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## Augmenting Marine Food Production Through Fisheries Management and Mariculture

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# 1 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 (Department of Fisheries 2017). Marine aquaculture, which is limited to coastal and brackish water 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 1). 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<sup>2</sup> 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.

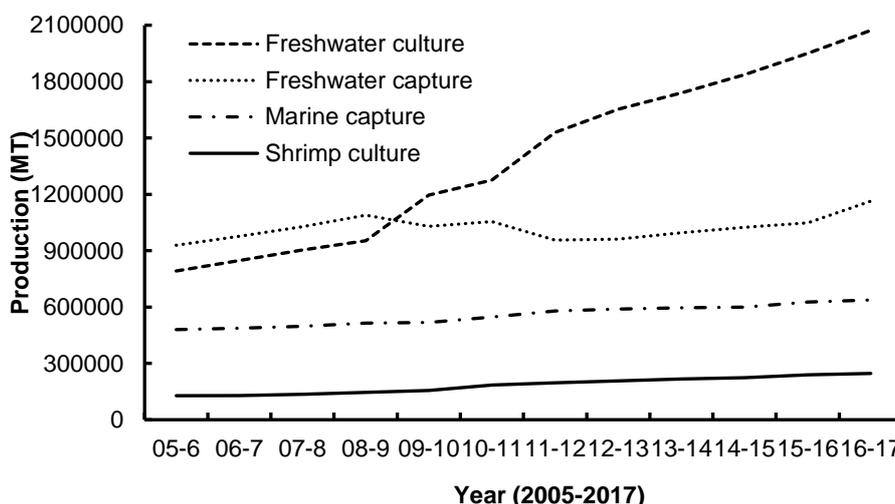
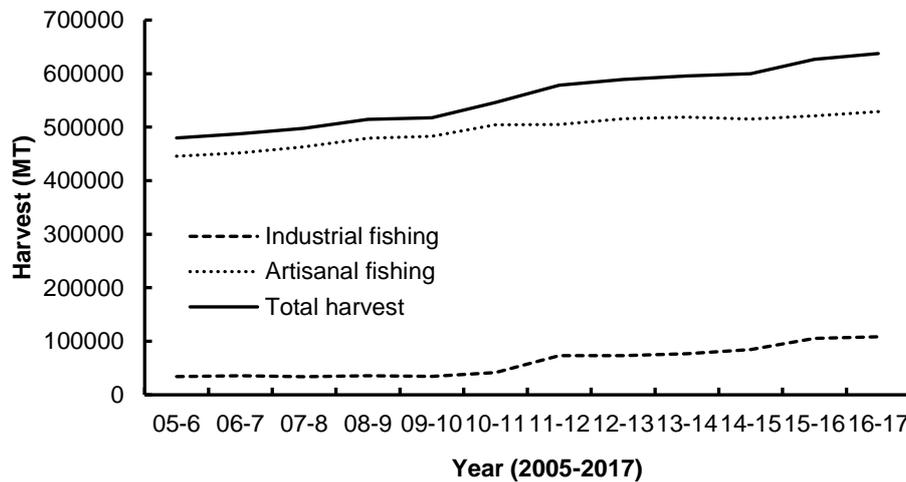


Figure 1 : Culture and capture fisheries production from 2005-06 to 2016-17. Source : Department of Fisheries 2017.

## 1.1 Unlocking the blue fisheries economy

### 1.1.1 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 2).

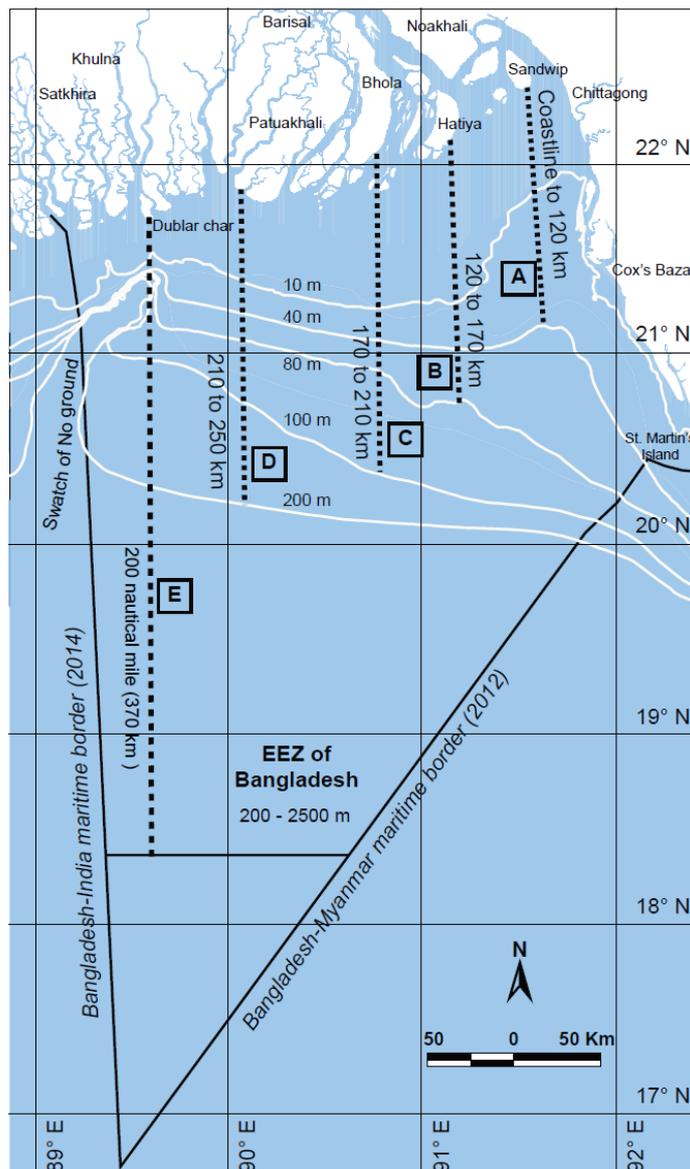


**Figure 2 : Trends in sector-wise marine fisheries production (data Department of Fisheries 2017)**

At present more than 67,000 mechanized and non-mechanized 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 (trawler fishing) remain underdeveloped. In 2017, industrial fishery contributed only 2.62% to total fish production of the country, while artisanal fishery contributed 12.79% (Department of Fisheries 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 (Department of Fisheries 2017).

### 1.1.2 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 3). 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 3 : 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, mechanized and non-mechanized 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.

### 1.1.3 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 4). 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 4 : A high value fish species, lakkha (left) and bulk of sardines in trawl fishing (right)**

#### **1.1.4 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.

#### **1.1.5 Fisheries stock assessment**

The stock assessment of fishery resources was carried out in 1973, 1981 and 1983, and the current survey (Department of Fisheries, FAO 2016-17) is ongoing with the research vessel ‘RV Meen Sandhani’ (Table 1). 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 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)

## 1.2 Unlocking Blue mariculture Economy

### 1.2.1 Present status

Bangladesh has 272,717 ha (Department of Fisheries 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 (Department of Fisheries 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.

### 1.2.2 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 5). 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.

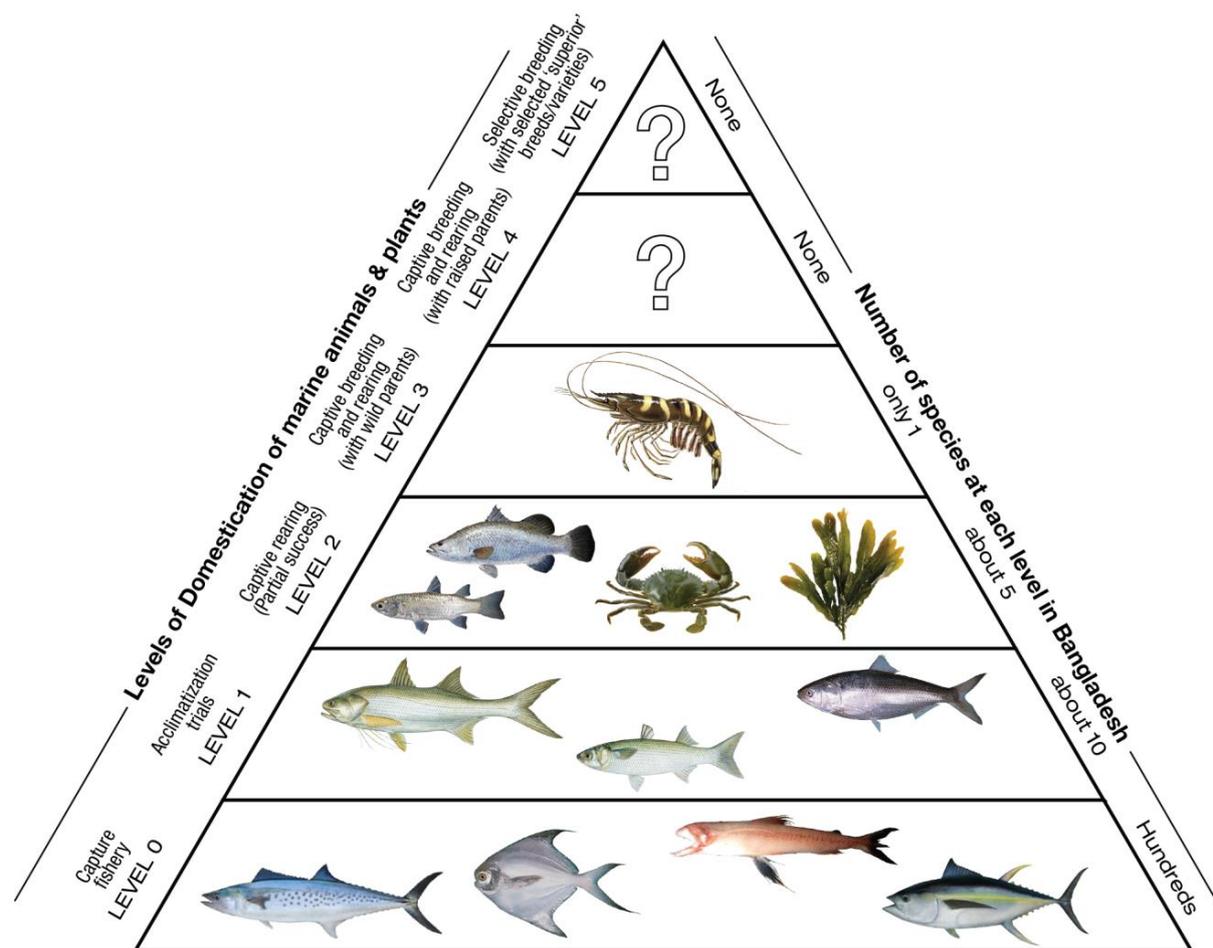


Figure 5 : Domestication levels of marine species in Bangladesh. Source: Hossain et al. 2017.

### 1.2.3 Adopting new farming techniques

Marine cage farming (Figure 6), 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 6 : Potential cage farming site at the Moheshkhali Channel (source: Hossain et al. 2017)**

#### 1.2.4 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 2). 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).

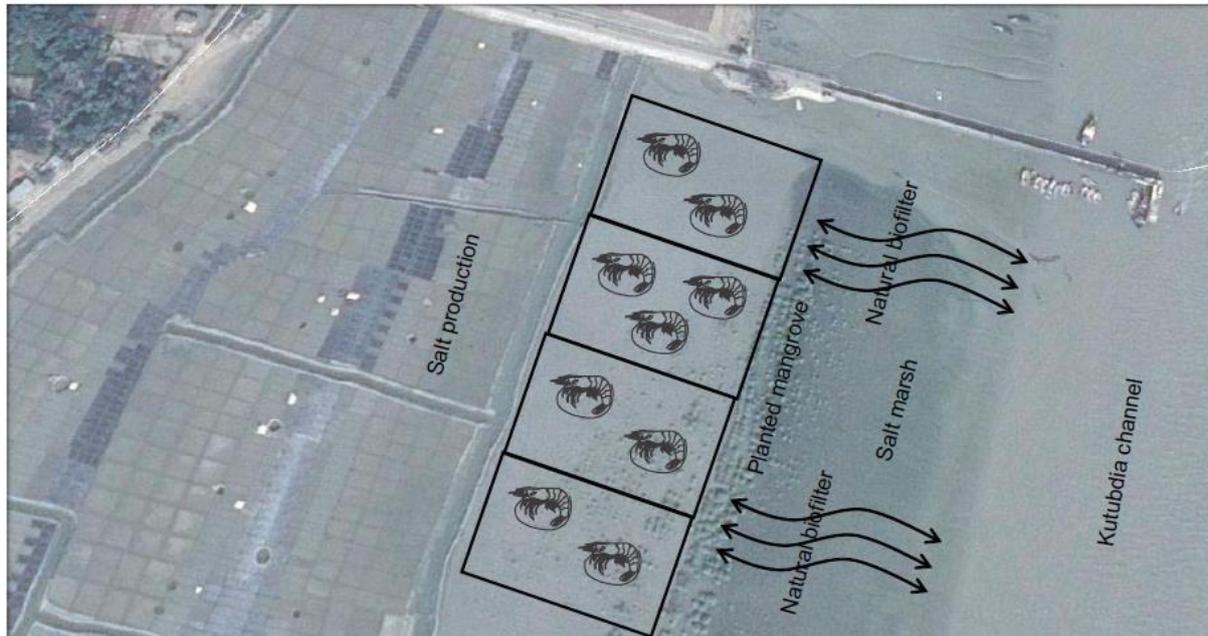
**Table 2 : Shrimp farming systems and level of production in Bangladesh (after Belton et al. 2011)**

Production	Characteristics
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system	Management	Stocking (PL/m <sup>2</sup> )	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

### 1.2.5 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, aqua-silviculture (= integrated mangrove-aquaculture) and integrated multi-trophic aquaculture (IMTA) system are promising eco-friendly options. Aqua-silviculture 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 6), 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 7 : 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.

### 1.2.6 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  $\mu\text{m}$  in size for bivalves, penaeid shrimps, rotifers, copepods and fish,
- (ii) rotifers *Brachionus plicatilis* and *B. rotundiformis* (50–200  $\mu\text{m}$  in size) for crustaceans and marine fish, and
- (iii) nauplii of brine shrimp *Artemia* sp. (400–800  $\mu\text{m}$  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, salt pans 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 4 : Harvesting of *Artemia* cysts (left) and biomass (right) from a saltpond. Source: Lavens and Sorgeloos 1996.**

### **1.2.7 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).

### **1.3 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.

### **1.4 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.

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