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A Review on Blue Economy in Shrimp Sector of Bangladesh

Md. Shirajul Islam Sarkar[1,*], Muhammad Mehedi Hasan[2], Parvez Chowdhury[3], Md. Golam Rasul[1], Murshida Khan[1], Md. Shahdat Hossain[4], Anas Al Islam[5], Md. Kamal[2]

[1]Department of Fisheries Technology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh
[2]Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[3]Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan
[4]Fisheries Biotechnology Division, National Institute of Biotechnology, Ganakbari, Ashulia, Savar, Dhaka, Bangladesh
[5]Bangladesh Academy for Rural Development, Comilla, Bangladesh

[*]**Corresponding Author: sislam@bsmrau.edu.bd**

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ABSTRACT

Rapid global population growth depleting finite terrestrial resources which directed towards sustainable utilization of the oceans. Blue economy is a macro-economy concept where eco-friendly innovations are applied for sustainable production of marine goods and services for social solvency. In this paper, global blue economy definition, blue economy potentials, resources, blue economy in fisheries and aquaculture sector, present shrimp cultivation status and blue economy of shrimp cultivation from Bangladesh perspectives have been reviewed. Potential blue economy sectors in Bangladesh are mariculture, deep sea fishing, biotechnology, marine energy, submarine cable connections etc. Blue economy resources are biological resources, government agencies, human resources, ports-harbors, vessels and submarines, in addition to remote sensing facilities. To embrace blue economy, fisheries and aquaculture should include technologies, such as big data analysis, machine learning, artificial intelligence and precision aquaculture. Shrimp cultivation occurs in Khulna, Chittagong, Cox's Bazar, Bhola regions mostly by traditional method. Shrimp pond management, culture practices, harvesting, grading, production, supply and future potential has been addressed. Shrimp production is increasing steadily. Blue economy of shrimp culture involves innovative solutions to settle down unsustainability issues. A conceptual framework addressing major challengaes and sustainable interventions has also been reported. Recommendations are directed to consider government policy declaration, public awareness, coordination among state agencies, establishing national marine data hub, supporting research and development, and employing more manpower, as well as regional and international collaborations.

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INTRODUCTION

Global human population is rapidly increasing and will reach 9.3 billion by 2050 **(UNDESA, 2017)**. Unfortunately, finite terrestrial limited natural resources cannot support the demands of this continuously growing population **(Bretschger, 2013)**. From 1960 to 2000, per capita crop area has reduced from 0.36 to 0.18 hectares **(World Bank, 2021)**, but to feed 9.2 billion people, at the present yield, crop and grazing area will have to increase by 50% to 70%, or food production will have to increase by 70%, whereas global level annual increases in maize, rice, and wheat production has increased slightly more than 1% since the 1990s **(FAO, 2017)**.

Competition over limited terrestrial natural resources has been causing socio-economic-political disparity among humans **(OECD, 2015)**. Increasing terrestrial pollution due to overpopulation is further impairing the capacity of terrestrial ecosystems to respond to the basic needs of all life on earth **(UNEP, 2020)**. In this situation, beside terrestrial production, the utilization of unexplored and underutilized sea and ocean resources in a sustainable manner might be one of the most possible strategies to solve the dilemma of balance among unprecedented increase in global human population, resource scarcity, and wellbeing of environment **(Ritz & Rosamarina, 2015)**.

In regard to the utilization of marine resources, 'Blue Economy' is the most pronounced term. Generally, the term 'Blue economy' denotes the sustainable utilization of marine resources for economic prosperity and improvement of livelihood. By two international verdicts against neighboring country India and Myanmar, Bangladesh has achieved about 131,098 km^2 new area in the bay of Bengal **(Bhuiyan *et al.*, 2015)**. Bangladesh has a scope to utilize this newly found marine area for blue economy purposes. Fisheries and aquaculture are one of the major areas of blue economy. Not only marine fisheries and mariculture but also coastal and inland fisheries and aquaculture are included in blue economy **(Boto *et al.*, 2013; Hossain *et al.*, 2017; Islam *et al.*, 2018)**. Bangladesh is the habitat of 260 species of freshwater and 475 species of marine fish species, providing approximately 60% of total animal protein intake. In 2018-19 fiscal year, the fisheries sector contributed 3.50% in total GDP, and 25.72% in agricultural GDP. The livelihoods of more than 11% of people in Bangladesh is directly or indirectly dependent on fisheries sector. This sector creates about 0.6 million new employment positions every year **(DoF, 2020)**. To elaborate the blue economy concept in the context of Bangladesh, the government has undertaken a number of consultations since 2015 e.g. Ministry of Foreign Affairs hosted Second International Blue Economy Dialogue in late 2017 **(Patil *et al.*, 2018)**. However, literature on blue economy in Bangladesh, especially from perspectives of fisheries sector are very few, and self-explanatory and blurry concepts, rather than the actual and specific concepts that rightly address blue economy. Thus, the first objective of this review was to provide advocacy on blue economy

potentials, resources, what aspects should be considered in blue economy of fisheries sector and present a model framework to way forward to establish blue economy in Bangladesh.

In the fisheries sector, shrimp is commonly referred to as 'White gold' given its high economic value. Shrimp export is recognized as the backbone of fisheries export earnings. Many stakeholders are associated with shrimp cultivation. From hatchery, nursery and natural fry harvesters, shrimp seed reach farms through traders. In shrimp farms, at least 5-6 stakeholders are involved such as land lessors who lease the land to farmers, farm workers, backyard feed manufacturers, commercial feed suppliers, and farias (middlemen) who connect and facilitate marketing between shrimp farmer and domestic market and/or primary depots. In this segment, depot workers and ice manufactures participate. Primary depots supply shrimps to secondary depots. Shrimp processing plants (freezing plants) collect shrimp from secondary/terminal depots and export them to international markets **(Karim *et al.*, 2006)**. Approximately, 0.5 million people are involved in prawn and shrimp culture **(DoF, 2020)**. Thus, shrimp cultivation is an important blue economy frontier for Bangladesh. But blue economy aspects in shrimp sector has not been addressed yet. In this case, there are two major research gaps: 1) to work on blue economy of shrimp cultivation in Bangladesh, an in-depth understanding on current shrimp farming practice in Bangladesh is necessary. Many literatures on shrimp cultivation in Bangladesh is available. Therefore, a compact but comprehensive review is necessary and 2) rather than improving the existing technology, innovative technologies has to be applied to establish blue economy in shrimp sector of Bangladesh; however, there is no existing idea about such technologies which would be eligible in current shrimp farming scenario in Bangladesh. Thus, the second objective of this paper was to provide a comprehensive review on current status of shrimp cultivation in Bangladesh so that academics, researchers, policy makers, government officials, NGO workers, and other stakeholders can use this reference work to innovate possible blue economy interventions in shrimp industry, and to providie an idea about blue economy technology interventions, and major challenges and their solutions to establish blue economy in shrimp sector of Bangladesh.

The blue economy in Bangladesh

Blue economy: characteristics and understanding

Gunter Pauli (2009) in his book 'The Blue Economy: 10 years, 100 innovations, 100 million jobs' first presented the 'Blue Economy' philosophy/concept: an innovative economic model; in which based on common natural physical processes, seemingly disparate environmental problems are connected and combined with open-source scientific solutions to transform a scarce society into a society of solvency **(Pauli, 2010)**.

McGlade *et al.* (2012) reported that, worldwide water crisis is bottlenecking the existing economy. As a way of ascension, in 2012 in the Rio + 20 conference on sustainable development, 'Blue Economy' meant to 'develop sustainable marine economies' concept supported by coastal countries, got acceptance in international society **(UNDESA, 2014)**. **Behnam, (2012)** first outlined a scheme for establishment of blue economy.

In Australia, blue economy means traditional and emerging marine industries, while in India, it means economic activities for marine ecosystem or seabed. In blue economy, coastal and deep-sea area are included **(Wenhai *et al.*, 2019)**. Blue economy is a macro-economy concept, a kind of policy, a strategic framework that forwards basic principles of green economy through the introduction of marine innovative technologies expected to create new cash flow, and thus new jobs while maintaining dynamic equilibrium between growth and conservation **(Kathijotes, 2013; Soma *et al.*, 2018; Wenhai *et al.*, 2019)**. There are 26 blue economy sectors: fisheries and aquaculture, maritime trade and shipping, ship building, mineral resources development, marine genetic resource and biotechnology, marine bioproducts, renewable energy, surveillance, tourism, equipment deployment, communication cable laying, water desalination, sea salt, artificial island, construction, and education, and research etc. (Fig. 1) **(Alam, 2019; Islam *et al.*, 2018; van den Burg *et al.*, 2019; Wenhai *et al.*, 2019)**. Landlocked countries by employing direct and indirect ancillary activities for these sectors can participate in blue economy **(OECD, 2016)**. By nature, blue economy is complimentary to Sustainable Development Goals (SDGs), especially for Goal 14 'Life below water' **(Keen *et al.*, 2018)**.

Fig. 1. Blue economy word frequency **(Voyer *et al.*, 2017)**.

In academia, researchers have been working on several themes of blue economy. **Kathijotes (2013)** highlighted the principle of blue economy as marine resource

utilization and tackle associated environmental pollution. **Mulazzani *et al.* (2016)** focused on ecosystem service management tool, while **Soma *et al.* (2018)** included social innovation- stakeholder's adaptation of positive attitude for long term collaboration. **van den Burg *et al.* (2019)** put forward spatial planning and possible limit for growth of marine industries

To establish blue economy, EU (**European Commission, 2020**), Indonesia **(Sari & Muslimah, 2020)** has strategic frameworks and action plans. Universally, the blue economy development policy includes marine innovations i.e., Blue Silicon Valley, widen horizon (deep sea, polar seas exploration, ocean observation network) and deep ocean stewardship **(Wenhai *et al.*, 2019)**.

Blue economy practical instances are *in-situ* ocean monitoring, disaster prevention e.g. forecast harmful algal bloom, pollution prevention e.g. microplastic removal technology, marine industrial support tool e.g. aquaculture site selection, ecosystem, fisheries management tool, mapping CO_2-optimal maritime tracks, system platform services in addition to ecological restoration e.g. coastal mangrove afforestation (**Wenhai *et al.*, 2019)**.

The Blue economy potentials in Bangladesh

Global oceans in 2010 generated ~$1.5 trillion USD; or about 2.5% of world's gross economic value and the equivalent of 31 million full-time jobs **(OECD, 2016)**. In Bangladesh, $6.2 billion USD gross value was generated by the ocean economy in 2015. All the potential blue economy sectors for Bangladesh that are mentioned dispersedly in previous literatures are presented in the Fig. (2).

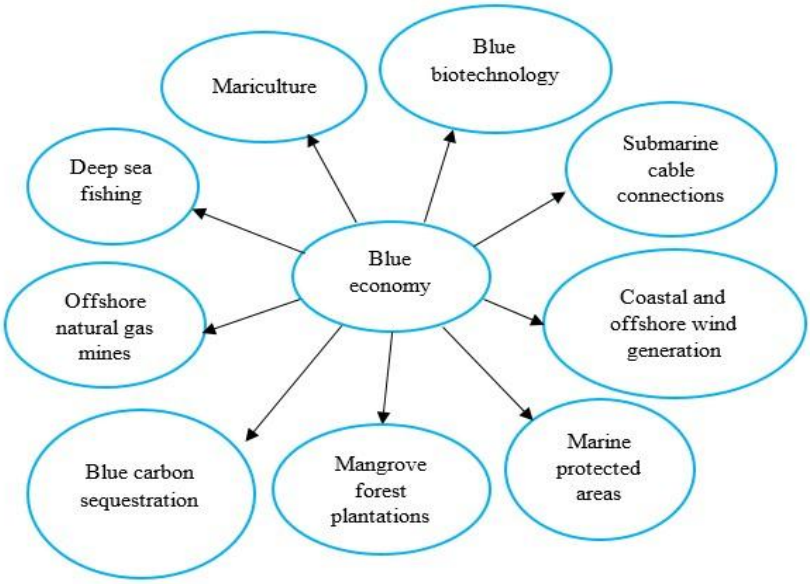

Fig. 2. Potential blue economy sectors in Bangladesh (Source: **Hossain *et al.* 2014; Patil *et al.*, 2018; Sarker *et al.*, 2019**).

The Blue economy resources in Bangladesh

In Bangladesh, if 32% terrestrial area under tidal range is considered as blue economy area, then blue spaces account more area than land area of the country **(Chowdhury, 2017)**. Bangladesh has 710 km long uninterrupted coastline. The continental shelf of the bay of Bengal spreads over about 24,800 square nautical miles. About 37,000 square kilometer of this continental shelf is shallow and within 50 meters depth. About 10,000 square kilometer of the Bengal Bay is considered as an effective fishing area **(Ahsan, 2013)**.

Available biological resources are fish (525 species), crustaceans (91 species), mollusk (301 species), plankton (135), seaweed (200 species), 'Sundarbans' largest mangrove forest (345 plant species) in the world, wildlife (58 species) and bird (270 species) **(Hossain, 2001; Hossain *et al.*, 2014)**. Mineral resources include zircon, kyanite, rutile, garnet, ilmenite, magnetite, leucoxene and monazite **(Hossain *et al.*, 2014**). Other blue economy resources such as organizations, human resources, ports, research vessels etc. has been shown in Table (1).

Sectors at present comprising ocean economy of Bangladesh has been displayed in Fig. (3). Blue economy policies are important resources in Bangladesh. Bangladesh Delta Plan 2100 draft report has identified indicative actions to support key approaches for high priority blue economy sectors **(Bangladesh Planning Commission, 2017)**. To address blue economy in the 7th Five Year Plan of Bangladesh, three prime strategic policies are under development; namely, Integrated Coastal and Ocean Management Policy (ICOMP), National Sustainable Development Strategy (NSDS), Bangladesh's Climate Change Strategy and Action Plan (BCCSAP) **(Patil *et al.*, 2018)**. Constraints and challenges to develop blue economy include lack of policy; researchers, technical knowledge, expert work force, investment, public consciousness, marine defence, regional and international coordination and IUU fishing, climate change, anthropogenic pollution etc. **(Islam *et al.*, 2018)**. Bangladesh Oceanographic Research Institute has declared their short, medium-long- and long-term action plan to develop blue economy in Bangladesh **(MoST, 2020)**.

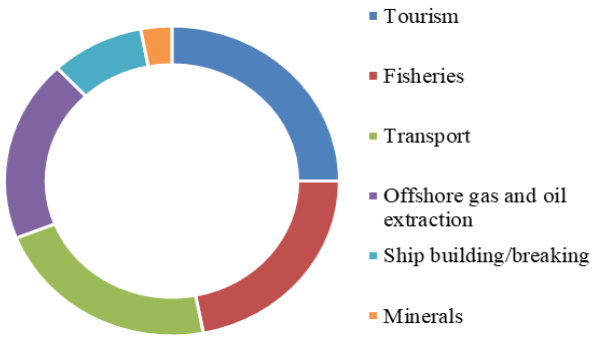

Fig. 3. Present ocean economy sectors of Bangladesh (Source: **Patil *et al.*, 2018**).

Table 1. Organizations, human resources, ports, vessels and remote sensing facilities for blue economy in Bangladesh

A. National organizations	
• Government universities • Department of Fisheries • Bangladesh Fisheries Research Institute • Bangladesh Fisheries Development Corporation • Marine Fisheries Academy • Bangladesh Oceanographic Research Institute • Bangladesh Institute of Marine Technology • National Institute of Biotechnology	• Bangladesh Meteorological Department • Space Research and Remote Sensing Organization (SPARRSO) • Bangladesh Shipping Corporation • Ministry of Power, Energy and Mineral Resources • Ministry of Finance • Ministry of Commerce • Institute of Water Modelling • Ministry of Civil Aviation and Tourism • Ministry of Environment and Forest
B. Human resource	**C. Vessels**
• Total of 30 million people are involved • 1.3 million people in marine fisheries sector • 6 million people in sea salt production, 300 shipyard and 125 ship breaking industry	Hydrographic survey and research vessels: • RV Meen Sandhani, RV Dr Fridtjof Nansen • BNS (Bangladesh Navy Ship) Darshak, BNS Tallashi Submarines (Type 035G-Ming class): • BNS Nabajatra, BNS Joyjatra
D. Ports-harbors	**E. Remote sensing facilities**
Chittagong, Mongla and Payra deep sea port	• Bangabandhu-1 (Satellite) • National data center, Government of Bangladesh

The blue economy of fisheries and aquaculture

Globally, Bangladesh is 3rd for inland fish production **(FAO, 2020)**. In the last 15 years, aquaculture growth in Bangladesh has been remarkable and this sector contributes about 56% of total fish production. The reasons behind increasing trend in aquaculture production are dissemination of improved technology packages and supportive extension services at farmer's level. During the 60's, about 90% of the total fish production came from inland wild fisheries; whereas at present, the open water contributes only about 28.19%. Inland capture fisheries has been replaced as top fish producing sources by aquaculture due to mainly decline and the degradation of natural water bodies (Fig. 4). Notably, fisheries represent the second largest export sector of Bangladesh (Fig. 5) **(DoF, 2020)**.

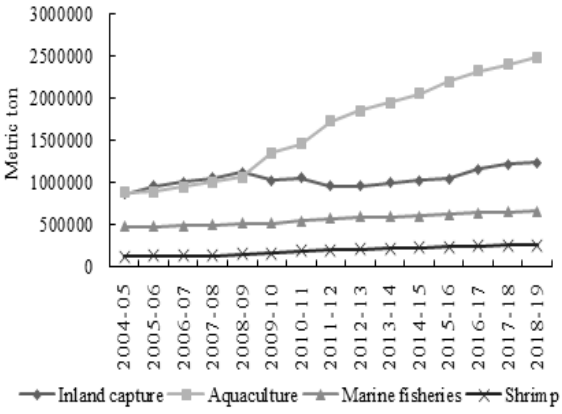

Fig. 4. Fisheries production of Bangladesh in the last 15 years (Source: **DoF, 2020**).

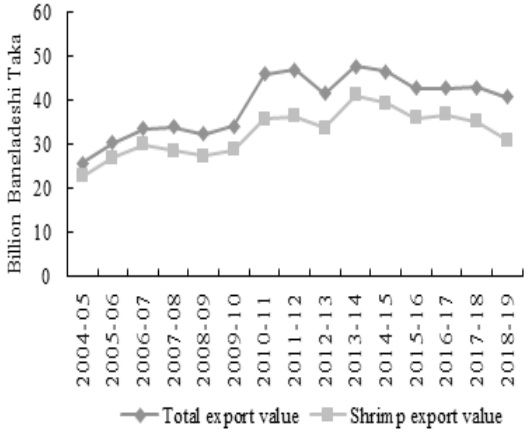

Fig. 5. Fisheries export of Bangladesh in the last 15 years (Source: **DoF, 2020**).

In previous literature, superficially development in fisheries sector is identified as blue economy but precisely what interventions are actually fall within blue economy theory ought to be reported. In this section actual blue economy interventions in fisheries of Bangladesh has been mentioned. From blue economy perspectives, significant marine fisheries activities are identity card for fishermen, vessel monitoring system device in commercial trawlers and database for all fishing vessels **(DoF, 2020)**. Future considerations should be focused on to modernize fishing fleet, fisheries product, by-product development **(Hossain *et al.*, 2017)**, big data analysis (www.seaaroundus.org), and machine learning and artificial intelligence **(Cui *et al.*, 2020)**.

One of the critical criteria for any activity to be considered as blue economy intervention is the conservation and sustainable management of aquatic natural resources. From that point of view, in case of inland waters, initiatives taken by Bangladesh government such as implement ban fishing period for *Tenualosa ilisha*, community-based fisheries management, set up fish sanctuaries, beel nurseries, declared Halda River as fisheries heritage, and the Sundarbans mangrove forest conservation project **(Halls *et al.*, 2017; Rahman *et al.*, 2019)** comply with blue economy concept. Aquaculture is an important blue economy component **(Boto *et al.*, 2013)**. Following aquaculture technologies using at present in Bangladesh such as biofloc, aquaponics, use of probiotics, cage, pen culture, non-traditional species culture e.g., *Monopterus cuchia* **(Shamsuzzaman *et al.*, 2017)**, fish marketing android application **(Tiger Park Limited, 2020)**, Bangladesh Technology and Innovation Platform (BATIP) **(Bush *et al.*, 2021)**, are innovative. Such technologies can be considered as blue economy interventions. Aquaculture of Bangladesh should require to incorporate some other innovative technologies such as precision aquaculture and mechanization **(Antonucci & Costa, 2019),** biotechnology in breeding, feed/nutrition, disease management industries **(Edun & Uka, 2011)** to utilize the potential of blue economy. In regard to fish processing and utilization by people, setting up new modern dry fish plant **(TBS News, 2020)** can be

considered as a blue economy approach. Biorefinery approaches applying for fisheries wastes **(Nguyen *et al.*, 2017)** are an important blue economy technology.

Way forward to blue economy in fisheries sector of Bangladesh

A conceptual framework to way forward for establishing the blue economy of fisheries and aquaculture in Bangladesh has been depicted in Fig. (6). To establish blue economy in fisheries and aquaculture, both financial investment and intellectual (research, education, training) efforts should be integrated and provided as inputs. In case of private or commercial finance, along with business profit, public welfare has to consider cautiously. Blue economoy assets can be classified as renewable and non-renewable type. Renewable assets include existing attitude and practices, while non-renewable assets include natural waterbodies, environment and native biodiversity. To establish blue economy in Bangladesh, for both renewable and non-renewable assets, short-, mid- and long-term schemes should be operated simultaneously. Some examples of short-, mid- and long-term tasks has been provided in Fig. (6). Ultimately, renewable assets have to be taken to market, i.e., to consumers through processing into marine products in commercial or industrial scale. This is the main economic activity, which forms the base of blue economy concept. When the above- mentioned inputs are given to blue economy assets, four types of outputs, i.e., provisioning, supporting, regulating, and cultural services will start to benefit the community directly and indirectly. In this system, to manage input (assets and outputs), a strong and robust governance is a critical component. It is worth mentioning that, every system including this conceptual framework contains some uncertainties.

Current status of shrimp farming

In this section summation of different aspects of shrimp culture practice in Bangladesh from previous literatures were presented to construct a complete farm to fork scenario and future potential of shrimp cultivation in Bangladesh.

Shrimp farms in Bangladesh

Shrimp farming is an ancient practice in Bangladesh (Table 2). A total of 0.25 million hectares (ha) (DoF, 2020) is in use to culture *Penaeus monodon* (Bagda) (70% of production), then *Macrobrachium rosenbergii* (Golda) (15%) and other mixed species (15%), namely, *Metapenaeus monoceros*, *Fenneropenaeus indicus*, *P. semisulcatus*, *F. merguiensis* in brackish and fresh water of Khulna, Satkhira, Bagerhat, Chittagong, Cox's Bazar, Barguna, Bhola regions **(Hossain and Hasan, 2017)**.

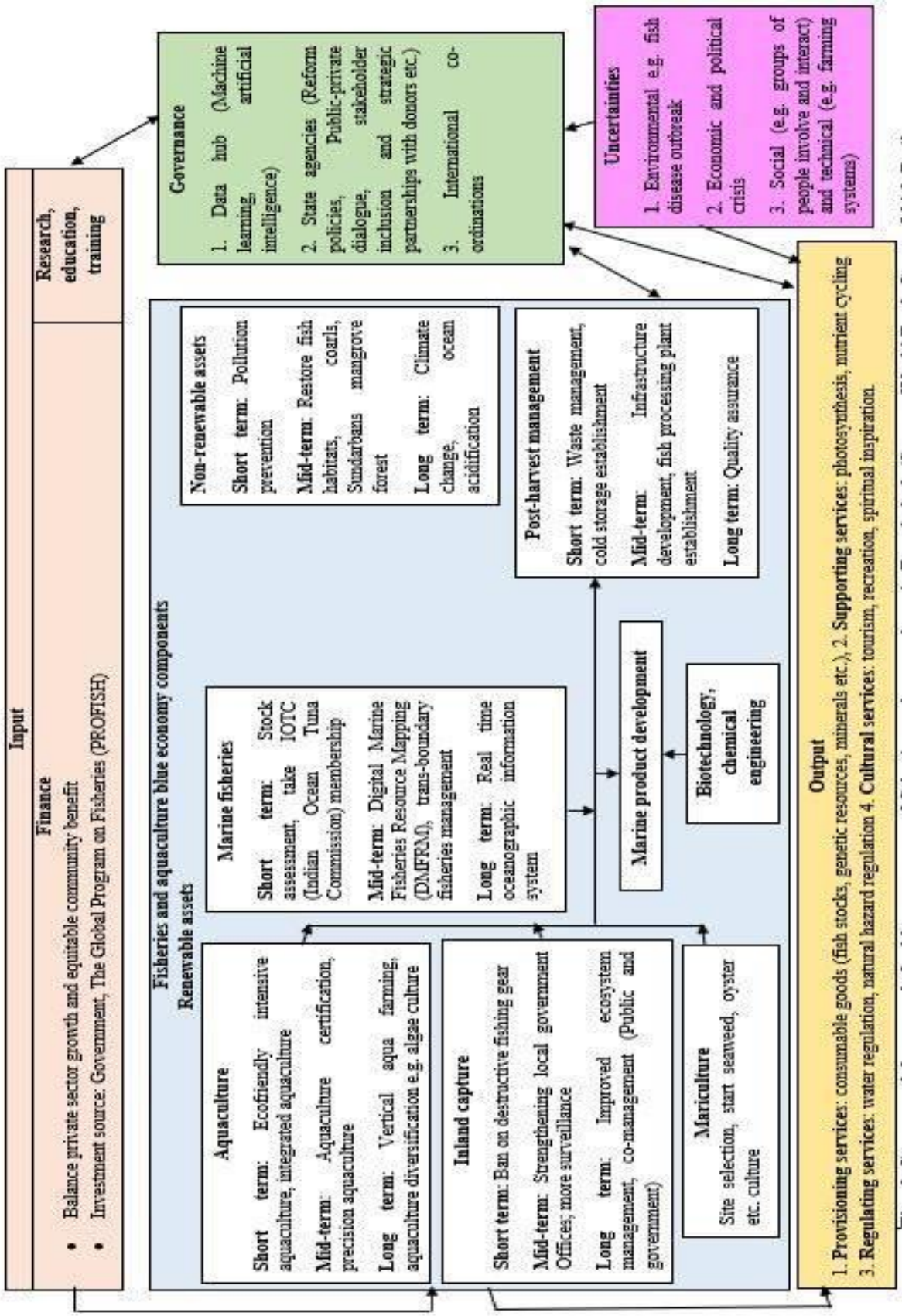

Fig. 6. Conceptual framework for blue economy of fisheries and aquaculture in Bangladesh (Source: World Bank Group, 2016; Patil et al., 2018).

Table 2. Historical development of shrimp farming in Bangladesh

Phase	Time frame	Factors contributed
Entrap wild shrimp and fish within small dykes constructed over low-lying intertidal lands at new or full moon	Ancient time-1970	• No management
Traditional subsistence oriented shrimp farming by local farmers	1970-1985	• Export demand increased market price • *Gher*/*Bheri* (enclosure having higher dikes) farming, polder area with sluice gate
Local elites and outside entrepreneurs started export oriented commercial farming	1986-1997	• Selective stocking of wild caught shrimp post-larvae (PL) • Infrastructure, technology and financial incentives by govt. in cooperation with international organizations • Farms licensing system • *khas* (govt. owned) land lease • Semi-intensive shrimp culture
Local smallholder shrimp farming	1998 – to date	• Capital loss for disease outbreaks • Govt. withdraw license system • Local land owners non-renewed old lease deeds/ increased land rent

Source: Hossain and Hasan (2017).

Climate and cropping patterns

The majority (80%) of shrimp farms are located in Khulna. This region is situated in a subtropical monsoon climate zone characterized by four seasons, namely, pre monsoon (March-May), monsoon (June-September), post monsoon (October-November) and dry winter season (December-February). Highest and lowest mean temperatures are 35.5 °C in August and 12.5 °C in January, respectively. Farming practices and culture periods vary from the southwest (Khulna) to southeast (Cox's Bazar) region of Bangladesh as salinity fluctuates with the amount of rainfall. For example, shrimp is cultured round the year in Satkhira. But in Khulna shrimp and paddy is cultured from January to July and August to December, respectively. Again, in Cox's Bazar salt and shrimp is cultivaed from December to July and August to November, respectively **(Alam and Phillips, 2004)**.

Pond management

Design of all the farms are common, rectangular or irregular in shape, open systems (no treatment pond), bottom topography is irregular, and located in inter-tidal area **(Alam and Phillips, 2004)**. Farms containing 1-5 ha, 6-10 ha and >10 ha area are

considered as small, medium and big farms, respectively **(Islam *et al.*, 2005)**. Most farmers own small farms **(Mamun *et al.*, 2020)**. Height and width of dike vary from 0.4-1.2 m and 0.2-0.7, respectively. Culture practice involves multiple stocking, multiple harvesting method **(Alam and Phillips, 2004; Rahman *et al.*, 2017)**.

Culture practices

Four types of shrimp farming methods are practiced- extensive traditional, improved traditional, organic, and semi-intensive. Occurrence of epidemic in 1994, 1996 and 2001 transformed shrimp farming practice from traditional to improved traditional method. Total 77 shrimp and prawn hatcheries produced 980.95 billion PL in 2018-19 **(DoF, 2020)**. Most farmers stock 30-50 PL/decimal **(Mamun *et al.*, 2020)**. In extensive traditional farming, farmers seldom use commercial feed. In extensive traditional and organic farming, no commercial feed is used, farmers depend on natural food available in pond ecosystem. Except semi-intensive farming method, in other methods, during tidal regimes i.e., at 15 days interval, 20-30% pond water is exchanged with river water to flush out farm effluents **(Alam and Phillips, 2004; Mamun *et al.*, 2020)**. Organic shrimp farming is least costly but production is higher followed after semi-intensive farming among all the farming practices. In improved traditional farming, farmers use various insecticides indiscriminately before pond preparation to remove undesirable organisms and at harvest to kill fish, eel, crab, shrimp. Farmers also use pesticides to protect shrimp from pests. Use of insecticides is imposing adverse effect on local ecosystems. In contrast, in organic farming, inorganic fertilizer is not used, in case of insecticide or pesticide, permissible dose is applied and only certified organic inputs are used. Shrimp produced by extensive traditional and organic farming has been creating a brand image 'Bangladeshi organic shrimp' in international market **(Sarkar *et al.*, 2019)**.

In semi-intensive shrimp farms, bleaching powder (250 kg/ ha) (CaOCl)Cl is used to disinfect the water that first introduced in pond and then after lime application ponds are aerated up to 7 days by pulling horra or electric aerator. Then after mixing and heating of molasses, wheat bran or rice bran and yeast, the mixture is kept for two days and then applied (80–100 kg/ha) for plankton production. PCR tested PL (15–20 days old) is stocked. Feeding frequency is 4 times/day and aerator is used after 2-3 hours of feed application **(Rahman *et al.*, 2017)**.

Common prawn diseases are black spot or shell disease, white muscle, bacterial diseases. Shrimps are affected mostly by white spot syndrome. Other shrimp diseases are tail rotten, black gill disease, soft shell disease, external fouling and antenna breaking disease **(Begum and Alam, 2002)**. Farmers randomly check shrimp growth and health status by body color, size variation, external gut, shell. If shrimp disease outbreaks in neighboring farms, farmers harvest early and sundry the bottom of culture pond as preventive measure **(Alam and Phillips, 2004)**. Chemicals (salt, potassium permanganate, sumithion, melathion etc.), active ingredients of antibiotics

(oxytetracycline, amoxicillin, sulphadiazine), growth promoters (amino acid premix, vitamin premix etc.), and probiotics (*Bacillus subtilis* with *Rhodoseudomonas*, *Saccharomyces cervisiae*, Coated Vit-C) are commonly used in heath management **(Shamsuzzaman and Biswas, 2012)**. Hygiene and biosecurity are practiced in semi-intensive farms **(Rahman *et al.*, 2017)**. Social and economic aspects of shrimp cultivation has described by **Rahman and Hossain (2013)**.

Harvesting methods and grading

In extensive shrimp farming, after 90-120 days of culture, harvesting is carried out during full and new moon. In Gai method, when fresh tidal water enters into pond, excited shrimp gathered in catchment area constructed at water inlet and then caught by cast net. Bamboo traps (standard 2 ft x 2.5 ft x 2 ft) with bait (small shrimps) are set up 8-10 feet intervals at peripheral dikes. In case of less catch by Gai, trap method, cast net or seine net is used **(Alam and Phillips, 2004; Mamun *et al.*, 2020)**.

On the basis of weight, shrimps are graded as Grade A (price BDT 700/kg), B (price BDT 500/kg) and C (price BDT 400/kg). U-5 means, ≤ 5 prawns make 1 kg (Grade A), while 8/12 means 8-12 prawns make 1 kg (Grade A) **(Omar *et al.*, 2014)**.

Production and supply chain

Shrimp production (kg/ha) is increasing steadily (Fig. 7). Although prawn is more profitable than *T.* (transplanted) *Aman* paddy but per ha investment is higher for prawn culture **(Rahman *et al.*, 2013)**.

Although total cost is more or less same for small, medium and big farms but small farms receive relatively high investments on inputs and labor; which results in less shrimp mortality, higher production, thus maximum gross returns. So, production and profit is greater in small shrimp farms **(Islam *et al.*, 2005)**.

Shrimp supply chain is complex and involves many stakeholders, e.g., fry collectors at sea, hatcheries, farmers, feed mills, local depot owners, middleman, processing plants, international buyers **(Islam, 2008)**.

Future potential of shrimp cultivation

Bangladesh has 105 (EU approved- 76) fish processing plants. In 2018-19 Bangladesh exported 0.033 metric ton frozen shrimp in Vietnam, USA, UK, UAE, Netherland, Japan, India, Saudi Arabia, Germany, Kuwait, France, Belgium, Portugal **(DoF, 2020)**. By 2030, globally there will be 50-60% growth in shrimp production whereas per capita fish consumption will increase from 17.2 kilograms/year in 2010 to 18.2 kilograms/year in 2030 **(World Bank, 2013)**. At this slow rate, as a developing country Bangladesh might face challenges to maintain current export earnings.

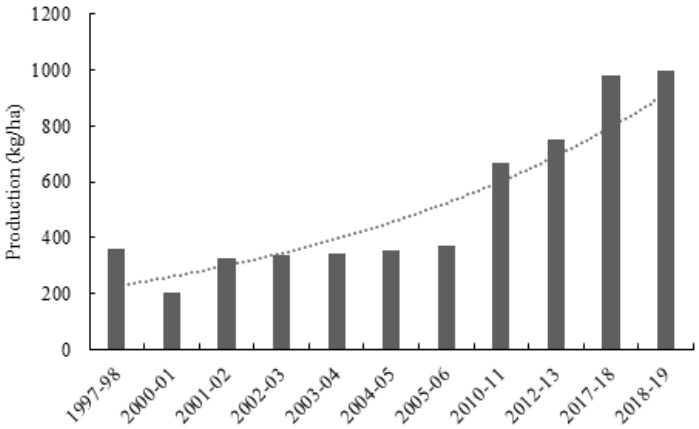

Fig. 7. Shrimp production trend in Bangladesh (Source: DoF, 2020).

The blue economy of shrimp cultivation

No blue economy interventions in shrimp cultivation of Bangladesh has reported yet. In this section, some blue economy interventions has been mentioned; which might act as examples to innovate and/or implement new blue economy interventions in shrimp sector of Bangladesh.

Some sustainability issues of shrimp culture in Bangladesh are environmental and ecological, e.g., mangrove forest and wetland destruction, soil acidity, local biodiversity loss, soil and water quality deterioration and pollution, intrusion of saline water, waterlogging condition in localities **(Hossain *et al.*, 2013; Hossain & Hasan, 2017)**, socio-economic, e.g., land use conflict, rural to urban migration of poor and unskilled inhabitants, violation of labor law (child labor), gender equity, low technical knowledge of farmers, and disease e.g. white spot syndrome; indiscriminate use of antibiotics **(Begum & Alam, 2002; Islam & Bjarnason, 2008)** etc. To develop blue economy, these sustainability issues should be resolved in innovative ways, for example, environmentally adjusted production performance **(Jahan & Ancev, 2017)**, life cycle assessment (LCA) **(Medeiros *et al.*, 2017)**. In addition to the previously mentioned examples, geographic information system (GIS) is useful for land use zoning **(Dawwas, 2014)**, insurance scheme for shrimp farmer, alternatives of antibiotics, solar power for farm machinery, and the national shrimp policy 2014 **(Ministry of Fisheries & Livestock, GoB, 2014)** etc. are to be considered. The national shrimp quality assurance programs include Good Aquaculture Practice (GAP), HACCP, traceability **(Alam, 2013; Mondal *et al.*, 2013)** etc. A conceptual framework addressing some major challenges, possible intervention to overcome the challenges to establish blue economy in shrimp sector of Bangladesh are presented in Fig. (8). An online platform will harbor all stakeholders including international buyer and regulatory bodies, associated with shrimp business. Through this platform Department of Fisheries will detect new problems and the monitor the progress

of implementing schemes by collaborating with universities, research organizations and other agencies.

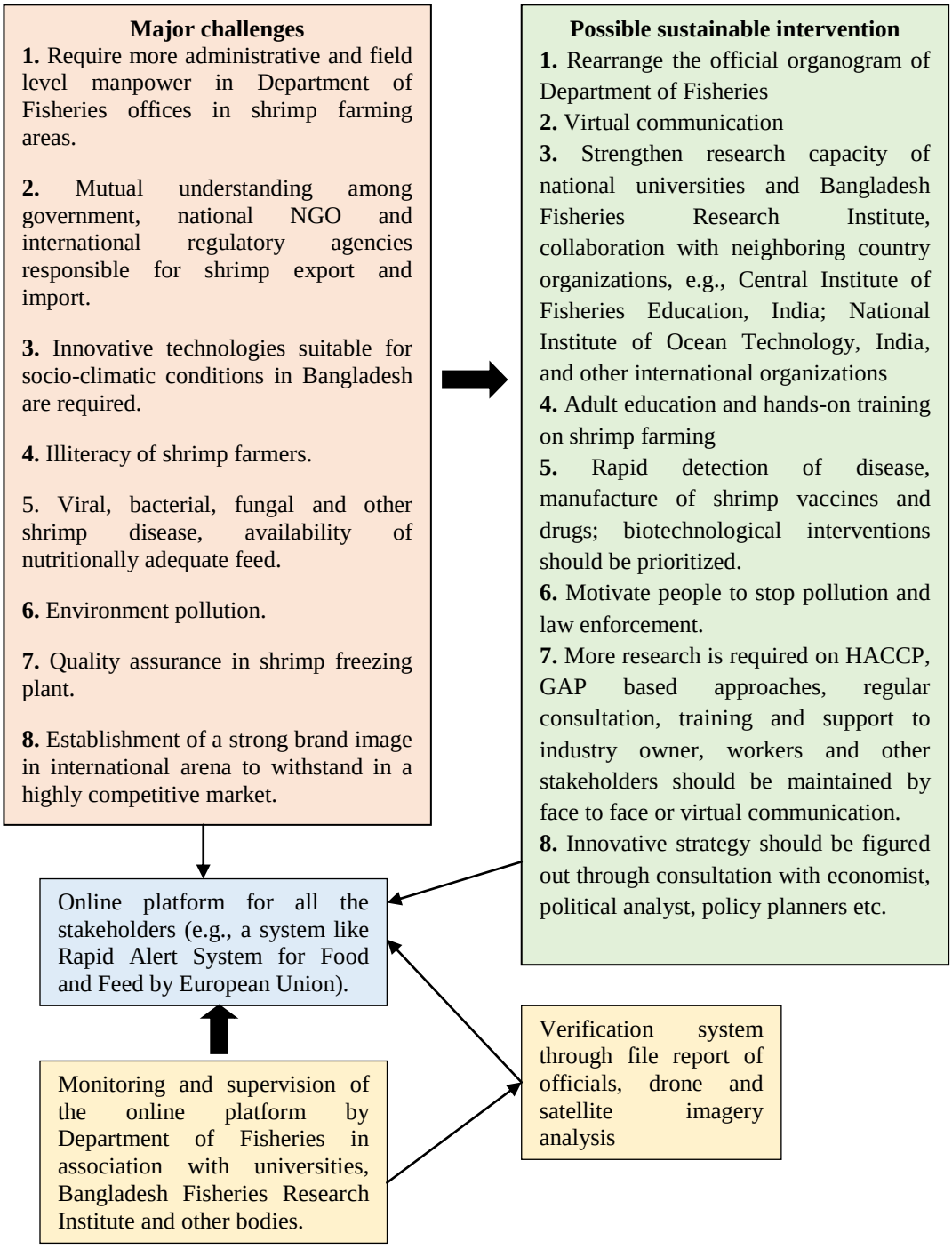

Fig. 8. Conceptual framework to establish blue economy of shrimp sector in Bangladesh.

CONCLUSION AND FUTURE RESEARCH NEEDS

There is a significant difference between blue economy and other developmental economy. The redical rule of blue economy is the state of the art innovation and sustainability. Bangladesh has got several potential blue economy sectors. In order to utilize the blue economy potential, Bangladesh government has to play the main role. Government should declare national blue economy policy and aware mass people. Many state agencies are related thus coordination is important, and for this purpose, a national marine data hub dedicated only for blue economy uses might be effective. By including blue economy in the priority research themes, government should support universities and research organizations. In marine waters, future research is required on fish location using eco-ranger and other sophisticated devices, mariculture technology for seaweed and other shellfishes e.g., lobster, mussel, oyster, understanding hydrodynamics, oceanography of Bay of Bengal, traditional knowledge and attitude of local inhabitant in utilizing marine resources, commercial product development from marine organisms e.g. medicine from jelly fish toxin etc. Innovative blue economy technologies should be applied to upgrade shrimp cultivation in Bangladesh from improved traditional to intensive culture system for a greater production. Research should be focused on shrimp biology, disease, reduction of magnitude of negative impacts on shrimp farming for local ecology and community in addition to establishment of intensive culture protocol for higher production. Shrimp farmers and other stakeholders should be trained up. Government should employ more expert and skilled manpower for administrative maintenance. The total scheme for establishing the blue economy in Bangladesh should be a holistic, international approach. Thus, private-public partnership, regional and international collaborations should also be incorporated.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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