Blue economic development in Bangladesh: A policy guide for marine fisheries and aquaculture

Technical Report · August 2017

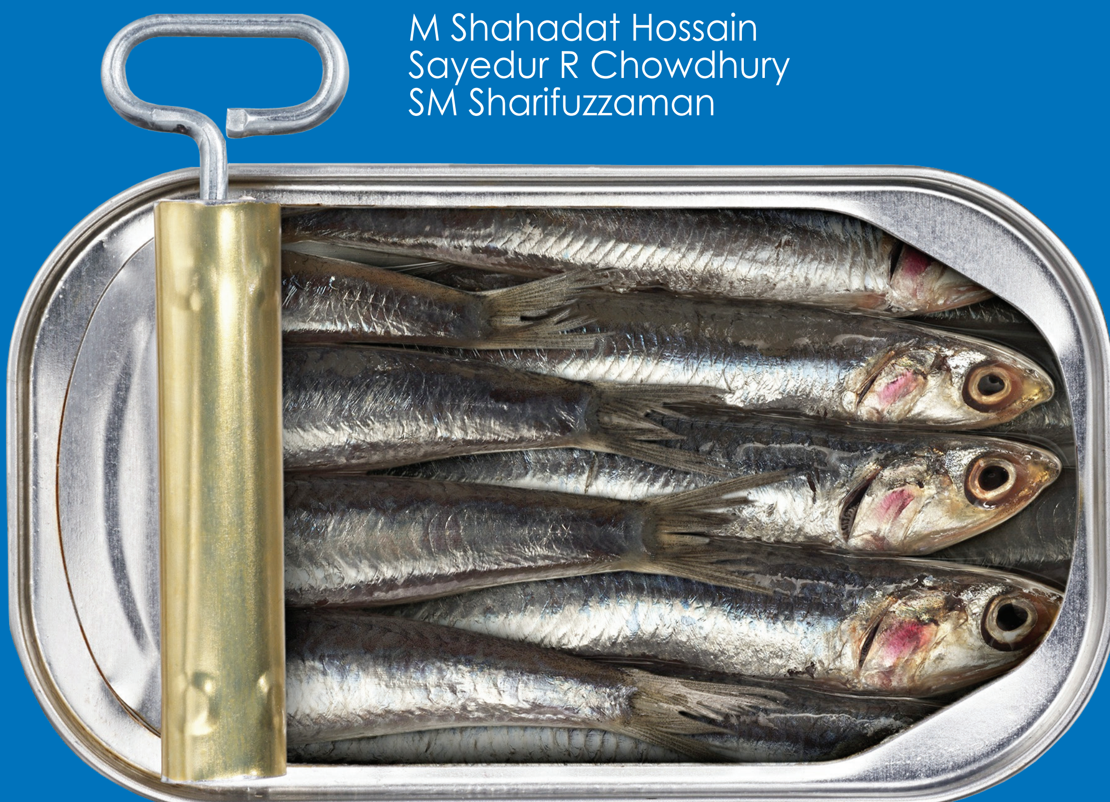
M. Shahadat Hossain
University of Chittagong

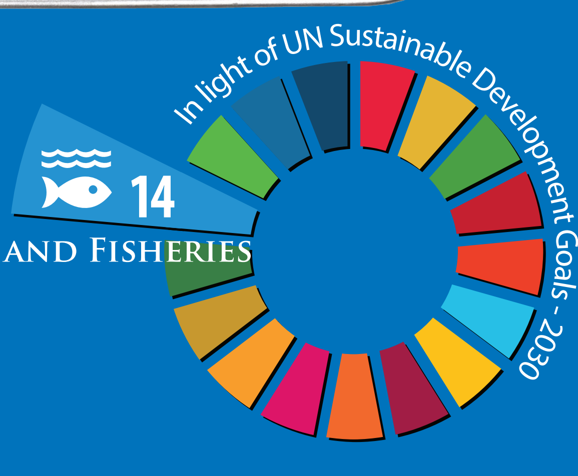
Blue Economic Development in Bangladesh

A policy guide for marine fisheries and aquaculture

From the authors of the ***7th 5-year Plan*** background study
Strategy for Ocean and River Resources Management (2014)

M Shahadat Hossain
Sayedur R Chowdhury
SM Sharifuzzaman





INSTITUTE OF MARINE SCIENCES AND FISHERIES
UNIVERSITY OF CHITTAGONG

August 2017

Blue Economic Development in Bangladesh

A policy guide for marine fisheries and aquaculture

From the authors of the ***7th 5-year Plan*** background study
Strategy for Ocean and River Resources Management (2014)

M Shahadat Hossain
Sayedur R Chowdhury
SM Sharifuzzaman

INSTITUTE OF MARINE SCIENCES AND FISHERIES
UNIVERSITY OF CHITTAGONG

August 2017

Publisher

The authors, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh.

ISBN

978-984-34-2845-5

Cover concept and design

Sayedur R Chowdhury

Front: Symbolizing marine fisheries development and value addition

Back: RV Meen Sandhani at sea (background), newspaper clippings of newly reported fish species from the Bay of Bengal (insets)

Printers

SAMS Creation, Anderkillah, Chittagong. Cell: 01711-760 988

Citation

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 pp.

M Shahadat Hossain is a Professor at the Institute of Marine Sciences and Fisheries of University of Chittagong, Bangladesh. He is involved in teaching and research in fisheries geoinformatics, aquaculture planning, blue economy development, coastal zone management, ecosystem-based approaches, climate change challenges, and coastal resilience modeling.

Sayedur Rahman Chowdhury is a Professor at the Institute of Marine Sciences and Fisheries of University of Chittagong, Bangladesh. His research interests span a wide range of topics in oceanography, marine fisheries survey, maritime climatology, remote sensing and GIS, coastal geomorphology, and coastal environmental changes.

SM Sharifuzzaman is an Associate Professor at the Institute of Marine Sciences and Fisheries of University of Chittagong, Bangladesh. His research interests center on aquaculture, fish/shellfish nutrition and diseases, marine biology and ecology, climate change adaptation, and marine biodiversity.

CONTENTS

Preface

The ocean, which covers 72% of our planet, is regarded as the earth's largest life support system due to its capacity for generating oxygen, absorbing carbon dioxide, providing food, recycling nutrients, regulating climate and so on. The oceanaire vision of our government has already set the context for inclusive economic growth and social development for 21st century. On the basis of pragmatic approach, ocean resource-based economy is being treated as the measuring scale of power, prosperity and peace from local and global perspectives as well.

Realizing the importance of ocean in our everyday lives, the University of Chittagong has started marine science education since 1971 by establishing the Institute of Marine Sciences and Fisheries (IMSF) and taking the advantages of promoting ocean-based research. IMSF is the only institute of its kind in Bangladesh that deals with marine biology, oceanography, marine fisheries and aquaculture, marine pollution, and relevant educational activities and research. Interestingly, recent settlements of maritime border disputes with neighboring countries have opened up opportunities to address blue economy development in Bangladesh. In this regard, IMSF has a leading role to play in the sustainable utilization and management of marine resources and services.

This document delineates new scope for venturing blue economy in a befitting manner and also emphasizing effective interventions in marine fisheries and aquaculture. The proposed ideas of our scholarly researchers are profound contribution to the growth of blue economy of the nation. I am extremely happy to see the sincere efforts of the scholars and do appreciate their innovativeness. I further would take this opportunity to urge upon and place my advices to the scholars to create more options and find ways to initiate collaborative programmes with local and international academic institutions. I believe this will not only benefit the students but also the researchers of the university and the globe at large.

I wish all the best of the researchers and the institute.

Professor Dr Iftekhar Uddin Chowdhury
Vice Chancellor
University of Chittagong
Chittagong, Bangladesh

Executive summary

Bangladesh, being a maritime country, needs to adopt the blue economy as a top priority to promote socio-economic growth. After the settlement of maritime border disputes with neighboring states, the country is now legitimately entitled to 118,813 km^2 of sea area, comprising the territorial sea and Exclusive Economic Zone, in the northern Bay of Bengal. There is wide shallow shelf region extending more than 100 nautical miles (185 km), which is 3–4 times wider than global average (65 km) provide a much greater shallow water fishing area per unit length of coastline.

The scope of blue economic development includes activities of marine fisheries, oil and gas, minerals, marine tourism, maritime trade, renewable energy, ship building and recycling, maritime human resources and related fields. Specifically, potential interventions in marine fisheries involve – (i) expansion of the commercial fishing area, which is currently taking place to a depth of 40 m for artisanal fishing and 40–100 m for trawl fishing, for harvesting high valued species (such as tuna, lakkha/threadfin) using high-tonnage vessel; (ii) introduction of new fishing gears and techniques, such as deepsea long-lines; (iii) exploration for new fishing grounds and fisheries; (iv) value addition and reducing post-harvest losses; (v) assessment of fish stocks, which was last carried out in the 1980s, for estimation of potential yields and optimum sizes of harvest from a fishery; and (vi) protection of fish spawning grounds, habitats and ecosystem-based fisheries management.

Coastal and marine aquaculture development largely relies on – (i) domestication of mariculture species, which is currently limited to only tiger shrimp, for product diversification (such as finfish: seabass, mullet, hilsa shad, grouper; crustaceans: penaeid shrimps, mud crab, lobster; molluscs: oyster, mussel; plants: seaweeds) and risk reduction (such as losses due to diseases) towards economic stability; (ii) production intensification and adoption of innovative fish/shellfish farming (such as marine cage culture, aquasilviculture, integrated multi-trophic aquaculture) for optimum use of natural resources and create additional business opportunities; (iii) live feeds (such as rotifers, artemia biomass) production for larviculture; and (iv) capacity building in marine biotechnology for breeding/genetic improvement of broodstock and developing novel aquatic health products, such as probiotics, immunostimulants, vaccines.

A thrust in blue economic growth may come through sustainable ocean governance involving necessary institutional set-up and management tools (such as coastal and marine spatial planning), skilled and knowledgeable workforce, and science-based planning and decision making. Maritime education is already underway since 1970s, and institutions such as the University of Chittagong, Bangladesh University of Engineering and Technology, Bangladesh Marine Academy, Marine Fisheries Academy, and National Maritime Institute are the oldest and unique of their kind. Thus, inclusion of marine and maritime human resources in the BCS cadre services has become a top priority for building a knowledge-driven blue economy to stimulate innovation and creative thinking. Climate change and associated phenomena such as sea-level rise, weather and climatic shift, changing rainfall patterns, extreme climate events, ocean acidification and hypoxia may directly or indirectly affect the blue economy, and thus mitigation and adaption options can help address climate change challenges.

While blue economy strategies are yet to be developed, the Government of Bangladesh has recently prepared a background paper titled ‘Strategy for Ocean and River Resources Management’ for the Seventh Five Year Plan (2016-2020) for an inclusive development and growth. The country, in particular, would be greatly benefited from the regional and global cooperation for growing its blue economy. Nevertheless, innovations and investments in marine fishing and harvesting methods, new mariculture technologies, marine biotechnology, R&D, and formulation of sound ocean development policy and effective ocean management including development of a strong human resource base are expected to contribute to the blue economic development in Bangladesh.

1. Marine system of Bangladesh

The Bay of Bengal (BoB), which shares many characteristics of the Indian Ocean, is a distinctive system due to shallow oceanic arm, thickest sediment deposits, fresh seas, turbid waters, coast for land reclamation, hotspot for tropical cyclones, seasonal reversal of ocean currents (clockwise in monsoon and anti-clockwise in winter), semidiurnal tides, well-oxygenated shallow waters (<200 m), rich biodiversity, and abundance of fisheries resources[1]. With a melange of characteristics like these, BoB also has some uniqueness in its fisheries and mineral resources, and economic prospects and challenges. Strategizing and planning for exploration, management and exploitation of the economic potential from BoB does, therefore, require well-proven approaches from other large Bays. Some of the important features of the Bay of Bengal are illustrated in Figure 1.

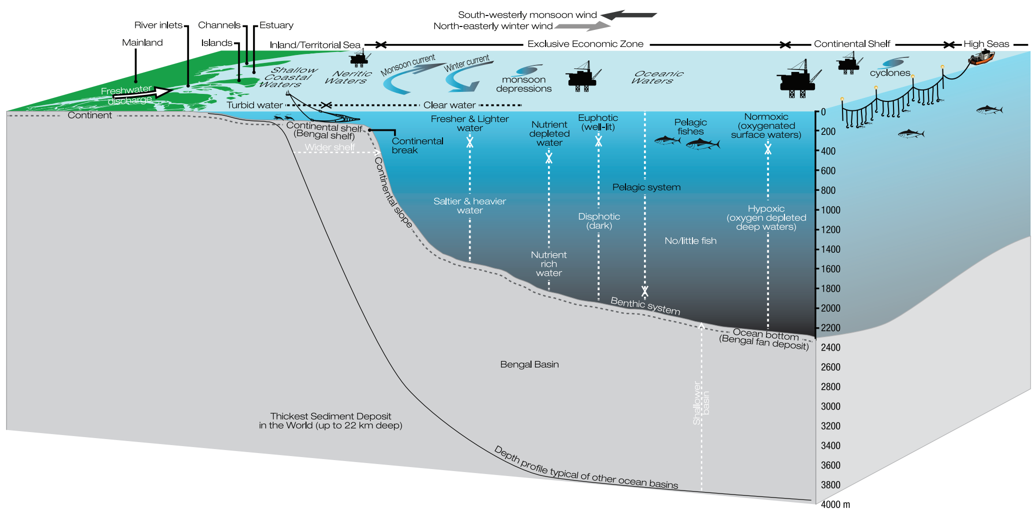


Figure 1. Salient characteristics of the marine system of Bangladesh. The actual depth profile of the Bay of Bengal (vertically exaggerated) and other elements not to scale (source: Hossain et al. 2014)[1]

After the settlement of maritime border disputes with neighboring states, Bangladesh is entitled to 118,813 km^2 of the Bay of Bengal, comprising her territorial sea and the Exclusive Economic Zone. The shallow coastal waters (including internal waters and estuaries) and the shallow shelf sea constitute about 20% and 35% respectively, while the rest (45%) belongs to deep water region. Also,

[1] Hossain et al. 2014. Background paper for preparation of the 7th Five Year Plan 2016-2020, Economic Relation Department, Ministry of Planning, The Government of Bangladesh, 67 pp.

Bangladesh has the widest shallow shelf region extending more than 100 nautical miles (185 km), 3–4 times wider than those of Myanmar, eastern coast of India and global average (65 km), providing a greater shallow bottom fishing area per unit length of coastline than the neighbors. Marine fishing activity is mostly carried out in the shallow coastal and shelf water areas, beyond which virtually no fishing is being currently operated due to lack of adequate capacity of fishing vessels and appropriate fishing technologies.

2. The blue economy and the SDGs

The oceans cover 72% of the surface of our planet and constitute more than 95% of the biosphere. They directly and indirectly support nearly all life on earth by generating oxygen, absorbing carbon dioxide, recycling nutrients, and regulating the global climate and temperature. In addition, oceans are crucial for global food security and human health. Thus, ocean resources are extremely important to the society and economy. *Blue economy is the utilization of ocean resources for increasing food security, improving nutrition and health, alleviating poverty, creating jobs, generating alternative energy, lifting seaborne trade and industrial profiles while protecting ecosystem health and biodiversity.* Globally, the blue economy represents 5.4 million jobs and generates a gross added value of almost €500 billion a year. For instances, China's ocean economy contributed US$962 billion or 10% of GDP in 2014, employing 9 million people. The US valued its ocean economy at US$258 billion or 1.8% of GDP in 2010. The estimate for Indonesia is 20% of GDP, which represents similar ratio to other low-middle-income countries with large ocean territories[2].

The United Nations has adopted ocean development as part of 17 Sustainable Development Goals (SDGs) and their associated 169 targets to achieve by 2030. Each goal is important itself and they are considered indivisible. SDG 14, by the name 'Life below water' includes 10 targets predominantly designed for the well-being of the oceans and the living resources therein. This component has strong linkages to other SGD components such as poverty, food, economic growth, cities, production and consumption, and climate (Figure 2)[3]. Oceans, seas and coastal areas form an integrated and essential component of the Earth's ecosystem and are crucial to sustainable development. Over three billion people worldwide depend on coastal

[2] The blue economy: Growth, opportunity and a sustainable ocean economy. An Economist Intelligence Unit briefing paper for the World Ocean Summit 2015. The Economist Intelligence Unit, London, 20 pp.

[3] ICSU (International Council for Science), 2017. A guide to SDG interactions: from science to implementation. ICSU, Paris, 239 pp. https://www.icsu.org/cms/2017/.

resources and as a place to live, work and take their leisure time. Thirteen out of 20 megacities of the world are located in coastal areas, whilst coasts represent some of the most vulnerable areas to climate change and the impacts of human activities. Likewise, an estimated over 35 million people live in the coastal zone of Bangladesh, and two of the three most populous places are coastal cities.

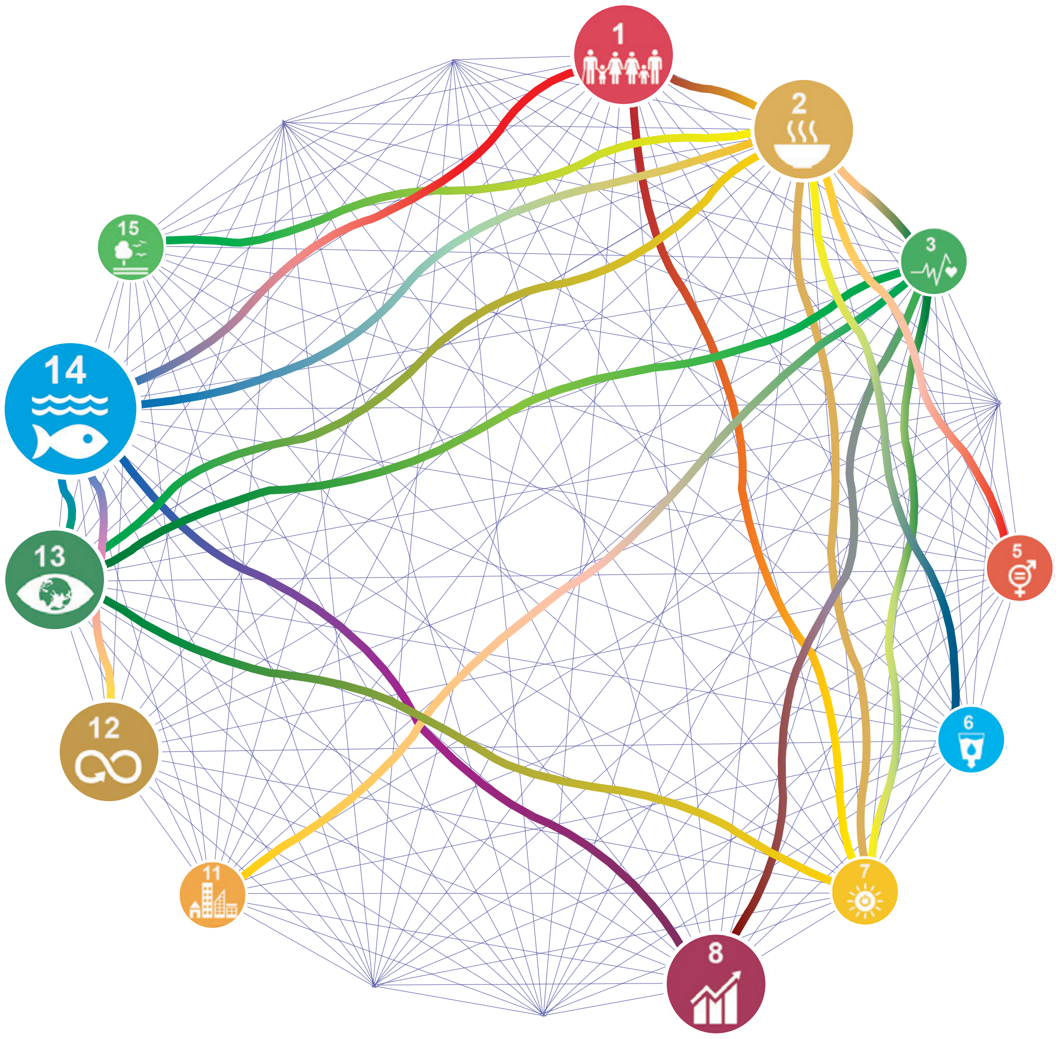


Figure 2. SDG 14 and its linkages to the blue economy and other SDGs (modified from ICSU 2017)[3]

3. Bangladesh's blue economy

The key areas of blue economic development in Bangladesh include marine fisheries, oil-gas and minerals, marine tourism, maritime trade, renewable energy, ship building and recycling, and maritime human resources with related activities (Figure 3). The uses of the seas and coasts have increased as traditional industries grows and as new industries emerges. A number of maritime activities are in the early stages of growth including shipping and commerce, producing skilled workforce, marine fishing, coastal aquaculture, coastal tourism, sea salt production and offshore oil/gas extraction (Figure 4). Industries such as shipbuilding, deep seaport operations and renewable energy are expected to grow in the next decade.

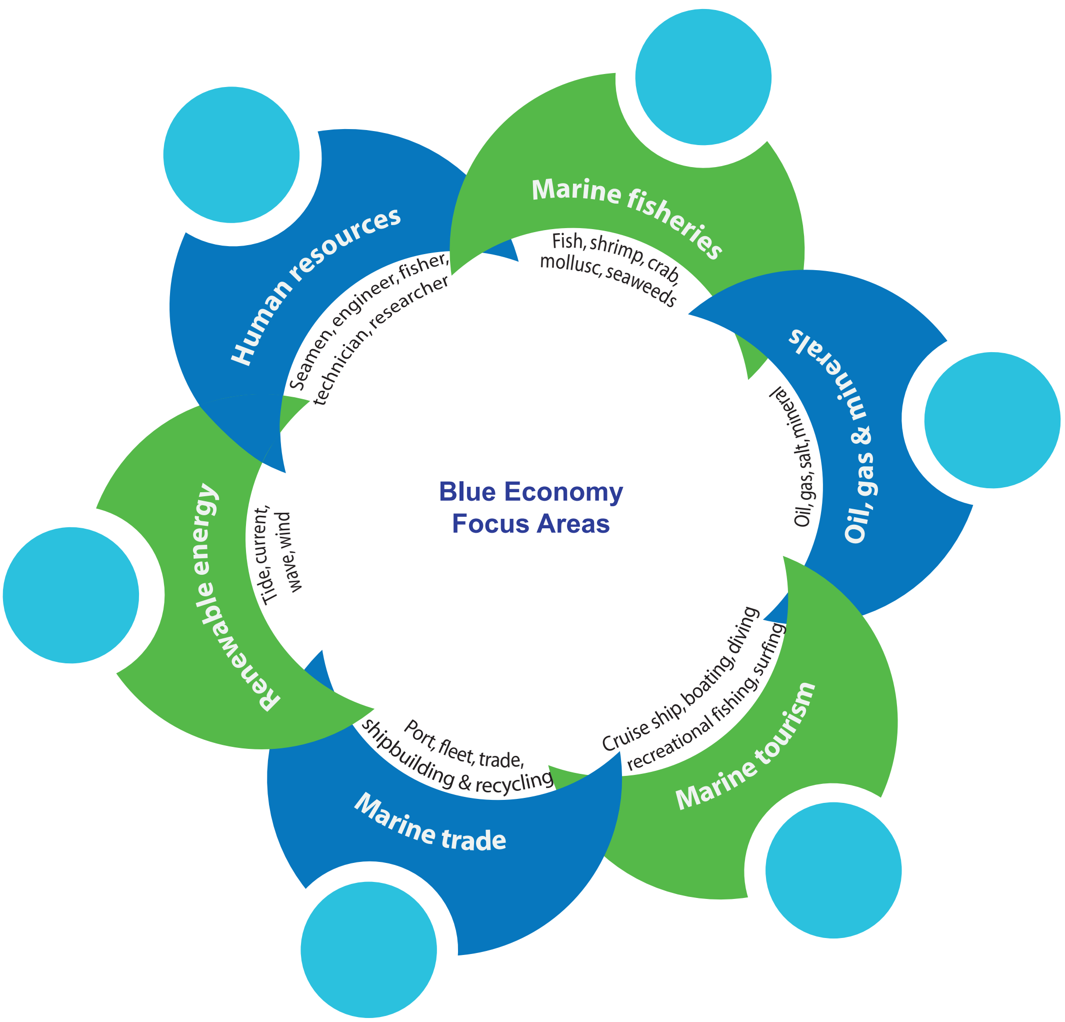


Figure 3. Major blue economy sectors of Bangladesh

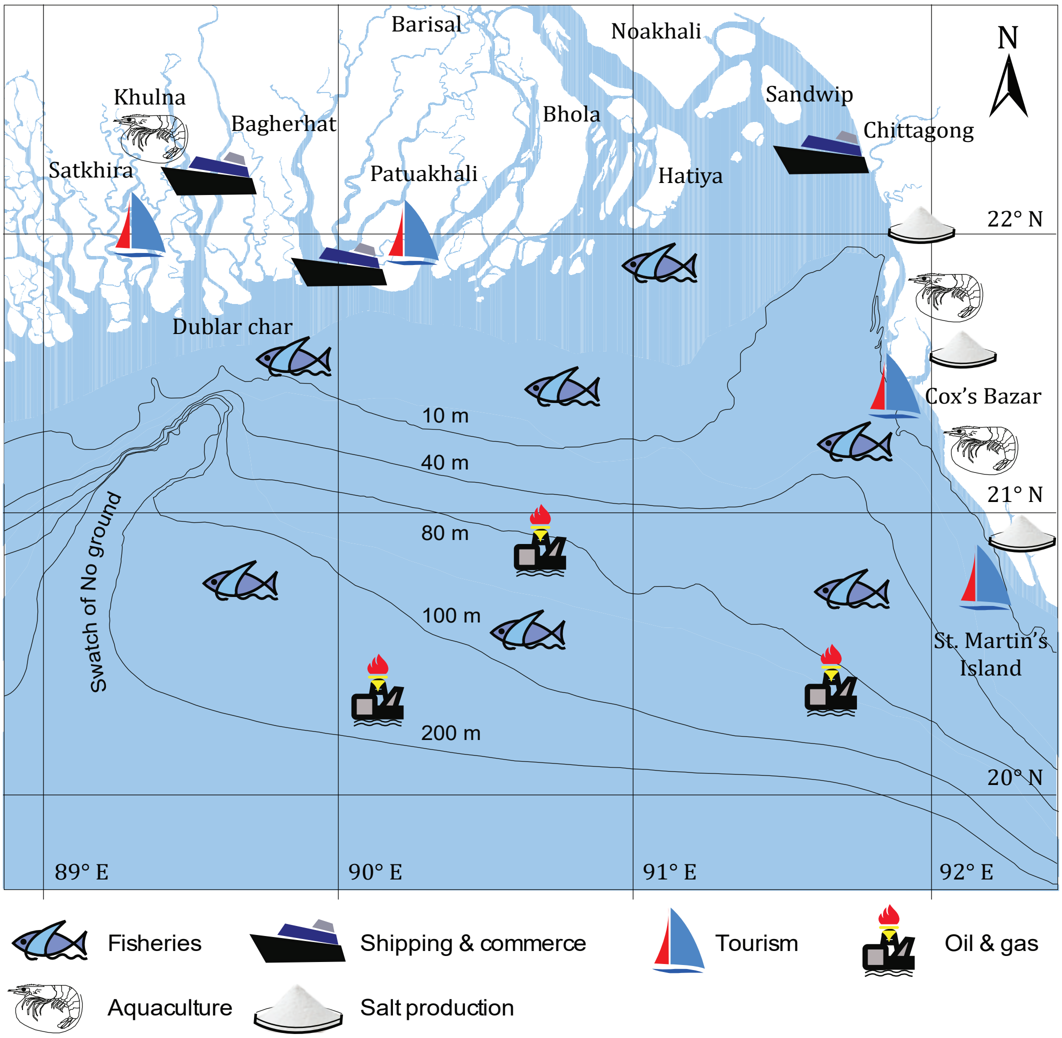


Figure 4. Blue economic activities in the coastal and maritime zones of Bangladesh

4. Marine fisheries and aquaculture interventions

4.1 Capture fishery

The marine fisheries sector contributes significantly to the country's food and nutrition security as well as economy through direct income, employment and foreign exchange. The activity accounts for 4.4% of national GDP, and supports ~22% to the agricultural GDP and <3% to the foreign exchange earnings through exports of fishery products[4]. There are ~1.4 million people in full-time employment and further 12 million

[4] DoF 2015. Department of Fisheries, Government of the People's Republic of Bangladesh. Available from: http://www.fisheries.gov.bd/node/143.

are employed part-time in this sector. Industrial trawl fishing is carried out in offshore areas and artisanal fishing (or subsistence fishing) is limited to near shore zones (Figure 5). Major food fishes include hilsa, tuna, sardine, seabass, snapper, pomfret, grouper, catfish, threadfin, bombay duck, hairtail, jewfish (Figure 6), and non-conventional fishery item consists of squid, octopus, lobster, oyster, mussel and seaweeds. Among the crustaceans, penaeid shrimps (brown shrimp, tiger shrimp, white shrimp) is the most dominant followed by some crab species (mud crab and swimming crab). In the subsequent sub-sections, interventions in fisheries are highlighted.

Figure 5. Coastal and marine capture fishing - industrial (left) and artisanal (right)

Figure 6. Some commercially important marine fish species

4.1.1 Extending the fishing horizon

Marine fishing is effectively limited to continental shelf region, i.e. a depth <200 m, but the majority fishing boats and vessels operate in the coastal areas within 40 m depth. The fishing grounds could be divided into five distinct zones (A-E), of which the nearest two zones (A and B) are subject to active fishing and the remaining zones (C, D and E) have the potential to provide new business opportunities (Figure 7). Starting from the coastline, up to a depth of 40 m and distance of 120 km is used by the artisanal fishers. The fishing zones extending up to 80 m depth and 170 km distance are for trawling. All other zones are either lightly fished or unexploited at present. Thus, there is scope of extending the fishing activities in deep waters and high seas, i.e. zones C, D, E and beyond.

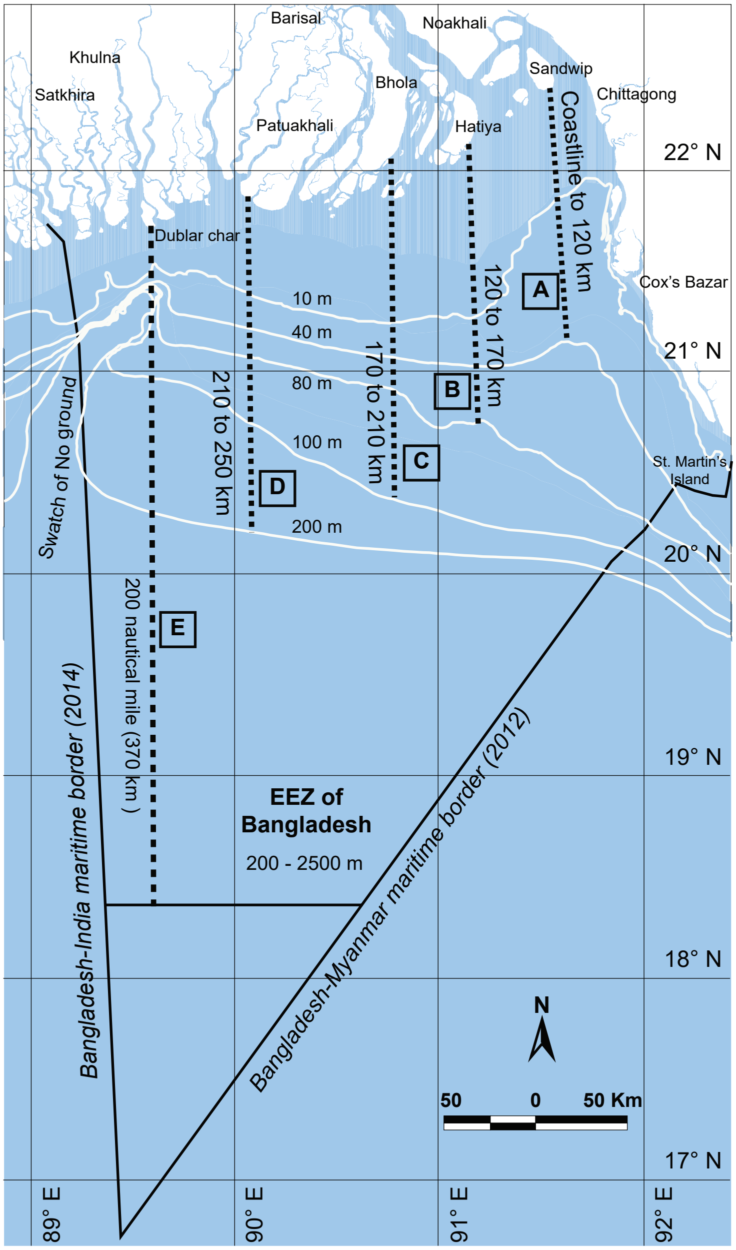


Figure 7. Marine fishing zones of Bangladesh

Note: 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).

4.1.2 New fishing gears and techniques

Current fishing practices are carried out with smaller tonnage vessels (e.g. <20 m length, <1000 HP, <250 GT) and selective gears. This is substantially limiting the scope of fishing across the geographic extent, i.e. specifically restricting the harvest of deepsea and distant water fishery resources occurring at depth >80 m and distance >170 km. It is, therefore, imperative to develop necessary capacity to venture into distant and deep water fishing with high-tonnage vessels (e.g. >50 m length, >2000 HP, >500 GT) using gears such as tuna long-lines and hooks (e.g. long liner 30-50 nautical mile, 1000-2000 hooks) (Figure 8). This would not only expand the fishing horizon on geographic front but also on technological, economic and nutritional fronts.

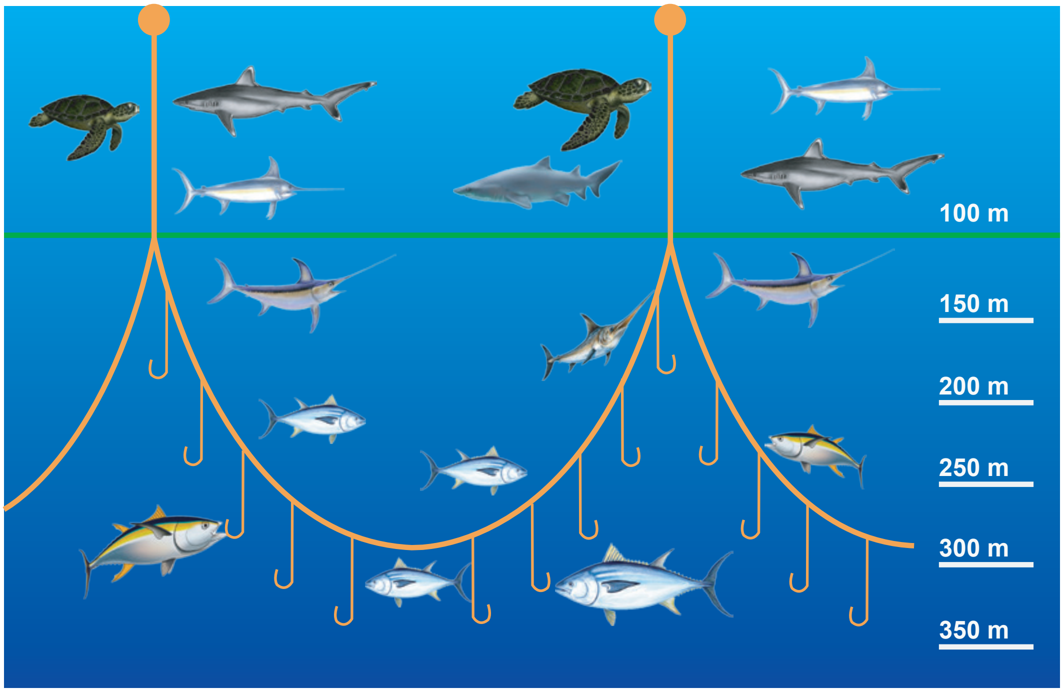


Figure 8. Deepsea long-line gear for fishing high-valued fish species

4.1.3 Discovering new fisheries

Certain high-valued species, such as pelagic tuna (Scombridae), swordfish (Xiphidae), and lakkha/threadfin (Polynemidae) are rarely appear in catches despite their presence in deep water areas. In addition, habitats across the lifecycle of valuable species need to identify for choosing the right fishing season and to allow sufficient time for recruiting stocks. In connection to this, analyses of hydrometeorological, biological, oceanographic and bathymetric data are necessary to identify the distribution of valuable species. For instance, hilsa (*Tenualosa ilisha*) lives in the marine waters and migrates up rivers to spawn, mainly the lower stretches and estuarine system of the Meghna River during October-November (Figure 9).

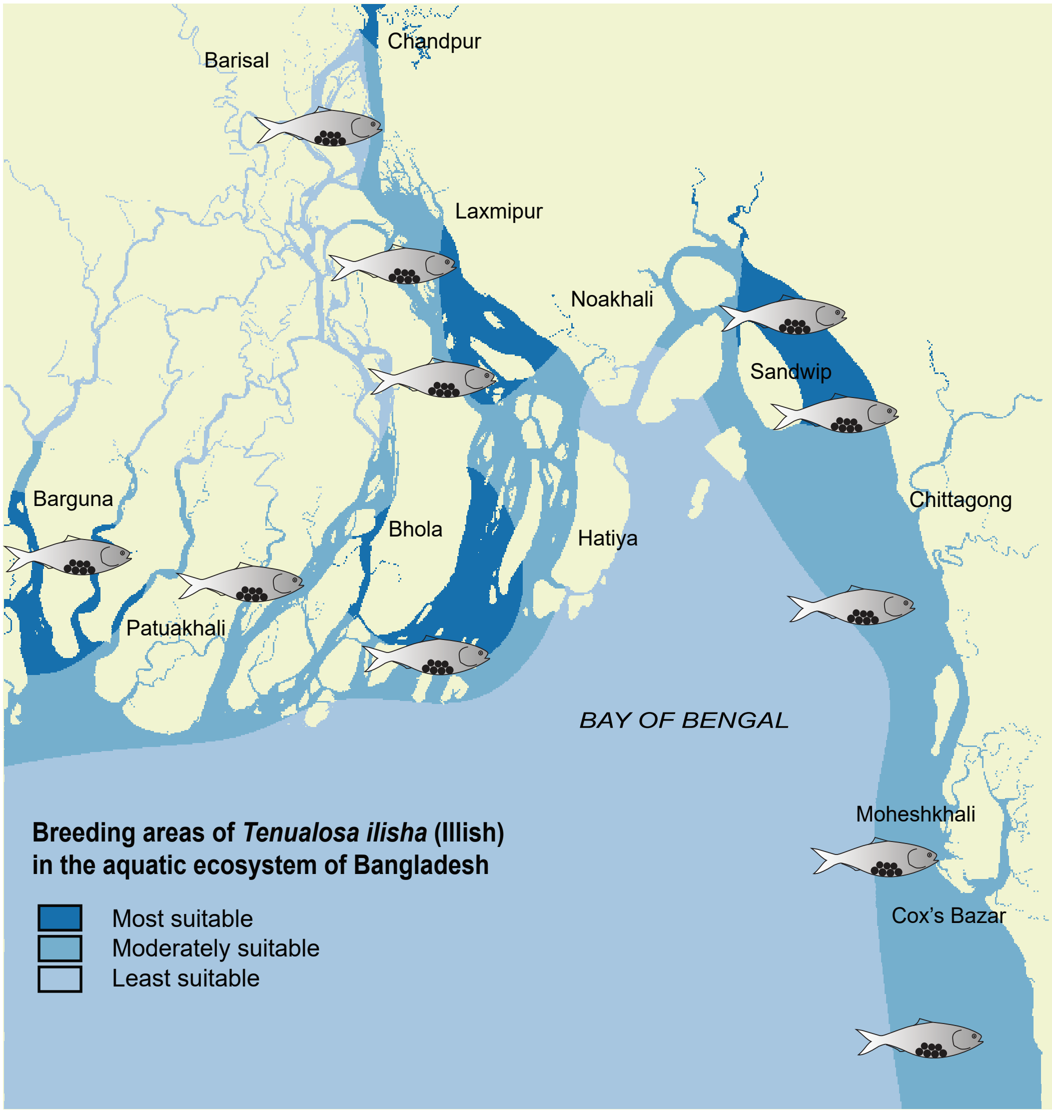


Figure 9. Geo-spatial modeling of hilsa spawning habitats (source: Hossain et al. 2014)[5]

[5] Hossain MS, Sarker S, Sharifuzzaman SM, Chowdhury SR, 2014. Discovering Spawning Ground of Hilsa Shad (*Tenualosa ilisha*) in the coastal waters of Bangladesh. *Ecological Modelling*, 282: 59-68.

4.1.4 Value addition and reduce post-harvest losses

Bycatch 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 (Figure 10).

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.

Figure 10. Example of value added fish and shrimp products (source: online materials)

4.1.5 Fish 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 1). However, recent declining trends of the catch-per-unit-effort (CPUE) by 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 statistcal 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 1. 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)

4.1.6 Ecosystem-based fisheries management

Many interacting hydrometeorological, economic and social factors influence the occurrence, distribution, abundance and diversity of fish species. Thus, fishes of a single species (e.g. hilsa) is not an isolated resource, rather is an integral part of the ecosystem that it lives in, and it interacts in many ways with the ecosystem itself and all other living/non-living elements of the ecosystem in a very delicate and intricate way. Thus, ecosystem-based fisheries management (EBFM) 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. EBFM seeks to account for the interspecies biocommunication with each other, with the environment, and with humans. Making EBFM operational is a key challenge and needs strong partnerships among the policy maker, private sector, researcher, and fishing community. The goal of EBFM includes (i) balance the needs of fishing communities with species sustainability and (ii) balance the pressure from human activities (such as pollution) that may upset the ecological integrity of coastal-marine systems, thereby decreasing fish populations. Figure 11 depicts the goals of EBFM approach.

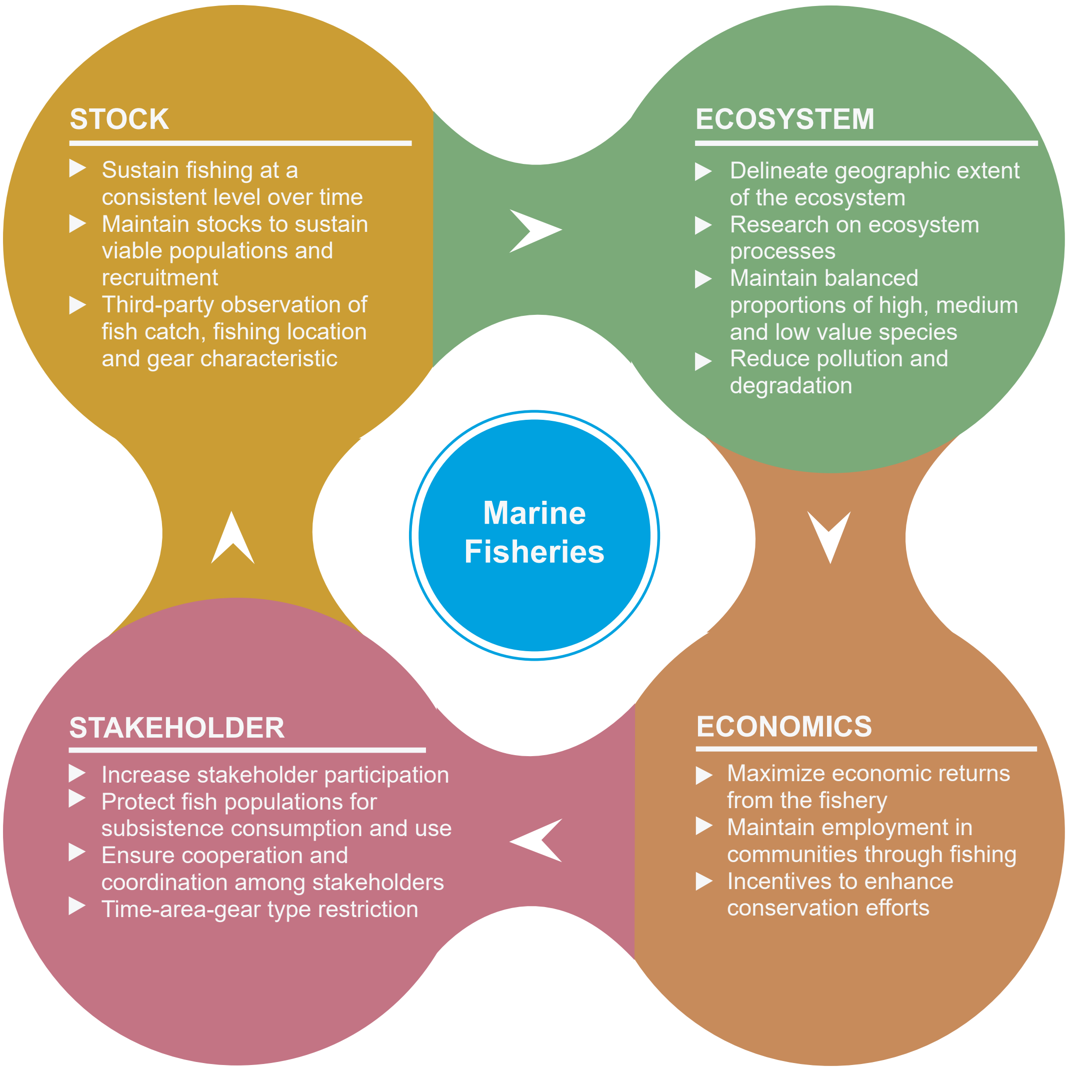


Figure 11. The overarching goals of ecosystem-based fisheries management approach

4.2 Aquaculture

Bangladesh has 150,000–180,000 ha suitable area for coastal aquaculture. Although shrimp farming is common in coastal areas, the production level is low due to increased disease outbreaks and mortality, poor water quality and unscientific use of inputs by farmers. Consequently, 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. In addition, seabass and mullet farming in tide-fed coastal ponds need integrated initiatives in order to realize commercial production. Table 2 shows culture species and potential candidate species of interest for development of mariculture.

Table 2. Mariculture species and potential interventions

Common name (Scientific name)	General information			Existing culture techniques		Scope for development
	Biology	Ecology	Life history	Hatchery	Growout	
Crustaceans						
Shrimp (*Penaeus monodon*)	Known	Known	Known	Yes	Mainly extensive, with some semi-intensive pond culture	Production intensification, develop artificial broodstock, selective breeding for specific pathogen free (SPF) and specific pathogen resistant (SPR) broodstock
Mud crab (*Scylla* spp.)	Known	Known	Known	None	Fattening in ponds and floating cages	Fry production in hatchery, farming intensification
Finfish						
Seabass (*Lates calcarifer*)	Known	Known	Known	None	Extensive pond culture	Fry production in hatchery, farming in ponds and cages
Mullet (*Mugil cephalus*, *Liza* spp.)	Known	Known	Known	None	Extensive pond culture	Do
Threadfin (*Eleutheronema tetradactylum*)	Known	Known	Known	None	Grow in tide-fed coastal ponds	Do
Seabream (*Acanthopagrus* sp.)	Known	Known	Known	None	Grow in tide-fed coastal ponds	Do
Seaweeds						
Green/red/brown algae (*Caulerpa* sp., *Hypnea* sp., *Catenella* sp., *Sargassaum* sp.)	Known	Known	Known	None	Grow/cultured in selected inter- and sub-tidal zones	Mass culture
Species of interest						
Hilsa shad (*Tenualosa ilisha*)	Known	Known	Known	None	None	Fry production in hatchery, farming in ponds and cages
Grouper (*Epinephelus* sp.)	Known	Known	Known	None	None	Do

Table 2. Continued

Shrimp (*Penaeus indicus*)	Known	Known	Known	None	None	Do
Oyster (*Crassostrea* sp.)	Known	Known	Known	None	None	Do
Mussel (*Perna* sp.)	Known	Known	Known	None	None	Do
Swimming crab (*Portunus* spp.)	Known	Known	Known	None	None	Do
Lobster (*Panulirus* sp.)	Known	Known	Known	None	None	Do

4.2.1 Domestication

There is huge diversity of species and farming techniques in aquaculture, but not all farmed species are domesticated. Estimation suggests that 90% of the global aquaculture industry is based on wild and undomesticated stocks. This is because success in domestication (i.e. a condition wherein the lifecycle, breeding, care and feeding of an organism are totally controlled by humans) has only been achieved on a small number of species such as carp, trout, catfish, tilapia, shrimp/prawn and molluscs[6]. In Bangladesh, the domestication process of marine species has been extremely slow compared to their freshwater counterparts, and limited to a few fish and crustaceans (Figure 12). As of now, only the entire lifecycle of tiger shrimp (*Penaeus monodon*) 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, corsula mugil, and silver biddy in tide-fed coastal ponds and hilsa in freshwater pond with significant bottlenecks of closing the lifecycle in captivity. Moreover, there are over hundred species of commercially important capture fisheries (= 'zero level' domestication). Therefore, future growth of mariculture will largely depend on our ability to successfully domesticate of both currently farmed and new species. The advantages of domestication are that the growth (quantity and quality), the reproduction (timing), and the costs (time and labour) of domesticated organism can be controlled or manipulated.

[6] Teletchea F, Fontaine P, 2014. Levels of domestication in fish: Implications for the sustainable future of aquaculture. *Fish and Fisheries*, 15: 181-195.

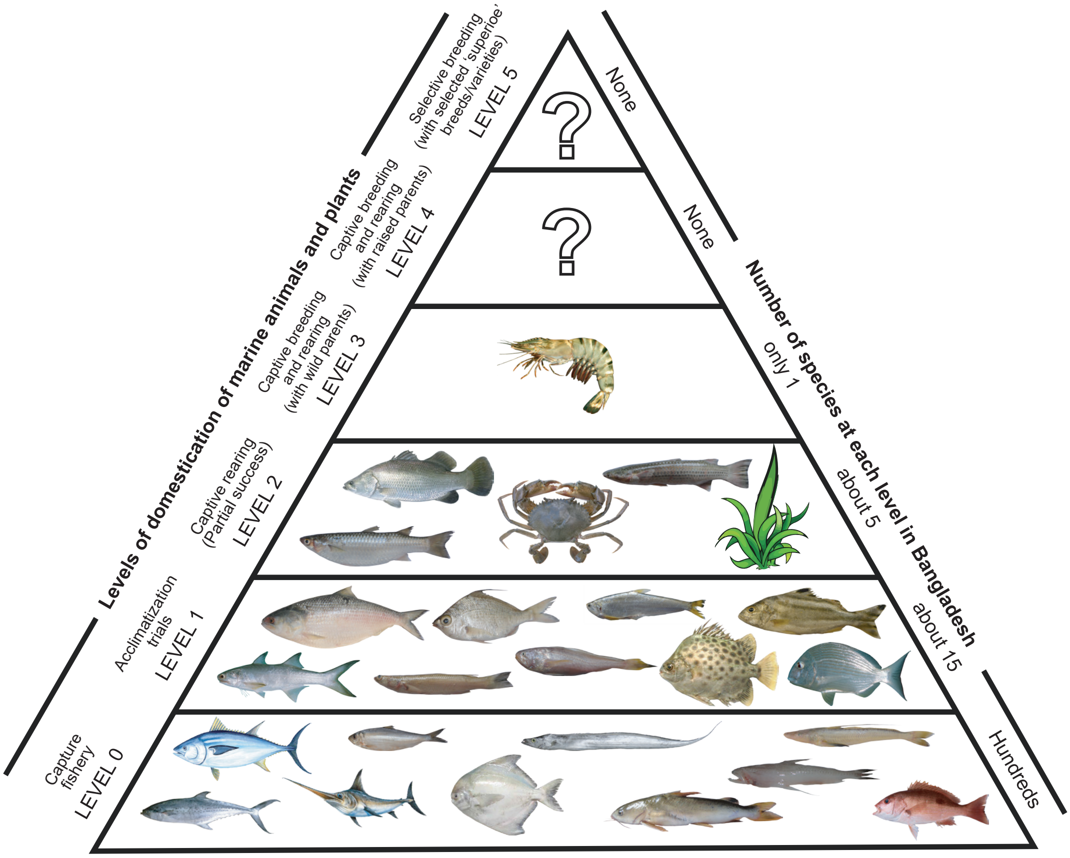


Figure 12. Domestication levels of marine species in Bangladesh

4.2.2 Production intensification

Regardless of the size of the operation, aquaculture must be economically and environmentally sound. It must also be scalable in a way that ensures continued growth. Shrimp farming in Bangladesh mostly carried out following traditional or extensive cultivation methods characterized by low-stocking density and zero to minimum inputs that result in low yields (250 kg/ha), hence making suboptimal use of the land-water resources. These outdated modes of production need to be upgraded to semi-intensive methods with the introduction of healthy seed, quality feed, innovative farming methods, good husbandry practices and improved health management techniques (i.e. probiotics, bio-security), reaching a plausible boost in production up to 5,000 kg/ha. In this connection, the collective knowledge of the international community (i.e. China, Thailand, Vietnam and Malaysia) should be useful.

4.2.3 Innovative fish/shellfish farming

a) Coastal and off-shore cage culture

Marine cage farming, not in practice at present, can be introduced at artisanal level with simple design and small size (i.e. 3×3 m to 5×5 m, and 4–5 m in depth). Local fishers/farmers themselves can make cages using locally available materials including bamboo, wooden boards, steel/PVC pipe, and nylon nets. Fish farming cages can be of the inshore, sheltered, open sea or offshore types, installed either individually or connected together to form floating raft. Floating cages can be mobile (towed away) and stationary (fixed) for farming species such as seabass (*Lates calcarifer*), hilsa (*Tenualosa ilisha*), mullet (*Mugil cephalus*) and seabream (*Acanthopagrus* sp.) (Figure 13).

Figure 13. Potential site for marine cage fish farming at the Moheshkhali Channel, Cox's Bazar

b) Aquasilviculture

Aquasilviculture, silvofishery or integrated mangrove-aquaculture is a low-input farming system. It promotes harmonious co-existence between aquaculture and mangrove forests that supports income, food security, coastal defense, community resilience, and restoration and/or conservation of the mangroves. Thus, for example, suitable locations for 'integrated' mangrove-shrimp, 'separate' mangrove-shrimp (i.e. mangroves as biofilter for shrimp pond effluents; Figure 14), mangrove-crab, and nipa-shrimp systems include the Chakaria Sunderbans and adjacent Cox's Bazar coasts. Among these silvofishery models, mangrove-crab farming in pens or cages holds great potential for strengthening the livelihoods of coastal communities without environmental damage[7]. The nipa-shrimp system could be promising alternative as nipa palms offer immediate economic return to farmers. The area of a silvofishery farm needs to be at least 4 ha to provide a decent livelihood to farmers. Silvofishery also has the potential to restore the abandoned or unproductive land-water resources into productive condition.

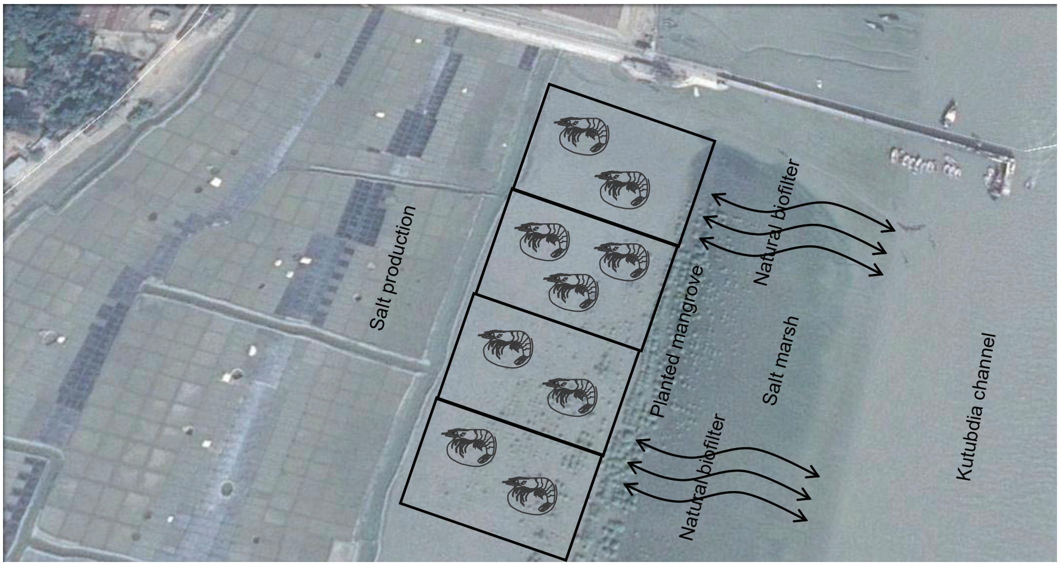


Figure14. A provisional 'separate' mangrove-shrimp culture site at the Kutubdia Island, Cox's Bazar

c) Integrated multi-trophic aquaculture

In the Integrated multi-trophic aquaculture (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 (Figure 15). Thus, IMTA is a suitable approach providing environmental sustainability, economic diversification and social acceptability for the aquaculture sector within the broader perspective of responsible coastal zone management. 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.

[7] Hossain MS, Sharifuzzaman SM, Chowdhury SR, 2015. Scientific Feasibility Assessment of Integrated Mangrove Shrimp Culture or Similar Silvofishery Practice in the Coastal Zone of Bangladesh. IUCN Bangladesh Country Office, Dhaka, 49 pp.

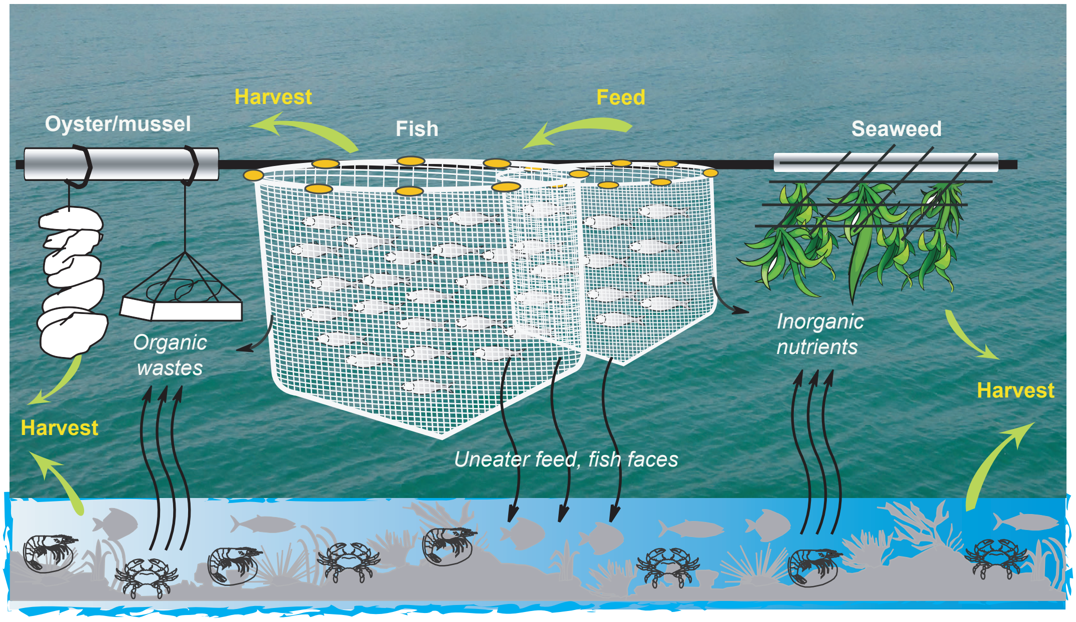


Figure 15. An illustration of IMTA model in coastal water of Bangladesh

4.2.4 Live feeds for larviculture

Farmed fish and shrimp are given manufactured feeds as well as small fish, chopped trash fish, meat scraps, grains, plant meals and even fish meals. But, feeding of most species of interest for aquaculture still relies on live feeds during the early life stages (i.e. larviculture) (Figure 16). Three groups of live diets are commonly used in commercial 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 postlarvae/broodstock and marine 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* biomass production. Therefore, it is necessary to acquire technology for the production of live feeds for sustaining the marine aquaculture industry.

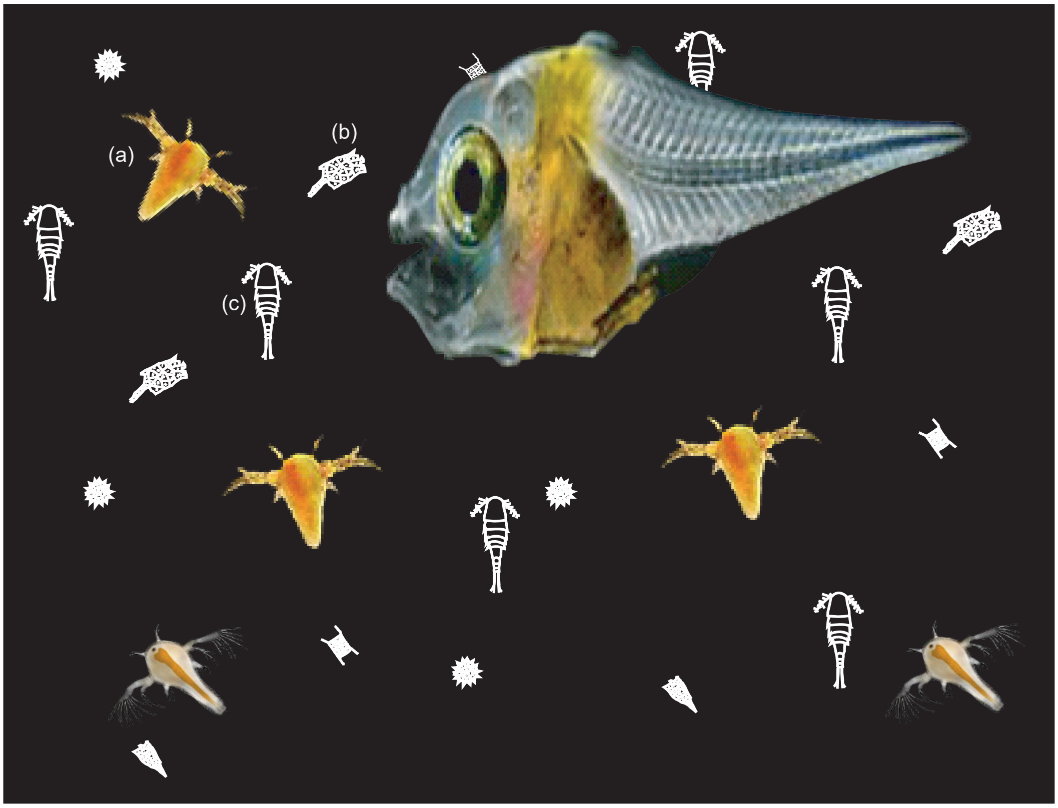


Figure 16. Fish larvae to feed on live prey – Artemia nauplii (a), rotifers (b), and copepods (c)

4.2.5 Disease and health management

Despite the immense potential for further growth, shrimp cultivation in Bangladesh is facing challenges from disease outbreaks (e.g. WSSV, luminous vibrio) and poor compliance with quality standards. Some of the interventions may include developing disease resistant stocks, improvement of husbandry, application of bio-security and eco-friendly health management techniques (i.e. probiotics, immunostimulants), avoid and prevent the irrational use of antibiotics, and embracing organic farming and traceability requirements.

4.2.6 Marine biotechnology

Modern biotechnology is already making important contributions in establishing aquaculture as a successful long-term industry. It has been applied to improve product quality (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, and specific pathogen free (SPF) and specific pathogen resistant (SPR) stocks], eliminate domestication challenges, and other commercially important traits of cultured organisms. However, Bangladesh is lagging far behind other nations in terms of the rapidly evolving knowledge and support facilities in molecular biology and genetics, and their application to increase production from marine species in captivity is still a dream.

In parallel, unique bioactive compounds derived from marine organisms, which constitute nearly half of the global biodiversity, have gained enormous interest in pharmaceutical, nutraceutical and cosmeceutical industries because of their broad spectrum of bioactivities, including antimicrobial, antioxidant and anti-aging activities. To uncover these opportunities capacity building in biotechnology is of utmost importance.

5. Support facilities

A thrust in blue economic growth may come through sustainable ocean governance involving necessary institutional set-up and management tools, skilled workforce, and science-based planning and sound policy decisions.

5.1 Marine spatial planning

Marine spatial planning (MSP) is a tool that demarcates specific activities in designated marine areas. It provides information on the geography, environment, natural phenomena, current and future uses for better planning of existing and future utilization of resources and space (Figure 17). The current practice of fragmented 'sector-by-sector' or 'use-by-use' planning strategies, which are governed by discrete laws/regulations and implemented by disconnected agencies/bodies, lead to multiple user of resources often in conflict and/or competition with each other. MSP brings all these spaces, resources, agencies, uses and times together in one analytical framework to resolve and/or reduce conflicts. MSP, which is not in place yet, can help to develop the blue economy in a way that is socially, economically and environmentally sustainable.

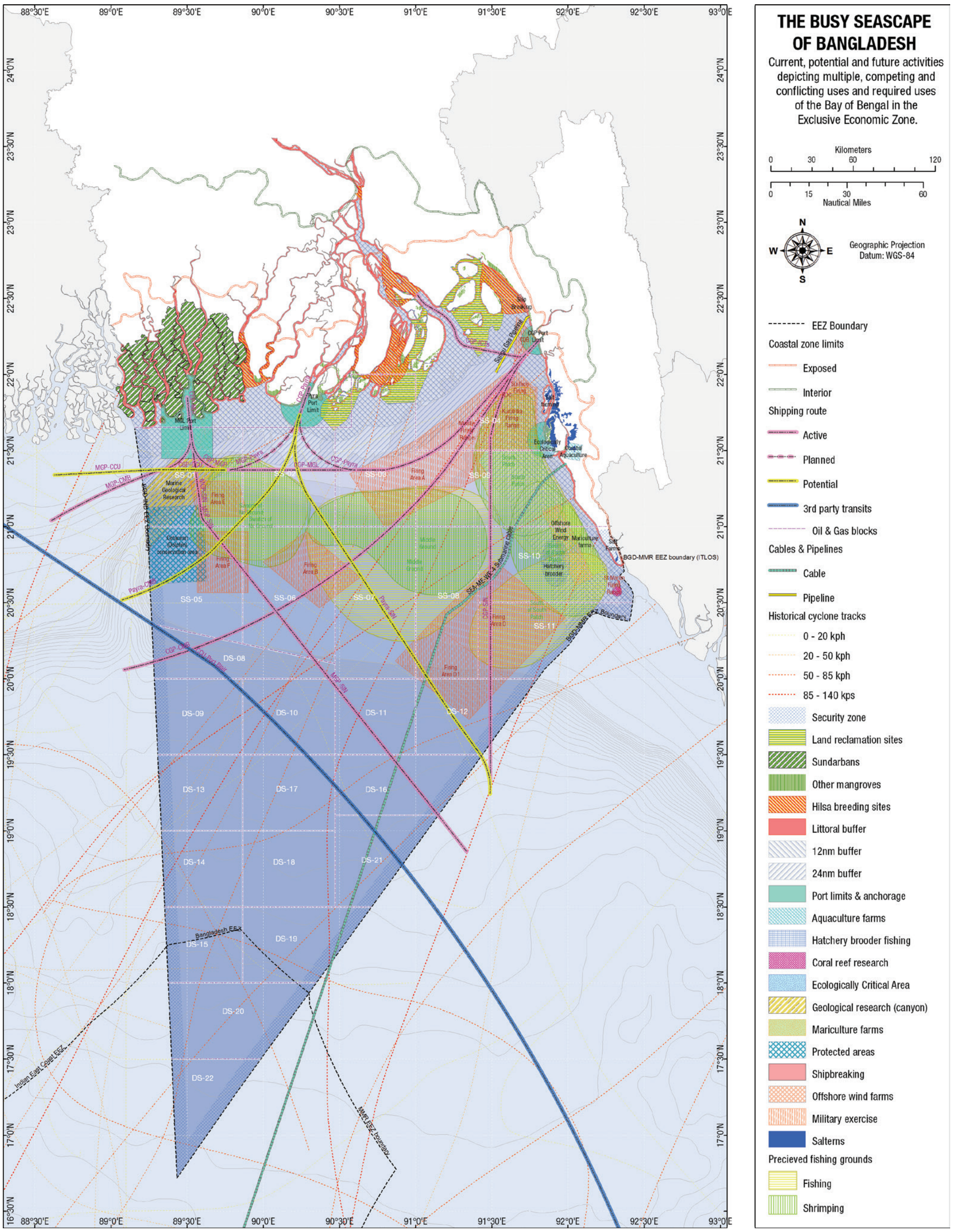


Figure 17. The busy seascape of Bangladesh: a precursor for developing the MSP framework[1]

5.2 Institutional set-up

Considering the legal provisions available for fostering various maritime economic activities, and also the lacking therein, particularly cross-sectoral integration and coordination, it seems only logical to craft an ocean governance framework utilizing existing and new instruments for the much anticipated economic growth and sustainable development of the country. Despite enormous opportunities and provisions, ocean-based economic development is often unsuccessful by a number of challenges, which must be overcame through a wisely crafted ocean governance mechanism to deal with the compound nature of the system (Figure 18).

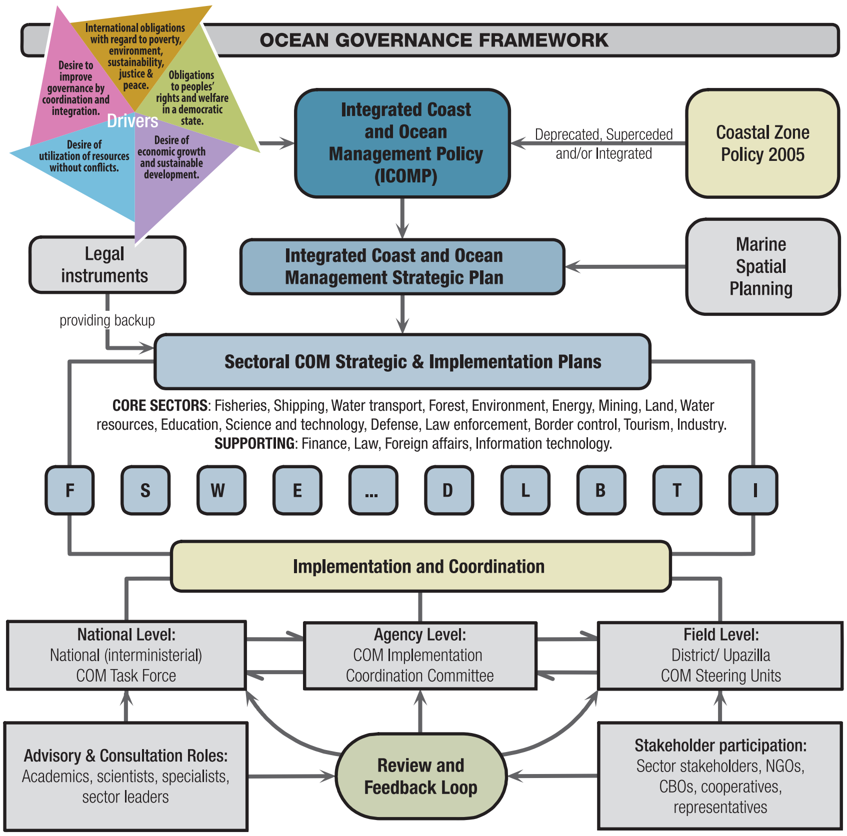


Figure 18. Complex interactions of resource base, users, actors, challenges and opportunities of ocean management leading to the logical response of governance[1]

5.3 Maritime education and human resources

Skilled and educated workforces in maritime sectors are the driving force of blue economy, and thus appropriate training courses and educational programs on maritime science and technology, shipping, business, and management are essential in vocational/technical and tertiary education levels. Realizing the importance of ocean in our everyday lives, maritime education by some academic institutions, such as University of Chittagong, Bangladesh University of Engineering and Technology, Bangladesh Marine Academy, Marine Fisheries Academy, and National Maritime Institute, are already underway since 1970s.

These institutions are among the oldest and unique of their kind. A list of institutions and their educational activities is given in Table 3.

Table 3. Marine, maritime and fisheries sciences education in Bangladesh

Institution	Since	Educational program		
		Bachelor's degree	Master's degree	Diploma/training
A) Marine and maritime sciences				
Ministry of Shipping				
Seamen's Training Centre (STC)	1952	-	-	Training
National Maritime Institute (former STC)	2004	-	-	Training
University of Chittagong				
Department of Marine Biology (DMB)	1971	Marine Biology	Marine Biology	-
Institute of Marine Sciences (former DMB)	1983	Marine Science	Marine Science[a]	-
Institute of Marine Sciences & Fisheries (former DMB)	2006	*Marine Science*	Marine Science[a]	-
	2012	Marine Science Oceanography	Marine Science[a] Oceanography	-
Bangladesh University of Engineering & Technology				
Department of Naval Architecture and Marine Engineering	1971	Naval Architecture and Marine Engr.	Naval Architecture and Marine Engr.	-
Ministry of Shipping				
Marine Academy (MA)	1972	-	-	Diploma
	1992	Science	-	Training
	2003	Maritime Science	-	Training
Bangladesh Marine Academy (former MA)	2010	Maritime Science	-	Training
Ministry of Fisheries & Livestock				
Marine Fisheries Academy	1973	-	-	Diploma
	2003	Marine Fisheries, Marine Engineering, Navigation	-	-
University of Dhaka				
Department of Oceanography	2012	-	Oceanography	-
	2014	Oceanography	Oceanography	-
Bangabandhu Sheikh Mujibur Rahman Maritime University				
Department of Port and Shipping Management	2015	-	Port and shipping management	-
Department of Maritime Law and Policy	2015	-	Maritime Law and Policy	-
Department of Oceanography and Hydrography	2017	Oceanography	-	-
Noakhali Science and Technology University				
Department of Oceanography	2016	Oceanography	-	-
Shahjalal University of Science and Technology				
Department of Oceanography	2016	Oceanography	-	-

Table 3. Continued

Institution	Since	Educational program		
		Bachelor's degree	Master's degree	Diploma/training
B) Fisheries science				
Bangladesh Agricultural University				
Faculty of Fisheries	1967	Fisheries	Fisheries[b]	-
Khulna University				
Fisheries and Marine Resources Technology Discipline	1992	Fisheries	Fisheries	-
University of Dhaka				
Department of Fisheries	1999	Fisheries	Fisheries	-
Rajshahi University				
Department of Fisheries	2000	Fisheries	Fisheries	-
Sheikh Fazilatunnesa Mujib Fisheries College	2000	Fisheries	-	-
Hajee Mohammad Danesh Science and Technology University				
Faculty of Fisheries	2005	Fisheries	Fisheries[c]	-
Noakhali Science and Technology University				
Department of Fisheries and Marine Science	2006	Fisheries	Fisheries	-
Sylhet Agricultural University				
Faculty of Fisheries	2007	Fisheries	Fisheries[d]	-
Jessore University of Science and Technology				
Department of Fisheries and Marine Bioscience	2008	Fisheries	Fisheries	-
Patuakhali Science and Technology University				
Faculty of Fisheries	2010	Fisheries	Fisheries[e]	-
Bangabandhu Sheikh Mujibur Rahman Agricultural University				
Faculty of Fisheries	2009	Fisheries	Fisheries[f]	-
University of Chittagong				
Institute of Marine Sciences & Fisheries	2013	Fisheries	Fisheries	-
Chittagong Veterinary and Animal Sciences University				
Faculty of Fisheries	2014	Fisheries	-	-
Sher-e-Bangla Agricultural University				
Faculty of Fisheries and Aquaculture	2017	Fisheries	-	-

Source: respective websites. Please note this table is intended to be representative and not exhaustive

[a] Major in Aquaculture, Environmental Pollution, Fisheries, Oceanography, Nutrition and Feed Technology
[b] Fisheries Biology and Genetics, Aquaculture, Fisheries Management, Fisheries Technology
[c] Fisheries Biology and Genetics, Fisheries Management, Fisheries Technology, Aquaculture
[d] Aquaculture, Aquatic Resource Management, Coastal and Marine Fisheries, Fish Health Management, Fisheries Biology and Genetics, Fisheries Technology and Quality Control
[e] Aquaculture, Fisheries Biology and Genetics, Fisheries Management, Marine Fisheries and Oceanography, Fisheries Technology
[f] Aquaculture, Fisheries Biology and Aquatic Environment, Fisheries Management, Fisheries Technology, Genetic and Fish Breeding

The maritime academic institutions of the country have been dedicated to produce the skillful and energetic maritime professions (Table 4) to work with the diversified sectors nationally, regionally and globally. Simultaneously, maritime academic innovations and modern research facilities are essential to realize the full potential of the blue economy.

Table 4. Maritime human resources for judicious use and management of marine resources

Scientists	Marine scientist, marine ecologist, marine fisheries biologist, marine biotechnologist, aquaculturist, maritime meteorologist, climatologist, marine geologist, petroleum geologist, etc.
Engineers and technologists	Offshore engineer, naval architect, marine engineer, coastal engineer, mining engineer, marine energy engineer, aquaculture technologist, biotechnologist and hatchery technologist, seismologist, remote sensing and acoustic technologist, geomorphologist, sedimentologist, etc.
Maritime professionals	Coastal zone planner & manager, coastal forest manager, marine fisheries manager, tourism manager, maritime lawyer, merchant mariner, port manager, maritime trade analyst, marine pollution & environment expert, marine conservationist, hydrographer, surveyor, shipping liner & entrepreneur, etc.
Skilled workers	For ship building &recycling, shipping & port operations, fishing & fish cultivation, post-harvest fish handling & processing, coastal & offshore structure, etc.

5.4 BCS cadre in marine affairs

Bangladesh Civil Service, popularly known as BCS, has 27 cadre services in general and professional/technical categories, but there is no scope for the marine and maritime human resources. Thus, addition of 'BCS Marine Affairs Cadre' would be a timely response to provide expert services to the Government of Bangladesh for its blue economy agenda. Specifically, bachelor's degrees in Marine Science, Oceanography, Naval Architecture, Marine Engineering, Nautical Science, Port & Shipping Management, Maritime Law, and related marine and maritime education programmes (see Table 3) should be immediately included in the BCS examination.

5.5 Climate change mitigation and adaptation

Climate change and associated phenomena such as sea-level rise, weather and climatic shift, changing rainfall (precipitation) patterns, depression, extreme climate events (intensification of tropical cyclones), ocean acidification and hypoxia are now visible and established facts through scientific investigations. These anomalies may directly or indirectly affect production from fisheries and aquaculture. For example, recent changes in the distribution and productivity of a number of fish species can be ascribed to regional climate variability, such as the El Niño-Southern Oscillation. Such a phenomenon can affect our multi-billion dollar hilsa fishery negatively. Therefore, blue economy policies must contribute to climate change mitigation and adaptation strategies.

6. Roadmap for implementation

Blue economy development must include major stakeholders and actors in order to reconcile problems in different sectors and coordinate solutions so as to minimize conflicting interests and actions (Table 5). No major decision in one sector should be made unilaterally or without being vetted by other stakeholders/sectors. This may be achieved by forming and activating an integrated blue economy development committee consisting of all major sectors and stakeholders, academic and research institutions, and the users of ocean resources (Figure19). The committee should have a clear mandate of what it should be doing, and a well-defined charter describing how it works. Legal grounds should be created, and legal bottlenecks and difficulties should also be removed for such the committee to exert its authority on blue economy development issues.

Table 5. Implementation approch for marine fisheries and aquaculture interventions

Intervention	Priority class	Activity	Actor
Extending fishing horizon	2	Fishing in deep and high seas	DoF, private sector
New fishing gears and techniques	2	Engage high-tonnage vessels with long-lines and hooks	DoF, private sector
Discovering new fisheries	2	Trace habitats and migration route of leading species	DoF, researcher
Fish stock assessment	3	Comprehensive survey (on board observer, landing data)	DoF, researcher
Ecosystem-based fisheries management	2	Establish sanctuary and MPAs, fisher's awareness and responsibility	DoF, fishing community, researcher
Value addition and reduce post-harvest loss	2	Preparation of fish cutlet, chip, ball, cake, oil, enzyme and fishmeal	DoF, private sector
Domestication of mariculture species	3	R&D on leading species i.e. seabass, mullet, hilsa, crab	DoF, researcher
Production intensification	2	Ensure healthy fry, quality feed, good husbandry and improved health management techniques	DoF, private sector, researcher
Coastal and off-shore cage farming	2	Specify zones, ensure inputs	DoF, researcher, private sector
Aquasilviculture	2	Mangrove-friendly shrimp and crab farming	DoF, researcher, private sector

Table 5. Continued

Intervention	Priority class	Activity	Actor
Integrated multi-trophic aquaculture	1	Introduce multi-species aquaculture	DoF, researcher, private sector
Aquaculture live feed for larviculture	1	Plankton stock preservation and indoor culture, Artemia production in salt pans	DoF, private sector, researcher
Disease and health management	3	Disease resistant stocks, bio-security and eco-friendly health management	DoF, private sector, researcher
Marine biotechnology	2	Capacity building in molecular biology & genetics, extract bioactive compounds, disease control (probiotics, SPF, SPR)	DoF, private sector, researcher
Develop Marine Spatial Planning	2	Demarcate activities in designated marine areas	DoF, user, researcher
Institutional set-up for cross-sectoral coordination and governance	3	Workshop, dialogue, round table, exchange visit	DoF, user, researcher, private sector
Maritime human resources and education (research, safety and security)	3	Curricula, training, exchange visit, capacity development (funding, infrastructure, equipment)	Academic, research and training institutions
Climate change mitigation and adaptation	2	Strengthen resilience elements of coastal community	DoF, researcher, community
Develop a set of indicators of success	1	Workshop, dialogue, round table, exchange visit	DoF, researcher, private sector
External evaluation to measure indicators of success	1	Select and appoint qualified team or institution	DoF, researcher

Priority scale: 3 = high priority; 2 = moderate priority; 1 = least priority

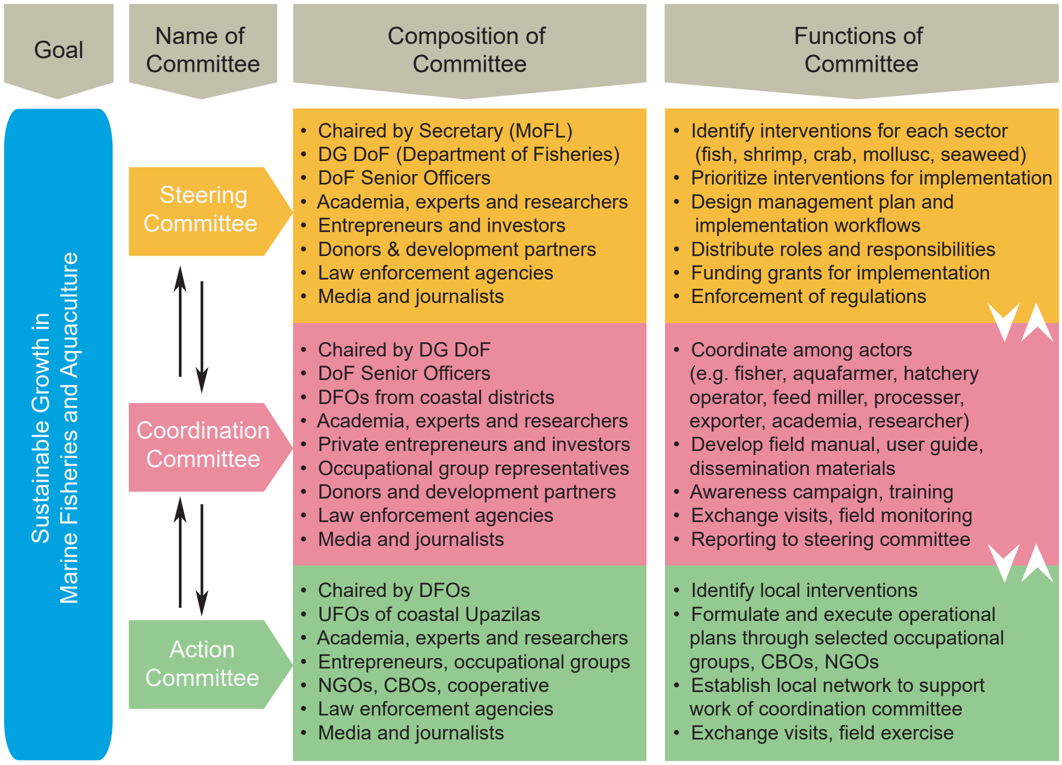


Figure 19. Proposed committee for blue economy development

7. Conclusion

Activities related to fisheries and aquaculture, which contribute significantly to food security and livelihoods of millions of people, are vital for realizing the full potential of the blue economy. This requires a paradigm shift to embrace new, innovative, responsible and sustainable approach that is more environmentally and economically operational. Thus, this document specifically sets out what interventions are necessary to promote fisheries and aquaculture in the context of Bangladesh's blue economy, and how the actions will contribute to economy, society and ocean ecosystem, including the SDGs. Important challenges of the blue economy are fully addressing the impacts of climate change, both already observed and anticipated, on marine and coastal ecosystems as well as understanding (i.e. science and education) and better management (i.e. policy) of the different aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health. Moreover, sustainable management requires effective multi-sectoral coordination and integration mechanism, and collaboration across the public-private sectors and on a scale that has not been achieved in the past.

Research Vessel Meen Sandhani of the Department of Fisheries has started working in the Bay of Bengal to generate scientific information for Fisheries Management and Blue Economic policy advices.

ISBN 978-984-34-2845-5