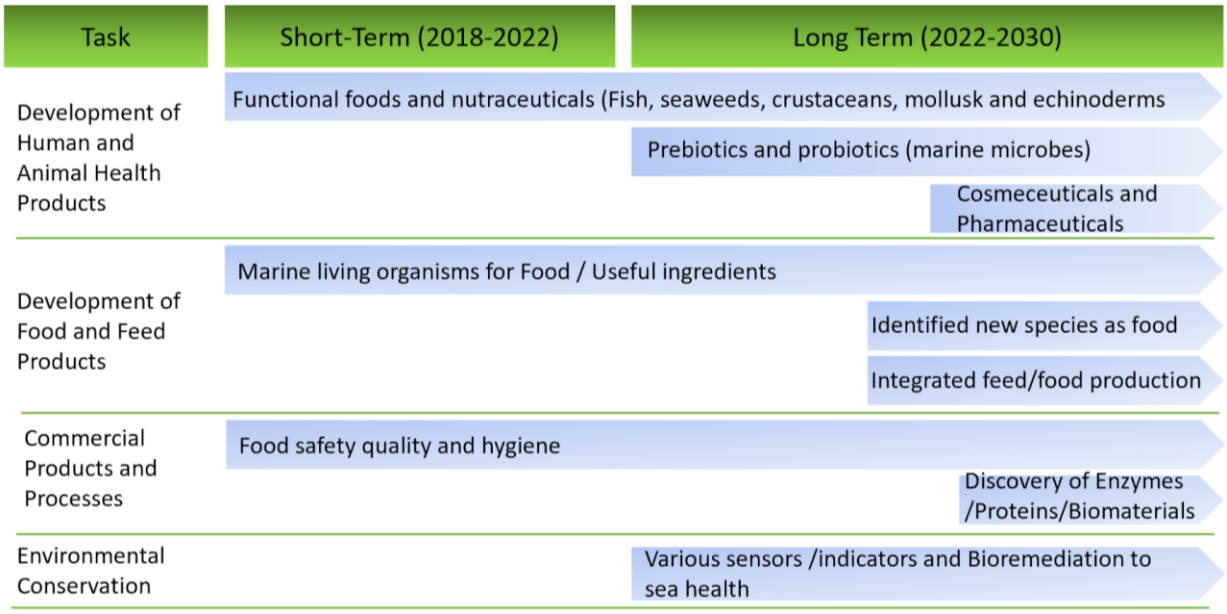

Figure 49: Marine product innovation and development strategy in Bangladesh.

7.4.7 Enabling technologies and infrastructure:

Bangladesh marine biotechnology activity has no significant progress over the past decade, but there remains an intense need to build research and innovation capacity — in cooperation with the government research centers, marine science institutes and other private and non-government sectors to develop the science and innovation research foundation in this sector. Many tools and techniques applied in marine biotechnology are being utilized as a part of different sections of science and innovation technology such as radioactive testing lab, biotechnology lab at various universities. Collaborative multidisciplinary research ventures are an opportunity to access these offices/facilities. Building up a connection amongst researchers/specialists and the variety of end-clients is important to inspiring the advancement. Assumptions regarding upgrading the accessible research framework to help product and process advancements must be met. Such frameworks include research vessels, exploration stages, labs, pilot plant, databases and archives and a variety of progressively complex systematic tools.

7.4.8 Policy initiatives, support and stimulation for blue biotechnology:

For Bangladesh, policy relatives to marine biotechnology must have to include the marine fisheries, mariculture, marine food, health, natural resources and industrial application. Research activities can create information to advise the policy and strategy, which thus stimulates future development. State-of-the-art policy can stimulate collaboration between research organization and industry. The significance of such collaboration is essential in empowering marine biotechnology-based development. Information got from marine biotechnology research informs how the marine environment can be monitored and managed reasonably and realize its role in giving ecological facilities to the country as well as the world. Data acquired from the marine environment could help the decision makers to take initiatives in public and private sectors.

- Find approaches to extend the access toward marine bioresources for revelation purposes in Bangladesh marine waters.

- Create an extensive, set of policy research program to apply the information picked up from marine biotechnology research to advise public strategy, governance and regulation of sea environment and sea-originated items.

- Establish policy developments to advance marine biomass production and processing capabilities and to reduce barriers to the development of existing and new markets for marine-derived products (Figure 50)

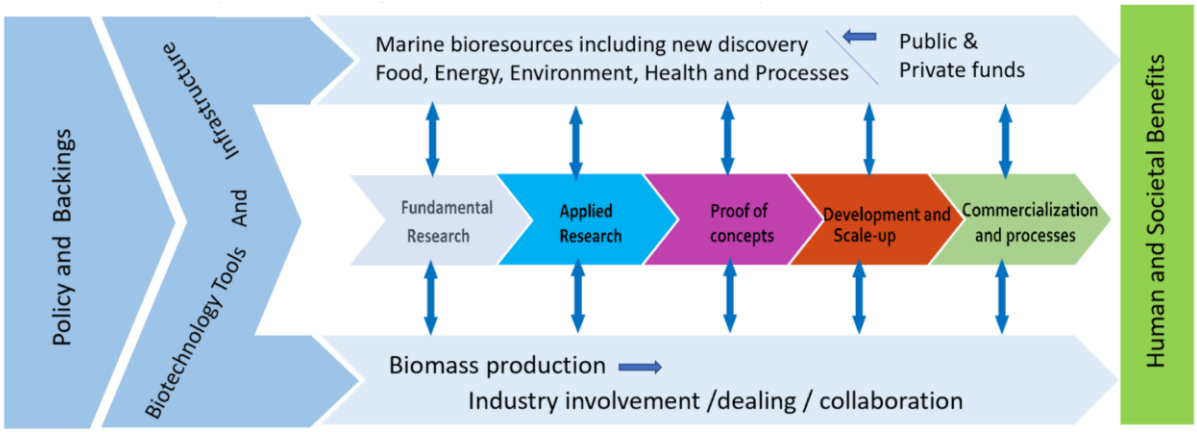

Figure 50: Activity connecting policy and research to support the product delivery and benefits to human and society.

7.5 Renewable Energy

7.5.1 New Frontier for the Future of Renewables: Bangladesh

Growing economies of Bangladesh must upsurge its energy capacity and need clean, competitive generation technology to do so. Bangladesh is starving for energy for most recent couple of decades since its power generation is predominantly relied upon imported petroleum fuel and natural gas. The government of Bangladesh is trying to increase its electricity generation, yet grid electricity is not reachable in the remote areas of the country due to lack of infrastructure and longstanding distribution facilities.

Bangladesh is the new frontier for renewables. Renewable energy in Bangladesh alludes to the utilization of renewable energy to generate electricity in Bangladesh. To ‘access the electricity for all’ secure and pollution free clean electricity is crucial; but there isn't much option accessible for Bangladesh except for renewable energy. The current renewable energy comes from hydro power, solar, biogas and wind, however, tide and wave energy have good potential. Right now, renewable energy remains a little part of Bangladesh's energy producing portfolio. Introduced renewable energy production capacity is at present 437 MW, with the 230 MW Kaptai Hydro powerplant being the main grid associated renewable resources (Figure 51). The rest of the MWs incorporate off-grid establishments and solar based home system (Faijer and Arends, 2017).

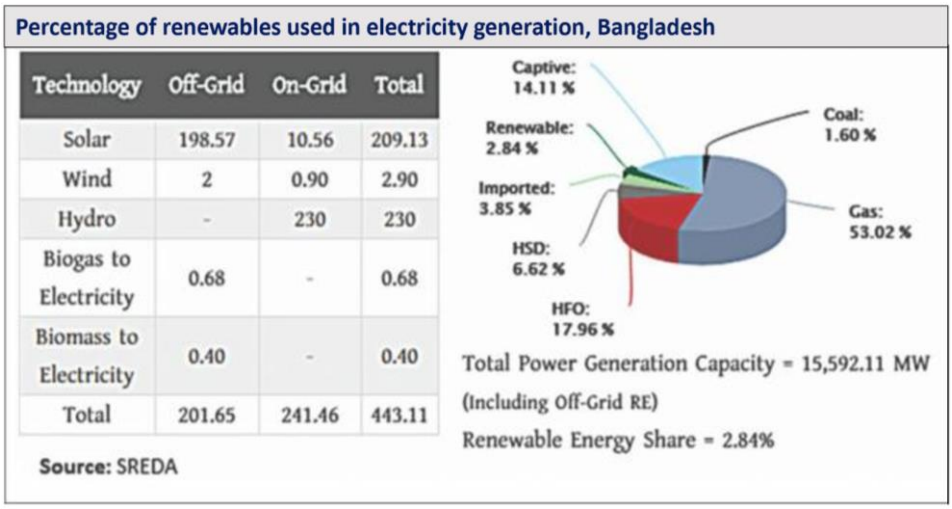

Figure 51: Energy generation in Bangladesh, (source SREDA 2017).

The long-haul wind stream, particularly in the islands and the southern coastal belt of Bangladesh is a great opportunity for the use of wind mills for generating electricity. In any case, amid the late spring and monsoon seasons (March to October) there can be low pressure regions and storm wind speeds 100 to 200 km/h can be normal. As of date, wind energy based physical implementations have been carried out mainly by Bangladesh Power Development Board (BPDB).

The tides at Chittagong Division are transcendently semidiurnal with a substantial variation in comparing to the seasons, the maximum high tide happening during the south-west monsoon. The average tidal range was found within 4-5 meter and the abundancy of the spring tide surpasses even 6 meters (Flemming and Bartoloma 2009). From different counts, it is foreseen that there are various appropriate locales at Cox's Bazar, Maheshkhali, Kutubdia and different other places where fixed basins with pumping provisions may be built which would be a twofold activity scheme (Koppel 2007).

Bangladesh has promising conditions for wave energy particularly during the period starting from late March to early October. Maximum wave height of more than 2 meter with a flat out most extreme of 2.4 meter were recorded. The wave time periods varieed from 3 to 4 seconds for waves of around 0.5 meter and around 6 seconds for influxes of around 2 meter (Uqaili and Harijan 2011).

7.5.2 Offshore Wind Energy: Innovation frontier for technology, Industry, Market and Investment

Offshore wind is the world's most monetarily and innovatively created marine renewable energy subsector and is moving quick from being a specialty innovation into a mainstream provider of electricity. There are presently 18,814MW of introduced offshore wind capacity in 17 markets around the globe (GWEC 2017). At the end of 2017, almost 84% (15,780MW) of every single offshore establishment were situated in the waters off the shoreline of eleven European nations. The remaining 16% is found to a great extent in China, trailed by Vietnam, Japan, South Korea, the United States and Taiwan (GWEC 2017). The UK is the world's biggest offshore wind market and records for a little more than 36% of introduced capacity, trailed by Germany in the second biggest with 28.5%. China comes third in the worldwide offshore rankings with just over of 15% (Figure 52). Offshore wind market activity is currently focused in Asia.

Bangladesh started its first wind energy venture in 2005. There are two wind energy projects in Bangladesh, the Muhuri Dam wind power project and in Kutubdia Island. Muhuri Dam Project is the first grid connected wind energy production plant in Bangladesh. The assessed yearly electricity supply from this 4×225 kW wind plant is around 2 GWh. Kutubdia Island is Bangladesh's other wind battery

hybrid venture situated in Chittagong. It produces 50×20 kW with assessed yearly generation of 2 Gwh (Faijer and Arends, 2017).

Ongoing Projects:

- Steps have been taken to introduce a 15 MW Wind Power Plant over the coastal districts of Bangladesh following multiyear Wind Resources Assessment in Muhuri Dam Area of Feni, Mognamaghat of Cox'sbazar, Parky Beach of Anwara in Chittagong, Kepupara of Borguna and Kuakata of Patuakhali. Wind Mapping is going ahead at Muhuri Dam zone of Feni and at Mognamaghat of Cox's bazar by Regen Powertech Ltd. of India.

- Installation of Wind Monitoring Stations at Inani Beach of Cox's bazar, Parky Beach of Anwara, Sitakundu of Chittagong and at Chandpur under USAID TA venture is in progress.

- 7.5 MW off Grid Wind-Solar Hybrid System with HFO/Diesel Based Engine Driven Generator in Hatiya Island, Noakhali.

Projects under Planning:

- BPDB has intended to execute 50-200 MW Wind Power Project at Parky Beach territory, Anawara in Chittagong on IPP basis.

- BPDB has likewise wanted to extend inshore wind energy plants along the coastline of beach front areas of Bangladesh.

The government of Bangladesh has set renewable energy (RE) improvement focuses for a few advance technologies for each year from 2015 to 2021, the "RE Development Targets". These targets require an extra 3,100 MW of renewable energy production ability to be introduced by 2021. The clear majority of the new capacity could come from solar powered (1,676 MW, or 54%) and wind (1,370 MW, or 44 %). There are likewise goals for biomass (47 MW), biogas (7 MW) and hydroelectricity (4 MW). Figure 52 demonstrates the renewable energy advancement targets for every innovation from 2015 to 2021.

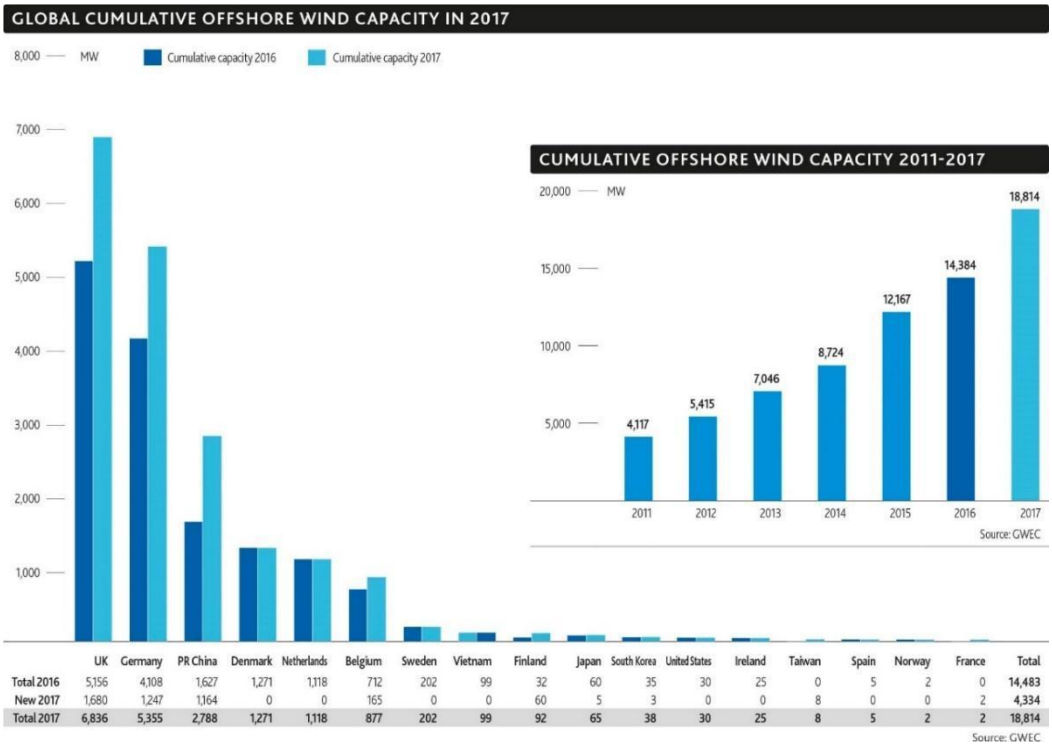

Figure 52: Global offshore wind energy production at the end of 2017. Source: GWEC 2017.

There are some national and international organizations that give financial directions or subsidizing to advancements in the energy sector in Bangladesh, concentrating on renewable energy. The Bangladesh Bank Refinancing Scheme for renewable energy is a rotating renegotiating system that gives credits at low interest to renewable energy and energy proficiency undertakings, for example, biogas, solar, bio-gas plants, SHS, solar irrigation systems and wind turbines. The highest quantity of loans for wind turbines is anyway insufficient to back a cutting edge expansive wind turbine (costs per turbine of a few million US$). Local and outside business banks have been the main lenders. In 2014, Local commercial banks loaned US$ 287.57 million to fund renewable energy ventures, 90 percent of the aggregate amount distributed by the rotating scheme. Foreign commercial banks loaned US$ 8.05 million to finance this sector, 3 percent of the aggregate amount distributed by the revolving plan. However, some international organizations like World Bank 9WB), Asian Development Bank (ADB), Climate Investment Fund (CIF) and Scaling up Renewable Energy Program (SREP) is actively involved in both energy policy developments and investments in Bangladesh.

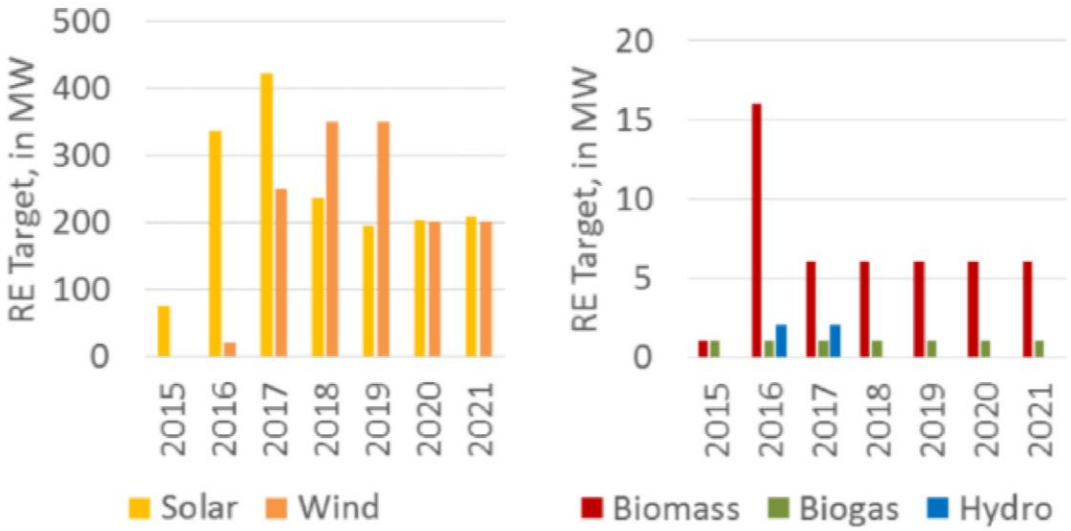

Figure 53: Renewable energy development targets from various sources (SREDA 2015)

7.5.3 Wind resources and uncertainties of wind energy

The sub-tropical atmosphere of Bangladesh, amid monsoon and cyclone seasons, Bangladesh is gone up against with a lot of precipitation and intermittently high wind speeds during the tropical storm season. The mean annual wind speeds in Bangladesh are not very much recorded and couple of information is accessible. The readily accessible information demonstrates that low wind speeds prevail on the Bangladeshi grounds. By inland wind speeds, no extensive information is promptly accessible relating to offshore wind speeds.

At present an operational wind mapping project is running with financial support by EC-LEDS (Enhancing Capacity for Low-Emission Development Strategy) which is a part of the USAID. This project comprises of 9 places where a two-year wind speed metering program is in advance at heights between 20 and 200 meters. The preliminary data of the project are still under prohibition with the Ministry of Power. Detailed results of the project are expected to become public in 2018. Figure 54 shows a rough map of the wind resources of Bangladesh to give an impression of the wind atmosphere, (available at: http://www.vortexfdc.com/assets/docs/vortex_3km_bangladesh_wind_map_resource.pdf).

No commercial scale offshore wind energy project has yet been decommissioned globally, however some single turbines and small projects have been decommissioned. There is a lot of uncertainty about the process. Usually, it is expected that turbines and change pieces will be removed with establishments cut off at a profundity beneath seabed which is probably not going to prompt revealing. Cables probably going to be pulled up, because of the reusing esteem. Ecological checking will be directed after the decommissioning procedure. It might be that some wind projects will be repowered utilizing new establishments, cluster links and turbines, re-utilizing most transmission and grid connection.

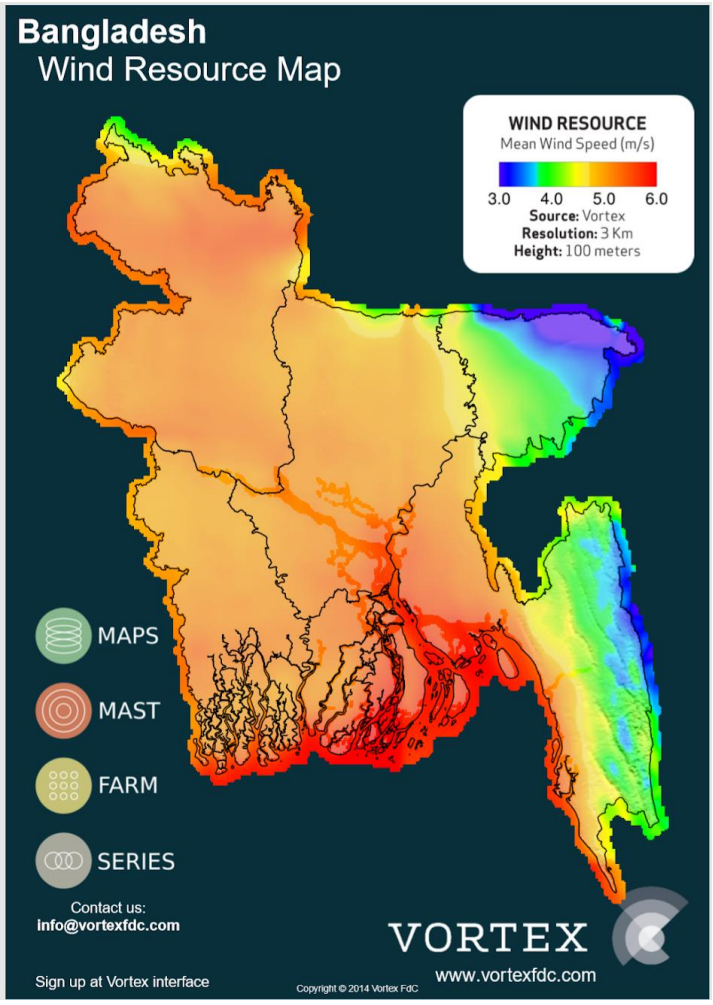

Figure 54: A rough map of the wind resources of Bangladesh.

7.5.4 Ocean Energy-Tide and Wave action

Tidal energy is foreseeable up to 100 years ahead of time (Alcorn, Dalton et al. 2014), making tidal energy interesting to grid operators by including more unsurprising and steady sources of renewable energy which has the result of pressing out the overall power supply from renewables. In tidal energy, there has been a general convergence of the innovations (Figure 55), with several developers testing full-scale prototypes and plans for commercial deployments. Limited availability of sites with insufficient high tidal ranges or flow velocities make the Bangladesh not appropriate for tide energy generation, moreover, a higher wave power resource is located near the St. Martin's Island, Bangladesh.

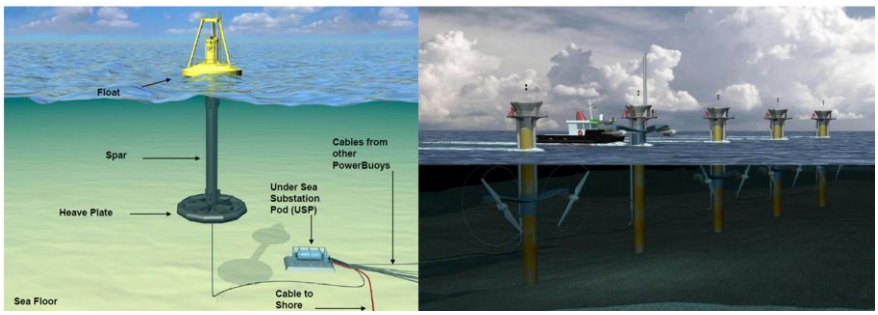

Figure 55: Tidal power generation

7.6 Introduction part: (Why non-conventional fishery important?)

Fisheries resources of Bangladesh has important role in food security, income and livelihoods for millions of people in Bangladesh. Particularly, fisheries often provide most affordable sources of animal protein for rural poor people. However, except hilsa fishery, capture fisheries' contribution to total fisheries production of Bangladesh is on decreasing trend. Though aquaculture has important role for enhanced fish production in Bangladesh, however extensive conversion of already decreased rice field into aquaculture pond many negatively affect rice production of the country. Further, scope for expansion of inland fisheries capture fisheries rather limited due to loss of habitat, population growth. Thus, it is important find alternative ways for enhance production to meet protein demand for increasing population of Bangladesh. In this context, fisheries resources of the Bay of Bengal hold promise. Though capture fisheries production in Bangladesh is increasing trend, however expert believe that increased fisheries production in Bangladesh is mainly related to increase fishing efforts rather than enhanced fisheries productivity. Further, harvestable fishery species in Bangladesh is limited to few species (e.g Hilsa, Bombay ducks), so if stock of these species collapse due to over-exploitation, it will cause negative impacts on the food security, employment and livelihoods of the millions of the people who are dependent on fishery resources for a livelihood option. Additionally, it is anticipated that climate change impacts will negatively affects the production of major commercial species harvesting from the Bay of Bengal (Fernandes et al. 2015). Thus, it is urgent to explore alternative harvestable species to compensate and or enhance fisheries production for ensuring food security and or enhancing income of coastal population

7.6.1 Potential unconventional fishery products in the Bay of Bengal

Unconventional fisheries are the species that are not considered as main target species when they are harvested, and mainstream population usually don't consume these species in traditional ways. Though unconventional fishery makes a rather small contribution to landings from capture fisheries relative to that of regular fishery of Bangladesh, in recent years, many artisanal fishers are involved in exploitation of non-conventional fishery species as their main occupation. Some of these fisheries can be considered as the unconventional fisheries those could be further harnessing in the blue economy context. These fisheries include squid, loligo, octopus, edible jellyfish, seaweeds, sea cucumber, sea turtle, lobster, mollusk species, small pelagic species and mangrove horse-shoe crab. Some of these species could directly be consumed by the consumers of the country; other could be exploited or cultured for export. At present, commercial trawlers usually catch non-conventional fishery species as by-catch. Unconventional fisheries remain under-utilized due to their unattractive appearance, color, texture, bones and small size. However, some species are used industrially for fishmeal production, though utilization of unconventional fishery species has potential for human consumption which could prevent post-harvest fishery losses (Hossain et al. 2017; Ahmed et al. 2007). Though non-conventional fishery species has economic potential, but the sector sectors failed to draw adequate attention both from academician and policy makers to explore these potentials.

7.6.2 Status and usage pattern of unconventional products in the Bay

The table below presents an overview of the status and usage pattern of unconventional products.

Table 14: Marine unconventional fisheries items, their present status and recommended extraction practices

Important Unconventional fishery items	Exploitable species in Bangladesh marine waters	Current usage pattern and harvest technique	Recommended extraction practices	Reference
Seaweeds	*Caulerpa racemosa*, *Hypnea pannosa* *Enteromorpha* spp.	Extraction from nature use as vegetables, salad, main ingredients for soup, export items. Mostly collected from beach by hand.	Extraction from nature within sustainable limit. Culture practices should be introduced for exploitation	Zemke-White and Ohno, 1999

Important Unconventional fishery items	Exploitable species in Bangladesh marine waters	Current usage pattern and harvest technique	Recommended extraction practices	Reference
	Gelidiella tenuissima Gelidium pusillum Sargassum spp.			
Mangrove horseshoe crab	*Carcinoscorpius rotundicauda*)	No extraction is reported	Extraction from natural source within sustainable limit	Vestbo et al. 2018
Lobstar	*Panulirus ornatus* Panulirus polyphagus *Panulirus* versicolor	Mainly collected from deep seas and rocky beach in the south-eastern coast. Mostly sale at local market as fresh or frozen some time exported. Dry specimens also sold as souvenirs. Usually harvested by bottom set gillnets, trawl nets and by diving.	Extraction from natural source within sustainable limit. Culture practices should be introduced for exploitation	Ahmed et al. 2007
Sepia	*Sepia haraonis Sepia intermis*	In recent years, these species are heavily exploited in the Cox's bazaar-Teknaf region. Became a delicacy for their thick and tender flesh, mainly consumed by tribal people and tourists. Also exported to south-east Asian region at lesser scale.Usually caught by light lures, traps, push nets, purse seins and hook and line.	Extraction from nature within sustainable limit.	Siddiqui et al. 2007
Octopus	*Octopus macropus* Octopus rugosus	The octopus fishery also became important for local consumption by the coastal people as well as export industries. This fishery has high demand in the south-east Asian countries, usually harvested in the sub-tidal habitats by trawl and spear, and on the intertidal reefs and rocky shore by hand or spear.	Extraction from nature within sustainable limit.	Siddiqui et al. 2007
Loligo	*Loliolus Hardwicke, Photololigo duvaucelii*	Recent years fishers involved in this fishery and became a profit oriented fishery. The species is marketed as fresh, frozen, dried or processed into cleaned mantle (whole hoods, rings). Captured by fishing techniques using light attraction.	Extraction from natural source within sustainable limit	Siddiqui et al. 2007
Oysters	*Crassostrea ariakensis, Crassostrea gigas, Crassostrea gryphoides Crassostrea virginica*	Meat of oyster use as food, mainly by tribal people in Bangladesh, shell use for lime production. This fishery has market potential in south-east Asia.	Extraction from natural source with sustainable limit. Culture practices should be introduced for exploitation	Siddiqui et al. 2007
Edible Jellyfish	*Cephea cephea Catostylus mosaicus Crambione mastigophora Crambionella orsisi Lobonema smithii*	No extraction practice is reported in Bangladesh jellyfish industry. Its future looks promising due to the abundance of these jellyfish in Bay of Bengal waters, and the increasing Asian demand. Processed jellyfish, as a delicacy, have potential Japanese market.	Extraction from natural source	

Important Unconventional fishery items	Exploitable species in Bangladesh marine waters	Current usage pattern and harvest technique	Recommended extraction practices	Reference
	Rhizostoma pulmo *Rhopilema hispidum* *Neopilema nomurai*			
Turtle	*Lepidochelys olivacea* Chelonia mydas Eretmochelys imbricate Caretta caretta Dermochelys coriacea	Local people indiscriminately porch turtle eggs for sale and consumption in the Cox's bazaar-Teknaf region. Turtle meat consume by tribal population.	Sea turtle farming (Green turtle) can be a promising ocean-based economic activity for Bangladesh	Sarker et al. 2018

7.6.3 Major barriers in exploitation of un-conventional fishery species:

Exploitation of unconventional marine species could be an important driver for enhancing blue growth, but there are some challenges ahead to make these extractions ecologically, economically and socially sustainable. These barriers include limited knowledge about harvestable stock of these species. Until recently started exploratory survey by a research vessel, *Meenshandani*, there has been a long gap in the exploratory survey on fisheries stocks assessment. Some of these species may be under intense pressure of degradation. Thus, before starting commercial exploitation, it is important to set exploratory survey to the stock assessment of all major species these species to determine Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY). For certain species, there are lack of awareness and interest among the fishers and consumers. The mainstream consumers still are less interested about seafood particularly unconventional fishery items. Fishers and consumers are also reluctant because some of unconventional fishery items are prohibited by religious customs. Some other though not prohibited, but due to their appearance, lack of habit for consumption, less knowledge about nutrition value, social taboos, mainstream people usually do not consume. Lack of technological regarding exploitation and processing of unconventional fishery items is another impediment. Though the majority of these items have huge foreign demand. But fishers usually don't get appropriate supports from the government in terms of training on exploitation practices, knowledge about processing or foreign market. Thus, many fishers are not interested about some of these unconventional species. On the hand, inspired by huge profit and booming foreign market, some of the previously unconventional fishery species face risk of over-exploitation. To check this imbalance, appropriate legal framework is necessary. Though the legal coverage for coastal and marine living resources of Bangladesh is extensive; however specific rule for a number unconventional fishery species is missing. There is no provision of law regarding sustainable exploitation of cephalopod fish fishery in Bangladesh. Hundreds of fishers involve in this fishery using illegal gears such as current jal which could negatively affect the sustainability of this fishery.

7.6.4 Management approach of unconventional fishery species

Despite their importance as potential fisheries very little are known about their ecological status, potential harvest technology and utilization are not sufficiently studied and reported in the literature in Bangladesh context. Allowing commercial exploitation will require detailed knowledge of the abundance of the target species. For example, Size at sexual maturity is needed to know to set size limits

to protect immature species, Identification of the areas where these species occur is needed to close fishing in some areas to protect a proportion of the population, to protect the habitat, Identification of the unit stock is needed to protect a proportion of each stock to ensure that individual stocks are not over fished. In this context, Bangladesh should actively develop a marine fisheries management plan to sustainable management marine conventional and unconventional fisheries. Development of a legal framework covering all unconventional fishery items is important before commercial exploitation these species starts. The Government should actively promote sustainable exploitation and conservation of unconventional fisheries through providing training, awareness building and market development.

7.7 References

Aftabuddin S., Zafar M., Noman A. S. M., Sharmin A., (2008) Isolation and identification of Vibrio spp. and Aeromonas spp. in wild and hatchery reared Penaeus monodon post larvae from Cox's Bazar, Bangladesh. Pak J Mar Sci 17(Special Issue):161-167.

Ahmed, A.T.A., Kabir, S.M.H., Ahmad, M., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A. and Khondker, M. (eds). (2007) Encyclopedia of Flora and Fauna of Bangladesh, Vol. 18. Part II. Arthropoda: Crustacea. Asiatic Society of Bangladesh, Dhaka 226pp.

Blunt, J.W., Copp, B.R., Keyzers, R.A., Munro, M.H.G., Prinsep, M.R. (2014) Marine natural products. Nat.Prod.Rep. 2014, 31, 160–258.

Ebel, E.R.A., and Jaspars, M. (2015) Report of the 9th European Conference on Marine Natural Products. Marine Drugs. Dec; 13(12): 7150–7249.

European Science Foundation-Marine Board. (2010) Marine biotechnology: a European strategy for marine biotechnology. Irelend: European Science Foundation.

Faijer, M.J., Arends, E. (2017) Final report, Baseline Study: Wind energy potential Bangladesh. Wind mind international, Netherlands Enterprise Agency, 1-25.

Fernandes, J. A., Kay, S., Hossain, M.A., Ahmed, M., Cheung, W.W., Lazar, A. N., & Barange, M. (2015) Projecting marine fish production and catch potential in Bangladesh in the 21st century under long-term environmental change and management scenarios. ICES Journal of Marine Science, 73(5), 1357-1369.

Flemming, B.W., Bartoloma, A. (2009). Tidal Signatures in Modern and Ancient Sediments: (Special Publication 24 of the IAS) Volume 28 of International Association of Sedimentologists Series. John Wiley & Sons. p. 329. ISBN 9781444304145.

Greco, G. R., and Cinquegrani, M. (2016) Firms Plunge into the Sea. Marine Biotechnology Industry, a First Investigation. Front. Mar. Sci. 2:124.

GWEC 2017. Global wind report 2017. A snapshot of top wind markets in 2017: Offshore wind, 54-63. http://gwec.net/wp-content/uploads/2018/04/offshore.pdf (accessed on 22 June 2018).

Hemmer-Hansen, J., Nina Overgaard Therkildsen, N. O., and José Martin Pujolar, J.M. **(**2014). Population Genomics of Marine Fishes: Next-Generation Prospects and Challenges, Biol. Bull. 227: 117–132.

Heppell, J., Wu, T., Lorenzen, N., Ellis, A.E., Efler, S.M., Armstrong, N. K., Schorr, J., and Davis, H. L. (1998) Development of DNA vaccines for aquaculture. In Gal, YL., and Halvorson, HO. (Eds.), New development in marine biotechnology. New York: Plenum Press. http://marinepharmacology.midwestern.edu/clinPipeline.htm (accessed 13 June 2018).

Hossain, M.S., Chowdhury, S.R., Sharifuzzaman, S.M. (2017) Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.

Islam, S., Khan, M.Z.R. (2017) A review of energy sector of Bangladesh. Energy Procedia 110: 611 – 618.

Kaul, P. and Srivastava, A. (2017) Cephalosporin Market by Generation (First-generation, Second-generation, Third-generation, Fourth-generation, and Fifth-generation), Type (Branded and Generics), Route of Drug Administration (Injection and Oral), and Application (Respiratory Tract Infection, Skin Infection, Ear Infection, Urinary Tract Infection, and Sexually Transmitted Infection) - Global Opportunity Analysis and Industry Forecast, 2017-2023, pp 1-224. https://www.alliedmarketresearch.com/cephalosporin-market, accessed on 10 June 2018.

Komoroske, L.M, Jensen, M.P., Stewart, K.R., Shamblin, B.M., and Dutton, P.H. (2017) Advances in the Application of Genetics in Marine Turtle Biology and Conservation. Front. Mar. Sci. 4:156. doi: 10.3389/fmars.2017.00156.

Koppel, T. (2007) Ebb and Flow: Tides and Life on Our Once and Future Planet. Dundurn. ISBN 9781459718388.

Lightner, D. V., (1996) A handbook of shrimp pathology and diagnostic procedures for diseases of cultured penaeid shrimp. Baton, Rouge, L. A., World Aquaculture Society, pp.1-72.

Liu, Z. J., and Cordes, J.F. (2004) DNA marker technologies and their application in aquaculture genetics. Aquaculture 238:1-37.

Martins, A., Vieira, H., Gaspar, H., Santos, S. (2014) Marketed marine natural products in the pharmaceutical and cosmeceutical industries: tips for success. Marine Drugs 12, 1066-1101.

Mayer, A.S.M. (2018) Marine Pharmaceuticals: The Clinical Pipeline, Midwestern University, Available at: http://marinepharmacology.midwestern.edu/clinPipeline.htm

Miller, L. M. 2003. Microsatellite DNA loci reveal genetic structure of yellow perch in Lake Michigan. Transactions of the American Fisheries Society 132:503-513.

Molinski, T. F., Dalisay, D. S., Lievens, S. L., and Saludes, J. P. (2009) Drug development from marine natural products. Nature Reviews. 8: 69-85.

Montaser, R., Luesch, H. (2011) Marine natural products: A new wave of drugs? Future Med. Chem. 3: 1475–1489. [

Olsen, J.B., Bentzen, P., Banks, M.A., Shaklee, J.B., and Young, S. (2000) Microsatellites reveal population identity of individual pink salmon to allow supportive breeding of a population at risk of extinction. Transaction of the American Fisheries Society 129:232-242.

QY Research (2018) Global Omega-3 PUFA Sales Market Report 2018. Pp 1-113, Harrisburg, NC 28075, United States. Available at: https://www.marketinsightsreports.com/reports/0612590385/global-omega-3-pufa-sales-market-report-2018 (accessed on 14 June 2018).

Research and Markets (2018) Global Nutraceuticals Market Analysis 2014-2017 & 2025: Increasing cost of healthcare, growing demand for omega-3 and dietary supplements & increasing healthcare awareness. Available at: https://www.prnewswire.com/news-releases/global-nutraceuticals-market-analysis-2014-2017--2025-increasing-cost-of-healthcare-growing-demand-for-omega-3-and-dietary-supplements--increasing-healthcare-awareness-300587393.html (Accessed on 14 June 2018).

Sarker, S., Bhuyan, M.A., Rahman, M.M., Islam, M.A., Hossain, M.S, Basak, S.C., Islam, M.M. (2018) From science to action: Exploring the potentials of Blue Economy for enhancing economic sustainability in Bangladesh. Ocean & Coastal Management. 157:180-92.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.T.N., Hassan, M.A., Khondher, M. and Rahman, M.M. (eds). 2007.

Encyclopedia of Flora and Fauna of Bangladesh, Vol. 18. Part II. Arthropoda: Crustacea. Asiatic Society of Bangladesh, Dhaka 415pp.

Smithers Group (2015) The Future of Marine Biotechnology for Industrial Applications to 2025. Available at: http://www. smithersrapra.com/products/market-reports/biomaterials/the-future-of-marine-biotechnology-for-industrial.

SREDA (Sustainable and Renewable Energy Development Authority) (2015) Energy Efficiency and Conservation Master Plan up to 2030. Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh.1-113.

Torok, E., Moran, E., Cooke, F. (2009) Oxford Handbook of Infectious Diseases and Microbiology, OUP Oxford, p 56.

Uqaili, M.A., Harijan, K. (2011) Energy, Environment and Sustainable Development. Springer. p. 19. ISBN 9783709101094.

Vaseeharan, B., Ramasamy, P., Murugan, T., and Chen, J.C. (2005) In vitro susceptibility of antibiotics against Vibrio spp. and Aeromonas spp. isolated from Penaeus monodon hatcheries and ponds. International Journal of Antimicrobial Agents. 26: 285-291.

Vestbo, S., Obst, M., Quevedo Fernandez, F.J., Intanai, I. and Funch, P., (2018) Present and Potential Future Distributions of Asian Horseshoe Crabs Determine Areas for Conservation. Frontiers in Marine Science, 5, p.164.

Zemke-White, W.L. and Ohno, M., (1999) World seaweed utilisation: an end-of-century summary. Journal of Applied Phycology, 11(4), pp.369-376.

Zhang, P., Xu, Y., Zongzhu, L., Xiang, Y., Du, S., and Hew, C. L. (1998) Gene transfer in red sea bream (Pagrosomus major). In Gal, Y. L., and Halvorson, H. O. (Eds.), New development in marine biotechnology New York: Plenum Press. pp. 15-18.

8 Bangladesh national plan for the implementation of SDGs for a Sustainable Maritime Security

8.1 Abstract

Within the BE development process the enhancement of the Maritime Security is fundamental in the context of the SDG. Some of the SDG14 targets don't have yet an equivalent in the 7th FYP. In the opposite, some of the 7th FYP targets regarding Blue Economy, Coast Guard and overall sustainable maritime security don't fit within the SDG frame. There is therefore a need to develop a consistent national plan for the implementation of the SDGs for ensuring a sustainable maritime security. The current chapter presents the patway to develop such a plan and the identification of the afferent set of indicators.

8.2 Introduction

The urgency of improving the implementation of sustainable development agreements was at the heart of the decision, at the 2012 UN Conference on Sustainable Development (UNCSD, or Rio+20), to negotiate the Sustainable Development Goals (SDGs). In September 2015 Heads of State and Government agreed to set the world on a path towards sustainable development through the adoption of the 2030 Agenda for Sustainable Development. This agenda includes 17 Sustainable Development Goals, or SDGs, which set out quantitative objectives across the social, economic, and environmental dimensions of sustainable development—all to be achieved by 2030. The goals provide a framework for shared action for people, planet and prosperity, to be implemented by all countries and all stakeholders, acting in collaborative partnership. A set of 169 targets accompanies the 17 goals and set out quantitative and qualitative objectives for the next 15 years. These targets are global in nature and universally applicable, taking into account different national realities, capacities and levels of development and respecting national policies and priorities. A set of indicators and a monitoring framework will also accompany the goals. The indicators have been defined by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs), which has presented its recommendations to the UN Statistical Commission in March 2016.

The call for all countries to develop plans to voluntarily implement globally agreed goals represents a break with the past. The 2030 Agenda for Sustainable Development (UNGA, 2015) seeks to set the global community on a different path, in the hope that it will result in a better outcome on the ground. A critical component for implementation of the 2030 Agenda will be the decisions taken by each country as it conducts national SDG implementation planning. Given that the SDGs themselves represent a break with the traditional global approach to spurring sustainable development (which was, *inter alia*, based on the negotiation of intergovernmental agreements that largely promoted a "work in silos" approach), the process of defining national SDG plans also represents a new direction. But while it is a new process, countries may be able to draw on lessons from the past.

The SDGs build on the success of the Millennium Development Goals (MDGs) in mobilizing collective action around a time-bound set of globally agreed goals. The SDG Agenda responds to these compound challenges, and is therefore broader and more complex than the MDGs. Most importantly, it adopts sustainable development as the organizing principle for global cooperation, meaning the combination of economic development, social inclusion, and environmental sustainability. Hence, the overarching name "Sustainable Development Goals," as the key message to the world community. Furthermore, the SDGs and related agenda apply to all countries, developed and developing alike. The post-2015 agenda calls for actors to move away from business-as-usual (BAU) approaches towards the sustainable use of resources and peaceful and inclusive societies.

The scale of human impact on the physical Earth has reached dangerous levels, which threatens long-term progress against poverty and the well-being of rich and poor countries alike. The world economic

system is already trespassing on the Earth's planetary boundaries. Many natural resources and ecosystems essential for human and societal well-being are being threatened or destroyed, such as loss of biodiversity, air pollution, water shortages and pollution, deforestation and grasslands degradation, and soil contamination. Climate change is no longer a future threat but a stark current reality. Consequences of rising carbon dioxide concentrations and higher global temperatures are already seeing, such as changes to the intensity and duration of extreme weather events and ocean acidification. Thus, the SDGs commit to protect the planet from degradation, including through sustainable production and consumption and the sustainable management of natural resources (including terrestrial and marine ecosystems), as well as taking urgent action to tackle climate change.

The ocean was given a marginal role in the Millennium Development Goals, despite its significant contribution to sustainable development. Poverty eradication and sustainable development cannot be ended without including the ocean and seas. In that regards, Goal 14, LIFE BELOW WATER, was established to Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Recently, at the UN Climate Change Conference in Marrakech[3] (Nov. 2016), numerous events, including the first-ever Oceans Action Day, underscored the role of the ocean in mitigating climate change and regulating the climate while recognizing the challenges that ocean acidification and habitat degradation pose to the conservation and sustainable development of oceans and the livelihoods and well-being of coastal and island communities. UN agencies and others also launched roadmaps, initiatives and publications related to oceans and climate change.

Oceans Action Day featured a high-level showcase segment with sessions on 'Oceans and Climate: Solutions to the core issues (food security, mitigation, adaptation, building resilience)' and 'Oceans and Climate: Science Solutions;' as well as dialogues on adaptation, mitigation and access to financing. The event featured ministers, scientists, private sector representatives and policy makers who elaborated on policies, action plans, initiatives and commitments to implement the Paris Agreement, achieve the Sustainable Development Goals (SDGs), particularly SDG 14 (life below water) and work towards fulfilling their Nationally Determined Contributions (NDCs).

Roadmap recommendations include: recognizing the central role of oceans in climate and the need to implement stringent reductions in greenhouse gas (GHG) emissions to avoid disastrous consequences on coastal and island communities, marine ecosystems and ocean chemistry; further developing and applying mitigation measures using the ocean, such as blue carbon policies, reducing carbon dioxide from ships, and ocean-based carbon capture and storage (CCS); implementing ecosystem-based adaptation (EbA) strategies through integrated coastal and ocean management institutions to reduce vulnerability of coastal and ocean ecosystems and human settlements and build management capacity, preparedness, resilience and adaptive capacities of coastal and island communities; developing and supporting measures to address issues associated with displacement of coastal and island populations as a result of climate change; providing sufficient funding for adaptation and mitigation efforts in coastal and small island developing States (SIDS); developing countries and economies in transition to build capacity on a number of issues.

Bangladesh has registered remarkable progresses in the areas of poverty alleviation, ensuring food security, primary school enrolment, gender parity in primary and secondary level education, lowering the infant and under-five mortality rate and maternal mortality ratio, improving immunization coverage; and reducing the incidence of communicable diseases. However, the attainments of a few targets of MDGs are associated with several challenges also. The existence of poverty pockets, prevalence of unemployment and underemployment among the youth, stunting and wasting among the under five

[3] The 22nd session of the Conference of the Parties (COP 22) to the UN Framework Convention on Climate Change (UNFCCC) convened from 7-19 November 2016, in Marrakech, Morocco. COP 22 was the first time an Oceans Day was officially included in the UNFCC's Global Action Agenda alongside agriculture, energy, forests, transport and water.

children, reducing the dropout rate and enhancing the quality of education at the primary level, universal access to reproductive health and resource constraints are identified as stumbling blocks in fulfilling all the targets of MDGs in Bangladesh.

After achieving most of the MDGs[4], Bangladesh has to develop now national plans of action for implementing SDGs. This exercise will be carried on within the Vison 2021, the plan to transform Bangladesh into a middle income country by 2021, the vision 2041, the aspiration to turn Bangladesh into a developed country by the year of 2041, encapsulated into the 7th Five-years plan (FYP) for the period 2016-2020. The enlargement of the EEZ and the particular vulnerability of the country to climate changes effects has lead to the need of developing an action plan on marine security, based mainly on the SDG 14.

8.3 7th Five Years Plan and Sustainable Marine Security

Since the start of the 7th FYP coincides with the final year of MDGs and the launch of UN's post-2015 Sustainable Development Goals (SDGs), the development approach underlying the 7th Plan is consistent with the global agenda for higher growth in developing countries with appropriate measures for protection of the environment. The FYP approaches Sustainable Maritime Security through the Blue Economy approach, the role of the coast guard and the Climate change challenges.

8.3.1.1 Unlocking the Potential of Blue Economy

Blue economy concept has ushered in a new horizon for economic development of the coastal countries through utilising the sea and marine resources at national and international level. Blue Economy comprises of activities that directly or indirectly takes place in the seas, oceans and coasts using oceanic resources and eventually contributing to sustainable, inclusive economic growth, employment, well-being, while preserving the health of ocean. It includes activities such as exploration and development of marine resources, appropriate use of ocean and coastal space, use of ocean products, provision of goods and services to support ocean activities and protection of ocean environment. The Blue economy approach emphasised that ideas, principles, norms of Blue Economy lend significant contribution towards eradication of poverty, contributing to food and nutrition security, mitigation and adaptation of climate change and generation of sustainable and inclusive livelihoods. It is needless to say that for most developing States particularly for Bangladesh, making transition to Blue Economy would entail fundamental and systemic changes in their policy-regulatory–management– governance framework(s) and identification of various maritime economic functions.

Maritime functions in the context of Blue economy are not just economic sectors; they cover the relevant maritime value chains – including backward and forward linkages. This is important since large parts of the economic activities take place not in core sectors themselves, but in adjacent economic activities. Twenty-seven blue economic functions can be identified from among the following six major broad areas, such as, i) Maritime traded and shipping; ii) Food and Livelihood; iii) Energy; iv) Tourism;

[4] In the 2015 UNDP report, it is mentioned that: Bangladesh has made outstanding progress in MDGs achievement. She has already met several targets of the MDGs like reducing headcount poverty and poverty gap ratio, reducing the prevalence of underweight children, attaining gender parity at primary and secondary education, under-five mortality rate reduction, containing HIV infection with access to antiretroviral drugs, children under five sleeping under insecticide treated bed nets, cure rate of TB under DOTS and others. In addition, Bangladesh has made remarkable progress in, increasing enrolment at primary schools, lowering the infant mortality rate and maternal mortality ratio, improving immunization coverage and reducing the incidence of communicable diseases. On the other hand, areas in need of greater attention are hunger-poverty reduction and employment generation, increases in primary school completion and adult literacy rates, ensuring quality education at all levels, creation of decent wage employment for women, increase in the presence of skilled health professionals at delivery, increase in correct and comprehensive knowledge on HIV/AIDS, increase in forest coverage, and coverage of Information and Communication Technology.

v) Coastal protection/Artificial islands/Greening coastal belts; vi) Human resource, maritime surveillance and spatial planning.

The recent verdict given by the International Tribunal for the Law of the Sea (ITLOS) and International Arbitration Tribunal over dispute of maritime boundary with Myanmar and India legitimately settles the EEZ of Bangladesh up to 200 nautical miles from the baseline comprising 118,813 sq. km of maritime waters. The newly opened development window of Blue Economy can significantly contribute in the socio- economic development of Bangladesh as a growth driver during the 7 FYP. Research shows that economic development utilizing ocean resources appears promising for Bangladesh. Nonetheless, this is contingent on maintaining good health of the ocean, its ecosystem and biodiversity. Available evidence suggests that while there are some prospects for oil and gas resources, the potential is most promising for marine fishing, transportation and tourism.

The following would be the appropriate actions/programmes that Bangladesh can undertake to create and maintain prosperous and sustainable blue economy bases during the 7th Plan period.

- B1. protecting and managing the fisheries for the present and the future generations,
- B2. developing a strong renewable energy sector using ocean and atmospheric forces,
- B3. maintaining existing (*e.g.,* ship building) and developing new maritime industries;
- B4. extending fishing areas using new technologies and methods even beyond EEZ in the international waters,
- B5. developing a strong human resource base for domestic utilization, and export to foreign job markets,
- B6. substantially increasing fisheries production and export earnings through improved aquaculture and introduction of mariculture,
- B7. creating a competitive tourism industry, including ecotourism and marine cruises,
- B8. further increasing revenue from shipping and commerce by the expansion of domestic fleet and destinations, transhipment and transit provisions, linking neighbouring states to the sea-ports, etc.
- B9. give special priority to anticipated Climate Change impacts on all relevant matters, and adjust policies and plans,
- B10. maintain the inland river systems and ecosystems for fishery, sediment transport, and inland shipping,
- B11. building a solid science, research and education base and
- B12. along with other coastal areas, establishment of marine academy in Khulna may be considered. Above all, for maintaining seamless and coordinated planning and actions, an integrated Coastal and Ocean Management Policy would be put in place.

8.3.1.2 Bangladesh Coast Guard

Bangladesh Coast Guard is dedicated to maintain order at coastal and sea area of Bangladesh including other areas of its jurisdiction and to contribute indirectly for the economic development of the country. In the seventh plan Blue economy has been prioritized to exploit the opportunities of using the resources from ocean for economic development of coastal belt, which will be secured by an efficient coast guard. The targets for the 7 FYP are the following:

- B13. To ensure safety and security of the ports, harbours, seafarers including water craft and offshore installations within areas of jurisdiction.

- B14. Protection against illegal fishing, human trafficking, gun running, smuggling, narcotics trafficking and piracy.

- B15 Pollution control and preservation of environment.

- B16. To ensure capability to assist the government in times of various needs like disaster management and relief operation.

8.3.1.3 Addressing climate change challenges and water constraint

The low lying delta of Bangladesh is highly vulnerable, both to the normal and tidally enhanced monsoon floods as well to regular impact from tropical cyclones. In addition, salt water intrusion affects drinking water quality and limits food production in the coastal zone while drainage congestion and water logging also have great impact, e.g. in urban areas. Floods intensify the contamination of drinking water, causing outbreaks of contagious diseases. These problems are likely to become worse due to climate change, land subsidence and population growth. Climate change is expected to result in sea level rise, salinity intrusion and more frequent droughts and floods. Climate change and water constraints are thus threatening the economic growth process by increased flood vulnerability especially in the coastal zone, loss of valuable assets, pressures on land use for agriculture and food security as well as for industrial and urban purposes. These problems stand in the way of economic development and improvement of livelihood of many people. A long term vision has been developed and comprehensive measures have to be taken with the development and implementation of a long term Bangladesh Delta Plan to adapt to climate change and manage the water challenges.

8.4 Goal 14 Life below water

Activities related to the sustainable management of the ocean, marine resources and coastal areas; includes efforts that recognize the ocean's contribution to the climate change challenge as a carbon sink, as well as the interactions between climate change and the ocean, such as carbon dioxide-driven acidification, impacts of rising ocean temperatures, carbon storage in the ocean seabed, and ocean fertilization; with regard to biodiversity and ocean health, activities related to fisheries and aquaculture such as dwindling fish stocks and illegal, unreported and unregulated (IUU) fishing, pollution and debris, and biodiversity and ecosystem protection and conservation, including the impacts of invasive species; also includes activities related livelihoods and the Blue Economy.

The ocean goal (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) places the critical role of oceans to our planet and to humanity squarely in the post----------2015 development agenda, and provides a framework to orient development of new measures to tackle existing governance gaps in relation to the high seas. By reducing many of the direct stressors to ocean life from human activities like industrial fishing, the SDG Ocean targets will help to support resilience and abundance, regenerating ocean life with benefits that extend across communities and beyond borders. An Ocean SDG alone is not enough to guarantee a secure future for the global ocean but it

sends a number of important messages, garners valuable recognition, and builds momentum and resources. It should trigger the kind of action necessary for international recognition that the global ocean is an Earth system, the health of which is essential to communities around the world, and to the planet as a whole. It must address the fragmented approach that is currently driving ocean decline. A concerted effort is required, underpinned by key reforms in global ocean governance and implemented by every government, by civil society and by the private sector so that the words on paper become action in the water.

Table 15: Targets and indicators of the Goal 14

Target	Indicator
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation[c]	14.6.1 Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries
14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular	14.a.1 Proportion of total research budget allocated to research in the field of marine technology

Target	Indicator
small island developing States and least developed countries	
14.b Provide access for small-scale artisanal fishers to marine resources and markets	14.b.1 Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

Source: http://unstats.un.org/sdgs/indicators/indicators-list/

In "The Future We Want", Member States noted that the new SDGs should focus on priority areas for the achievement of sustainable development, while being guided by the outcome document, of which oceans comprised a considerable part. The majority of existing proposals made with regard to oceans in the context of SDGs are based on the common understanding that the achievement of healthy, productive and resilient oceans is indispensable to poverty eradication and sustainable development. In this regard, and despite the fact that other ocean-related topics remain of utmost importance, the following elements could be taken into closer consideration, which are based on the "The Future We Want":

(i) Ensure conservation and sustainable use of the oceans and seas and of their resources: Effectively apply an ecosystem approach and the precautionary approach in the management, in accordance with international law, of activities having an impact on the marine environment; Meet the 2015 (JPoI) target on an urgent basis and maintain or restore all fish stocks at least to levels that can produce the maximum sustainable yield, in the shortest time feasible, as determined by their biological characteristics; Develop and implement science-based management plans, including by reducing or suspending fishing catch and fishing effort commensurate with the status of the stock; Enhance action to manage by-catch, discards and other adverse ecosystem impacts from fisheries, including by eliminating destructive fishing practices; Eliminate, prevent and combat IUU fishing; Eliminate subsidies that contribute to IUU fishing and overcapacity; Implement area-based conservation measures, including marine protected areas.

(ii) Reduce the incidence and impacts of marine pollution, including marine debris, especially plastic, persistent organic pollutants, heavy metals and nitrogen-based compounds, from a number of marine and land-based sources; take action to achieve, by 2025, based on collected scientific data, significant reductions in marine debris to prevent harm to coastal and marine environment.

(iii) Prevent introduction of alien invasive species and manage their adverse environmental impacts.

(iv) Address ocean acidification and the impacts of climate change: accelerate the reduction of global greenhouse gas emissions; prevent further ocean acidification; adapt to climate change;

enhance resilience of marine ecosystems and coastal communities; reduce disaster risk and build resilience to natural disasters.

Effective implementation and the bridging of implementation gaps, strengthened compliance and enforcement together with the adoption of necessary measures, including through the development of national, regional and global action plans, strategies, policies, institutional and fiscal reforms as well as protocols, would contribute to better addressing the ongoing challenges on the path towards sustainable development. In particular, the strengthened compliance with, and enforcement of, UNCLOS and its implementing agreements, as well as the other instruments adopted by competent international organizations, specialized agencies, Funds and Programmes and other relevant bodies, would significantly contribute to the protection, conservation and sustainable use of the oceans and their resources, including through the promotion of capacity-building, cooperation in marine scientific research, and the transfer of marine technology.

Capacity-building programmes, when tailored to the needs of the different regions and aimed at human resource development, knowledge transfert and the strengthening of institutional capacity in the law of the sea and marine affairs, including planning, management and monitoring capacities, can have significant impacts. Together with the transfer of marine technologies which are accessible, affordable and adaptable to needs and particular circumstances of countries, such capacity-building programmes will play an important role on the path to sustainable development. To increase citizen engagement, dedicated oceans-related curricula should be an essential part of education for sustainable development to raise public awareness and change consumer behavior.

Improved governance, political will and the targeted allocation of sufficient resources will be essential to the achievement of SDGs, including a possible stand-alone goal on oceans. The building of an improved interface between science and decision-making in oceans-related issues and the proper valuing of goods and services provided by marine and coastal ecosystems are likewise essential. New financing mechanisms that leverage available funding and increase efficiency in development aid, public private partnerships, together with investments in the oceans-based economy, can play an important role. As the various basins of the oceans are interconnected, even smaller projects can have significant impacts on a global scale. The promotion of decent work and respect for international labour standards can further contribute to improve labour conditions for women and men, safety of navigation and maritime security, thus not only protecting seafarers, fishers and their communities, but also ensuring their effective stewardship of the marine environment and resources.

It will be crucial to improve our knowledge about the state of the oceans and marine ecological processes. In 2014, the first World Ocean Assessment under the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, will provide decision makers with timely information. Understanding changes in the oceans in real time is vital in order to enable timely and effective responses. The creation of an enabling environment is crucial, including through maintaining and expanding ocean observation, data management and information systems. Additional centers for the coordination of scientific activities at global scale would be beneficial. The need of adapting to climate change and supporting climate-sensitive sectors (e.g. fisheries, tourism) in coastal regions will require the development of information products and services based on climate predictions.

Increased cooperation and (cross-sectoral) coordination among all stakeholders at local, national, regional and global levels are crucial toward a new global partnership for sustainable development, especially in the areas of technical and scientific cooperation, information sharing and resource mobilization. While the manner in which oceans will be dealt with in the future SDG framework is yet to be defined (stand-alone goal or cross-cutting inclusion), these elements are crucial in the way forward.

8.5 SDG 14 and Sustainable maritime security in Bangladesh

Bangladesh is one of the marginal coastal countries of the Bay of Bengal (BoB) with a land area of 144,054 km2 and population of around 160 million, located on the northern tip of the BoB. Its marine waters cover an area of 165,887 km2 which is greater than the land area. Fishery resources play a very important role to the economy of Bangladesh not only as an important means of animal protein, income and employment, but also as an important source of foreign exchange earnings. The BoB is an arm of the Indian Ocean, between India on the west and the Malay Peninsula on the east, measuring about 2,090 km long by about 1,600 km wide. The Bay is generally considered to extend southwards beyond Sri Lanka, and as far as the coastlines of Thailand, Malaysia and the Indonesian island of Sumatra that border on the Andaman Sea and the Straits of Malacca, after which it merges into the waters of the Western Indian Ocean. The BoB region is defined as including selected coastal and Exclusive Economic Zone (EEZ) areas of eight countries (Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand) as well as the international waters between them.

In fact, the marine and coastal resources are highly vulnerable to climate change resources. Almost a fourth of the total population of the country lives in the coastal areas of Bangladesh, where majority of the population are somehow affected (directly or indirectly) by Coastal Floods / Tidal Surges, River-bank Erosion, Salinity, Tropical Cyclones etc. With the rise of Sea-level up to one meter only, Bangladesh could lose up to 15% of its land area under the Sea water and around 30 million people living in the coastal areas of Bangladesh could become Refugees because of Climate Change impacts. Agriculture, Industry, Infrastructures, Livelihoods, Marine Resources, Forestry, Biodiversity, Human Health and other Utility services will suffer severely because of the same. Salinity Intrusion from the Bay of Bengal already penetrates 100 kilometers inside the country during the dry season and the Climate Change in its gradual process is likely to deteriorate the existing scenario to a great extent. Since most of the country is less than 10 meters above Sea level and almost 10% of the population of the country is living below 1 meter elevation - the whole coastal area is Highly Vulnerable to High Tides and Storm Surges. Moreover, the Bay of Bengal is located at the tip of the north Indian Ocean, where severe Cyclonic storms as well as long Tidal waves are frequently generated and hit the coast line with severe impacts because of the Shallow as well as Conical shape of the Bay near Bangladesh.

The marine resources of Bangladesh are blessed with rich coastal and marine ecosystems, hosting a wide range of biodiversity, such as fishes, shrimps, mollusks, crabs, mammals, seaweeds, etc. Bay of Bengal and coastal areas is one of the most important areas of national economy of Bangladesh. The blue economy can create some opportunities to resolve the issues of climate changes at the coastal areas by addressing the challenges. On the other hand, it might generate jobs for millions and bring about tangible changes in the lives and livelihood of the millions of people living along the coastline, in islands and across Bangladesh, if the resource management is governed by principles of biodiversity protection, conservation is community-led and efforts for care are intertwined with a vision of scientific understanding.

In Bangladesh, discussions on Blue Economy[5] started after the settlement of maritime boundary delimitation dispute with Myanmar and India (Hussain et al. 2017a). The declaration of verdict by the International Tribunal for the Law of the Sea (ITLOS) in Germany, in the delimitation case with Myanmar on 14 March in 2012. The award helped Bangladesh establishing sovereign rights over the

[5] The Blue Economy conceptualizes oceans and seas as "Development Spaces" where spatial planning integrates conservation, sustainable use of living resources, oil and mineral wealth extracting, bio-prospecting, sustainable energy production and marine transport. It is envisaged as the integration of Ocean Economy development with the principles of social inclusion, environmental sustainability and innovative, dynamic business models. At the United Nations Conference on Sustainable Development (UNCSD) held in Rio de Janeiro in 2012, blue economy was viewed as ocean economy that aims at the "improvement of human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. The European Commission (2012) has defined the concept of blue economy as "all economic activities related to the oceans, seas and coasts.

living and non-living resources of the Bay of Bengal in the Exclusive Economic Zone within 200 nm and in the continental shelf beyond 200nm. In the same way, the verdict with India declared on 7 July 2014 also allowed Bangladesh's sovereign rights on all the living and mineral resources of the Continental Shelf extending up to 354 nautical miles. Bangladesh's economy is sea borne to a good extent and with $ 130 billion GDP the country's economy stands the 44th in the world. Under this development recently the country broadly identified a number of important sectors viz. i) Fishing, ii) Marine Biotechnology, iii) Minerals, iv) Marine Renewable Energy, v) Marine manufacturing, vi) Shipping, Port & Maritime logistics, vii) Marine Tourism & Leisure, viii) Marine Construction, ix) Marine Commerce, x) Marine ICT, xi) Education and research. The concept of blue economy in Bangladesh can be developed as emerging sectors. There exist tremendous opportunities for the country to strengthen Ocean Based Economy. Among the above mentioned 11 sectors Ministry of Fisheries & Livestock have wide scope for developing Fishing, Marine Bio-technology and Education & Research Sectors (Failler et Hussain, 2017).

The Government of Bangladesh has recently started discussions with stakeholders to adopt the concept of Blue Economy across relevant policies and plans. The objective is to exploiting untapped potential of the marine environment using smart solutions and innovations for increasing food security, alleviating poverty, improving nutrition and health, creating jobs, lifting trade and industrial profiles while protecting ecosystem health and biodiversity, and also improving regional security (incl. maritime security) and peace. In order to achieve all these issues more effectively, Government of Bangladesh has already set up a High-level Committee lead by the Secretary to the Prime Minister's Office, to move forward the blue economy agenda in Bangladesh and enhance coordination across relevant ministries. Marine sector in Bangladesh is remarkably short in skilled manpower and this shortfall should be fulfilled through training, higher study and new recruitments. Also, to develop human capacity and improve understanding of related issues, the country has recently created a Department of Oceanography at the University of Dhaka, and the new Maritime University.

Preserving natural resources, creating opportunities for all through ensuring growth sustainability and building resilience is one of the core element in the European Union's Multi-Annual Indicative Programme 2014-2020 for development cooperation with Bangladesh, through formulation of a national vision and governance framework in the field of the blue economy, and to it's implementation in a broader partnership including government, private sector, academia, and other stakeholders (Hussain et al. 2017b). Through an intervention based on European experiences and practices, which combines both the broader blue economy governance aspects and some more specific thematic & scientific support on marine fisheries, mariculture (culture of marine fish and other suitable aquatic species) and coastal aquaculture (shrimp, crabs and other suitable brackish water fin fish species) areas in Bangladesh.

Table 16: SD Goal 14 targets and 7 FYP targets regarding Sustainable Maritime Security

SDG Target	7th FYP targets
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	B15 Pollution control and preservation of environment
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	B10. maintain the inland river systems and ecosystems for fishery, sediment transport, and inland shipping,
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	B9. give special priority to anticipated Climate Change impacts on all relevant matters, and adjust policies and plans

SDG Target	7th FYP targets
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	B1. protecting and managing the fisheries for the present and the future generations B4. extending fishing areas using new technologies and methods even beyond EEZ in the international waters B14. Protection against illegal fishing, human trafficking, gun running, smuggling, narcotics trafficking and piracy
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	-
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation[c]	B1. protecting and managing the fisheries for the present and the future generations
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	B6. substantially increasing fisheries production and export earnings through improved aquaculture and introduction of Mariculture B7. creating a competitive tourism industry, including ecotourism and marine cruises
14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	B11. building a solid science, research and education base and B12. along with other coastal areas, establishment of marine academy in Khulna may be considered. Above all, for maintaining seamless and coordinated planning and actions, an integrated Coastal and Ocean Management Policy would be put in place
14.b Provide access for small-scale artisanal fishers to marine resources and markets	-
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	-

Some of the SDG targets don't have yet an equivalent in the 7th FYP (14.5[6]; 14.b; 14.c). In the opposite, some of the 7th FYP targets regarding Blue Economy, Coast Guard and overall sustainable maritime security don't fit within the SDG frame. Namely:

[6] According to the 7th FYP: all possible interventions were undertaken to conserve biodiversity of the Sundarbans Mangrove Forests. To protect the Royal Bengal Tiger, Tiger Action Plan has been prepared for 2009-2017 period

- B2. developing a strong renewable energy sector using ocean and atmospheric forces,

- B3. maintaining existing (*e.g.*, ship building) and developing new maritime industries;

- B5. developing a strong human resource base for domestic utilization, and export to foreign job markets,

- B8. further increasing revenue from shipping and commerce by the expansion of domestic fleet and destinations, transhipment and transit provisions, linking neighbouring states to the sea-ports, etc.

- B13. To ensure safety and security of the ports, harbours, seafarers including water craft and offshore installations within areas of jurisdiction.

- B16. To ensure capability to assist the government in times of various needs like disaster management and relief operation.

In that regards, there a need to develop a national plan of actions for the Goal 14 (in line with current and further developed targets) as well as a set of indicators for the monitoring of the implementation of the 7th FYP targets. Table 17 below provides an indicative set of indicators for the 7th FYP targets link to Sustainable Maritime Security. They need to be further developed.

Table 17: 7th FYP Sustainable Maritime Security targets and indicators

Target	Indicator
B1. protecting and managing the fisheries for the present and the future generations	IB.1.1 No undersize fishes are landing IB.1.2 No destructive fishing methods are used
B2. developing a strong renewable energy sector using ocean and atmospheric forces	IB.2.1 X% of the national produced energy originates from the ocean (to be quantified with the ministry of energy)
B3. maintaining existing (e.g., ship building) and developing new maritime industries	IB.3.1 Value added and employment of ship building and ship breaking are maintained IB.3.2 New maritime industries are recorded
B4. extending fishing areas using new technologies and methods even beyond EEZ in the international waters	IB.4.1 Percentage of landings of species from new fishing areas / total landing increase every year IB4.2 National tuna vessels operate in high seas
B5. developing a strong human resource base for domestic utilization, and export to foreign job markets	IB.5.1 Annual increase of the number of Maritime job trainees
B6. substantially increasing fisheries production and export earnings through improved aquaculture and introduction of mariculture	IB. 6.1 Annual increase of the high-tech aquaculture production IB. 6.2 Annual increase of the mariculture production

and consequently different conservation activities have been implemented. Nevertheless, no specific action is planed towards the establishment of marine protected areas.

Target	Indicator
B7. creating a competitive tourism industry, including ecotourism and marine cruises	IB. 7.1 Annual increase of the number of night stays in tourism locations IB. 7.2 Annual increase of the eco-tourism enterprises
B8. further increasing revenue from shipping and commerce by the expansion of domestic fleet and destinations, transhipment and transit provisions, linking neighbouring states to the sea-ports, etc.	IB. 8.1 Annual increase of shipping revenues IB. 8.2 Annual increase of regional freight
B9. give special priority to anticipated Climate Change impacts on all relevant matters, and adjust policies and plans	IB. 9.1 Number and size of anticipated projects implemented along the coast
B10. maintain the inland river systems and ecosystems for fishery, sediment transport, and inland shipping	IB. 10.1 Maintaining of the health of the coastal ecosystems (baseline to be defined)
B11. building a solid science, research and education base	IB. 11.1 marine research effective (publications, patterns, etc. (number to be defined)) IB. 11.2 University degrees in marine sciences in progress annually
B12. along with other coastal areas, establishment of marine academy in Khulna may be considered. Above all, for maintaining seamless and coordinated planning and actions, an integrated Coastal and Ocean Management Policy would be put in place.	IB. 12.1 Khulna marine academy operational IB. 12.2 Integrated Coastal and Ocean Management Policy implemented
B13. To ensure safety and security of the ports, harbours, seafarers including water craft and offshore installations within areas of jurisdiction	IB. 13.1 Coast guard fully operational
B14. Protection against illegal fishing, human trafficking, gun running, smuggling, narcotics trafficking and piracy	IB. 14.1Number of annual cases
B15 Pollution control and preservation of environment	IB. 15.1 number of annual samplings

Target	Indicator
B16. To ensure capability to assist the government in times of various needs like disaster management and relief operation	IB. 16.1 Coast guard full operational capacity for extreme weather events

8.6 References

Failler, P., Hussain, M.G., Karim, A.A., K. Alam, M.K. & Drakeford, B. 2017. Opportunities and Constraints of Blue Economy Development in Bangladesh. In the proceedings of International Workshop on Blue Economy Dialogue, 22– 23 November 2017; Hotel Pan Pacific Sonargaon, Dhaka, Bangladesh.

General Economic Division 2015, 7th Five Year Plan 2016-2020, Planning Commission, 726 p.

Hussain, M.G., Failler, P., Karim, A.A. and Alam, M.K. 2017a. Review on opportunities, constraints and challenges of blue economy development in Bangladesh. Journal of Fisheries and Life Sciences, 2(1): 45-57.

Hussain, M.G., Failler, P., Karim, A.A. and Alam, M.K. 2017b. Major opportunities of blue economy development in Bangladesh, Journal of the Indian Ocean Region, Vol. 13, Issue no.1, pp. 111-118.

9 Prospects of Bangladesh shipping industry

9.1 Abstract

Bangladesh is traditionally a ship building nation and has a rich heritage of timber shipbuilding of many hundred years. Germanischer Lloyd has declared Bangladesh as a shipbuilding nation of international standards in September 2008. She is presently contributing to the shipbuilding industries globally through its exported workforce. These facts do not speak only of a heritage but of an inbuilt ability of shipbuilding of people of this region. For the development of shipbuilding industry, we need to generate adequate demand in the local and foreign market, elevated engineering skills, reasonable infrastructure, long term government policy support along with attractive investment climate. National and international issues and factors which apparently do not encourage shipbuilding in Bangladesh need to be addressed. Impacts of those issues will be evaluated and measures towards finding a solution will be incorporated. In this paper at first, an overall picture of this industry has been depicted by identifying the actual shipbuilding practice in both public and private sector. Relevant data have been explored through extensive review of literature, field visits, interacting with shipyard and ship owners. The potentiality, capability and problems of the shipbuilding sector of Bangladesh have been identified.

9.2 Introduction

Shipbuilding is a growing industry in Bangladesh with great potentials. Bangladesh has a long history of shipbuilding dating back to the early modern era. However, shipbuilding has become a major promising industry in recent years when the locally made ships began to be exported. The optimism about this industry arose from the success attained by a number of local entrepreneurs who brought the name and fame to Bangladesh as a country with great potentials in shipbuilding by building and handing over some ocean-going vessels to overseas buyers. Since then, the shipbuilding in Bangladesh did not have to look back and now new opportunities are knocking at the door to flourish this industry further.

It has 9,000 sq km of territorial waters, 720 km long coastline. It has 700 rivers that come down from the surrounding countries and which provide 24000 km long inland waterways. At present about 10,000 inland and coastal ships have been working all over the country, which carry more than 90% of total oil product, 70% of cargo and 35% of passengers. More than 150,000 skilled and semi-skilled workers are employed in this labour intensive sector. Two million people are related directly or indirectly with shipbuilding industry. All inland and coastal ships are constructed and repaired locally in Bangladeshi shipyards. Recently Bangladesh has successfully exported her first ocean going ship to a high-end market like Denmark competing with giant competitor like China, India and Vietnam in 2008. Bangladesh has now over 200 shipbuilding companies, mostly concentrated in Dhaka, Chittagong, Narayanganj, Barisal and Khulna. However, due to global nature of this industry, an assessment of suitability to modern shipbuilding in terms of global standard is of prime importance.

In this report, an effort has been made to evaluate the present shipbuilding industries in Bangladesh. At first, an overall picture of this industry has been depicted by identifying the actual shipbuilding practice in both public and private sector. Relevant data have been explored through extensive review of literature, field visits, interacting with shipyard and ship owners. The potentiality, capability and problems of the shipbuilding sector of Bangladesh have been identified & some recommendations have been made in line with this report.

9.3 Methodology used for data collection

Data were collected through extensive review of literature, field visits, survey, consultations and meetings with Government Authorities, Shipbuilding Associations, existing and upcoming shipyards and its related stakeholders. Private and public shipyards around the country were visited to collect primary data and information about the local shipbuilding practice through interacting with structured, unstructured and open ended questionnaires. Secondary information about shipbuilding tradition and

potentiality of Bangladesh and other nation of the world were collected from both external and internal means. Shipbuilding process (such as ship design, steel treatment, plate and section preparation, welding quality, steel work, fabrication, outfitting work, hull erection and launching) was observed toassess the standard of work. Primary and Secondary data about labor, labor hour and labor cost were collected to assess the labor productivity of local shipbuilding industries and to evaluate the standard of local shipyards and comparing them with other shipbuilding nations.

Professional participations were conducted through Information, Questionnaire and Interviews. The organizational set up, working environment, management practices, performance and future vision of local shipyards were compared with other shipbuilding nations.

9.4 Historical Background

Because of the revering geography of Bangladesh, ships have been playing a major role in the trade affairs of the people of this country since the ancient times. According to the accounts of the 14th century Moroccan traveler Ibn Batuta, there used to be large fleets of warships docked in various ports of the country. A medieval European traveler Caesar Frederick documented that the port city of Chittagong was a manufacturing hub of large ships during the mid-15th century. The volume of shipbuilding swelled extensively during the Mughal period. During the 17th century, the shipyards of Chittagong used to build warships for the Sultan of Turkey.

The Royal Navy had many warships built in Chittagong, some of which were also used in the Battle of Trafalgar in 1805. Khulna Shipyard, the first modern shipyard of Bangladesh, was established in 1957, constructed by a German firm. Initially a private concern, the shipyard was later nationalized and came under the control of Bangladesh Navy in 1999.

During Pakistan period public sector enterprises dominated the shipbuilding Industry. There are more than fifty shipyards concentrated at Dhaka, Chittagong, Narayanganj, Barisal and Khulna regions where inland costal and fishing fleets are being built. In 1979, FAO funded contract for supply of 8 food grain carrying vessels to Bangladesh Inland Water Transport Corporation (BIWTC) was secured by High Speed Shipyard, Narayanganj. Mitsui Engineering and Shipbuilding Industry of Japan entered into a joint venture in shipbuilding with High Speed Shipyard and constructed 4 deep sea fishing vessels. Recently some shipbuilding industries including Ananda Shipyard and Slipways Ltd, Dhaka and Western Marine Shipyard Ltd, Chittagong have come up with modern shipbuilding facilities that enabled them to receive export orders. However, in 2008, Ananda shipyard exported her first ocean going ship Stilla Marriage to Denmark and earned reputation for Bangladesh as the ship exporting country in the world.

9.5 Present Status of Bangladesh shipbuilding industry

There are more than fifty shipyards in Bangladesh and a hundred of shipbuilders or contractors and marine workshops are actively involved in shipbuilding activities. 70% of the shipyards are located in and around Dhaka, 20% are in Chittagong and 10% are in Khulna and Barisal. Almost all inland/coastal/bay crossing ships are constructed and repaired locally in these shipyards. Local shipyards can design and fabricate ship up to 3500 DWT to fulfill the demand of local market. Few local shipyards are capable of making ships up to 10,000 DWT (deadweight tonne) as per international standard. Most of the Shipyards are operating under individual management with nominal supervision of government. All inland and coastal ships are built by local shipyards, and the number of vessels built per year counts an average of 250. They employ huge number of skilled, semi-skilled and unskilled labour. Most of the private shipyards use plate, engine, component and machinery of old merchant ships which are collected from Bhatiary ship breaking industries.

Recently few local shipyards have attained the capability to manufacture the ships of 10000 DWT. Nearly fifty thousand skilled workers and one lac semi-skilled workers, are now working in these

industries. There are eleven local shipyards of international standard capable of making ships up to 10000 DWT. These are:

(i) Ananda Shipyard and Slipways Limited, Dhaka;

(ii) Western Marine Shipyard Limited, Chittagong;

(iii) Khulna Shipyard Limited, Khulna;

(iv) Karnafuly Slipways (Pvt) Limited, Chittagong;

(v) Highspeed Shipbuilding and Engineering Works Limited, Narayanganj;

(vi) Dhaka Dockyard and Engineering Works Limited, Dhaka;

(vii) Dockyard and Engineering Works Limited, Narayanganj;

(viii) Chittagong Dry Dock Limited, Chittagong;

(ix) Narayanganj Engineering and Shipbuilding Ltd, Narayanganj;

(x) Chittagong Shipyard Ltd, Chittagong; and

(xi) Basundhara Steel and Engineering Ltd, Narayanganj.

If the shipyards are considered on the basis of modern shipbuilding requirement, the shipyards of Bangladesh (Total 67) can be categorized into 4 classes which are shown in Figure 56.

Class A: Shipyards which are ready for construction of ships (Small & Medium Category) of international standard.

Class B: Shipyards with some renovation & expansion program will be ready for construction of ships (Small & Medium Category) of international standard.

Class C: Proposed shipyards which are coming in production of ships (Small & Medium Category) of international standard very soon.

Class D: Remaining shipyards which can make inland vessels under local regulatory standard.

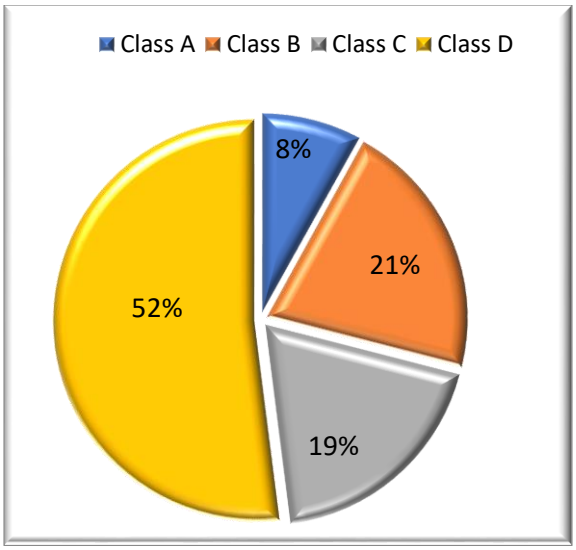

Figure 56 : Categorization of shipyard in Bangladesh shown in the Pie-Chart

9.5.1.1 Type and Sizes of Ships in Bangladesh

On the capability of the technological compatibility of shipbuilding, past & present trend, ability of the existing shipyards of Bangladesh and the interest of new comers in shipbuilding, it is anticipated that

Bangladesh can build various types of ships (small & medium category) for both inland and sea going. The present facilities will limit the size of the vessel up to 10,000 DWT, but if expansions programme of various shipyard are taken in consideration, Bangladesh will be able to build up to 50,000 DWT vessels in near future.

A number of diversified types of vessels are built in various shipyards around the Bangladesh, such as: multipurpose vessel, fast patrol boat, container vessel, cargo vessel, tanker, dredging barge, ferry, passenger vessel, landing craft, tourist ship, tug boat, supply barge, deck loading barge, pleasure craft/hatch, crane boat, speed boat, deep sea trawler, self-propelled barge, inspection vessel, cargo coaster, troops carrying vessel, double decker passenger vessel, hydrographic survey boat, pilot boat, hospital ship, water taxi, etc.

9.5.1.2 Identification of existing shipyards

There are hundred shipyards and workshops in Bangladesh of which 124 have been reported to be registered with the Department of Shipping (shipyard statistics, 2012). Out of these shipyards, approximately 70% are located in and around Dhaka and Narayangong along the side of the river bank of Buriganga, Shitalakha and Meghna. About 20% shipyards of Chittagong division are located along the side of Karnapuli River and 6% are located along the bank of Poshur river of Khulna division and remaining 4% are located in Barishal division (Shipyard Statistics, 2012). Almost all inland/coastal/bay crossing ships are constructed and repaired locally in these local shipyards.

9.5.1.3 Type and Sizes of Ships that can be built in the short, medium and long run

On the capability of the technological compatibility of shipbuilding, past & present trend, ability of the existing shipyards of Bangladesh and the interest of new comers in shipbuilding, it is anticipated that Bangladesh can build various types of ships (small &medium category) for both inland and sea going. The present facilities will limit the size of the vessel up to 10,000 DWT, but if expansions programme of various shipyard are taken in consideration, Bangladesh will be able to build up to 50,000 DWT vessels in near future.

9.5.1.4 Global trend of shipbuilding industry

In the past, shipbuilding industry of the East enjoyed superiority and made the region leader of civilization. After World War II shipbuilding becomes a European Industry in which Britain took the lead. This is followed by Japan (1960s to 1980s). Then South Korea took the lead. Thus the world shipbuilding market is moving east and presently Japan and South Korea have nearly equal shares of 70 percent of that market. Now, the most rapid growth in market share observed and planned is in China. But, the countries where labor costs are going up are shifting their role from small to medium and large ships. The other emerging forces are Vietnam and India. In fact, emergence of Vietnam is largely a result of efforts by European countries to relocate their shipbuilding industry to low labor cost countries. India is another rising giant in shipbuilding industry where private entrepreneurs started establishing shipyards with government support and by now the country has come to a good position in the world's shipbuilding countries and receiving orders of hundreds of millions of dollars.

Thus, shipbuilding has shifted from Europe to Japan to Korea and these days are shifting to China and Vietnam and India and now in Bangladesh and the single most driving force behind this phenomenon is lower labor cost and overhead.

9.6 Potential of shipbuilding in Bangladesh

9.6.1.1 Workforce

Shipbuilding, an ancient assembling industry producing tailored products, accordingly having the largest human input per unit of produce, is always moving to countries with lower wages of required skills. Bangladesh has comparatively a lower cost of human inputs and can offer the best combination of cost, quality and productivity with its fast growing young workforce.

Table 18 : Comparison of labor costs

Country	Average hourly rate of wage (in US$)
Bangladesh	0.5
India	1.0
China	1.5
Singapore	3.0
South Korea	6.0
Japan	12.0
Italy	13.0
France	13.0
Norway	14.0
Finland	15.0

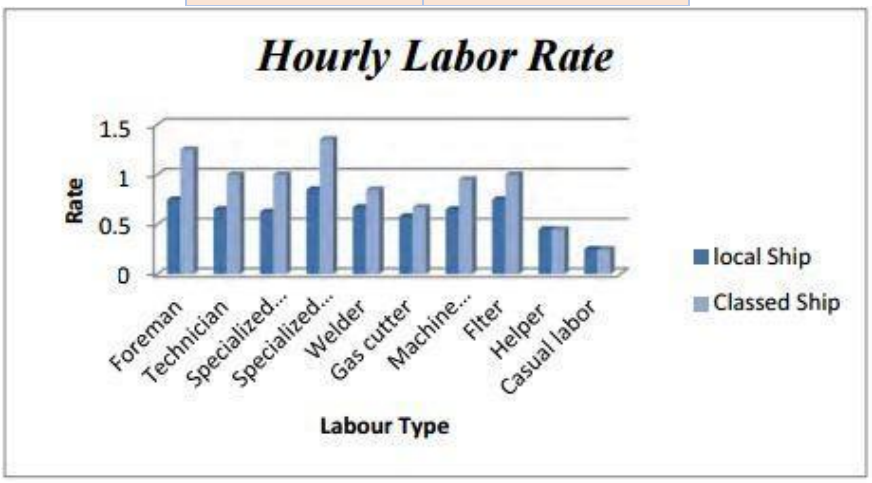

Figure 57 : Hourly Labour Charge (in USD) for shipbuilding industry in Bangladesh

9.6.1.2 Productivity and working hour in Shipyards

The productivity of Bangladeshi Shipbuilding labours is 11.43 which has been shown in Table 19 as compared with other countries. But proper training and automation of work will definitely improve the productivity. On the other hand, average hourly labour charge in Bangladesh is only US$ 0.50 which has been shown in Table 20 as compared with other countries. This is also the lowest in the world.

Table 19 : Comparison of productivity

Country	Productivity
Japan	1
European countries	2
United States	4
India	10
Bangladesh	11.43

Country	Completion of M DWT	Employees	Productivity DWT person/ year
Japan (2004)	23.2	80,000	290
Korea (2004)	23.0	71,800	320
China (2004)	8.8	158,000	56

India (2006)	0.6	12,000	50
Bangladesh	0.5	12,000	40

So, the relative labour rate in Bangladeshi Shipyards is 0.50 which has been shown in Table 20 as compared with other countries. A drawn comparison of the coast and productivity of few shipbuilding countries and Bangladesh reveals that India and China, the nearest competitors, are 2.5 times away and Koria is 4 times away in terms of labour cost alone.

Table 20 : Cost effectiveness

Country	Weighted labour rate	Weighted productivity	Weighted average output cost
Bangladesh	0.5	1.0	0.50
India	1.5	1.2	1.25
China	1.5	1.4	1.07
Korea	6.0	3.0	2.00
Singapore	4.0	2.0	2.00
Germany	15.0	5.0	3.00

9.6.1.3 Cost analysis of export ship manufacture

Additional financial cost of ship manufacture in Bangladesh is about 15% to 20% (Bank Interest 3% to 6% + Bank Guarantee 8% to 16% + L/C Commission 4 to 8% + other charges 1%) higher than the other competing countries like China, Korea, Japan, India, Vietnam etc. Again tax on imported shipbuilding machineries and components enhances the costing to a further extent. On the other hand, India has only 10% financing cost and a 30% cash subsidy and is altogether about 30%-40% ahead in ship building business of Bangladesh. So, only low labour cost cannot promote the survival of Bangladesh in the shipbuilding industry. Again, at present Bangladeshi component manufacturers and shipyards can manufacture 50% of the total material, machineries and equipment for the local inland and coastal vessels built in Bangladesh and the rest must be procured either from foreign market or second hand market at Bhitiary. This proportion for an international standard vessel to be built in Bangladesh is at present 10%-15%, which if properly ventured by experienced foreign manufacturer, can be taken to 45%. Share of the local contribution for export quality ship built by the Bangladeshi shipyards is about 40% of total ships' cost.

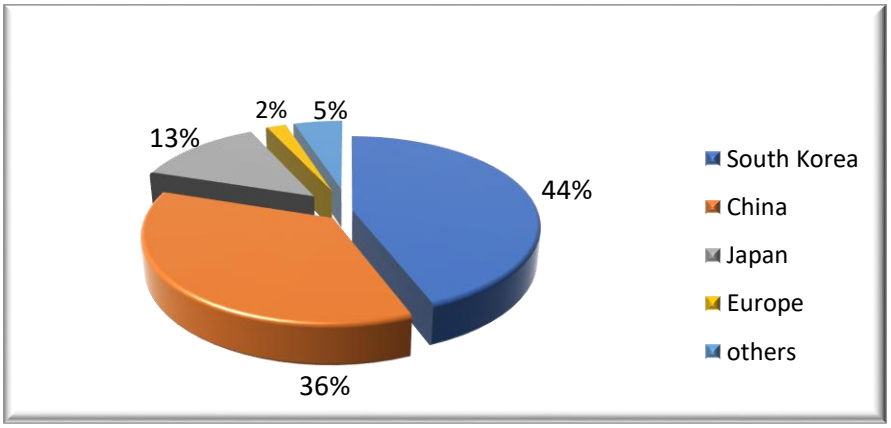

Figure 58: Global shipbuilding share in million DWT by nations, 2012

Once Europe was the market leader but now it is replaced by South Korea and China. If consider the shipbuilding industry with a product life-cycle perspective, the prospect and challenges of Bangladesh can be easily realized at a glance.

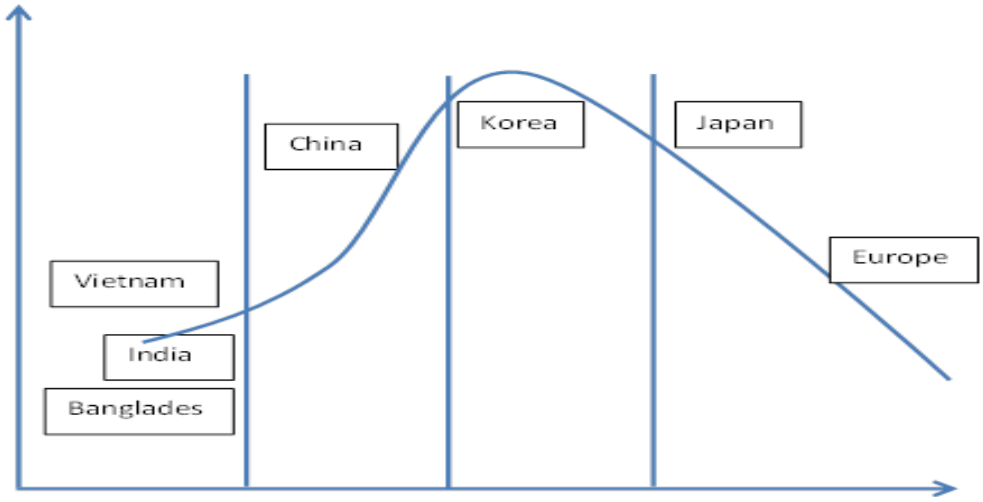

Figure 59: Shipbuilding Lifecycle around the world

9.6.1.4 Demand of global shipbuilding

Shipyards in Japan, China, Korea, India, Singapore and Vietnam are booked up to 2012 with minor exception as some yards have been affected by the cancellation of orders due to economic recession. Presently the demand for new shipbuilding has superseded the capacity of the shipyards. However, traditional market leaders of world shipbuilding industry are over-booked primarily for construction of large ships. So the ships' buyers/ entrepreneurs are in search of new, suitable and reliable markets in Vietnam, Bangladesh, India, Brazil, Pakistan, Turkey, etc. As a result shipbuilding capacities are rapidly expanding in Asian Countries. It is estimated that shipbuilding demand increases 5% annually and number of shipyards is not increasing. Again new regulations of International Maritime Organization (IMO) have made it almost impossible to have the older ships upgraded and thus have to be replaced by new ships. Presently world turnover and movement of goods has been increased manifold in the last few years. As a result, demand of ship and shipbuilding activities have been increased multifariously.

9.6.1.5 Trend Analysis of Shipbuilding in Bangladesh & World

As per World Trade Organization (WTO), global shipbuilding market size is US$ 1,600 billion. If only 1% market share can be captured by Bangladesh, it will be worth US$ 16 billion. If we can grab 1% of the global order for only small ships market the amount will be worth US$ 4 billion. Two leading local shipyards, Ananda and Western Marine have bagged orders to make 41 small vessels worth about US$ 0.6 billion mainly from European buyers. Again, by 2025the world will need more than 20,000 vessels, mostly small to medium sized and all single hull tanker will be replaced by double hull as per IMO rules. So small and medium shipbuilding market is flourishing and future of Bangladeshi shipbuilding is brightening day by day. Bangladesh is suitable for small and medium combine cargo vessel, multipurpose vessel and oil tanker up to 15000 DWT and some extend to 25000 DWT, However it predicts that small cargo and containership market will also be feasible for Bangladesh in coming years.

Table 21 shows year-wise contract for number of vessels in world shipbuilding market and the share received by some major shipbuilding countries and Bangladesh during 2007 to 2014.

Table 21: Year-wise contract for number of vessels and country's share

Year	World Total (Vessel Number)	China	Japan	Korea	Bangladesh
2007	2500	16.00	20.80	9.20	0.08
2008	2250	11.11	22.22	10.00	0.00
2009	2850	16.29	22.58	16.45	0.10
2010	3000	20.25	21.79	13.08	0.10
2011	3950	20.78	13.25	12.73	0.03

Year	World Total (Vessel Number)	China	Japan	Korea	Bangladesh
2012	5050	29.38	14.85	14.85	0.35
2013	6600	33.33	11.21	19.70	0.08
2014	5400	30.00	16.50	13.33	0.57

The table shows how China and Korea takeover Japan after 2010. The world market shows an upward trend and so does the relative share of Bangladesh. Bangladeshgot a jump in receiving orders in 20012 and got a little slack afterwards due to the world recession. But in 2014 it bounced back as the demand for small and medium vessels increased due to recession.

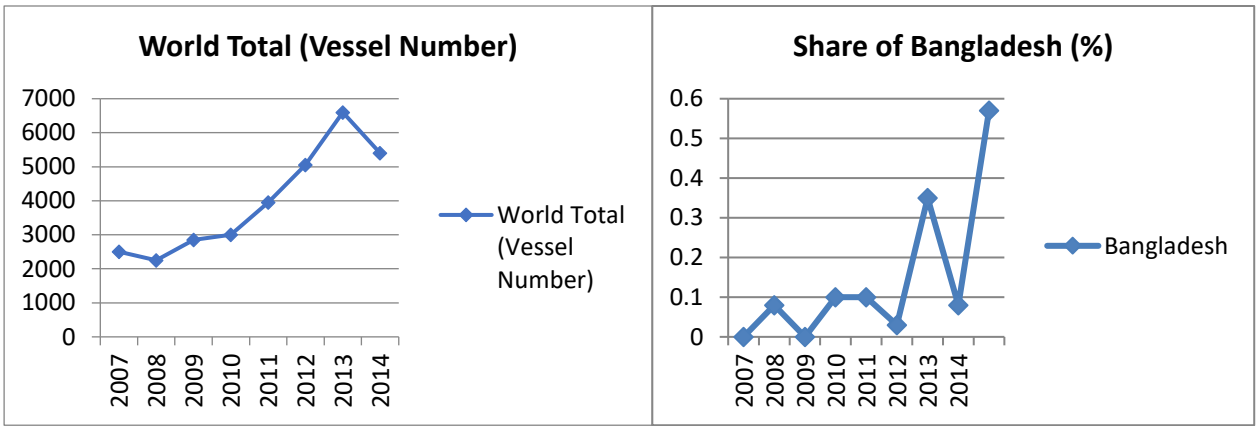

Figure 60: Year-wise contract for number of vessels and country's share

9.6.1.6 Global recession and position of Bangladesh

It is nice to mention that the market of small-ships and vessels of various types is remaining unaffected by on going global recession. Recession has caused a drop in demand for large vessels. Global giant shipbuilders cannot capitalize on this new market demand, as their projects will prove to be unfeasible because of the high overhead costs they already bearded. So far Bangladesh does not face any blow like cancellation of orders.

Expert views that orders for small ships have gone up because of the global financial crisis; so demand for small vessels will continue and activities of Bangladeshi shipyard will remain on. It is good time for us to prepare for the future with the help of government so that local shipyards can receive orders after recovery from current recession.

9.6.1.7 Forecast of local and global shipbuilding in gross tonnages

It may be said that in the year of 2025 shipbuilding capacity of Bangladesh and world will be 1.0 and 92.5 million gross tonnages respectively. So Bangladesh is going to achieve the capacity of 1.50% of global shipbuilding share within 2025. Forecast of local and global shipbuilding in gross tonnages.

9.7 Underlying problems of shipbuilding in Bangladesh

9.7.1.1 General Problems in Bangladeshi Shipbuilding

In the past, shipbuilding industry of Bangladesh failed to keep pace with consistency due to lack of proper government and private initiatives as well as anti-industry mindset of the nation. This has ultimately caused non-penetration in international business as a shipbuilding nation. In future, some issues like safety, efficiency and environmental concerns will turn this sector into a more innovative one, which may enable the new generation to face the challenges to resolve the problems arising out of it. Countries with large population like Bangladesh may feel encouraged to come forward in labour intensive shipbuilding sector due to their abundant manpower. Currently the world is passing through

economic recession. Shipping and shipbuilding of the world are affected from this recession resulting cancellation of new building orders at least for the time being. The present shipbuilding sector in

Bangladesh is not that big industry and only a few shipyards are involved in exporting ships, but revenue generated from this sector is promising. In spite of enormous possibilities of expanding shipbuilding industry in Bangladesh there are also some problems. These existing problems of this sector may be categorized13 in the following broad headings:

(i) Financial problem

(ii) Human Resource Development problem

(iii) Infrastructure problem

(iv) Marketing problem

(v) Management problem

(vi) Technical problem

(vii) Quality control problem

(viii) Delay delivery problem

(ix) Pricing problem

(x) Safety, health, and environmental aspect

(xi) Economic recession and its effect on Bangladeshi shipbuilding

9.7.1.2 Financial problem

Shipbuilding is capital and labour intensive industry. The local commercial banks are not individually capable of making required investment in this industry. There is dearth of capital and investment especially when the scale of investment is to the tune of 100 to 1000 crore or more because of the risk is considered too high for both the entrepreneurs and bankers

Besides, consortium financing is time consuming and a complex process, which is not so favorable for making investment in this sector. There is no standard framework for forming consortium and as a result when a shipbuilding contract is obtained, the time lag of securing finance by forming consortium kills the contract.

High rate of interest is applied on industrial and working capital loan. Existing rate of interest, ranging from 12% to 16% for industrial and working capital loans, is not suitable for the development of this sector. Whereas 7% rate of interest on export credit is prevailing for other export sectors like ready-made garment sector.

As the buyers do not accept the guarantee provided by the Bangladeshi commercial banks, counter guarantee has to be given from the foreign banks. As a result, guarantee from both local and foreign banks is mandatory for export of ships from Bangladesh. The prevailing cost of bank guarantee due to double bank guarantee system has become a real burden for local shipyards. Bank guarantee for export of ships from Bangladesh is about 16% (local 4% and foreign 4% for two year period). Such bank guarantee requires equivalent amount of advance payment and price of raw materials received by the builders from the importing company. Bank guarantee commission for other sectors in Bangladesh is charged at the rate of 1% - 2%. On the other hand, it is 0% in other competing countries like Korea, China, Japan, India etc. Commission at the rate of 0.20% is charged by banks of other competing

countries for opening import L/C whereas 1% per quarter i.e. 1×4 %× 2 years = 8% is charged by the Bangladeshi commercial banks. The breakup of the cost incurred for payment of interest and service charges indicates that the additional financial cost of ships built in Bangladesh is about 15 to 25% (bank interest 3 to 6% + guarantee 8 to 16% + L/C commission 4 to 8% + other charges 1%) higher than the other competing nations like China, Korea, Japan, India, Vietnam, Brazil etc.

9.7.1.3 Human resource development problem

The number of available graduates, skilled supervisors, foreman, specialized welders, cutters, fitters, machine operators and other technical skilled manpower that are required for shipbuilding and allied industries are far less than the minimum requirement. Substantial number of skilled manpower leaves the country for overseas employment as there is inadequate number of shipyards in the country. The local shipyards lack of dedicated human resource department. Government also does not have long-term vision as well as accomplishing her mission for human resource development for the country. In fact, everything is running in Bangladesh on ad-hoc basis.

9.7.1.4 Technical problem

There is insufficiency in the number of ancillary industries to support the shipbuilding industry as backward linkage by providing service and supplying ships' components. The local shipyards are having lack of research and development (R&D), which ultimately fail to bring about any innovation and technological development for price competitiveness in international ship markets. At present Bangladesh is not working in the field of ship design, though skilled manpower is available. As a result, lack of adequate and expert design firms and expertise in design are an impediment for high value added product. Moreover, most of the local shipyards are lacking of modern shipbuilding tools, machineries and technology. At the same time lack of expert machine operators is found in the most local shipyards. Local shipyards owner considers every human resource development program as money drain, not gain. That's why they are maintaining poor training facilities of the technical personnel. Despite long heritage, Bangladesh has failed to keep pace with consistency with the continuous technological development of global shipbuilding industry.

Bangladesh does not produce inert gases. Therefore, production with aluminum and other similar works suffer. Importation of inert gases is insufficient and schedule of import is planned for monopoly profiting. Non-availability of inert gases in local market put obstacles for these projects. Other required gases are also not easily available.

In a ship, there are about 4000 different components, which are to be installed within a very limited space of the ship. Unlike land installation, electrical fitting and installation are very delicate in ships and needs more precision. There is a lack of skilled manpower in Bangladesh in such specified field and particularly in electrical installation and fitting.

Lack of model testing and other facilities in Bangladesh also matter. The age of the Department of Naval Architecture and Marine Engineering in Bangladesh University of Engineering and Technology is 35 years. Towing tank was expected by the Department since its establishment. But the hope has never seen the light. NDT and Design Lab facilities are also poor in every institutions and shipyards around Bangladesh.

9.7.1.5 Infrastructure problem

Access to the rivers and sea, that is, foreshore for shipbuilding entrepreneur is restricted by bureaucracy problem like unfriendly attitude of the administration toward local shipbuilding. Impositions of foreshore charges, which are abnormally high as well as the charges on erected installations such as service jetty, etc. are also high and in some cases duplicate charges are imposed. The lack of electricity and gas supply is a major impediment which hinders the setting up of shipbuilding industries in Bangladesh. Existing ban on importation of rail and sheet pile imposed by railway authority also obstructs developing this industry. Under the present import policy and foreign currency regulation,

import on CIF basis is not permissible. But this industry cannot run under such a rule. Shipbuilding industry needs a lot of components, parts and accessories leading to emergency import during the construction period. Existing facilities are not adequate for emergency import requirements14.

There should be a proper association of export oriented shipbuilding industries in the country to maintain mechanism for proper implementation, monitoring and updating strategy for ship export Other than government owned dry-dock, none of the shipyards have the dry docking facilities. Most of the shipyards are located in and around Dhaka, far away from the sea. This is not a good approach to develop shipyards for building sea going vessels. The rivers and channels are frequently silted. It is very difficult to maintain channel for desired level of navigability for ships maneuver. The restricted draught (Maximum 4.0 to 4.5 Meters) is the limitation to the size of a ship that can be built in these shipyards. Bridges and overhead cables may induce new restriction to the ship size that may be built in a shipyards located in the hinterland. There is no adequate backup industry to produce required standard of MS plate need for ship construction.

So, a proper and long term planning is required to promote this industry in coastal area like Potuakhali, Vola, and Chittagong etc. When this industry evolved, most of the shipbuilding firms concentrated in Dhaka because they were to meet the local demand which was not more than 5000 dwt. But now we are to build ship more than 10000 dwt for international market. So gradually the international market oriented shipbuilding firms have to shift their facilities towards coastal area mentioned above.

9.7.1.6 Management problem

Most of the local shipyards do not follow corporate management culture. Family members and friends occupy the important managerial appointment like director, executive committee member etc. of the local shipyards. Such family and friend management culture is one of the hindrances to the development of the industry and also will not commensurate with international arena. Poor communication between upward and downward grid in the managerial chain exists. Middle management neither enjoys any financial authority nor decision-making process (with little exception in few shipyards). As a result, poor command and control as well as negligible dedication of the employees toward the organization observed16. Most of the local shipyards practice one man show management culture. Every decision comes from owner as per his/her desire and wish.

Many of the owners do not care about the welfare of the employees. So poor job satisfaction observed in most of the shipyards and employees do not feel belongingness to the organization. As a result, huge absenteeism and turnover of labours and skilled manpower observed. Workforce never enjoys fringe benefit and other labour welfare activities like medical, pension, travel and daily allowance, accident and other compensation etc. Most of the labours are employed in casual basis. Every valued customer looks at the quality of management. How is the management performing? What are the managerial tools that are using by the yards to ensure continuous improvement of product? Are the managerial staffs responsible and capable enough to solve the day-to-day problems? Is the management prompt to solve the daily problem? But it is really discouraging that answers to those questions are negative for most of the local shipyards. The government policies are complicated and not very pleasant in supporting the expansions of the industry as a whole.

9.7.1.7 Safety, health and environmental aspect

Safety, health and environmental (SHE) aspects of using various shipbuilding materials in the shipyards including the affect of harmful substances and related exposure in movement of materials and also the required measures were identified. Only a few shipyards have been found to be conscious about safety, health and environmental aspects, which are again at average level. The shipbuilders are more engaged in enhancing their skill in technology, financing and marketing. Safety, health and environment are yet to be recognized as important issues in all spheres of the society. The long term effect of safety, health and environmental measures are yet to be understood. Proper awareness and training and govt. regulations are required for improvement of the SHE aspects.

The regulations are to be made in a way that the prospective shipbuilders do not take these as hindrance. These aspects should be shipbuilder friendly, specially, because Bangladesh has just started developing the export oriented shipbuilding industry. The foreign buyers have a major role in enhancing the level of SHE in the builders' yard. Currently, nothing allures more public attention than the environmental aspect. In the shipbuilding process, many working procedures are polluting if proper preventing measures are not in place. Among them, the process of shot blasting, plate and section preparation, welding and painting is the most significant troublemaker. In case of shot blasting in open air, the controlling and diminishing of waste, which is dust and sound, require expensive appliances. The costs to reduce pollution absolutely go to the accounts of the shipyards. Such additional expenses are unavoidable in developed countries. In shipyards paints are widely used. These paints contain volatile organic compound (VOC). VOC is an element that produces Ozone by responding to sunlight. Developed countries like countries in European Union limited the quantity of emission or disposal of contamination of this kind. It is possible to use the paints that contain no VOC, but the expenditure for painting of the ships will go high.

9.7.1.8 Quality control problem

Lack of quality control groups and their work and capability are in question. A number of questions against them are raised by the foreign ship owners or by their representatives. But many of the local shipyard owners are failed to satisfy them. Shipyards must remember that quality accelerate entire process to get the next contract18. Lack of sincerity of workers due to poor job satisfaction and working environment limits the opportunity of further development. The owners do not bother about working environment due to the availability of labour with lower cost.

Quality is the prime requirement of shipbuilding industry. A ship, which plies on the sea far away from the shore for quite a many days at a stress, must have to be flawless. Quality in a shipyard usually maintain by quality control group of shipyard itself, by the classification society and by the owners' representative. This is very demanding that everyone in the system must be cautious, dedicated as well as prepared to undergo strenuous activities. A chain of such professionals is necessary. But it is missing in local shipyards. It needs time to develop such quality assurance activities in local shipyards19.

Bangladesh is lacking in the safety culture. Safety is a long-term investment. Though the initial cost for safety assurance may be high, the gain in the long run is accumulative and it adds to the quality. Bangladesh has to be competitive with the other shipyards around the world. Government may sponsor benchmarking activities.

9.8 Challenges in Bangladeshi shipbuilding

Challenges of Bangladeshi shipbuilding have been illustrated below:

(i) Like Bangladesh, many other countries such as Vietnam, Brazil, India, Indonesia and Turkey are also trying to capture the surplus global shipbuilding market.

(ii) Draining out skilled manpower from local to foreign shipbuilding industry is a usual and unavoidable threat for local shipyards.

(iii) More than 80% of raw materials and ship's components are in import-based for export oriented Bangladeshi shipbuilding. Ultimately unit price of export ships and foreign dependency increases.

(iv) Most of the shipbuilding nations have developed close links between shipbuilding and support industry for reducing delivery time. But due to non-availability of industries of classified marine equipment and limited infrastructure in Bangladesh the delivery time is deferred and shipbuilding cost in increased as compare to the competitors.

(v) To accelerate the shipbuilding activities, most of the shipbuilding nations maintain a good relation between shipbuilding industry and other supportive industries. But due to lack of

quality local marine industries and poor infrastructures, local shipbuilding fails to achieve her goals. As a result, shipbuilding cost and ship delivery time increases.

(vi) Overall management practice and planning process for most of the shipyards is not up to the international standard. Lack of expert financial personnel, absence of corporate management culture, poor forecasting process and central decision-making culture in day-to-day matter make local shipyards handicapped.

(vii) Absence of adequate backward linkage industries is also a main cause of delaying delivery and adding extra cost of export ships.

(viii) Scarcity of sufficient land in Bangladesh, deficiency in power supply and weak infrastructure facilities are the major impediments for rapid development of shipbuilding industry.

(ix) Due to the global economic recession both ship and steel market have become unstable. As a result, cancellation of a contract in shipbuilding industry is one of the recent enormous threats to local shipyards.

(x) Europeans are the valued customers for Bangladesh. They put the condition that 60%-65% of the total contract value is to be imported from abroad. But the equipment manufacturers of foreign countries do not place competitive offers for Bangladeshi shipbuilders; rather they quote higher cost on imported items that increases ship's price.

(xi) Most of the shipyards are located at the banks of few rivers around Dhaka, which are far away from the sea. These rivers are losing their navigability due to continuous filtration. As a result, the restricted draught (maximum 4.0 to 4.5 meters) dictates the size of a ship that can be built in these shipyards. Again bridges and overhead cables may induce further restriction to the ship size built in most of the local shipyards.

(xii) Now-a-days quality is very demanding and everyone in the system must be dedicated. A chain of such professionals is necessary, but it is missing in local shipyards. Again lack of adequate quality control group and their performances and capabilities in the local shipyards are in question.

(xiii) Financial matter like lack of adequate working capital, high rate of interest on industrial and working capital loan, high bank guarantee margin and high import LC margin make shipbuilding industry of Bangladesh a cumbersome and complicated enterprise.

Shipbuilding is a semi high-tech and capital-intensive sector. It is both promising and challenging industry in the World. Bangladeshi shipbuilding is not in competitive and international standard and also is in vulnerable stage.

9.9 Conclusion

Shipbuilding industry plays an important role in assisting national defense, promoting shipping and industrial development, increasing employment and foreign currency inflow. It is therefore an attractive industry for Bangladesh. Bangladesh shipbuilding is capable of producing international standard ship of small to medium category and at present, more than 25% shipyards are ready or to be ready with little renovation for construction of small and medium sized vessels of international standards. Productivity of Bangladeshi work force in shipbuilding is 11.4 which are lowest in the world. It is essential to upgrade the productivity through conducting training program, incorporating process enhancement, modernizing yard facilities and employing more integrated production technology, otherwise it is difficult to sustain in this competitive industry in the long run.

Bangladesh is a developing country. Each and every citizen of this country expects the overall development of the country. But in most of the cases it is not materialized in reality. In the past, we

failed several times to take the advantages and lucrative opportunities of modern trade and commerce due to the delay in our response. For this reason, our overall economic development has undoubtedly been interrupted. So the concerned authorities have to be watchful and careful to take the opportunity to push the shipbuilding sector ahead as a thrust sector through fixing the identified problems leaving no delay.

9.10 References

Alam, Com.M.K., 2004, "Bangladesh MaritimeChallenges in the 21st Century", PathakShamabeshPublication, Dhaka, pp. 21.

Chittagong Port Authority, 2007, Year Book ofthe Chittagong Port Authority.

Chou, C. C. and Chang P.L. (2001): Modeling and Analysis of Labor Cost Estimation for Shipbuilding: TheCase of China Shipbuilding Corporation, Vol.17, No.2, May 2001, pp 92-96.

Churchill, G.A. (1995): Marketing Research Methodological Foundation, Sixth edition, Harcourt Brace CollegePublishers, USA.

CPA (2007): Year Book of the Chittagong Port Authority, CPA, Chittagong.

Department of Shipping, 2009, Shipyard

DOS (2009): Shipyard Statistics, Engineering Section, Department of Shipping of Bangladesh, Dhaka.

Fisher, J.O. and Holbaach, I.G (2008): Cost Management in Shipbuilding, The Naval Architects, November,2008.

Hossain, K. A. and Zakaria, N. M. G., 2008: Potentiality and Prospect of Shipbuilding Industries in Bangladesh, Journal of NOAMI, Vol.25, No.2, pp. 33-54.

Khan, J. U. (2008): Bangladesh Local Firm to Build 10 Ships for Japan, 20 June, www.thedailystar.net.Accessed on June 27, 2008.

Lamb, T. and Hellesoy, A. (2002): A Shipbuilding Productivity Predictor, Journal of Ship Production, Vol.18, No. 2, May 2002, pp.79-85.

LR (2008): World shipbuilding report, Lloyd's Register, (www.lrfairplay.com).

Shenoi, R. A. (2007): Ship Production Technology, University of Southampton, UK

Statistics, Engineering Section.ASSL (2008): Brochure of Ananda Shipyard and Slipways Ltd, Ananda Group, Dhaka.

Stopford, M. (1998): Maritime Economics, Unwin Hyman Press, London.

Talukdar, N.S. (2008): Prospect of Shipbuilding in Bangladesh, Undergraduate Thesis, Dept. of Naval Arch &Marine Engg., BUET.

Wägar Patrik (2008): Regional Sales Direct, Ship Power, Wärtsilä Corp.

WMSL (2008): Booklet of Western Marine Shipyard Ltd, WMSL, Chittagong.

10 Ship breaking and its future in Bangladesh

10.1 Abstract

Ship breaking is comparatively a sustainable business, particularly in the developing world, but the conditions where it is practiced is non-sustainable. Ship breaking is the process of dismantling ships and selling their parts - primarily the steel - for scrap. The main impetus for breaking a ship down is that maintenance costs go up as a ship ages. Shipping companies also have to pay port charges, crew salaries and oil fees for their ships, so when they are no longer economically viable they are sold to ship recyclers who strip the old ships down, salvaging anything of value. Bangladesh is one of the top ship recycling countries in the world. Ship breaking is becoming increasingly important economically in the country. In the developing world, ship breaking not only employs thousands of people in breaking down a ship, but the materials produced are also important to other industries, such as re-rolling steel plants. However, it is deadly too. Despite having huge employment opportunities and material supplies, it costs high in terms of environmental degradation and human health. It is reported that most of the ship recyclers avoid 'polluters pay' and other principles. Ship breaking activities are being practiced in the coastal areas of Bangladesh and have gained importance in the macro and micro-economy of poverty stricken Bangladesh. If this sector take some eco-friendly steps in compliance with the principles of blue economy and overcome challenges it will be a big and sustainable industry in future. This chapter explored the background of this migrant industry along with existing realities, practices, legal regulations, problems and prospects, and suggests some voluntary guidelines connecting 'blue economy' concept associated with this industry in Bangladesh.

10.2 Introduction

Ship recycling aspects have been considered as a potential business since the dawn of mechanized operation though the history in Bangladesh is shorter. The dismantling of ships is sustainable from a slight economic point of view, but the potential consequences to the human and environment are some concerning issues. Before 1960, this practice was confined in some industrialized countries like the United States, the United Kingdom, Germany and Italy. Chronologically, in the next decade this industry and associated activities were migrated to some semi-industrialized countries such as Spain, Turkey and Taiwan due to the availability of low-priced labour and steel market. Since 1980s, to enhance the monetary benefits from the industries, these activities had been introduced in the scrap yards of India, China, Pakistan, Bangladesh, the Philippines and Vietnam where health and safety standards are nominal and workers were likely to engage themselves in laborious works. YPSA (Young Power in Social Action, an NGO) and World Bank studies found that 22,000 to 50,000 workers are employed at ship breaking yards in Bangladesh directly whereas the number is around 100,000 to 200,000 indirectly.

However, accidentally, after a stern cyclone in 1960s, a Greek ship 'MD Alpine' was stranded on the Chittagong shore (particularly in Sitakund), Bangladesh. The ship remained there for a long time before the Chittagong Steel House brought the vessel and scrapped it. During the Liberation War in 1971, a Pakistani ship 'Al Abbas' was damaged by bombing. It was later reclaimed and brought to the Fauzdarhat seashore. In 1974, Karnafully Metal Works Ltd bought it as scrap, introducing commercial shipbreaking in Bangladesh (Figure 61).

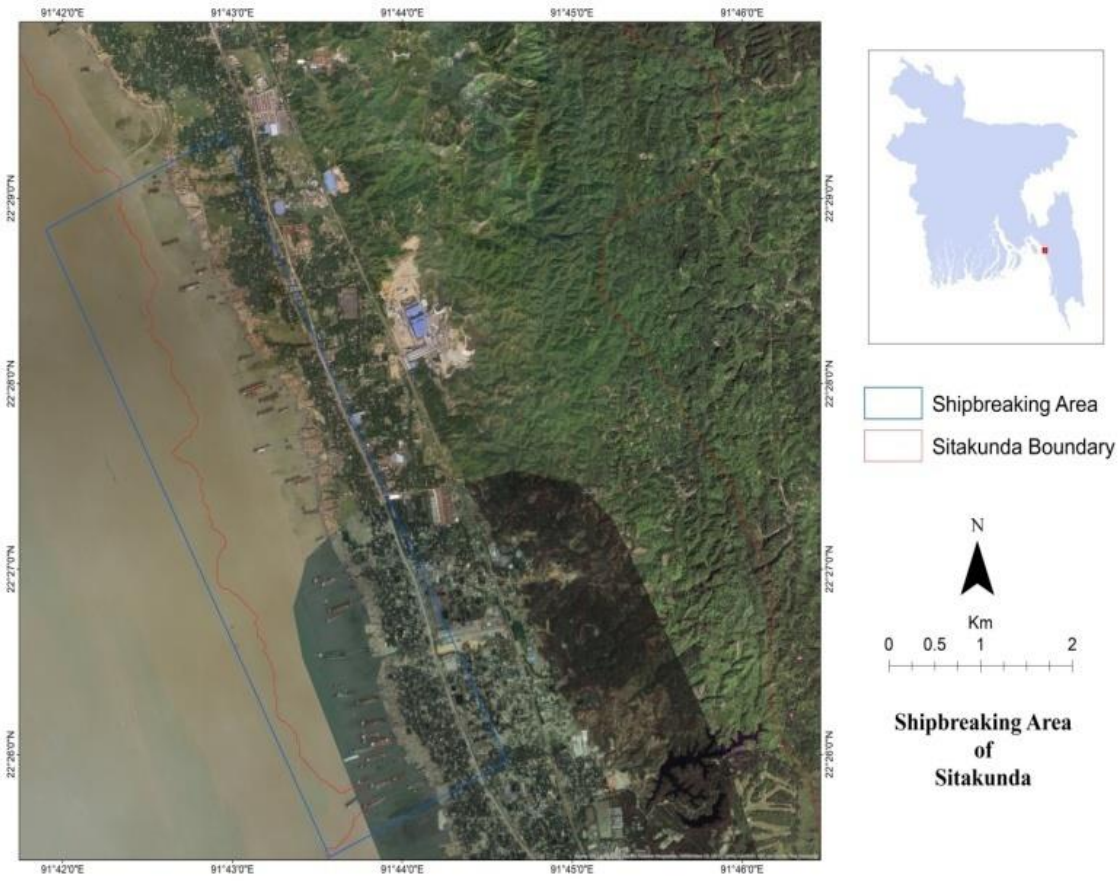

Figure 61: Ship Breaking Industries in Sitakunda, Bangladesh

The industry flourished during the 1980s. Hossain et al. (2008) stated that Bangladesh coast possesses higher tidal range, suitable intertidal zone for beaching large vessels, cost-effective labour and flexible environmental regulations. According to many reports, the ship breaking industry in Bangladesh is estimated worth an annual turnover of around 1.5 billion dollars in an average. It is estimated that app. 30 percent of the world's Light Displacement Tonnes (LDT) were scrapped in Bangladesh during the period 2000-2010. Today it has become large and profitable industry for Bangladesh. In 2015, a total of 21.80 million Gross Tons (GT) was recycled in the world and Bangladesh was the biggest ship recycler with 7.52 million GT (34.5%). (World Casualty Statistics 2015). In compare to the processes called sinking or abandonment, ship recycling is the most suitable and environment-friendly one which ensures the reuse of obsolete vessels' steel. But, the recycling practices are hazardous industries that depict both the engaged manpower and environment to some potential risks. In South Asia, ship breaking is basically accomplished on the intertidal beaches where the grounding, pulling, cutting and breaking are performed. These activities do not comply with safe working environment for the workers and detrimental ramifications to the associated environment in terms of pollutions. ILO (2004) claimed that ship recycling needs management of structural complexity, and also it involves environmental, safety and health issues and hence it is a challenging operation. Scientific researchers also stated that this industry has impacts on the local ecology in terms of environmental contamination (Hossain and Islam 2006; Siddiquee et al. 2012; Abdullah et al. 2013; Rahman et al. 2016; Sharifuzzaman et al. 2016).

This chapter tried to delineate an overview of the ship breaking industries in Bangladesh, its potentialities and challenges, legislation issues, probable interventions to ensure a smooth sustainable business and eventually to explore the dimensions to connect this sector with blue economy concepts in Bangladesh. The following points will discuss about existing problems and aspects of ship breaking industries in Bangladesh along with pollution, hazard analysis and human right issues, international and

national legal frameworks and policies, economic benefit from the sectors, problems and prospects, challenges and way forward to enhance sustainable ship breaking industries operation in Bangladesh.

10.3 Problems and Aspects

10.3.1 Existing realities

The authors of this article believe that there are some positive changes are happening in few of the ship breaking yards but most of it does not having such improvements. It's true that ship recycling has been resourceful in supplying steel and other metals for reusing purpose. In some cases, it is also contributing in newly emerged ship building industries of the country. But, this more than 30 years practice has been found to contribute in hazardous material accumulation in surroundings if it continues the current trend. Aktaruzzman et al. (2014) mentioned that ship recycling yards are responsible for higher metal pollutants concentration in yard-associated sediment textures. Ship recycling yards in Bangladesh usually follow beaching methods rather than dry dock. It is a common demolition practice worldwide due to cost-effectiveness and ease maintenances. Usually, ships are beached along the mudflats and dismantled using semi-skilled and unskilled labour forces. Finally, the dismantled parts are pulled to the nearest dry shore area by the help of electric winch and manual labours. A common practice is gas cutting to piece the bigger parts into small (Hossain KA et al., 2015). End-of-life ships sent for breaking to South Asia contain hazardous materials that are potentially harmful to human health and the environment. Ships that today are broken on the beaches of South Asia are highly likely to contain toxic materials in their structure. The accidental deaths in the yard are regular. The dismantling process demands minimum safety knowledge. Otherwise, there are possibilities of explosion, injuries, disabilities and fatal deaths. On average, 10–15 workers are died and 150 are injured every year in the Bangladeshi ship breaking industry. (Sujauddin et al. 2014; Bailey 2000; Andersen 2001). Currently, about 100 yards are operational along the coastal areas in Sitakunda, mainly in Kumira, Bhatiary and Fouzdarhat. The yards reside in only about 4000 m^2 of land, representing intense economic activity per square meter of land (Rahman and Mayer 2015). Hundreds of end-of-life ships are dismantled every year on the beaches of Sitakunda without sufficient concern for environmental protection and workers' rights in most of the yards.

10.3.2 Pollution

Though ship breaking has earned a good reputation for being a profitable industry in developing countries there are a number of environmental and human health hazards. It was found that on an average 95% steel are coated with 10-100 tons of paints which contain lead, mercury, zinc, arsenic, chromium etc. PCBs, asbestos and a huge quantity of oil cause environmental pollution when the ship is broken for scrap (Islam and Hossain, 2006). Ships also contain a wide range of other hazardous wastes (Figure 62), sealants containing PCBs, up to 7.5 tons of various types of asbestos and; several thousand litters of oil (engine oil, bilge oil, hydraulic and lubricants oils and grease). Tankers additionally hold up to 1,000 cubic meters of residual oil. Most of these materials have been defined as hazardous waste under the Basel Convention. In Bangladesh, ships containing these materials are being cut up by hand, on open beaches, with no consideration given to safe and environmentally friendly waste management practices in. almost, all the yards. A worker working barefoot without any protective footwear Ship breaking activities is a threat to both the terrestrial and marine environment as well as to public health.

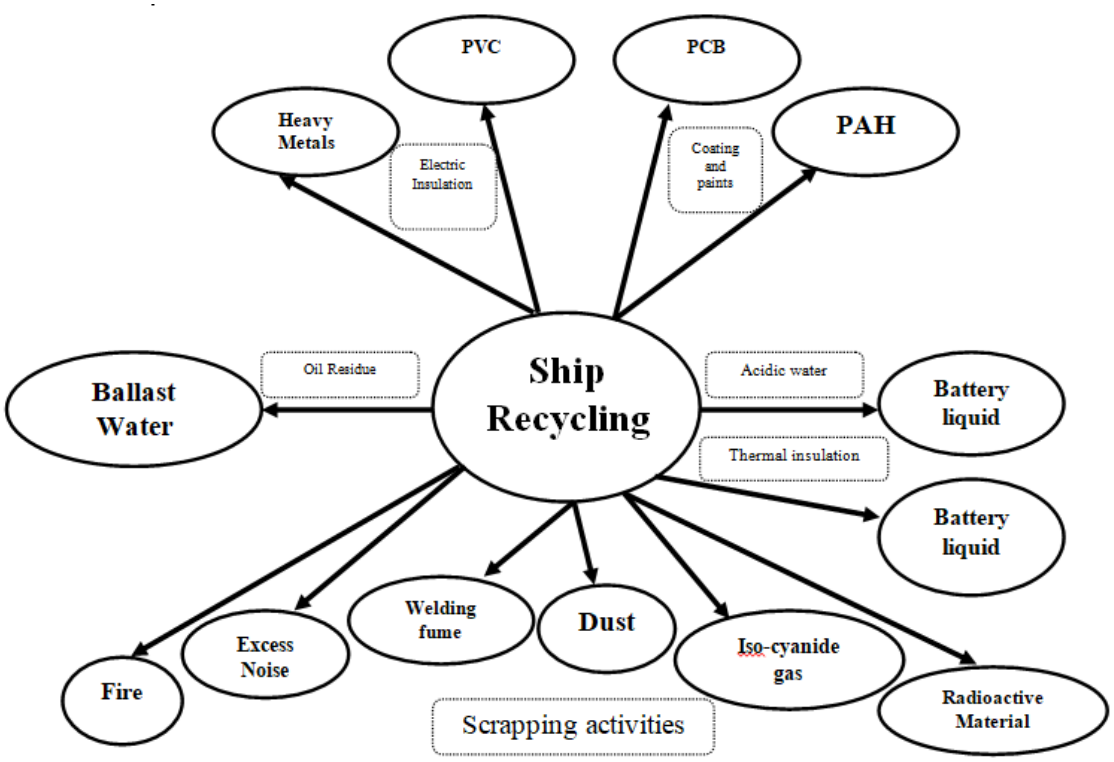

Figure 62: Major pollutants from ship recycling activities. Source: Local Environmental Consultants 2016.

10.3.3 Hazard analysis

Muhammad Muhibbullah (2013) categorized hazards (Table 22) and risks of ship breaking activities in Bangladesh as follows;

Table 22: Hazard categories and mechanisms

SL No.	Category of hazards	Mechanisms of hazards
01	Serious accident related hazards	• Fire and explosion by explosives flammable materials • Being stuck by falling materials • Compressed between heavy materials • Snapping of cables, ropes, chains, slings • Handling heavy objects; poor access to progressively dismantled vessels (floor, stairs, passage ways) • Falls from height inside ship structures or on the ground • Stuck by moving objects • Slipping on wet surfaces • Sharp materials • Oxygen deficiency in confined spaces. Lack of PPE, housekeeping practices, safety signs
02	Physical hazards	• Noise pollution • Extreme temperatures • Vibration • Poor illumination

SL No.	Category of hazards	Mechanisms of hazards
03	Mechanical hazards	• Trucks and transport vehicles • Scaffolding, fixed and portable ladders • Impact by heavy an sharp-edged tools • Power-driven hand tools, saws, grinders abrasive cutting wheels • Shackles, hooks; chains • Cranes, winches, hoisting & hauling equipment; • Lack of safety guards in machines • Poor maintenance of machinery and equipment.
04	Biological hazards	• Toxic marine organisms • Risk of communicable diseases transmitted by pests, vermin, rodents, insects and other animals that may infest the ship • Bitten by insects, snakes and others • Infectious diseases (TB, malaria, dengue fever, hepatitis, respiratory infections etc.)
05	Economic and physiological hazards	• Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload • Long working hours, shift work, night work, temporary employment • Mental stress, strained human relations (aggressive behaviour, alcohol and drug abuse, violence) • Poverty, low wages, under age, lack of education and social environment.

Source: Muhibbullah, 2013

However, likeliness of hazards was studied and the frequency is quite alarming. Saha et al. (2013) designed a detail-oriented hazard identification table (Table 23) as follows;

Table 23: List of hazard identification

SL No.	Activity	Cause	Consequence	Frequency of happening
01	Crushing in metal cutting machinery	Hand in running machine due to inattention, in appropriate protective equipment	Finger or hand injury	1 in 10
02	Crushing in material pulling machinery	Sleepy floor, in appropriate protective equipment	Finger or hand injury	1 in 10
03	Being caught inside broken ship	Missing cover inattention	Significant body injury	1 in 1000
04	Fall from above	Inattention	Leg or hand injury	1 in 100
05	Damage from machinery splinter	Rupture during operations	Major wounds	1 in 10
06	Knock from edge, metal part etc.	Inattention	Wounds, cuts	1 in 10
07	Hair or cloths being caught in equipment	Inattention, inappropriate protective Cause	Significant body injury	1 in 1000
08	Bodily damaged from unobserved machinery start-up	Technical failure, Noise, inappropriate protective equipment	Significant body injury	1 in 100
09	Crushing when lifting Material	Sleepy floor, inattention	Finger or hand injury	1 in 10

SL No.	Activity	Cause	Consequence	Frequency of happening
10	Damage due to roll coming loose	Rupture of spindle, carelessness	Severe injuries, fatalities	1 in 100
11	Damage due to dropping material	Failure of tackle, inappropriate Fastening	Sever injuries, fatalities	1 in 10
12	Fire	Dust oil, smoking, sparks	Loss of machine, destruction of machines, injury to human body	1 in 10

Source: Ripon Kumar Saha et al., 2013

10.3.4 Human right issues

There is no doubt that ship breaking industries are necessary for Bangladesh. But, it is also utmost necessity to ensure that the sector is maintaining at least minimum standard for health, safety and environment. Human rights should be properly upheld. The workers in the process are not using proper personal protective equipment (PPE). Hossain KA (2015) found that the workers do not receive sufficient information regarding hazards and risks to health and safety, even they do not receive training on the issues associated with this sector management. Muhibbullah (2013) studied the problems and limitations (Table 24) associated with human rights and found the workers operate the loading activities manually and hence the major accidents are caused through gas explosion, toxic gases, iron plates and sheets fall down etc. The study also observed the workers' opinion in respect to tasks they perform which is given below.

Table 24: Major problems and limitations of the ship breaking workers

SL No	Types of problems	Frequency (f)*	Percentage (%)
01	Very hard work and risky job	240	16.33
02	Low wage/ salary	220	14.97
03	Absence of security on life	142	9.66
04	Lack of pure drinking water	88	5.99
05	Absence of hospital near ship yards	120	8.16
06	Lack of sanitation systems	102	6.94
07	Health problems and skin diseases	222	15.10
08	Absence of related training system	90	6.12
09	No job security	132	8.98
10	Lack of recreation facilities	66	4.49
11	Lack of health education and family planning concepts	48	3.27
12	Absence of life insurance	130	8.84
Total		1470	100.00

Source: Muhibbullah, 2013

Beside these, availability of child labors and no active trade union, lack of proper compensation in case of injury and death etc. are some other issues to address. Over the last twenty years more than 400 workers have been killed and 6000 seriously injured according to the Bangladeshi media. Mizanur et al. (2018) interviewed a local NGO who directly works with ship breaking sector and the reply regarding human rights in ship breaking industries was "*The ways the workers are treated in the yard are not humane. They [the yard owners] do not consider them as human. They are abusing these people as they do not get work. Does that mean that we will allow them to die? How can a man remain indifferent to*

the high number of casualties? It is their mentality that is rotten. They [yard owners] are no longer human; they hunger after money. They profit from the savings that they have to spend for workers training, medical treatment and others. Day by day the accidents are increasing and so are the deaths. We have our documents, please take them; we have documented all workers who died of accidents. Of course the available information we have, we do not have the lists of all casualties, and the actual number is even higher."

10.4 International and National Laws and Guidelines

Some of the regulatory developments have been able to lift up responsiveness towards the overwhelming outcomes of harmful waste export and increase few important principles associated with the threats to the sustainability of the fragile global system (Ruchi 2004). Shawkat et al. (2014) synthesized existing legal regulations regarding ship breaking industry in Bangladesh along with some challenges. According to the study, some of the international and domestic frameworks are mentioned here.

10.4.1 International Maritime Organisation (IMO) guidelines

The IMO keeps overall accountabilities in coordination of ship-recycling issues and monitoring during ship designing, building and operation. In 2003, IMO guidelines were adopted in this industry to ensure safe ship recycling and minimising hazardous materials uses in shipping operation. The guideline also addresses environmental safety, risks, and health and welfare concerns.

10.4.2 International Labour Organization (ILO) guidelines

ILO conventions deal with working conditions and worker rights. Sawyer (2002) stated that ship breaking countries are under obligation to guarantee standards for workers in yard such as right to form trade unions, standard health issues etc.

10.4.3 MARPOL (Marine pollution) Convention 1973/78

This convention deals with appropriate waste-reception facilities. Shawkat et al. (2014) found that Bangladesh has not ratified the relevant annexes of the MARPOL convention.

10.4.4 EU Waste Shipment Regulation

Because of being a major exporter of end-of-life ships to substandard "dismantling and recycling" facilities in South Asia, EU legislation concerning this regulation is of paramount importance. This regulation is mainly based on Basel convention.

10.4.5 International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (Hong Kong Convention)

According to World Bank (2010), the Hong Kong Convention has been adopted under the auspices of the IMO in 2009 having five year negotiations and is expected to enter into force in 2015.

10.4.6 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal 1989

This convention stays the principal international legal instrument of regulation of ship breaking industry. Choksi (2001) stated that the main purpose of the convention is to ensure that parties take responsibility for their own hazardous waste, establish their territory, minimise the generation and transboundary movement of hazardous waste, and ensure that they do not export the hazards and

damage to human health and the environment, to other countries. Another obligation of this convention is to ensure environmentally sound management.

10.4.7 The European List of ship recycling facilities

From 31 December 2018, large commercial seagoing vessels flying the flag of an EU Member State may be recycled only in safe and sound ship recycling facilities included in the European List of ship recycling facilities. The List was first established on 19 December 2016 and updated in May 2018. It will be further updated in the future through Implementing Acts to add more compliant facilities or to remove facilities which have ceased to comply. To be included in the European List, any ship recycling facility irrespective of its location has to comply with a number of safety and environmental requirements. In April 2016, the Commission issued technical guidelines on these requirements. The Commission assesses applications received from the ship recycling facilities located in third countries.

10.4.8 Inventories of Hazardous Materials

With the new Regulation, the installation or use of certain hazardous materials on ships will be prohibited or restricted. These hazardous materials include for instance asbestos and ozone-depleting substances. Each new European ship (or a ship flying the flag of a third country calling at an EU port or anchorage) will be required to have on board an inventory of hazardous materials verified by the relevant administration or authority and specifying the location and approximate quantities of those materials. From the publication of the first European List of ship recycling facilities, EU-flagged ships going for dismantling must also have an Inventory of Hazardous Materials onboard. EU Member States' port authorities will be authorised to control European ships to verify whether they have on board a ready-for-recycling certificate or a valid inventory of hazardous materials. In November 2016, EMSA, the European Maritime Safety Agency, published a Best Practice Guidance on the Inventory of Hazardous Materials for practitioners on the field, ship owners and national authorities.

10.4.9 Other international conventions relevant for ship breaking

Apart from the above mentioned conventions, some of the other international conventions deal with ship breaking industries such as the Law of the Sea Convention 1982, Stockholm Convention, Rotterdam Convention and International Convention on the Control of Harmful Antifouling Systems on Ships 2001 etc.

10.4.10Legal Regulations in Bangladesh

In Bangladesh, the rules and regulations related with ship breaking industries consider environment and labour relations. Sarraf et al. (2010) stated that the array of government departments involved with ship breaking issues in Bangladesh are Department of Environment (DoE) along with Department of Inspection for Factories and Establishment and the Explosive Department. The acts, Las and Rules which play vital role in this process are Environment Conservation Act 1995, the Environmental Law 1995 and Marine Fisheries Ordinance 1983 etc. Recently, a draft has been issued named ‘Rules on Ship Breaking and Hazardous Waste Management under the Bangladesh Environment Conservation Act 1995; and in 2011 Ministry of Development released ‘Ship Breaking and Recycling Rules’ which also introduced Ship Building and Ship Recycling Board (SBSRB) to issue certifications mainly. The Department of Environment is supposed to play vital role in controlling environmental pollution from ship breaking activities which is merely succeeded due to lack of manpower and adequate rules. However, A bill titled, 'Bangladesh Ship Recycling Bill, 2018,' was passed in the parliament keeping a provision of tougher punishment for violations of the law, and aiming to give a further boost to the country's potential ship recycling industry. In the bill it is stated that a zone will be established in Chittagong for the ship-recycling industry under Section 4 of the draft law and the industry owners will have to set up yards and conduct their activities within the zone. The law makes it mandatory to issue life insurance for each and every worker and employee by the owners. The industries will also have to

abide by the relevant international laws and conventions. It also said if anyone establishes a yard without permission, the punishment for such offence is maximum two-year jail or minimum BDT 10 lac fine or maximum BDT 30 lac fine or both. The punishment for importing ships without a no-objection certificate (NOC) is two years' jail or a fine of minimum BDT 10 lac fine to maximum BDT 30 lac. If anybody brings a ship ashore and recycles that without NOC certificate, then the punishment is also maximum two years' jail or a fine of minimum BDT 10 lac to maximum BDT 30 lac. The punishment for availing the facility through fake certificate is maximum five years' jail or a fine of minimum BDT 5 lac or maximum BDT 20 lac. In the case of setting up yards outside the zone, the punishment is two years' jail or a fine of minimum BDT 10 lac or maximum BDT 30 lac. Under the new law, a 13-member board will be constituted to oversee the activities of the ship recycling industries with an additional secretary of the Ministry of Industries as its chairman.

10.5 Economic Benefits

10.5.1 Growth of the industry

Currently, Bangladesh has been considered as one of the most emerging ship breaking nations. Sujauddin et al. (2017) stated that the total business revenue in fiscal year (FY) 2012 was the highest in Bangladesh (Figure 63); Ship Breaking Industries (SBI) met around 51% of the demand for raw materials and 37% of the demand for finished steel products. Rolling industries output in FY2010 was 1,451,000 t; 23% of the input for this production was from ship breaking sources. SBI was found to be the sole source of scraps for small rerolling industries in Bangladesh, and their output in 2008 more than doubled as compared to 2005. In 2017, Bangladesh scrapped a total of 197 ships and which was 6.5 million GT (www. shipbreakingplatform. org). Larger rolling industries fulfilled their input needs for steel scraps by using both SBI and imported materials. We found a sharp increase in input imports during the global ship breaking recession in 2003–2007 and when Bangladesh's SBI faced a temporary ban in 2010.

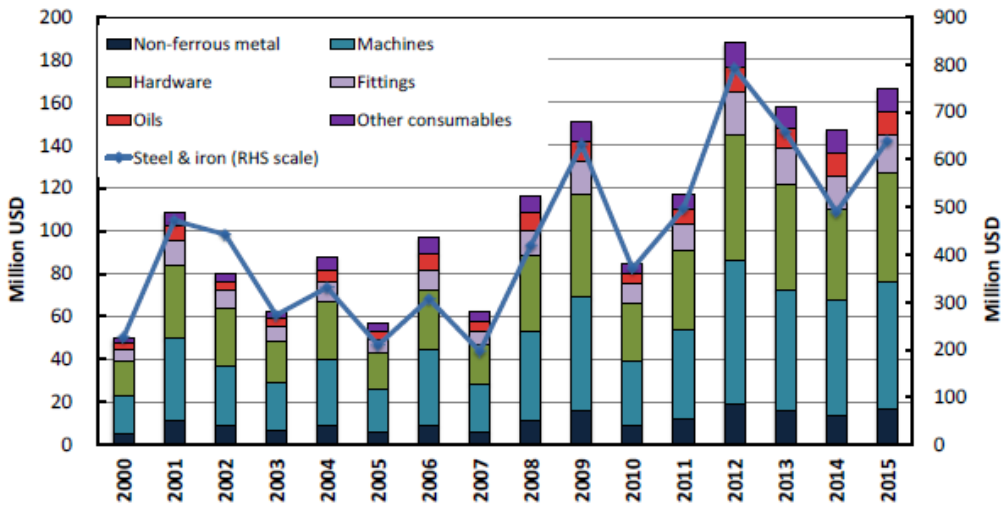

Figure 63: Estimated weight ('000 LDT), average weight (LDT), and number of ship recycled in Bangladesh. Source: Sujauddin et al., Administrative data.

Induction furnaces in Bangladesh in FY2010 produced a total of 787,000 t of billets; more than 40% was from ship-sourced scraps. In 2008, the country's steel consumption was 3,220,000 t, that is, 22 kilograms per person, and the intensity of steel use was 40 grams per U.S. dollar, which was much higher than that of other developing countries with a similar per capita gross domestic product (GDP). The country exhibited a high level of steel consumption relative to its GDP, which is indicative of the contribution of SBI.

10.5.2 Economic returns from the industry

Shipbreaking plays an important role in the national economy by different means. Because of having cost-effective human resources, simple importation facilities, enthusiastic entrepreneurships, Bangladesh is having a steady expansion (Figure 64) of this industry and hence the contribution is immense. The scrapping of ships provides the country's main source of steel and in doing so saves substantial amount of money in foreign exchange by reducing the need to import steel materials. Reports say, that at present Bangladesh has a demand for 50,0000 tons of metal / steels, but Bangladesh has no iron ore sources or mines, which make ship scrapping is the inevitable and important source of raw materials. More than 350 re-rolling mills have been using ship scraps as their raw materials. The industry is currently supplying more than 60 per cent of the raw materials for local steel industry. A good number of local industries including heavy and light engineering already been developed depending on ship breaking industry. In some ways it can be considered a "green industry". Almost everything on the ship and the ship itself is recycled, reused and resold. The scrapping of ships supplies raw materials to steel mills, steel plate re-manufacturing, asbestos re-manufacturing as well as providing furniture, paint, electrical equipment and lubricants, oil to the number of businesses that have sprouted up specifically as a result.

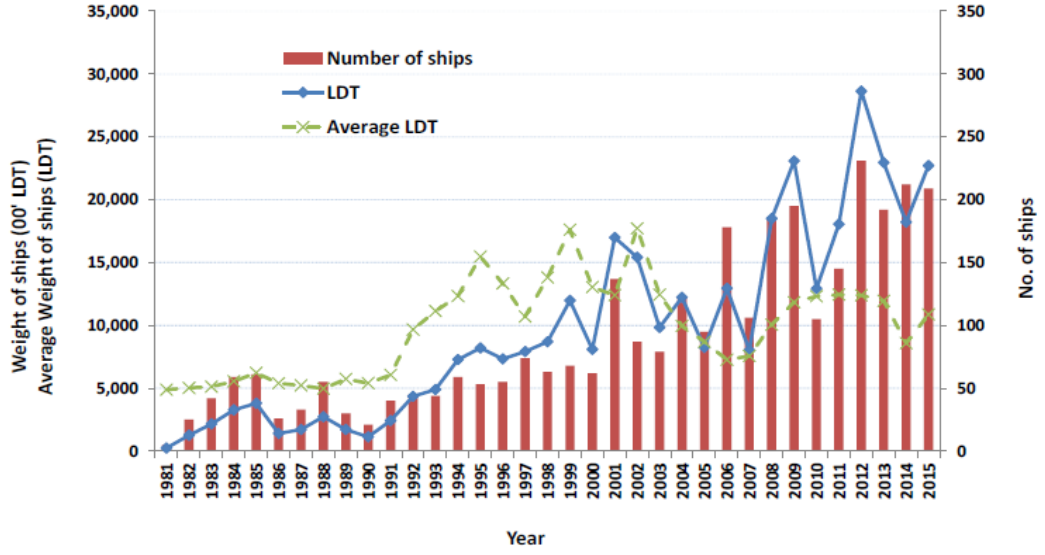

Figure 64: Gross value of production of the Bangladesh Ship Breaking Industry (Source: Ahammad, H., & Sujauddin, M., 2017)

10.6 Prospects and Potentialities

10.6.1 Connecting with 'blue economy' concepts

According to World Bank and United Nations Department of Economics and Social Affairs (2017), the "blue economy" concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas. The blue economy aims to move beyond business as usual and to consider economic development and ocean health as compatible propositions. The activities associated with marine and coastal environment differs from country to country. In Bangladesh, scrapping of old unusable ships is a must for the sea borne trade to continue for the foreseeable period, so also for the continual emancipation for the entire international community. Shipping is the bridge for wider world civilization. Older inefficient ships are detrimental to the sea and to the environment and in conflict with the concept of the Blue Economy. However, the present style and method of scrapping, especially as they are, for example, in Bangladesh, allegedly polluting the sea and the environment, and exploiting poor laborers,

by most of the ship recycling yards, are severely criticized by all concerned of the sea and the environment. On the other hand, for example, in these countries, especially in Bangladesh the scrapping is proving jobs and steel.

Ship breaking is the prime source of steel and iron materials to the growing industries and infrastructure of the country, which is the 2nd largest breaker, having no iron ore mines and base processing steel mills. This industry not only met the growing needs of furniture, household fittings of all classes, boilers, life saving boats, generators etc but also generated employment opportunities. There are about 125 ship breaking yards with annual turnover of about USD 2.4 billion. Ship recycling must be turned into modern industry with all eco- friendly infrastructures and compliance of international convention. Ship breaking is unavoidable for the international community and essential for a few countries. Therefore, a method must be adopted which may turn scrapping to a green industry. Implementation of The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships is the answer. The highest benefit from Shipping is derived by developed nations. They have therefore a major role, rather the vital role, to play. To turn scrapping 100% green without exploiting the workers it is indeed necessary to take necessary steps, such as, building up of funds for scrapping from income of the ship over her operational life. When scrapping is green, scrapping is one of the best fitted industries to the Blue Economy.

10.6.2 Probable interventions to boost up ship recycling aspects in Bangladesh in a sustainable manner

The government has also a plan to form a ship recycling board as one stop service for the ship recyclers. The involvement of multi ministries and government department is also a challenge for a sustainable ship recycling. If the government can form a legal body and do all the day to day activities by the consent of the body then it will be better for the business groups and helpful for reporting about any further problems or areas to be improved. As per the government intention, it's saying to establish and activate a body to regulate the ship recycling industry of Bangladesh. In Bangladesh, there is a lack of resources, and in some cases goodwill, to control the import of toxic vessels. The Basel Convention (trans boundary movement of hazardous waste), which is supposed to regulate the import of end-of-life-vessels is being completely ignored. The ships on the beach in Chittagong are in large coming from the developed world. Many of the shipping companies are based in Europe. These ship-owners are making huge profits as well by selling their ships to Bangladesh.

The principle of not transferring harm to developing countries is currently not being respected at the international level. Local activists are arguing that the developing countries like Bangladesh and their territories are not dustbins or any dumping place for the developed world. People who live in developing countries have the same right to a decent job; they also need to breathe fresh air and live in a protected environment. International shipping companies especially the European shipping companies have to support Bangladesh for establishing green ship recycling practices in Bangladesh. The country is dealing with all the toxic hazardous materials, on board, but with no financial incentive and technical support for maintaining waste management or waste disposal facilities. The country is seeking for establishing a TSDF (Treatment, Storage and Disposal Facilities) and EU shipping countries should come forward to help the government for the development of TSDF. The country should bring all its resources to ensure ship recyclers are taking effective steps to improve their yard in line with the EU guidelines. There is one yard in Bangladesh named PHP Ship Recycling yard, has achieved Hong Kong Convention certificate and according to the shipping stakeholders, it is a landmark accomplishment for the industry to improve their yards gradually following the examples set by country's leading ship recycling yard. The government is also encouraging other yards to be mobilized by government to ensure a safe and sustainable industrial environment.

10.6.3 Institutional arrangements

Regarding the operational management, monitoring and overall process of ship breaking industries in Bangladesh, there are concerns from plethora of stakeholders. Among government organizations mainly Ministry of Industries, Ministry of Labour and Employment, Department of Customs, Bangladesh Navy, Inland Water Transport Authority, Chittagong Port Authority, Radio Communication and Wireless Control Authority, Shipping Masters Office etc. are mentionable. Apart from these importers, the breaking yard owners and Breakers, survey authorities, banks and financial companies, shipping agents, steel re-rolling mill owners and traders also play vital role in the process (Haossain 2006). International concerns like IMO, ILO, UNEP, Greenpeace, NGO Shipbreaking platform, International Federation for Haman Rights etc. work as the presser groups to ensure safer and green ship recycling in world-wide especially in the south Asian countries. Among local NGOs mainly Young Power in Social Action (YPSA) and Bangladesh Environmental Lawyers Association (BELA) has been working since the dawn of the ship breaking history in Bangladesh.

10.7 Challenges ahead & way forward

According to the different experts and experienced national and international organisations the below issues can be prescribed:

10.7.1.1 Disclosure of Information

The corollary of the shipbreaking industry's lack of official status as 'industry' for a long duration is the lack of disclosure practice regarding the shipyards' activities and annual reports. Inquiring with the Shitakunda, Chittagong's local land office, it was revealed that on an average, out of these 154 yards, 90 yards remain operational in a year. Bangladesh Shipbreakers Association is the official agency responsible to ensure that shipbreaking activity is carried out in an environmentally friendly manner. Hence, the owner's association (Bangladesh Shipbreaking and Ship Recycler's Association-BSBRA) needs to maintain annual report that must disclose the certain information including the number of ships by country of origin, the inventory of the hazardous waste carried in each ship, the total amount of scrapped per yard by year, the deaths in the yards, number of work forces, etc. and other required information which will enable the government body to determine the deviation from the standards. It is imperative that such disclosures be made public in order to preserve the interest of different stakeholders. This demand conforms to the stakeholder theory used in social and environmental accounting research.

The stakeholder theory states that 'the corporation should be managed for the benefit of its stakeholders: its customers, suppliers, owners, employees, and local communities. The rights of these groups must be ensured, and, further, the groups must participate, in some sense, in decisions that substantially affect their welfare (Langtry 1994). Therefore, the community and other stakeholders affected by shipbreaking activity must possess the information in order to participate in the decision making process regarding their welfare. In the age of internet, environmental reporting in the web by the corporations is not uncommon. Indeed, for the activity which has greater degree of impact on environment, the company performing that activity is more obligated to disclose the related information to the stakeholders' concern. This phenomenon of lack of disclosure practice by the shipbreakers is also an indicator of the endemic underestimation of social cost due to the shipbreaking activity in Bangladesh. So, the disclosure of information is one of the major issues to ensure a sustainable ship recycling in Bangladesh. It should be mentioned here that there is no group who is saying to stop the ship breaking, it's the absence of disclosure is creating a big gap between the owner's and other stakeholders.

10.7.1.2 Using contained areas

Prompt and sustained action, both in the marketplace and in the courts, is required. The need is especially urgent because the global phase-out of single hulled oil tankers and current backlog of old vessels still in operation mean that the number of retired ships sold for breaking is about to spike. Ships should be dismantled in contained areas where safe use of heavy lifting gear and emergency access for fire-fighting equipment and ambulances can be ensured. A discussion is also there to increase the depth

of water in the ship breaking zone. A study for the environmental feasibility should be there before doing it.

10.7.1.3 Developing ship dismantling environmentally

It is difficult to imagine a better facility where to dismantle a ship than the one or equivalent to the one where the ship was originally built. In these docks ships can be separated from the sea and therefore, controlling the access of the harmful substances to the sea would be more manageable. The dockyards areas are also surfaced with strong and durable coating such as concrete or asphalt so the contamination of soil could be easily controlled as well.

10.7.1.4 The polluter pays

A ship dismantling fund fed by the shipping industry must be created in order to internalize costs currently borne by the environment and the health of impoverished communities in developing countries.

10.7.1.5 Eco Ship Design and Recycling

Ship owners should, together with shipbuilders and classification societies, commit to the building of clean ships to avoid future disposal problems and Green Ship Recycling Yards should be identified and rewarded.

10.7.1.6 Corporate Responsibility

The shipping industry should take immediate measures such as replacing hazardous materials with clean alternatives during maintenance and survey stops and gas-freeing their ship-for-scrap before export to developing countries to ensure the safe and environmentally sound dismantling of their vessels.

Apart from these specific recommendations there are some other issues should be considered to ensure a sustainable ship recycling industries in Bangladesh.

- The implementation of the national and international convention which is agreed with all parties can be used for a sustainable solution for the green and safer ship recycling in Bangladesh and a comprehensive action plan, engaging government and all other concerned bodies, is needed to work together towards environment and workers friendly ship recycling in Bangladesh

- Developed countries or exporting countries should take responsibility for pre-cleaning vessels as far as possible before exporting them to developing countries. It should be ensured, before importing, that the ship is pre-cleaned and not containing any hazardous and radioactive materials. It also should be ensured that the hazardous waste will not harmfully effect on environment and human health.

- The ship should be properly decontaminated by the ship owner prior to the breaking. All the wastes (asbestos, PCB, crude oil, toxic sulfur, toxic oil or paints) of the ships should be pre cleaned by an international pre cleaning company before importing the ships. The govt. can provide a list of international pre-cleaned companies. The ships will not get permission to import without prior pre-cleaned certificate from the international pre-cleaning companies.

- Ships are allowed to import for breaking, except war ships, ships used in the Naval, ships operated by atomic power, ships used to carry radioactive materials, the ships containing huge toxic hazardous materials.

- An environmentally sound management of ship dismantling Plan should be provided considering the inventory layout of breaking ships, present status of the ships yards. By this

plan it should be ensured the ship will be dismantled in an environmentally sound manner and the environment and human health will not be effected harmfully.

- The national legislation like Marine Pollution Act, Air pollution Act, Bangladesh Environment Protection Act 1995, and Environment Protection laws 1997 etc. should be enforced in case of operating ship yards and waste disposal.

- The policy intends to comply with the existing new legislation in Bangladesh regarding workers' rights like- Labour Law 2006, to protect all the rights (like – Wages, working hour, leave, security, compensation, registration, ID card, job contract, over time etc.) of the ship breaking workers.

- The shipbreaking plan should ensure the occupational safety and health protection for the workers so that the death and injury by accidents; work palace related diseases would be reduced in a minimum level. Personnel Protection Equipment (PPE) like safety belt, helmet, gloves, goggles, mask, coverall, shoes etc. must be provided and also the use of PPE should be ensured by the owners and contractors.

- Awareness of people about the risks, effects and remedies of pollution should be increased so that they can play important role in the abatement of pollution due to Ship-breaking activities. Assessment data should be published in national magazine, newspaper and international journals so that public awareness will be increased.

10.8 Conclusion

Ship breaking industry has gained one of the top places in the national economy. The benefits of ship breaking are enormous in sectors like steel company, ship building company etc. Despite having so much benefits, the ship breaking industries have some problems i.e. environment pollution, workers safety. Environment pollution can be kept to minimum by following international regulations for dumping leftover ship materials. Safety issues and health factors of the workers can be ensured by following some strict rules. Safety gears like goggles, helmets, hand gloves, face masks aprons should be provided to minimize the casualties. To hold the position in world ship breaking Bangladesh needs upgrade the infrastructure for waste management, health issues of workers. Ship breaking is global in scope. The Bangladesh ship breaking industry has proven to be internationally competitive and made valuable contributions to the domestic economy.

10.9 References

Ahammad, H., &Sujauddin, M. (2017). Contributions of Ship Recycling in Bangladesh: An Economic Assessment.

Anand Ruchi (2004). International EnvironmentalJustice, A North–South Dimension (Ashgate Publishing).

Bari, A. (2017). Our Oceans and the Blue Economy: Opportunities and Challenges. Procedia engineering, 194, 5-11.

Bruce Langtry (1994). Stakeholders and The Moral Responsibilities of Business', Business Ethics Quarterly, Volume 4, Issue 4. ISSN 1052-150X. 0431-0443,1994,pp 433

Choksi S. (2001). The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal: 1999 Protocol on Liability and Compensation. Ecology Law Quarterly 2001; 28: 509–540.

Hossain KA (2015). Overview of Ship Recycling Industries in Bangladesh. Journal of Environmental and Analytical Toxicology 5(5): 297-302

Hossain, M. M. M., & Islam, M. M. (2006). Ship breaking activities and its impact on the coastal zone of Chittagong, Bangladesh: Towards sustainable management. Chittagong, Bangladesh: Advocacy & Publication Unit, Young Power in Social Action (YPSA).

Muhammad Muhibbullah (2013), Health hazards and risks vulnerability of ship breaking workers: A case study on Sitakunda ship breakingindustrial area of Bangladesh, Global Advanced Research Journal of Geography and Regional Planning (ISSN: 2315-5018) Vol. 2(8) pp. 172-184, November, 2013

Muhibbullah, M. (2013). Health hazards and risks vulnerability of ship breaking workers: A case study on Sitakunda ship breaking industrial area of Bangladesh. Journal of Geography and Regional Planning, 2(8), 172-184.

Rabbi, H. R., &Rahman, A. (2017). Ship Breaking and Recycling Industry of Bangladesh; Issues and Challenges. Procedia engineering, 194, 254-259.

Rahman, S. M. Mizanur, and Audrey L. Mayer (2015). How Social Ties Influence Metal Resource Flows in the Bangladesh Ship Recycling Industry. Resources, Conservation and Recycling 104: 254–64.

Ripon Kumar Saha, Md. Saiful Islam and Md. Mahbubur Rahman, (2013). Safety Management for Bangladeshi Ship Breaking Industries, Global Journal of Researches in Engineering, vol 13, issue 5, version 1.0, ISSN: 0975-5861

Sawyer JF (2007) Ship breaking and the north–south debate: economic development or environmental and labor catastrophe. PennState International Law Review 2002; 20:535–562; Rousmaniere P, Nikhil R. Ship breaking in the developing world: problems and prospects. International Journal of Occupational and Environmental Health; 13(4): 359–368.

Shawkat Alam and Abdullah Faruque (2014). Legal regulation of the ship breaking industry in Bangladesh: The international regulatory framework and domestic implementation challenges, Marine Policy47(2014)46–56

World Bank (2010). The ship breaking and recycling industry in Bangladesh and Pakistan. Report No. 58275-SAS.

World Bank and United Nations Department of Economic and Social Affairs (2017). The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. World Bank, Washington DC

http://www.nationalgeographic.com.au/people/what-is-ship-breaking.aspx

https://onlinelibrary.wiley.com/doi/pdf/10.1111/jiec.12423

https://www.researchgate.net/publication/320262275

https://www.shipbreakingbd.info/overview.html

11 Institutional arrangements for blue economy: Marine Spatial Planning a way-forward

11.1 Abstract

Blue Economy is one of the important aspects of Sustainable Ocean Governance as it refers to sustainable use of ocean resources for economic growth and improved livelihood by maintaining healthy marine ecosystem. In order to achieve sustainable ocean governance, it is important to implement the contemporary and newly developed principles and concepts including Blue Economy and Ecosystem based management (EBM). As an implementation toll for sustainable ocean governance, Marine Spatial Planning (MSP) can play an important role to achieve the objectives of Blue Economy. Due to various reasons, the current institutional arrangements for sustainable ocean govern as well as exploring the concept of Blue Economy is at a very rudimentary stage in Bangladesh. The objective of this section is to analyze the significance of Blue Economy in achieving sustainable ocean governance through institutional framework. In this respect, relationship between MSP and Blue Economy is examined in the paper. This section is concluded with some recommendations to improve the institutional framework to achieve the objectives of Blue Economy in Bangladesh.

11.2 Introduction

Blue Economy is one of the important aspects of Sustainable Ocean Governance, as it refers to sustainable use of ocean resources for economic growth and improved livelihood by maintaining healthy marine ecosystem (Godfrey, 2016). In order to achieve the goal 14 of sustainable development goals -2030, it is important to implement the contemporary and newly developed principles and concepts including Blue Economy and Ecosystem-based management (EBM). It requires adequate institutional arrangements including a comprehensive legal and policy framework with appropriate management tools and operational strategies. As an implementation toll for sustainable ocean governance, Marine Spatial Planning (MSP) can play an important role to achieve the objectives of Blue Economy. Due to various reasons, the current institutional arrangements for sustainable ocean govern as well as exploring the concept of Blue Economy is at a very rudimentary stage in Bangladesh. These include lack of legal framework, lack of incentives, incapacity, lack of integration and coordination between various departments and political unwillingness.

The objective of this chapter is to analyze the significance of Blue Economy in achieving sustainable ocean governance through institutional framework. The importance of MSP in implementing newly developed management principles and concepts including EBM will be highlighted and examined. In this respect, relationship between MSP and Blue Economy will also be examined in the chapter. The chapter will be concluded with some recommendations to improve the institutional framework to achieve the objectives of Blue Economy in Bangladesh.

11.3 Blue Economy Concept

11.3.1 Emergence of Blue Economy

The concept of "Oceans Economy" or "Blue Economy" is a recent phenomenon, which originated from the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012 (United Nations, 2014). The Conference focused on two themes: Framework for sustainable development; and advancement of Green Economy. However, the coastal and developing countries were at the forefront, and strongly voiced for Blue Economy from very beginning of the Conference. Consequently, the concept of Blue Economy was recognized and included in the United Nations Conference on Environment and Development process, the Johannesburg Plan of implementation, and reaffirmed in the outcome document of the Rio+20 Conference (United Nations, 2014).

Despite the sky-high use of Blue Economy in global development process, there has no universally accepted definition of Blue Economy (WWF Global, 2015; Roberts, 2016). According to the World Bank report, Blue Economy refers to sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and healthy ocean ecosystem (World Bank, 2017). The concept refers to the economic activities that directly or indirectly take place in ocean, use outputs from ocean, and put goods and services into ocean's activities and the contribution of those activities to economic growth, social, cultural and environmental wellbeing (Roberts, 2016). Blue Economy has diverse components, including established traditional ocean industries, such as fisheries, tourism, and maritime transport; also new and emerging activities, such as offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting (World Bank, 2017; World Bank Group, 2017). The components of Blue Economy depend on each country's unique national circumstances in consideration with protecting and maintaining the diversity, productivity, resilience, core functions, and intrinsic value of marine ecosystems (United Nations, 2017).

The goal of Blue Economy is "improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities, endorsing low carbon, resource efficiency and social inclusion" (Godfrey, 2016). So, the goal of improved human wellbeing and social equity should be achieved through reducing environmental risks and ecological scarcities. Thus, Blue Economy ties up a balance between development and environmental protection. Therefore, Blue Economy seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas (World Bank Group, 2017), which is popularly known as 'Sustainable use'.

Sustainable use of ocean resources has been recognized the key component of Blue Economy. Sustainable use of ocean resources entails economic activity is conducted in a balance with long-term capacity of ocean ecosystem to support this activity and remain resilient and healthy (Goddard, 2015). Therefore, Blue Economy is, predominantly, understood with the sustainable use of ocean resources (World Bank Group, 2017). But ongoing trends of exploitation of ocean resources and therefore the degradation of marine and coastal ecosystems show that endeavors to date to ensure sustainable use have been insufficient (Bari, 2017).

11.3.2 Blue Economy and sustainable development goal'14

In September 2015, the United Nations adopted the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development at the historic United Nations Summit (United Nations, 2016). While the SDGs are not legally binding, governments are expected to establish national frameworks for the achievement of the 17 Goals (United Nations, 2016). The Goal 14 of SDGs, 'Life below water', pursues for conservation and sustainable use of the oceans, seas and marine resources (United Nations, 2015). The Goal 14 requires exploring and exploiting ocean resources in a sustainable manner which confirms conservation of ocean. The global leaders have fixed 7 targets to achieve the Goal 14. The targets comprise sustainable management and protection of marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans (United Nations, 2015). The Goal 14 aims for overriding that pressure by sustainable use of marine resources. The Goal 14 is of two folding: conservation of ocean and marine resources; and sustainable use of ocean and marine resources. The targets of the Goal 14 clearly reveal that the conservation of ocean should be achieved through the sustainable use of ocean resources. Therefore, sustainable use of ocean resources is the toolkit to achieve conservation of oceans under the Goal 14, which is also the key component of Blue Economy.

Sustainable use of ocean resources is the main driving component of Blue Economy, which essentially requires use of ocean resources in a sustainable manner to confirm the long-term capacity of ocean and protection of marine ecosystem. Apparently, exploration of Blue Economy will bring more human activities in Ocean, and threat to the natural ocean ecosystem. Ocean is facing threats of marine and

nutrient pollution, resource depletion and climate change, all of which are caused primarily by human actions (UN Global Compact, 2016). These threats place further pressure on sustainable use of ocean resources.

11.4 Blue Economy and sustainable ocean governance

Blue Economy is the concept where ocean is considered a development space, and offers hundreds of food, nutrition and livelihood. However, the ability of ocean to provide those food and nutrition over the long term is already under pressure from human activities; and it is being further threatened by fragmented, uncoordinated, and conflicted activities in ocean (WWF Global, 2015). In this backdrop, ocean needs sustainable ocean governance. Sustainable ocean governance confirms rational human activities through a coordinated, reconciled and balanced ocean management. In general, sustainable ocean governance means the coordination of various uses of the ocean and protection of the marine environment (Pyc, 2016). Sustainable ocean governance is shaped by programs and action plans promoting integrated management and the concept of sustainability (Vallega, 2000). The fundamental value of sustainable ocean governance is the maintenance of long-term sustainability of marine natural resources (Pyc, 2016).

Blue Economy aims for the economic development which is both inclusive and environmentally sound, and to be undertaken in a manner that does not deplete the natural resources. This balance approach to the economic, social, and environmental dimensions of ocean activities controls the over exploration of ocean resources (World Bank Group, 2017). Moreover, management of ocean resources is the prime mover factor for Blue Economy as well as sustainable ocean governance. Blue Economy and sustainable ocean governance require an integrated management of ocean resources to ensure exploring economic interest as well as protection of marine ecosystem. Sustainable ocean governance makes collaboration across nation-states and across the public-private sectors (World Bank Group, 2017), which is also crucial for Blue Economy. Blue Economy has a significant concern for environmental risk and ecological damage (World Bank Group, 2017), whereas sustainable ocean governance seeks protection of ocean ecosystem while exploring ocean resources. From management perspective, sustainable ocean governance is a precondition for Blue Economy.

11.4.1 Blue Economy and Ecosystem based management

Blue Economy restores, protects and maintains the diversity, productivity, resilience, core functions, and intrinsic value of marine ecosystems (WWF Global, 2015). The economic activity should be conducted in ocean with the long-term capacity of ocean ecosystems to support this activity and remain resilient and healthy. It is generally understood to be a long-term strategy aimed at supporting sustainable economic growth through oceans-related sectors and activities, while at the same time preserving the environment (UNCTAD, 2014). In this context, Ecosystem based management of ocean is a proven approach to maintain productivity of ocean for long time as well as confirming sustainable economic growth. The ecosystem approach focuses largely on preserving ecosystem functions, structures, and services (Kirk, 2015), which offers better economic growth and environmental protection. The goal of the ecosystem approach is to restore and sustain the functions of ecosystems, based on their health, productivity through management systems that are fully integrated with social and economic goals, for the benefit of current and future generations (UN General Assembly, 2006).

Ecosystem based management provides the process of making decision as well as the objectives to be achieved with specific guidelines for economic and environmental protection (Kirk, 2015). It can facilitate a coordinated approach to the application of different policies affecting the coastal zone and maritime activities, from traditional ocean sectors to new businesses focused on ocean health (World Bank Group, 2017). The objective of Ecosystem based management is the promotion of “conservation and sustainable use of ocean resources” (UN General Assembly, 2006). Ecosystem based management

ensures not only environmental aspects of ocean but also provides the process, objective and implementation of Blue Economy concept.

11.4.2 Blue Economy and MSP

There are different tools for the implementation of Ecosystem based management including Integrated Coastal Zone Management (ICZM), Marine Spatial Planning (MSP), Marine Protected Areas (MPA), and activities supporting carbon sequestration (World Bank Group, 2017). But MSP has become an essential tool for identifying and utilizing marine spaces, and for drawing up plans for sustainable ocean governance (Hassan & Haque, 2015). MSP is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through the political process (Ehler & Douvere, 2009). The objective of MSP is to ensure ecological, economic and social benefits through the Ecosystem-based management (Ehler & Douvere, 2009). The best feature of MSP is an integrated approach that allows planners to consider various uses of oceans at the same time with consideration of environmental impacts in the ocean spaces (Davies, Watret, & Gubbins, 2014). MSP is a significant departure from the sector-by-sector or use-by-use approach to integrated approach which allows planners to consider various uses of oceans at the same time (Hassan, 2013).

Blue Economy has introduced a new dimension in ocean management. It recognizes that diverse ocean uses and marine ecosystem services are interconnected, and additional value can be gained from managing these uses and services jointly rather than managing them separately (Burgess, Clemence, McDermott, Costello, & Gaines, 2018). The Blue Economy conceptualizes oceans as "Development Spaces" where spatial planning integrates conservation, sustainable use, oil and mineral wealth extraction, bioprospecting, sustainable energy production and marine transport (Ministry of Foreign Affairs, 2014)**.** Rapid growth of human activities in ocean to boost Blue Economy is creating unbearable threat to the marine environment. The various ocean energy technologies will potentially have significant adverse environmental impacts on the marine environment (Hussain, Failler, Karim, & Alam, 2017a). The mounting pressure on ocean due to the expansion of existing marine activities and new uses looks for new tools and approaches to foster a more rational and wise use of ocean space (Douvere, 2008). In this context, MSP is an effective implementation tool for sustainable ocean management through a rational use by balancing between economic growth and environmental protection (Domínguez-Tejo, Metternicht, Johnston, & Hedge, 2016). MSP provides a holistic ocean management for blue growth, which is analogous to the hypothesized advantages of ecosystem-based management.

Historically, economic activity in the oceans has been managed on a sectorial basis, with only limited coordination between ministries, regulatory bodies, and industry when overseeing, among other things, overlap of property rights, shipping routes, and fishing grounds (Economist Intelligence Unit, 2015). As a result, sector by sector management of ocean activities used to create innumerous conflicts among the users, and cause threat to economic development. In this case, MSP is the tool for promoting a more rational and integrated use of the oceans by mitigating inter and intra conflicts. MSP has a significant role in promoting a rationale use of ocean resource to overcome the various hurdles to the development of the blue economy (Young, 2015). Therefore, MSP can be a mean to confirm sustainable use of ocean resource, and to achieve the benefit of Blue Economy.

11.4.3 Blue Economy and Zoning

MSP is an implementation tool to achieve Ecosystem-based Management while zoning is the most important toolkit to implement MSP effectively. An effective MSP depends on effective marine space zoning as well as application of some other principles. Zoning is a mean of applying MSP to specific marine spaces, a toolkit for implementing the ecosystem approach with an aim of achieving a healthy marine ecosystem by separating potentially conflicting ocean uses; and enabling economic and social

benefits from various commercial and recreational activities (Hassan, 2013). One of the significant challenges to explore Blue Economy is to avoid conflicting uses of marine space. In this context, Zoning has long been regarded as a cornerstone of ocean resource management, separating conflicting uses through application of the various zones and determining the appropriateness of various activities (Day, 2002).

Zoning provides specific use of particular space either for single or multiple uses of ocean resources. A multiple-use zoning approach provides high levels of protection for specific areas whilst allowing a range of reasonable uses, including certain extractive activities, to continue in other zones (Day, 2002). Zoning gives a spatial planning basis for determining where many activities can or cannot occur (Kenchington & Day, 2011). Zoning is the outcome of a conciliation among the Blue Economy Sectors to use marine space according to space and time determined at policy level. Specific use of marine space accelerates adopting strategic goal for exploring that particular resource with specific target and evaluation. Zoning brings a spatial dimension to the regulation of marine activities by helping to establish geographical patterns of sea uses within a given area (World Bank Group, 2017).

Zoning, substantially, avoids conflicts among the relevant Departments and confirm functional separation to get optimal benefit of Blue Economy. Zoning provides integration across multiple uses and sectors, to minimize conflicts, to maximize sustainable economic development, and to protect important habitat and biodiversity areas (F. Douvere & C. Ehler, 2009). If the ocean spaces are properly planned and managed under MSP within a comprehensive framework of ecosystem based management, that will certainly generate strong foundation for huge earnings and economic benefits for the country (Hussain, Failler, et al., 2017a). Zoning regulations prescribe strategic management measures which confirms collective and community engagement for sustainable ocean resources management (Kenchington & Day, 2011), which ultimately ensure sustainable use of marine resources and sparks out Blue Economy through the collective engagement of multilayer Sectors.

11.5 Institutional arrangements for Blue Economy

Blue Economy conceptualizes a multi-dimensional use of ocean resources by a number of Sectors and Departments. Sustainable use requires those Sectors and Departments should be controlled and managed under an integrated institutional arrangement. Therefore, institutional design is at the central in managing blue growth to promote command-and-control management (Burgess et al., 2018). Moreover, Blue Economy emphasizes on active and effective stakeholder engagement and participation (WWF Global, 2015). Thus, all of the relevant Sectors and Departments should be identified, engaged and motivated through the common goal of Blue Economy. Therefore, the institutional arrangement for Blue Economy must be participatory, accountable, transparent, equitable and inclusive, in order to be responsive to present and future uses of ocean resources (WWF Global, 2015).

Designing institutions well is important, but what makes an institution well-designed is a question of the elements identified for managing the resources (Dietz, Ostrom, & Stern, 2003). The ideal sets of institutions are diverse and layered, have some degree of redundancy, and promote both dialogue among stakeholders and opportunities for learning and change (Dietz et al., 2003). The capacity of institutional system to absorb a disturbance and still retain its basic function and structure is an essential to design resource management in an uncertain and changing world, a world experiencing environmental shocks and unprecedented environmental conditions at an increasing rate (Burnes, 2007). Institutions with resilience to both of these sources of uncertain and changing will be needed to sustain blue growth in the long term (Burgess et al., 2018). Blue growth will require reducing or eliminating externalities found across sectors, communities, or countries, and across time, through institutional design that can be locally and departmentally supported and feasible (Burgess et al., 2018).

Designing proper institutional framework is a challenge to grasp the benefit of Blue Economy because of the multi-layer uses, complexities, allocation of activities, uncertainties and changing nature of resources, and external factors. In this context, MSP is an effective tool for multidimensional uses management by reconciling among the Sectors in setting objectives and implementation plans (Frazão Santos, Orbach, Calado, & Andrade, 2015).

11.6 Institutional arrangements for Blue Economy in Bangladesh

The Institutional arrangement is a ground-breaking condition for exploring Blue Economy in a coastal state. Identifying the appropriate Departments and engaging them in implementation and operation of Blue Economy activities is a challenge in sustainable ocean governance. Blue Economy as a new dimension of economic development which requires highly pre-planned and well-arranged institutional arrangements. Due to various reasons, the institutional arrangements for sustainable ocean governance and Blue Economy under current legal and institutional system is at a very rudimentary stage in Bangladesh. The current institutional arrangements for exploring Blue Economy in Bangladesh can be demonstrated in five points:

(i) Institutional arrangements for Marine Living resources (Fisheries)

(ii) Institutional arrangements for Shipping and maritime transportation

(iii) Institutional arrangements for marine non-living resources

(iv) Institutional arrangements for Maritime Security

(v) Institutional arrangements for Marine Environment and sustainable tourism

11.6.1 Institutional arrangements for Marine Living resources (Fisheries)

Marine living resources, particularly Fisheries, is one of the major Blue Economy opportunities for Bangladesh. The Ministry of Fisheries and Livestock is the highest governmental agency which is responsible for dealing with Fisheries resources management in Bangladesh. The Ministry has two divisions: Fisheries and Livestock. The Fisheries Division deals with the functions relating to Fisheries resources in general and marine fisheries particularly. The Division is engaged in the preparation of schemes, co-ordination of national policy; utilization of fish and fish wastes; development of fisheries resources and fishing; management of fishery resources; conservation of fish; control, management and development of Fisheries (Department of Fisheries, 2018). The Ministry has five agencies which are either directly or indirectly related to the management of marine fisheries resource. The agencies are:

- Department of Fisheries
- Marine Fisheries Academy
- Bangladesh Fisheries Research Institute
- Bangladesh Fisheries Development Corporation
- Fisheries and Livestock Information Office

11.6.1.1 Department of Fisheries

The Department of Fisheries has been working as the key agency for fisheries resource development and management in Bangladesh. The Department has a Marine Fisheries Wing which deals with all relevant functions of marine fishing. The Marine Fishing Wing is headed by a Director; and administered with other subordinated staffs. The functions of the Marine Fisheries Wing are mainly

vested by the Marine Fisheries Ordinance 1983 (Department of Fisheries, 2018). According to Article 5 of the Marine Fisheries Ordinance 1983, the Director has responsibility for the management, conservation, supervision and development of marine fisheries and the implementation of the objectives of this Ordinance. Article 8 of the Ordinance sates that the Director is responsible for issuing licences in respect of all marine fishing in the Bangladesh.

However, this is a challenging task for the Wing to manage a volume of activities through its limited resources. The Wing does not have any function to develop the capacity building for deep sea fishing. The current marine fishing is limited to territorial water. But with a view to expanding capture fisheries production, Bangladesh should adopt appropriate deep-sea fishing technologies, i.e. long line and hook fishing and the utilization of supporting (Hussain, Failler, Karim, Alam, & Todorova, 2017).

11.6.1.2 Marine Fisheries Academy

The Government established Marine Fisheries Academy to maintain proper management of sea fishes through the production of skillful resources for marine fishing. The Academy is entrusted to train cadets through modern techniques and equipment in order to meet the challenges of millennium in shipping sectors. The Academy is a national institution to train and educate personnel for Bangladesh maritime fisheries industries in Bangladesh. The Academy strives for skillful human resources for deep-sea fishing by an efficient fishing fleet. Since its inception, Academy is shouldering the responsibilities of exploring and pooling the seafaring talents of the country; and training them in well planned and well-organized manner as Navigator, Engineer and Fish Processing Technologist (Marine Fisheries Academy, 2018). However, adequacy of modern technologies and equipment in the Academy is a core barrier to produce skillful human resource for marine fishing.

11.6.1.3 Bangladesh Fisheries Development Corporation (BFDC)

Bangladesh Fisheries Development Corporation is an autonomous organization under the Ministry of Fisheries and Livestock. The Corporation is mainly involved in harvesting fisheries resources and developing marketing facilities in the country. BFDC has fish harbors, landing and distribution centers, ice plants, and processing plants in several locations of Bangladesh. In recent years, BFDC has played a vital role in supplying safe and quality fish in the domestic market (Bangladesh Fisheries Development Corporation, 2018). The Corporation may adopt effective marketing policy to boost national revenue from marine fisheries resources. But the current focus of BFDC is on fresh water fisheries; and have shown less success in marine fisheries.

11.6.1.4 Bangladesh Fisheries Research Institute (BFRI)

Bangladesh Fisheries Research Institute is also an autonomous organization under the Ministry of Fisheries and Livestock. The objectives of the Institute are: to carry out basic and adaptive research for development and optimum utilization of fisheries resources; to coordinate fisheries research activities in Bangladesh; to do experiment and standardize techniques for maximizing productions and better management of fisheries resources; to advise the Government in all matters relating to research and management of fisheries resources (Bangladesh Fisheries Research Institute, 2018). The Institute has a Marine Fisheries and Technological Station in Cox's Bazar. The Marine Fisheries Station conducts basic and applied research on marine fisheries. But the research station is going on lack of standard research due to scarcity of modern lab and strategic focus in marine fishing.

11.6.2 Institutional arrangements for Shipping and maritime transportation

The Ministry of Shipping is the apex body for formulation and administration of Shipping and maritime transportation in Bangladesh. The Ministry is responsible for formulating policies and plans to facilitate the quick implementation of various projects relating to standard shipping operation (Ministry of Shipping, 2018). The objectives of the Ministry relating to maritime shipping focus on modernization of sea ports; creation of efficient workforce in the maritime sector; safe and affordable transportation of goods; and facilitation of international trade (Ministry of Shipping, 2018). There are seven sub-

ordinate Departments and Organizations those are directly related to maritime shipping and operation. The departments/agencies are: Department of Shipping, Bangladesh Shipping Corporation, Marine Academy, National Maritime Institution, Chittagong Port Authority, Mongla Port Authority and Payra Port Authority.

11.6.2.1 Department of Shipping

The Department of Shipping was established in 1976 to act as the maritime safety administration of Bangladesh and the international focal point of maritime affairs. The Department is responsible for formulation and implementation of the national policies and legislations to ensure safety of life and ships at sea; development of shipping industry; maritime education and certification; employment and welfare of seafarers; and other shipping related matters. The department is also responsible for ensuring the compliance of international conventions relating to maritime matters (Ministry of Shipping, 2018). The Department operates its functions relating to Marchant shipping through 9 (Nine) major agencies: Mercantile Marine Department, Government Shipping Office, Seamen Welfare Directorate & Emigration Directorate, Bangladesh Shipping Corporation, Marine Academy, National Maritime Institution, Chittagong Port Authority, Mongla Port Authority, and Payra Port Authority.

Mercantile Marine Department: The Mercantile Marine Department (MMD) is responsible for controlling the shipping activities in accordance with the Merchant Shipping Ordinance 1983 for ocean going and coastal ships. The Principal Officer is the head of this Department. MMD has a branch office in Khulna for providing services to ships at Mongla Port. The main functions of the Mercantile Marine Departments are: registration, survey and inspection of ocean going and coastal vessels; issue of Safety Equipment Certificate; issue of Seaworthy Certificates to Vessels; issue of No Objection Certificate to vessels entering to and departing from the Ports; and attend to enquiries and investigations as to shipping causalities (Mercantile Marine Department, 2018). While MMD has to conduct huge operational activities, it has a limited number of staffs in comparison to the work load. Further, the management process is not up to the world standard level to compete at international playground.

Government Shipping Office: The Government Shipping Office is located in Chittagong. The main functions of the Government Shipping Office are: issue of Continuous Discharge Certificate (CDC) to seafarers; conduct sign on and sign off the seafarers; dealing matters relating to employment of Bangladeshi seamen on foreign and national flag vessels; arbitration and settlement of problems/disputes related seafarers' employment on board ships; maintenance and operation of Seaman's Funds (Government Shipping Office, 2018). Complexities in procedure and delay to resolve any issue are identified as two major drawbacks of the Office for effective functioning.

Seamen Welfare Directorate & Emigration Directorate: The Seamen Welfare & Emigration Directorate was created in 1971 by amalgamating three departments with a view to implementing the provision of the ILO Conventions for promoting the welfare of seafarers. The Directorate provides welfare services to seafarers and advises the Government on measures to be taken for promoting welfare of seamen as per requirements of Maritime Labour Convention 2006 (Department of Shipping, 2018). But the statistics and country report show that the position of Bangladesh is at the bottom of line in confirming the provisions of the ILO Convention.

Bangladesh Shipping Corporation: Bangladesh Shipping Corporation (BSC) is a government agency to act as the national flag carrier to provide safe and efficient shipping services and carry out all forms of activities connected with or ancillary to merchant shipping. BSC engages its vessels both on time and voyage charter. At present, most of the vessels are under time charter to various local and foreign companies. BSC also started feeder service in the Bangladesh-Singapore-Bangladesh trade from 1986. BSC has been entrusted with the responsibility of carrying crude oil from Middle East and Persian Gulf region to Bangladesh. BSC also acts as the local agent of various nationalized and private shipping companies in Bangladesh. BSC has its own marine workshop situated on the bank of the river

Kharnaphully to carry out maintenance and repair of BSC vessels (Bangladesh Shipping Corporation, 2018). But very limited number of Vessels and continual loss make frustrating outcome from the Corporation.

Marine Academy: Bangladesh Marine Academy is a maritime training institution located in Chittagong. The Academy has an excellent and prestigious past of four decades to produce world class mariner for shipping operation. The Academy has achieved the requisite professional status by being a branch of world maritime University in 1990 (Bangladesh Marine Academy, 2018). The academy provides theoretical and practical training to cadet, deck officer and marine engineer for merchant shipping. Undoubtedly, the Marine academy is a unique institution in South Asia and known for its maritime excellence. The Academy is committed to efficient and skillful manpower for maritime development in shipping line. But the Academy produces a limited number of mariners which is not adequate for the large shipping industry.

National Maritime Institution: National Maritime Institute (NMI) was permanently established in 1989. The Institution is one of the most modern & IMO white listed Institutes in the South-Asian region. NMI is occupied with a large area along with modern Training Blocks. National Maritime Institute is a well-equipped for Seafarer's Training. The Institute provides both practical and theoretical knowledge for operation of merchant shipping. NMI is presently conducting Pre-Sea courses on two main academic discipline (National Maritime Institue, 2018). The Institution is committed to develop competent and qualified maritime manpower for safe and efficient manning of world fleet. However, Bangladesh needs more trained Seafarer from other disciplines, for example, oceanography, hydrography and cartography.

Chittagong Port Authority: All of the three Sea Ports (Chittagong Port, Mongla Port and Payra Port) are autonomous bodies which are regulated by respective statute. The Chittagong Port is the principal seaport of Bangladesh. The Port handles about 90% of the total maritime trade of the country (Chittagong Port, 2018). The Chittagong Port Authority is regulated by the Chittagong Port Authority Ordinance 1976 (amended 1995). Board is the highest level of authority in discharging functions guided on questions of policy by such direction as may be given to it from time to time by the government. The functions of the port authority are: to manage, maintain, improve and develop the port; to provide and maintain adequate and efficient port services and facilities in the Port or the approaches to the Port; and to regulate and control berthing and movement of vessels and navigation within the Port. But the lack of efficient management process and scarcity of skillful human resources always hampers smooth service and causes extra-costing delay in Chittagong Port.

Mongla Port Authority: Mongla Port is en eco-friendly port in Bangladesh. The Port is operated by Mongla Port Authority. There is a board consisting of chairman and three members: Member (Finance), Member (Harbour & Marine), Member (Engineering & Development) to operate the Port. The Chairman is the Chief Executive of the port authority. The Board formulates the policy of operation, administration, finance & development of the port. There are 12 Departments to carry out day to day work of the authority (Mongla Port, 2018). Mongla Port Provides facilities and services to the international shipping lines and other concerned agencies providing shore based facilities like jetties, godowns, cargo handling equipment and maintaining adequate water deapth in the channel as well as making provision for safe day and night shipping. Although the Port is contributing in internal shipping significantly, it has less focus in merchant shipping in Bangladesh.

Payra Port Authority: In order to increase the economic activities in the central zone and meet the future demand, Payra Sea Port has been established as the 3rd sea port of Bangladesh. The Port is governed by the Pyra Port Authority. The objective of Payra Port focuses mainly on providing necessary services and facilities to the port users efficiently and effectively at competitive price (Payra Port, 2018). Though Payra Port Authority started its limited scale port operations by offloading bulk cargoes at inner/outer anchorage, with the passage of time it is going to handle maximum volume of container and bulk cargoes of Bangladesh using the geographical advantages, good hinterland connectivity. However, maintaining the channel and navigability is a challenge for fulfilling the goal of the Port Authority.

11.6.3 Institutional arrangements for non-living marine resources

The non-living resources, for example, Oil, Gas, Minerals and Renewable Energy, are very crucial Blue Economy sectors for Bangladesh. The Ministry of Power, Energy and Mineral Resources is the concerned Ministry to deal with these sectors. The Ministry has two divisions headed by two Secretaries: Power division; and Energy and Mineral resources division. The Energy and Mineral Resources Division has separate entities for oil and Gas (Ministry of Power, 2018a). There are six subordinate agencies under the Ministry to conduct the activities related to oil, gas, minerals and renewable energy in Bangladesh. The agencies are: Energy and Mineral Resources Division, Sustainable and Renewable Energy Development Authority (SREDA), Petrobangla, Geological Survey of Bangladesh, Bangladesh Hydrocarbon Unit, Bangladesh Hydrocarbon Unit and Bangladesh Energy Regulatory Commission (BERC).

11.6.3.1 Energy and Mineral Resources Division

Energy and Mineral Resources Division is responsible for management of all resources; planned development and control over mine and mineral classification; continuous monitoring and information collection; ensuring proper usage and supply of minerals for energy; industry and production of raw materials to maintain a flow in the national revenue; and earning revenue through lease and extraction of mineral resources (Ministry of Power, 2018b). In this context, the Division is supported by Bangladesh Mineral Development (BMD). The Division has initiated many programs for exploration, development and generation of onshore gas at offshore blocks in order to satisfy the demand in Bangladesh. The Division prepares budget to ensure energy security, necessity of casting, activities under the supervision of the department, timed planning and increased monitoring and performance of the implementation. However, the Division has less success in planning and managing marine minerals and resources.

11.6.3.2 Sustainable and Renewable Energy Development Authority (SREDA)

As per Sustainable and Renewable Energy Development Authority Act, SREDA has been established to act as a nodal organization of the Government to promote and develop renewable energy and energy efficiency activities in Bangladesh. Besides SREDA, there are some special cells/wings established in different power sector utilities to deal with renewable energy and energy efficiency issues. The Authority is working to promote and foster the renewable energy development in Bangladesh as per the Renewable Energy Policy 2008 (Division of Power, 2018). SREDA is performing the functions of: coordinating renewable energy and energy efficiency issues of the government; promoting sustainable energy; standardizing and labializing the products for renewable and efficient energy; piloting new technologies, and take initiatives for its expansion; research and development on renewable and efficient energy; capacity development; create awareness for renewable and efficient energy; and establish linkage with regional and international organizations. The initiatives and plans of SREDA to explore marine renewable energy are at very rudimentary stage which should be more focused and promoted.

11.6.3.3 Petrobangla

Bangladesh Oil and Gas Corporation (BOGC) was short-named “Petrobangla” in 1974, which deals with the exploration and development of oil, gas and mineral resources in Bangladesh. Petrobangla is also entrusted with mineral development in the country. While the exploration part of minerals activity falls under the charter of Geological Survey of Bangladesh (GSB), subsequent development of economic deposits is undertaken by Petrobangla. Petrobangla has shown significant initiatives in exploring the mineral resources from the maritime area of Bangladesh although failed due to maritime boundary dispute (PETROBANGLA, 2018). After the resolution of the Maritime boundary dispute with Myanmar and India, Petrobangla has rearranged the deep-water blocks on the eastern part. Proper planning, skillful resources and adequate modern technologies are essential for effective functioning of this leading mineral explorer corporation.

11.6.3.4 Geological Survey of Bangladesh

The Geological Survey of Bangladesh is envisaged for searching mineral resources' structure and technological development, urban planning, environmental protection, protection from natural and man-made disasters and the geological, geo- physical, geo- chemical investigation (Geological Survey of Bangladesh, 2018). The Wing conducts excavation activities which leads to the discovery of new fields of mineral resources within the land and water territory of Bangladesh. This specialized team works under direct monitoring and supervision of the Energy and mineral resources division. However, the wing needs coordination and collaboration with Petrobangla and BAPEX for better function and smooth management of mineral activities.

11.6.3.5 Bangladesh Hydrocarbon Unit

Energy and Mineral Resources Division established Hydrocarbon Unit in 1999. Hydrocarbon Unit is a Technical arm of Energy and Mineral Resources Division. Hydrocarbon Unit provides technical recommendation to Energy and Mineral Resources Division for the development of Oil, Gas and Mineral Resources. Besides, Hydrocarbon Unit assists to provide views/comments to international and regional organizations on different issues pertaining to energy sector (Bangladesh Hydrocarbon Unit, 2018). The Unit may be predominant force in exploring and exploitation of hydrocarbon reserve in the Bay of Bengal. But the Unit needs to be more acquainted with modern equipment to deal with marine Hydrocarbon aspects.

11.6.3.6 Bangladesh Energy Regulatory Commission (BERC)

The Bangladesh Energy Regulatory Commission was established in 2003. The Commission consists of the Chairman and five members. The commission has the mandate to regulate Electricity, Gas and Petroleum products for the whole of Bangladesh (Bangladesh Energy Regulatory Commission, 2018). Additionally, The Commission provides training to the technical staff. The Commission has a training institute to produce skillful manpower for effective management and operation of energy production. The Commission controls downstream energy activity and monitors the overall activities of all relevant agencies. The Commission analyze the existing energy frameworks and suggest Government for new policy if necessary. Although the Commission is the umbrella platform for energy regulatory activities, it has less stress on marine energy to adopt appropriate legal and institutional framework for Bangladesh.

11.6.4 Institutional arrangements for Maritime Security

Ministry of Defence is the responsible body to maintain the safety and security of the land, air and water territory of Bangladesh. The Defence Ministry maintains functional integration with the Armed Force. The functions of the Ministry related to maritime security are: conducting survey on water territory and preparing map for shipping; and research and updates on meteorological aspects in Bangladesh. There are five subordinate and affiliated agencies those deal with the maritime security aspects of Bangladesh under this Ministry of Defence: Bangladesh Navy, The Coast Guard, Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Bangladesh Meteorological Department and Survey of Bangladesh.

11.6.4.1 Bangladesh Navy

Bangladesh Navy (BN) has emerged as the guardian of the national maritime space in Bangladesh by playing primary roles in protecting territorial integrity, political independence, and safeguard the maritime interests. Ensuring safe and unfettered maritime commerce is an obligation of Bangladesh Navy (Bangladesh Navy, 2018). BN maintains round the clock vigilance at sea; and conducts special operations against armed robbery, illegal poaching, smuggling, gun-running and terrorism. Bangladesh Navy defends the country from threats emanating on, above and under the sea; promote and protect our maritime interest, and assist in maritime governance. It maintains an effective posture across the full spectrum of any conflict at sea. Bangladesh Navy shall also undertake constabulary and benign tasks to

ensure good order at sea for carrying out national maritime economic activities. BN has played an important role in confirming maritime security against traditional threat while non-traditional threat should be more focused to ensure the benefit of Blue Economy.

11.6.4.2 Bangladesh Coast Guard

The emergence of the Bangladesh Coast Guard as a new service was the result of an awareness to enforce national laws in the waters under national jurisdiction and ensure safety of life and property at sea. Bangladesh Coast Guard was established in 1995 following the Coast Guard Act 1994 (Bangladesh Coast Guard, 2018). Bangladesh Coast Guard is under the administration control of the Ministry of Home Affairs but has strong affiliation with the ministry of defence because of the function and origin. Bangladesh Coast Guard acts with the Motto of 'Guardian at sea'. Bangladesh Coast Guard carries out an array of civil and military responsibilities touching almost every facet of the Bangladesh maritime environment. It has been vested for ensuring maintenance of overall law and order situation by protecting national maritime borders and coastal area from piracy, illegal fishing, exploration of oil and gas, forest preservation including protection from marine pollution and port security. But a limited number of staffs and lack of adequate modern technologies and equipment makes shackles to perform their duties properly.

11.6.4.3 Bangladesh Space Research and Remote Sensing Organization (SPARRSO)

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) was established in 1980 and re-organised in 1991. This organization deals with space and remote sensing, forestry and environment, agriculture, fisheries, geology, cartography, water resource, land use, weather, geography and oceanography. Geology and oceanography are two focal aspects of the Organizarion (Bangladesh Space Research Organization, 2018). It provides necessary information and disseminates research results to the Government and different relevant user agencies to take necessary action to prevent any natural calamity either on land or in water. SPARSO conducts training, technical research, survey and monitor on space and remote sensing technology and cooperates national or international organization or institutes in the relevant matter. However, the Organization needs to be equipped with more modern technologies to ensure standard and effective service.

11.6.4.4 Bangladesh Meteorological Department

Bangladesh Meteorological Department is a scientific and technical institution of the Ministry of Defence. The Department provides information relating to weather and climate to other countries through its high modern Global Telecommunication System (GTS). The Department has five radar stations which accelerates weather and marine forecast. It provides marine warning based on composite and analysis process. The Department is connected with Wide Area Network (WAN). The Department is also affiliated with the Regional Tsunami Service Providers, which will accelerate to take emergency protection against natural calamity (Bangladesh Meteorological Department, 2018). The Department applies Storm Surge Model (IIT-D and MRI model) and Wave Model. Furthermore, the Department is implementing Coastal Inundation Forecasting Demonstration Project for Bangladesh (CIFDP-B) (B. M. Department, 2018). The Department has a substantial focus on Marine Warning for fishing troller in the coastal area of the Bay of Bengal; marine warning for sea going ships and fishing boat; marine warning for merchant shipping.

11.6.4.5 Survey of Bangladesh

Survey of Bangladesh (SOB) is the national mapping organization of Bangladesh. It has established Digital Mapping Center, modern printing press and Geodetic Detachment. In order to determine Mean Sea Level (MSL) for the country, it has established a Tidal Station at Rangadia, Chittagong. SOB maintains triangulation stations; and preparation of trigonometrical pamphlets as permanent record of Geodetic Control points for future use and references. Demarcation of International boundary lying in different Hilly areas is the responsibility of Survey of Bangladesh. It prepares special Maps for different Departments like Geological Survey and soil Survey, which reconcile functional coordination among

those departments. Although SOB has limited manpower and old equipment, it has acquired a remarkable progress in surveying and mapping activities in Bangladesh (Survey of Bangladesh, 2018). SOB may be a crucial entity to conduct and maintain marine survey in Bangladesh.

11.6.5 Institutional arrangements for Marine Environment and sustainable tourism

The Ministry of Environment and Forest is the responsible body for protecting and conserving environment in Bangladesh. The Ministry works to ensure sustainable environment and forest through conservation of ecosystem and biodiversity; controlling environmental pollution; addressing climate change; research, floristic survey; and development of environment. The organizational structure of the ministry includes a number of divisions, directorate, board, subordinate offices, autonomous institutions and public-sector undertakings (Ministry of Forest and Environment, 2018).

On the other hand, the Ministry of Civil Aviation and Tourism is the concerned and apex entity for dealing with all aspects of sustainable tourism. The Ministry was created in 1975 with two divisions, namely, Civil Aviation and Tourism. Tourism division has functional coordination with Bangladesh Tourism Board and Bangladesh Porjoton Corporation.

11.6.5.1 Department of Environment

The Department of Environment (DoE) was established in 1977 under the Environment Pollution Control Ordinance, 1977 (Department of Environment, 2018). The DoE has been placed under the Ministry of Forest and Environment as its technical wing which is statutorily responsible for the implementation of the Environment Conservation Act, 1995. The Department is the nodal agency in the administrative structure for the planning, promotion, co-ordination and overseeing the implementation programmes. The Department discharges its responsibilities through a head office and six Divisional offices. Moreover, the Government has been set up new offices at district level. However, the Department does not any specific wing for protecting marine environment. Absence of any specific legislative framework is considered the main reason behind the institutional gap for protection of marine environment in Bangladesh.

11.6.5.2 Bangladesh Climate Change Trust

Bangladesh Climate Change Trust (BCCT) is a statutory body formed under Climate Change Trust Act, 2010 to administer Climate Change Trust Fund (CCTF). BCCT is entrusted with the overall management of Climate Change Trust Fund (CCTF) including the release of funds for the projects approved by the Trustee Board. It coordinates with the Climate Change Focal Points of different ministries/divisions, communicates with concerned stakeholders including civil society, NGO, private sector and international agencies (Bangladesh Climate Change Trust, 2018). But BCCT has little concern about the climate change aspect in ocean, for example, ocean acidification. The ocean acidification is a major threat for climate chance all over the world which should be a major agenda for BCCT.

11.6.5.3 Bangladesh Tourism Board

Since its inception in 2010, the Bangladesh Tourism Board has been resolutely promoting a positive image of Bangladesh to the world by its promotion & marketing for tourism. The Functions of the Tourism Board are: adoption of national policy and recommend for implementing government plan related to tourism; suggesting on development of tourism; making attractive tourism area and creating public awareness; coordinating among government, private and local agencies; cooperate and maintain lianzo with foreign tourism industry and agencies; establishing and providing training for improving and development of tourism sector; and preparing database for tourism in Bangladesh (Banglaldesh Tourism Board, 2018). The Board is conducting research work through its enlisted agency MEL-CEMS Joint Venture. But the Board has minimum concern about the marine environment. A joint collaboration of the Board with the Department of Environment is essential to confirm sustainable marine tourism.

11.6.5.4 Bangladesh Porjoton Corporation

Bangladesh Porjoton Corporation is a national tourism agency in Bangladesh. The Corporation was established in 1972 and started its activities from 1973. The Corporation is an autonomous body working under the administrative control of the Ministry of Civil Aviation and Tourism. National Hotel and Tourism Training Institute (NHTTI) works under the supervision of the Corporation. The main function of the Corporation is to facilitate and develop tourism sector in Bangladesh (Bangladesh Porjoton Corporation, 2018). However, the Corporation is far away to explore marine tourism and providing world standard facility for tourist.

The current institutional arrangements in Bangladesh are significantly lack of integration, coordination and efficiency for effective management of Blue Economy activities. Moreover, some specialized institutions are essential to coup with the special aspects of Blue Economy. Nowhere it is reflected that the institutional arrangements under existing legislations and policies can confirm sustainable ocean governance to achieve the benefit of Blue Economy. Introduction of MSP can play an important role as a way forward to achieve the benefit.

11.7 Marine spatial planning as a way forward

As reflected in this chapter, the central challenge remains for Blue Economy is the integration of various departments and sectors in a comprehensive and cohesive plan, with ecosystems as the central framework (World Bank Group, 2017). MSP helps to achieve ecological benefits through the Ecosystem-based management (Hassan, 2013). MSP accelerates this integration among the relevant departments and brings on a common platform. MSP provides the strategy and framework to bring all relevant Sectors on a platform and to engage the Stakeholders in the ocean management process. MSP promises a forward-looking, strategic and integrated approach for allocating ocean space to different activities within the bounds of ecological limits and on an equitable basis (Young, 2015). MSP brings integrated and multi-objective, strategic and future oriented, and continuous and adaptive policy to use all marine resources for sustainable blue growth (Hussain, Failler, Karim, Alam, et al., 2017). MSP helps to identify and bring the relevant stakeholders; categorizes the potential means of addressing the concerns surrounding regulatory complexity on a more systemic level.

A long-time and strategic policy is a sin-qua-non- to explore Blue Economy. Strategic policy (master plan) controls the process, monitoring, evaluation, capacity building and outcome. Non-operative and theoretical action plan without analyzing the practical aspects is another barrier towards sustainable Blue Economy(Alam,2016). MSP accelerates the preparation of a comprehensive plan or policy document, often referred to as the master plan, which describes the vision for the future spatial development of the marine area (Douvere & Ehler, 2009). MSP has become an essential tool for identifying and utilizing marine spaces, and for drawing up plans for sustainable ocean governance (Hassan & Haque, 2015).

Blue economy needs a strong legislative framework to formulate appropriate body and rules to achieve the benefit of Blue Economy. Any confusion and uncertainty under multiple laws are not coordinated, and may possess conflict with each other, and thus creates the regulatory complexity and time spent trying to navigate the labyrinth of potentiality (Douvere & Ehler, 2009). MSP necessitates an umbrella legislation to avoid multiplicity of regulatory mechanism, for example, the Great Barrier Reef Marine Park Act 1975. The Great Barrier Reef Marine Park Act 1975 coupled with other subsequent supportive regulations fulfils its promise of delivering a more rational system for the use of the ocean resources (Douvere & Ehler, 2009). MSP, through this long-term vision and consistent mechanism, provides legal certainty, predictability, transparency and direction for the future development of an ocean area (Douvere & Ehler, 2009).

Collective and coordinated engagement of relevant stakeholders is a pre-requisition for smooth visualization of Blue Economy. Inter and intra coordination between academia-industry, public-private, resource-responsibility, and time-space are essential to bring forward the relevant departments related

to blue economy development (Hussain, Failler, Karim, & Alam, 2017b). MSP is a proven tool to override this challenge of coordination among the relevant departments and sectors. Engaging stakeholders is essential to understanding their objectives, and it increases information and capacity for economic development (Burgess et al., 2018). Inter-ministerial coordination is very much vital to bring forward all the relevant developmental issues related to blue economy (Hussain, Failler, Karim, Alam, et al., 2017).

Overlapping and conflicting activity is the main stream barrier towards development of Blue Economy. Conflicting human activities is significantly serious in case of dealing with ocean resources, which can explore irreversible loss to the marine environment and ecosystem. MSP designates ocean spaces for specific uses (Hussain, Failler, et al., 2017a), which avoid conflicting activities. MSP is the quinine for mediating conflicts and overlapping function in ocean management. Moreover, the primary appeal of MSP is to harmonise and coordinate the currently fragmented management regimes (Backer, 2011). MSP works from the assumption that planning can help alleviate stakeholder conflicts, thus turning an otherwise zero-sum game into one that can mutually benefit all groups (Smith & Jentoft, 2017). MSP makes a reconciliation among the conflicting users by a balance between economic and environmental interest. MSP prescribes an improved planning and management system for protecting marine ecosystem health and services, which emphasizes a balance between economic development and marine environmental conservation (Hassan, 2013).

MSP organizes the uses of the sea's resources in ways that will protect ecosystem for now and the future (Hassan & Haque, 2015). The realization that the sustainable management of ocean resources requires collaboration across nation-states and across the public-private sectors, and on a scale, that has not been previously achieved (World Bank Group, 2017). Transboundary MSP is an ideal approach to address the sustainable use of transnational marine resources. Transboundary MSP provides for a holistic approach to sustainable sea use management (Hassan & Haque, 2015). Negotiation for transboundary MSP is likely to emerge only after the development of MSP at national level to make it more effective (Backer, 2011).

11.8 Conclusion

Sustainable use of ocean resources is the core content of Blue Economy, which makes a balance between economic growth and environmental protection. Ocean is considered as a very useful space under Blue Economy concept where sustainable development goal 14 requires conservation of ocean through sustainable use of ocean resources. Sustainability of ocean to maintain long-term capacity of ocean to produce natural resource is also the key aspect of sustainable ocean governance. Both Sustainable ocean governance and Blue Economy require rational human activities in a coordinated and integrated management approach. From management perspective, Sustainable ocean governance is a pre-condition for Blue Economy.

Blue Economy protects and maintains the production of ocean in a long-time capacity of ocean ecosystem. The Ecosystem approach confirms preservation of functions, structures and services of ocean ecosystem. Ecosystem-based management provides not only an environmental protection but also the implementation of Blue Economy through sustainable use of ocean resources. In that context, MSP has become an essential tool for implementing Ecosystem-based Management which accelerates multidimensional uses of ocean space without any conflict among the users. Zoning also plays a crucial role in managing conflicting ocean activities through the application of MSP.

Multidimensional uses of ocean require identifying and engaging a number of departments for integrated institutional arrangements for coordinated management of Blue Economy activities. The current institutional arrangements in Bangladesh is based on sector by sector management approach, which is insufficient for sustainable ocean governance and effective management of Blue Economy activities. The current institutional arrangements are not integrated and coordinated, which will create a number of challenges in operation of economic activities in ocean. MSP is an ideal tool to adopt

integrated institutional arrangements through uniform legal framework in Bangladesh. A uniform and codified legislation will accelerate to build up a comprehensive, integrated and coordinated management system to use ocean resources in the Bay of Bengal. The uniform legislation should focus on the institutional arrangements for Blue Economy activities. Moreover, Bangladesh needs a comprehensive ocean policy based on sustainable ocean management system. A considerable attention needs to be given to introduce MSP to make the ocean policy comprehensive as well as to achieve the benefit of Blue Economy.

11.9 References

Alam, M. A. (2016). Marine Spatial Planning: Bangladesh Perspective. *Asia Pacific Journal of Energy and Environment, 3*(1). doi:journals.abc.us.org/index.php/apjee/article/download/870/pdf_8

Backer, H. (2011). Transboundary maritime spatial planning: a Baltic Sea perspective. *Journal of Coastal Conservation, 15*(2), 279-289. doi:10.1007/s11852-011-0156-1

Bangladesh Marine Academy. (2018). Welcome to Bangladesh Marine Academy Retrieved from http://macademy.gov.bd/welcome-to-bangladesh-marine-academy/

Bangladesh Tourism Board. (2018). National Tourism Policy. Retrieved from http://www.tourismboard.gov.bd/wp-content/uploads/2015/09/National-Tourism-Circular-2010.pdf

Bangladesh Energy Regulatory Commission. (2018). Functions. Retrieved from http://www.berc.org.bd/site/page/36c5ee50-6ddc-4439-b66f-32445a1b7378/-Functions

Bangladesh Fisheries Development Corporation. (2018). Aboud Bangaldesh Fisheries Development Corporation. Retrieved from http://www.bfdc.gov.bd/

Bangladesh Porjoton Corporation. (2018). Citizen Charter. Retrieved from http://parjatan.portal.gov.bd/sites/default/files/files/parjatan.portal.gov.bd/charter_of_duties/be7b62aa_5c2c_4057_92c3_1d9dc7ab28e2/Citizen%20Chater%20of%20BPC.pdf

Bangladesh Shipping Corporation. (2018). About us. Retrieved from http://bsc.portal.gov.bd/

Bangladesh Materological Department. (2018). Citizen Charter of BMD. Retrieved from http://www.bmd.gov.bd/?/p/=Citizen-Charter-of-BMD

Bangladesh Navy.(2018). About BN. Retrieved from https://www.navy.mil.bd

Bangladesh Hydrocarbon Unit. (2018). About. Retrieved from http://www.hcu.org.bd/site/page/0bacba2b-5d85-426e-9a81-c06538be1fe8/About-Us

Bangladesh Coast Guard. (2018). Aim and Purpose Retrieved from http://coastguard.gov.bd/site/page/e47f5581-c68f-4584-8867-970e1a34a0f6/Aim-and-Purpose

Bangladesh Fisheries Institute. (2018). Abous Bangladesh Fisheries Institute. Retrieved from http://www.fri.gov.bd/

Bangladesh Marine Fisheries Academy. (2018). About Marine Fisheries Academy. Retrieved from http://www.mfacademy.gov.bd/en/

Bangladesh Climate Change Trust. (2018). Citizen Charter. Retrieved from http://www.bcct.gov.bd/site/office_citizen_charter/620dfa62-c307-456c-9aa5-c2407ae8981e/Citizen-Charter

Bari, A. (2017). Our Oceans and the Blue Economy: Opportunities and Challenges. *Procedia Engineering, 194*(Supplement C), 5-11. doi:https://doi.org/10.1016/j.proeng.2017.08.109

Burgess, M. G., Clemence, M., McDermott, G. R., Costello, C., & Gaines, S. D. (2018). Five rules for pragmatic blue growth. *Marine Policy, 87*, 331-339. doi:https://doi.org/10.1016/j.marpol.2016.12.005

Burnes, K. I. (2007). VIEWPOINT. *Planning, 73*(3), 54-54.

Chittagong Port. (2018). Port Management Retrieved from http://www.cpa.gov.bd/site/page/0c701941-5364-4a62-ab32-90b793172c9e/Functions-of-Port-Management

Davies, I. M., Watret, R., & Gubbins, M. (2014). Spatial planning for sustainable marine renewable energy developments in Scotland. *Ocean & Coastal Management, 99*, 72-81. doi:https://doi.org/10.1016/j.ocecoaman.2014.05.013

Day, J. C. (2002). Zoning—lessons from the Great Barrier Reef Marine Park. *Ocean & Coastal Management, 45*(2), 139-156. doi:https://doi.org/10.1016/S0964-5691(02)00052-2

Department of Fisheries. (2018). About Department of Fisheries. Retrived from http://www.fisheries.gov.bd/site/page/43ce3767-3981-4248-99bd-d321b6e3a7e5/Background

Department of Environment. (2018). Facts about DoE. Retrieved from http://www.doe.gov.bd/site/page/03f09d82-fb8f-4952-b9cc-c46064635e3b/Brief-of-DoE

Department of Shipping. (2018b). Seamen Welfare Directorate & Emigration Directorate. Retrieved from https://www.dos.gov.bd/about-us/seamen-welfare-emigration-directorate/

Dietz, T., Ostrom, E., & Stern, P. C. (2003). The Struggle to Govern the Commons. *Science, 302*(5652), 1907-1912.

Division, S. R. E. D. A. P. (2018). Function. Retrieved from http://www.sreda.gov.bd/index.php/site/page/ea5e-cdac-19fd-2767-44be-4791-34ff-4c3d-4039-0194

Domínguez-Tejo, E., Metternicht, G., Johnston, E., & Hedge, L. (2016). Marine Spatial Planning advancing the Ecosystem-Based Approach to coastal zone management: A review. *Marine Policy, 72*(Supplement C), 115-130. doi:https://doi.org/10.1016/j.marpol.2016.06.023

Douvere, F. (2008). The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy, 32*(5), 762-771. doi:https://doi.org/10.1016/j.marpol.2008.03.021

Douvere, F., & Ehler, C. (2009). Ecosystem-Based Marine Spatial Management: An Evolving Paradigm for the Management of Coastal and Marine Places. *Ocean Yearbook Online, 23*(1), 1-26. doi:doi:https://doi.org/10.1163/22116001-90000188

Douvere, F., & Ehler, C. N. (2009). New perspectives on sea use management: Initial findings from European experience with marine spatial planning. *Journal of Environmental Management, 90*(1), 77-88. doi:https://doi.org/10.1016/j.jenvman.2008.07.004

Ehler, C., & Douvere, F. (2009). Marine Spatial Planning: a step-by-step approach toward ecosystem-based management. *Intergovernmental Oceanographic Commission Manual and Guides*(53, ICAM Dossier No. 6).

Frazão Santos, C., Orbach, M., Calado, H., & Andrade, F. (2015). Challenges in implementing sustainable marine spatial planning: The new Portuguese legal framework case. *Marine Policy, 61*, 196-206. doi:https://doi.org/10.1016/j.marpol.2015.08.010

Government Shipping Office. (2018). Citizen Charter. Retrieved from http://www.gsb.gov.bd/site/office_citizen_charter/1312794e-bced-4cc5-8f5f-800427654b1f/Citizen-Charter

Government Shipping Office. (2018). About GSO. Retrieved from http://gso.gov.bd/

Goddard, C. (2015). The Blue Economy: Growth, opportunity and a sustainable ocean economy. *Economist Intelligence Unit*. doi:http://www.greengrowthknowledge.org/resource/blueeconomy-growth-opportunity-and-sustainable-ocean-economy

Godfrey, S. S. (2016). Defining the Blue Economy. *Maritime Affairs: Journal of the National Maritime Foundation of India, 12*(1), 58-64. doi:10.1080/09733159.2016.1175131

Harris, L. R., Nel, R., Oosthuizen, H., Meÿer, M., Kotze, D., Anders, D., . . . Bachoo, S. (2017). Managing conflicts between economic activities and threatened migratory marine species toward creating a multiobjective blue economy. *Conservation Biology*, n/a-n/a. doi:10.1111/cobi.12992

Hassan, D. (2013). The Great Barrier Reef -Marine Spatial Planning-. *Environmental Policy and Law, 43*(4-5), 259-269.

Hassan, D., & Haque, E. (2015). Marine Spatial Planning in the Bay of Bengal Sub-region in South Asia. In D. Hassan, T. Kuokkanen, & N. Soininen (Eds.), *Transboundary Marine Spatial Planning and International Law* (pp. 202-218). United Kingdom: Routledge

Hussain, M. G., Failler, P., Karim, A. A., & Alam, M. K. (2017a). *Opportunities and Constraints of Blue Economy Development in Bangladesh*, Dhaka, Bangladesh.

Hussain, M. G., Failler, P., Karim, A. A., & Alam, M. K. (2017b). Review on opportunities, constraints and challenges of blue economy development in Bangladesh. *Journal of Fisheries and Life Science, 2*(1), 45-57.

Hussain, M. G., Failler, P., Karim, A. A., Alam, M. K., & Todorova, V. (2017). Major opportunities of blue economy development in Bangladesh. *Journal of the Indian Ocean Region*. doi:10.1080/19480881.2017.1368250

IUCN.(2012). *For an Effective and Sustainable Ocean Governance* Retrieved from https://www.iucn.org/sites/dev/files/import/downloads/position_paper_on_oceans_eng_1.pdf

Kenchington, R. A., & Day, J. C. J. (2011). Zoning, a fundamental cornerstone of effective Marine Spatial Planning: lessons learnt from the Great Barrier Reef, Australia. *Journal of Coastal Conservation, 15*(2), 271–278. doi:https://doi.org/10.1007/s11852-011-0147-2

Kirk, E. A. (2015). The Ecosystem Approach and the Search for An Objective and Content for the Concept of Holistic Ocean Governance. *Ocean Development & International Law, 46*(1), 33-49. doi:10.1080/00908320.2015.988938

Mercantile Marine Department. (2018). About us. Retrieved from http://mmd.gov.bd/

Ministry of Forest and Environment. (2018). Citizen Charter. Retrieved from http://moef.portal.gov.bd/sites/default/files/files/moef.portal.gov.bd/charter_of_duties/eccf59c6_177d_4525_8b46_e531aebd1991/Citizen%20Charter%20Corrected%2028-10-2015-%20Unicode%20(1).pdf

Ministry of Foreign Affairs. (2014). Acheivement of Ministry of Foreign Affairs Retrieved from http://mofa.portal.gov.bd/sites/default/files/files/mofa.portal.gov.bd/page/8ae0d605_279f_4ad0_925e_93346417bd9b/One%20and%20half%20year%27s%20acheivement.pdf

Ministry of Power, Energy and Mineral Resources. (2018a). About. Retrieved from https://mpemr.gov.bd/

Ministry of Power, Energy and Mineral Resources. (2018b). Energy and Mineral Resources Division. Retrieved from https://mpemr.gov.bd/power/details/80

Ministry of Shipping. (2018). About Ministry. Retrieved from http://www.mos.gov.bd/

Mongla Port. (2018). Port Management Retrieved from http://www.mpa.gov.bd/site/page/b470dce1-264b-4ecc-8ff6-e7f6ae621989/Port-Management

National Maritime Institue. (2018). Citizen Charter Retrieved from http://www.nmi.gov.bd/site/office_citizen_charter/662f1544-2673-4cc8-9a7a-7998f65fe694/Citizen-Charter

Payra Port. (2018). Welcome to Payra Port. Retrieved from http://www.ppa.gov.bd/site/page/baa1e3c7-9aaa-41ce-92be-b8fa8eb38582/Welcome-to--Payra-Port-

PETROBANGLA. (2018). Welcome to Petrobangla Retrieved from https://www.petrobangla.org.bd/

Pyc, D. (2016). Global Ocean Governance. TransNav: International Journal on Marine Navigation and Safety of Sea Transportation, 10(1), 159-162.

Roberts, J. (2016). The Blue Economy Progress on the Development of the Blue Economy in Seychelles.

SPARSO. (2018). Introduction to SPARRSO. Retrieved from http://www.sparrso.gov.bd/site/page/2e25fc8a-d381-4b9f-be97-afde3425f308/Introduction-to-SPARRSO

Smith, G., & Jentoft, S. (2017). Marine spatial planning in Scotland. Levelling the playing field? *Marine Policy, 84*, 33-41. doi:https://doi.org/10.1016/j.marpol.2017.06.024

Survey of Bangladesh. (2018). Functions. Retrieved from http://www.sob.gov.bd/site/page/b90704d1-b45a-4f15-914b-c9fe980f7eaa/Function

The Economist Intelligence Unit. (2015). *The Blue Economy: Growth, opportunity and sustainable Ocean economy.* Retrieved from http://www.eiuperspectives.economist.com/sustainability/blue-economy/white-paper/blue-economy?redirect=TRUE

The World Bank. (2017). What is the Blue Economy? Retrieved from http://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy

United Nations Global Compact. (2016). Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Retrieved from https://sdgcompass.org/wp-content/uploads/2016/04/Goal_14.pdf

United Nations. (2014). *Blue Economy Concept Paper*. Retrieved from https://sustainabledevelopment.un.org/content/documents/2978BEconcept.pdf

United Nations. (2015). Sustainable Development Goals. Retrieved from https://sustainabledevelopment.un.org/sdg14

United Nations. (2016). The Sustianable Development Agenda. Retrieved from https://www.un.org/sustainabledevelopment/development-agenda/

United Nations. (2017). Sustainable blue economy. Retrieved from https://oceanconference.un.org/coa/BlueEconomy

UNCTAD. (2014). The Oceans Economy: Opportunities and Challenges for Small Island Developing States (SIDS), United Nations, Geneva.

United Nations General Assembly. (2006). *Report of the Secretary General, Oceans and the Law of the Sea, paragraph 107*. Retrieved from https://documents-dds-ny.un.org/doc/UNDOC/GEN/N06/265/87/PDF/N0626587.pdf?OpenElement

Vallega, A. (2000). *Sustainable Ocean Governance: A Geographical Perspective*. London, UNITED KINGDOM: Taylor and Francis.

WWF Global. (2015). *Principles for a Sustainable Blue Economy*. Retrieved from http://d2ouvy59p0dg6k.cloudfront.net/downloads/15_1471_blue_economy_6_pages_final.pdf

World Bank Group. (2017). The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. Retrieved from https://sustainabledevelopment.un.org/content/documents/15434Blue_EconomyJun1.pdf

Young, M. (2015). Building the Blue Economy: The Role of Marine Spatial Planning in Facilitating Offshore Renewable Energy Development. *International Journal of Marine and Coastal Law, 30*(1), 148-174. doi:10.1163/15718085-12341339