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Shrimp value chains in Bangladesh

A scoping study of possible research interventions

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ABSTRACT

Shrimp is Bangladesh's main agricultural export and makes a substantial contribution to the economy of southern Bangladesh, but the sector has a checkered history. Bangladesh's shrimp production and exports have been in steady decline, since peaking in the early 2010's. Most shrimp exports from Bangladesh are used by the food service and niche ethnic markets in Europe.

The complex nature of shrimp supply chains in Bangladesh, comprised of hundreds of thousands of small polyculture farms and tens of thousands of small traders, make it difficult to implement traceability and certification initiatives – now a prerequisite for entry into most supermarket supply chains.

This report provides an overview of the sector and the challenges it faces, drawing on secondary and survey data, reviews of government reports and academic literature. We also report the findings of an expert consultation conducted to identify key constraints and potential solutions.

The consensus among industry stakeholders who were part of the expert consultations is that issues related to the supply and quality of shrimp seed and pond management practices represent some of the most pressing, yet relatively simple-to-solve challenges currently faced by the sector. This would serve as the foundation for establishing traceability and certification processes. Previous interventions aimed at upgrading production practices (such as promoting stocking of disease-free shrimp seed) and facilitating disintermediation and transparency in the supply chain (such as by establishing producer groups, shrimp collection centers, and contracts with processors), have met with limited success. We outline potential interventions and partners that might offer scalable solutions enabling small shrimp farmers to access global markets.

ACRONYMS AND ABBREVIATIONS

ABC	Alliance Bioversity-CIAT
AIN	Aquaculture for Income and Nutrition
AIT	Advance Income Tax
ASC	Aquaculture Stewardship Council
BANA	Bangladesh Aquaculture and Nutrition Activity
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka
BFDC	Bangladesh Fisheries Development Corporation
BFFEA	Bangladesh Frozen Food Exporters Association
BFRI	Bangladesh Fisheries Research Institute
BSFF	Bangladesh Shrimp and Fish Foundation
BWDB	Bangladesh Water Development Board
CBI	Centre for the Promotion of Imports
CGIAR	(formerly) Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CPF	Charoen Pokphand Foods PCL
DoF	Department of Fisheries
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FTF	Feed the Future Initiative
GAP	Good Agricultural Practices
GATE	Greater Access to Trade Expansion Project
GoB	Government of the People's Republic of Bangladesh
GVC	Global Value Chain
Ha	Hectares
HOSO	Head On Shell On shrimp
IDA	International Development Assistance
IDEA	Investigate, Discuss, Estimate, Aggregate protocol
IFPRI	International Food Policy Research Institute
ITC	International Trade Centre
kg	Kilograms
LMM	Land Management Manual
MFO	Marine Fisheries Ordinance
MoE	Ministry of Environment
MoFL	Ministry of Fisheries and Livestock
MSU	Michigan State University
NWP	National Water Policy
PCR	Polymerase chain reaction
PD	Peeled and Deveined shrimp
PL	Post-larvae
RMG	Ready-made garments
SAR	South Asia Regional Office
SEMP	Shrimp Estate *(Mohal)* Management Policy

SME	Small and medium enterprises
SPF	Specific pathogen free
TE	Triennium ending
TSP	Triple superphosphate
UK	United Kingdom
UNIDO	United Nations Industrial Development Organization
US/USA	United States of America
USAID	United States Agency for International Development
USD/US $	United States Dollars
WP	Work Package
WSSV	White Spot Syndrome Virus
WTP	Willingness to pay
VAT	Value-added tax

1 INTRODUCTION

1.1 Background

The One CGIAR Research Initiative on **"Rethinking Food Markets and Value Chains for Inclusion and Sustainability"** is a multi-country program spanning four Work Packages, each concerning different aspects of agricultural value chains: (1) global value chains for export markets, (2) domestic value chains, (3) cross-value chain support services (logistics and e-finance), and (4) knowledge, metrics and models.

Work Package 1 (WP1), titled **"Making globally integrated value chains inclusive, efficient, and environmentally sustainable"**, focuses on increasing participation and profitability of smallholders and small and medium enterprises (SMEs) in global value chains (GVCs). It aims to do this by testing and scaling interventions in three areas: (a) innovations to improve vertical coordination among GVC actors; (b) mechanisms for upgrading product quality, including food safety and sustainability; and (c) identifying and scaling digital innovations for tracing products and making market information accessible to GVC participants. Given this context, WP1 will study oilseeds in Ethiopia, horticulture in Uzbekistan, coffee in Central America, and shrimp in Bangladesh.

The motivation to study the shrimp value chain derives from the commodity's position as the largest food export commodity for the country and its importance for the livelihoods of a large segment of the population of southern Bangladesh. Although far eclipsed in earnings by the ready-made garments (RMG) sector, shrimp exports still totaled US$ 418 million in the 2021-22 fiscal year (Bangladesh Bureau of Statistics [BBS] 2022a). Aside from downstream links to processors and exporters, the sector also has strong upstream links to hatcheries and farmers and helps support rural livelihoods, particularly in southwest Bangladesh (Belton 2016). A USAID-funded study under the Greater Access to Trade Expansion (GATE) project estimated that in 2006, around 1.2 million people were involved in shrimp production, with an additional 4.8 million household members who indirectly benefited from the sector (USAID 2006).

In recent years, the shrimp sector has suffered from stagnant growth. The total value of shrimp exports shrank by 5.6% with respect to the triennium ending average (TE) between 2016 and 2019 (BBS 2022b). Earnings took a further hit in 2020 due to pandemic-related restrictions that affected both input imports (feed and disease-free shrimp post-larvae) and exports (processed, frozen shrimp), shrinking by 21.7% relative to TE 2019. The year 2021 has seen some form of recovery, with exports bouncing back to 97.6% of TE 2019 levels (BBS 2022b).

The plight of shrimp exports contrasts with the transformative growth of the aquaculture sector in Bangladesh. Rashid and Zhang (2019) document the declining trends in the real price of fish alongside rising demand, attributing the rise of aquaculture to technological improvements (such as the introduction of modern fish varieties, use of modern inputs and postproduction marketing practices), reduced transaction costs (due to improvements in infrastructure and access to information), and value chain innovations (specifically disintermediation, reducing the number of actors in the value chain).

1.2 Objectives

Given the backdrop described above, this scoping study has the following objectives:

1. Describe the structure and operation of the shrimp value chain, from input markets to primary production, processing, and export.
2. Diagnose problems in the value chain, defined as obstacles or constraints which reduce the earnings of participants, limit participation of women and other disadvantaged groups, and/or exacerbate the environmental impact.
3. Explore the merits of alternative solutions that may address one or more of these problems, where the evaluation is based on an analysis of secondary data, the views of stakeholders, pilot projects, and experience in other countries.

1.3 Methods

In tackling the first objective, we draw on existing academic and grey literature, government reports and policy documents, available secondary data and primary surveys undertaken by the CGIAR in the past.

For the second and third objectives, we rely primarily on consultations with stakeholders to secure more insights into the magnitude and urgency of the problems and challenges faced by shrimp value chain actors as well as potential solutions to tackle them. We attempt to approach these consultations systematically to ensure representation of different stakeholders and to provide a means of validating problems and the potential of proposed solutions.

We identify the following steps:

Step 1: Review literature and past consultations to develop a long list of perceived problems and potential solutions or interventions. Many reports speak of barriers that impede shrimp value chain actors from consistently tapping export markets globally. Further, as part of a recent study on Covid-19 impacts on fish and shrimp value chains in Bangladesh, we conducted two stakeholder consultations in collaboration with the Bangladesh Shrimp and Fish Foundation (BSFF) in February and September 2021. These provide rich characterizations of the state of the sector and the impacts of Covid-19.

Step 2: Identify an appropriate methodology for elicitation and develop protocols. It is well known that consulting experts with deep knowledge of sectors can provide grounded insights on challenges and potential solutions. At the same time, expert and participant views are often products of their own positions as stakeholders in the value chain. We therefore applied structured elicitation protocols that enable us to harness the judgments of stakeholders and inform critical decisions. Such protocols treat each step of the elicitation as a process of formal data acquisition. We drew on the IDEA (Investigate, Discuss, Estimate, Aggregate) protocol that has been applied to a wide variety of scientific and technical domains (Hemming et al. 2018; Burgman et al. 2011; Burgman 2015).

Step 3: Preparatory phase. The preparatory phase involves identifying a list of experts and stakeholders who represent different segments of the value chain. We designed these protocols and appointed an experienced consultant and engaged research support staff to implement them.

Step 4: Implementation of the elicitation process. The implementation of the elicitation process was done in person, with individual interviews with around 30 experts. There were one round of one-on-one interviews with each expert and one group consultation to arrive at a consensus on a short list of the top problems from among the many that were identified, and the pros and cons of potential solutions,

including scalability, impacts and tradeoffs of each of these. Our goal was to attempt to quantify some the subjective judgments while also capturing some of the non-quantifiable aspects of these issues.

Step 5: Analysis. We used the elicitation exercise based on IDEA protocols as the basis for identifying the key problems and potential solutions. We analyze these data in conjunction with other available materials, such as literature reviews, secondary data and so on, as a way of validating some of the views that emerged from this effort.

2 DESCRIPTION OF THE SHRIMP VALUE CHAIN

2.1 Exported shrimp species: *Penaeus monodon (bagda)* and *Macrobrachium rosenbergii (golda)*

Shrimp culture in Bangladesh started primarily in Satkhira district in the 1960s, and expanded to the coastal districts of Khulna, Bagerhat, Cox's Bazar and Chattogram in the decades that followed (Naureen et al. 2006). While several species of shrimp and prawn are farmed across Bangladesh, this study focuses on the two primary export varieties: namely, black tiger shrimp *(Penaeus monodon)*—locally known as *bagda*, and giant freshwater prawn *(Macrobrachium rosenbergii)*—known as *golda* (van der Pijl and van Duijn 2012).

Frozen black tiger shrimp is Bangladesh's premier export product, with almost 98% of farmed *bagda* shrimp being exported. Juveniles live in brackish, estuarine waters (inhabiting coastal estuaries, lagoons, or mangroves), while adults inhabit offshore marine environments. As adults, these shrimps function as benthic feeders of muddy sand or sandy bottom habitats. Females can produce anywhere from 500,000 to 750,000 eggs, which are in turn fertilized by spermatozoa released from the thylecum of the female following mating. The eggs are laid in offshore waters. Hatching occurs 12-15 hours after fertilization, resulting in tiny, free-swimming larvae termed nauplii. Following several stages of larval development with planktonic intermediaries, post-larvae form, which have characteristics similar to adult shrimp. These juvenile stages can tolerate salinity levels of 1-2% (FAO 2005).

Unlike *bagda* shrimp, the *golda* prawn inhabits freshwater systems such as rivers, lakes, swamps, canals, ponds and estuaries. They require brackish water in the early stage of their life cycle, and so they too are found in water either directly or indirectly connected to the sea. *Golda* prawn are typically found in very turbid water. In contrast to the penaeid *bagda* shrimp, *golda* females do not release eggs into the sea and instead carry them in brood chambers on their bodies. Females lay between 80,000 to 100,000 eggs in a single spawning. Hatchling larvae are planktonic and require brackish water to survive. The end stage of development results in post-larvae. These post-larvae are tolerant to a range of salinity conditions (FAO 2002).

Recently, the government of Bangladesh has tentatively allowed commercial farming of the non-native *Litopenaeus vannamei*, or whiteleg shrimp, in southern Bangladesh. The decision comes in the wake of *vannamei's* competitiveness in the global market, having overtaken black tiger shrimp in recent years, and the downturn in supplies from shrimp farms. Currently, eleven firms have permission to culture *vannamei* in the country (Parvez 2023).

2.1.1 Yield rates

Boyd et al. (2018) reported average annual yield rates of 7.86 ± 1.04 (SE) tons per hectare for *L. vannamei* (n = 89) and 3.88 tons per hectare for *P. monodon* (n = 11) in Indian shrimp farms. By contrast, Bangladeshi shrimp farms are far less productive, averaging 358 kg per hectare in the case of *bagda* and 710 kg per hectare for *golda* in 2020-21 (Department of Fisheries [DoF] 2022). Initial yield rates of *vannamei* culture pilots have been promising, ranging from 8.36 and 12.24 tons per hectare (Parvez 2023).

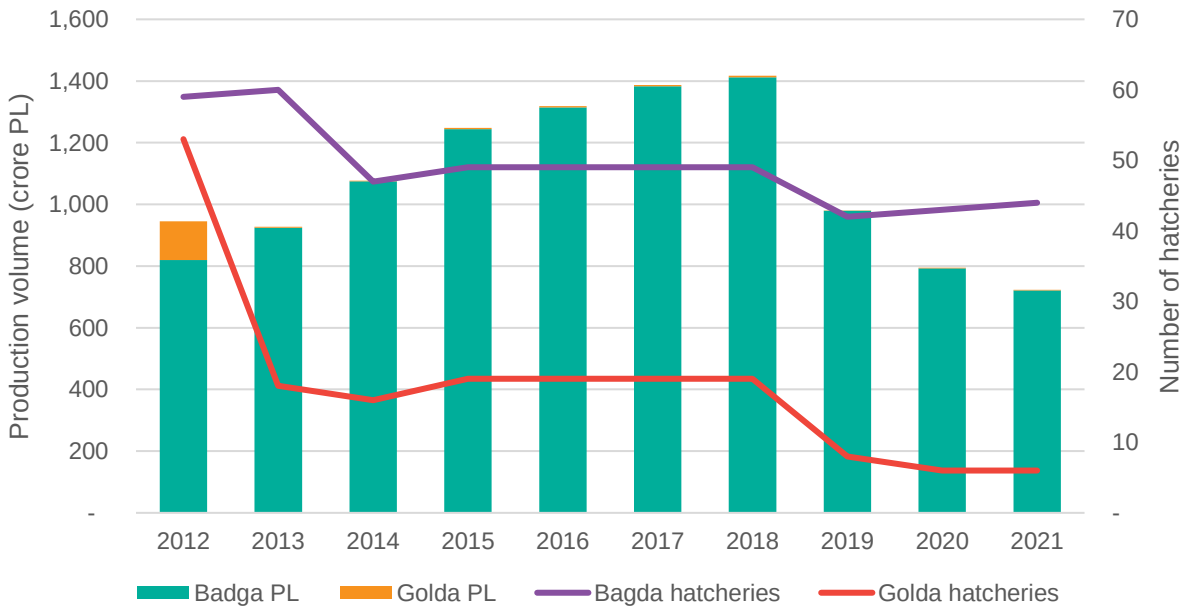
2.2 Inputs in shrimp production

The primary inputs in shrimp and prawn production are post-larvae (PL), feed, and chemicals for pond management and disease control. Around 30 percent of aquaculture farmers also report using water pumps to fill their ponds; of them, more than three-quarters use diesel to operate the pumps, while the rest use electricity (Hernandez et al. 2020).

2.2.1 Shrimp and prawn post-larvae

Shrimp and prawn have different PL supply chains. In the case of *bagda*, a marine shrimp, nearly all PL is sourced from hatcheries located in Cox's Bazar district, where salinity conditions are ideal for proper PL rearing. The PL is then transported by air and distributed by dealers and retailers to grow-out farmers in Khulna, Satkhira and Bagerhat districts. PL production peaked at 14 billion PL in 2018. Since then, PL production has halved to around 7.2 billion PL across 44 *bagda* hatcheries as of 2021 (Figure 1).

Figure 1: *Bagda* and *golda* PL production in private sector hatcheries, 2012-2021



Source: Yearbook of Fisheries Statistics of Bangladesh, DoF, 2012 to 2021.

Meanwhile, *golda* hatcheries have remained essentially non-functional for over a decade. Private *golda* hatcheries numbered 53 in 2012, but only six remain at present, owing to a disease outbreak in the hatcheries in the last decade that decimated production. In 2021, they only produced around 2 crore (20 million) PL. It can be assumed that *golda* prawn farmers largely rely on wild-caught PL for stocking.

Shrimp and prawn post-larvae are especially susceptible to viral disease and result in mass mortalities in shrimp ponds if infected with critical pathogens. Using PCR-tested and specific pathogen-free PL are two ways to help prevent such die-outs. PCR testing generally involves running diagnoses to test for viral pathogens of concern, such as white-spot syndrome virus (WSSV), among others (Flegel 2002). Haque, Anwar Siddique, and Hossain (2020) reported an overall prevalence rate of 17% for WSSV in collected samples from Khulna and Satkhira tested using PCR; *P. monodon* PL samples from Indian hatcheries had a 12.5% infection rate for WSSV (Joseph et al. 2015). SPF PL, meanwhile, are produced from shrimp broodstock known to be free from specified pathogens, preventing these PL from being conduits for pathogens to enter ponds (Lotz 1997). However, the use of these 'disease-free' PL often requires concurrent adherence to strict biosecurity and hygiene protocols to prevent horizontal transmission of pathogens to grow-out ponds.

Most shrimp farms in Bangladesh at present do not use PCR-tested or specific pathogen-free (SPF) PL. Belton and Ali (2022) found that less than 2% of farms used SPF PL in shrimp production, and that only around 8% used PCR-tested PL. The most frequently mentioned reasons behind the underuse of "disease-free" PL included not knowing about it, its unavailability, and perceived high prices relative to normal PL. Interviews by the study team with farmers and government officials also revealed that there is also a general concern regarding the "disease-free" status of SPF PL once it reaches the farmer, with anecdotal evidence of shrimp deaths despite the use of SPF PL. Stakeholders noted that some level of third-party certification would be desirable.

2.2.2 Feed

Prior to the use of commercially produced feed, prawn farms would traditionally use snails (specifically *Pila globosa*, the apple snail) as feed in Bangladesh, which subsequently led to the decline of snail populations. Some farms now use farm-made feed prepared using locally available ingredients and commercial sinking pellet feed (FAO 2017).

Commercial feed for black tiger shrimp contains fish meal, prawn meal, squid meal, soyabean meal, cod liver oil, broken rice, wheat flour, cholesterol, phospholipids, vitamins and minerals[1]. The protein content in these feed formulations is typically 38% and above, with 5% fats and 4% fiber. The moisture content of feed must be maintained at a maximum of 12%.

For the most part, shrimp feed in Bangladesh is sourced from dealers and retailers. While dealers trade mostly formulated feed, retailers largely appear to trade in other forms of feed. The "improved" modern shrimp feed is typically imported and sourced from companies such as Charoen Pokphand Foods PCL (CPF Prawn Feed 9003, 9004S and 9004) and Avanti (Profeed), primarily from India, Thailand and Japan. Imported feed is costly. Only recently have local companies such as Nourish Feeds Ltd begun to produce shrimp feed. Feed availability therefore remains a constraint for the shrimp sector in Bangladesh.

[1] Taken from CPF prawn/shrimp feed for black tiger *(P. monodon)*.

Interestingly, an association of shrimp farmers in the Baradanga beel cluster have recently started manufacturing grower feed, sourcing the raw materials[2] themselves. This feed is sold in the local market at BDT 57/kg[3] as “Baradanga Model Special Shrimp Grower Feed”.

2.2.3 Chemicals

A range of chemicals are used by shrimp farmers in Bangladesh. These fall under the following categories:

1. Water and soil treatment compounds to reduce acidity and remove ammonia and hydrogen sulfide gas (lime, salt and zeolite)
2. Disinfectants to control disease-causing organisms (chlorine, potassium permanganate and hydrogen peroxide)
3. Antibiotics to treat disease-affected shrimp (tetracyclines)
4. Pesticides to remove unwanted species (rotenone)
5. Feed additives (vitamin premixes)
6. Probiotics to inhibit the growth of pathogenic bacteria
7. Fertilizers to stimulate phytoplankton growth (cow manure, urea and triple superphosphate [TSP]).

Overall, several studies have noted that the use of these chemicals is relatively low in Bangladeshi shrimp farms, with particularly negligible levels of antibiotic use (Ali et al. 2016; Rico et al. 2013). Water and soil treatment compounds, particularly quicklime and zeolite, are used by nearly all farmers. Around a third of farmers use disinfectants (potassium permanganate) and pesticides (mostly rotenone). Farmers typically both source and acquire knowledge about these chemicals from retail supply shops. While chemical use has resulted in better survival rates in shrimp and prawn farms, there has been little research into the cost-benefit ratios of their use (Ali et al. 2016).

Given the largely extensive nature of shrimp and prawn farms in Bangladesh, a report by Seafood Watch (2021) concluded that on-farm chemical use was minimal, and that when used, the chemicals in question were mainly those approved for pond and shrimp health management, with little risk of adverse environmental impact if discharged. However, as shrimp ponds modernize and the use of chemicals becomes more prevalent, there remains the potential for effluent pollution in the future.

2.3 Shrimp and prawn production in Bangladesh

2.3.1 Production volumes

The total production of shrimp and prawn across all production sectors totaled 251,964 tons in 2020-21. Shrimp and prawn constitute a relatively small fraction of domestic fisheries production in Bangladesh. Although the volume of shrimp produced has increased by 65% (from 152,520 tons in 2001-02 to

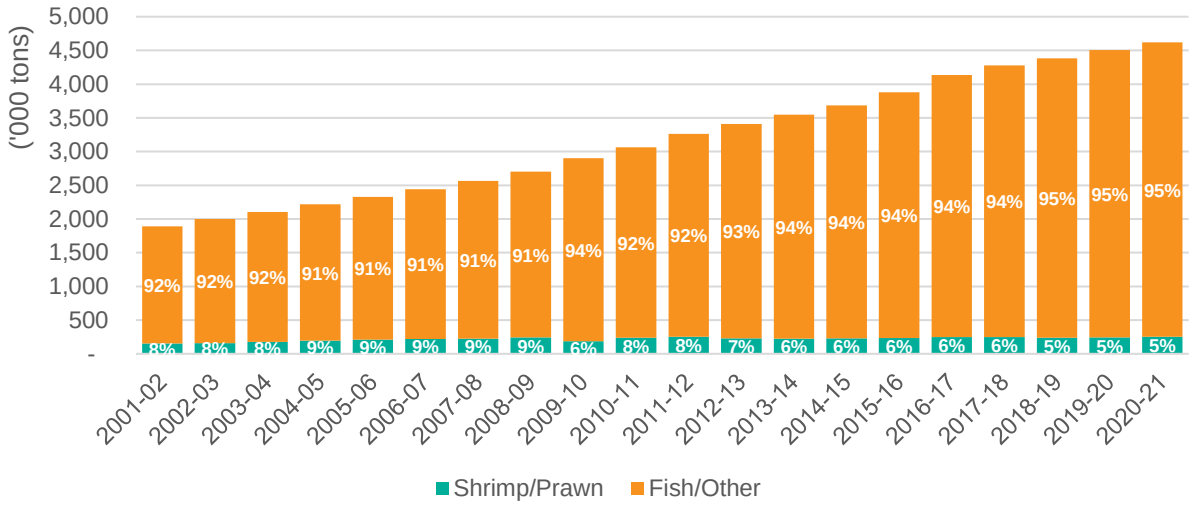
[2] Raw materials listed on the packaging include “corn, soybean meal, full-fat soybean, polished rice, animal protein, amino acids, vitamins, minerals and necessary feed additives”.

[3] Prices are set by this farmers’ association and fluctuated between BDT 57 and 65 per kg over the past few years, as per interviews with the farmers.

251,964 tons in 2020-21), the annual share of shrimp and prawn in overall fisheries production fell in the last 20 years, from 8.1% in 2001-02 to 5.5% in 2020-21 (Figure 2).

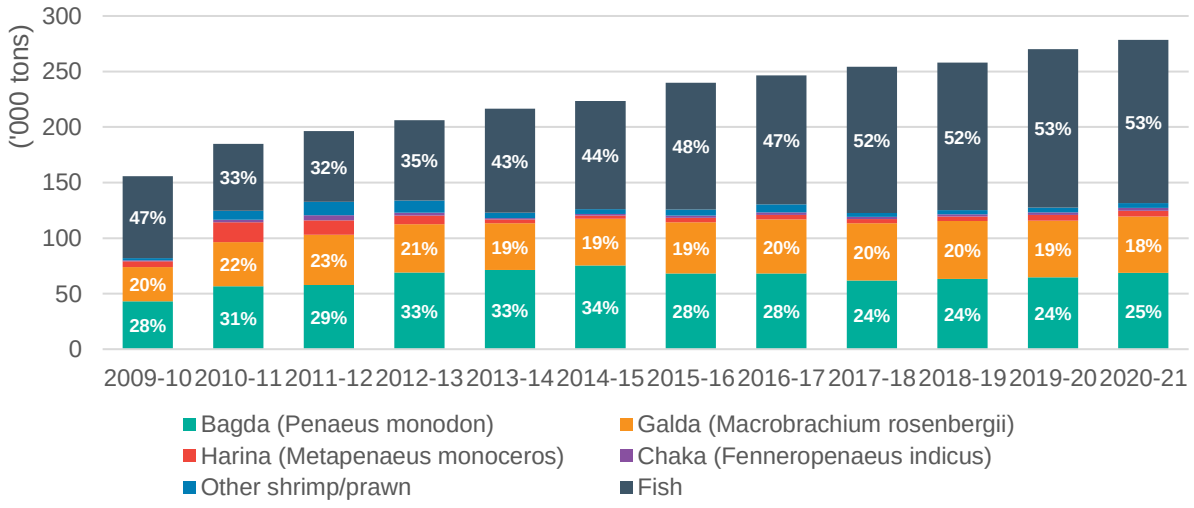
Most of the shrimp produced in Bangladesh for exports is farmed; 96% of *bagda* shrimp and 90% of *golda* prawn production occurs at the farm level (DoF 2022). At shrimp/prawn farms, total production increased by 79% between 2009-10 and 2020-21. However, this rise is largely attributed to polyculture with other fish, which accounted for more than half (53%) of the total production in these farms in 2020-21 (Figure 3). Based on a representative survey of >700 farms in Southern Bangladesh, Belton and Ali (2022) report that fish (mainly carp produced for the domestic market) comprises around 85% of the production of farms growing shrimp and/or prawn, with fish and freshwater prawn increasingly displacing disease-prone *bagda* shrimp.

Figure 2: Share of shrimp and prawn in total fisheries production, 2001-02 to 2020-21



Source: Authors' calculations using data from the Yearbook of Fisheries Statistics of Bangladesh, DoF, 2001-02 to 2020-21.

Figure 3: Annual production in shrimp and prawn farms by species, 2009-10 to 2020-21

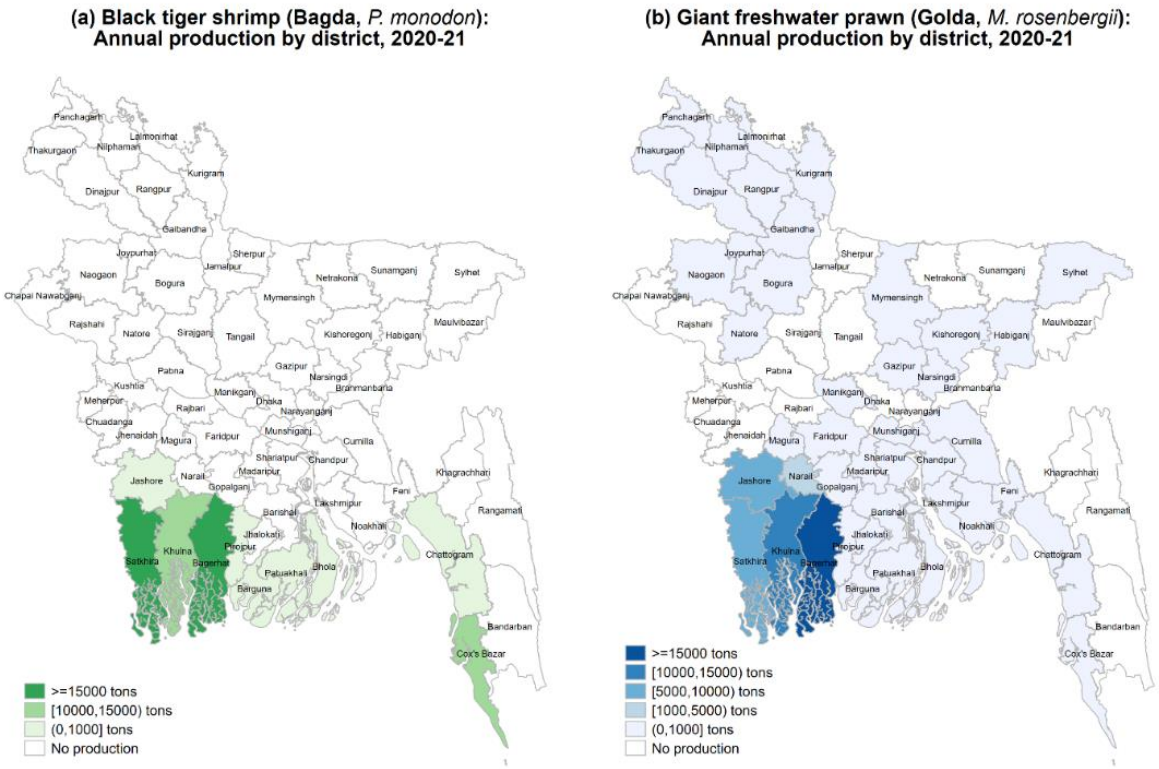


Source: Authors' calculations using data from the Yearbook of Fisheries Statistics of Bangladesh, DoF, 2014-15 to 2020-21.

2.3.2 Production zones

Bagda shrimp farms are clustered primarily in the three southwestern coastal districts of Khulna division (Satkhira, Bagerhat and Khulna) and the southeastern coastal district of Cox's Bazar in Chattogram division (Figure 4). These four districts account for 97% of all *bagda* production in the country. Although freshwater *golda* prawn farms can be found throughout the country, 90% of production is sequestered in the four districts of Khulna division – Bagerhat, Khulna, Satkhira and Jashore (Table 1). Unlike *bagda*, Cox's Bazar is not a major production cluster for *golda* prawn. Cox's Bazar is also the primary hatchery cluster for *bagda* shrimp production. Post-larvae are transported from this region to grow-out ponds in Khulna division by air.

Figure 4: *Bagda* shrimp and *golda* prawn production areas in Bangladesh, 2020-21



Source: Authors' illustration using data from (DoF 2022).

Table 1: Area, production, and yield under *bagda* shrimp and *golda* prawn farms, 2020-21

	Bagda shrimp farms			*Golda* prawn farms		
District	**Area (Ha)**	**Production (tons)**	**Average yield (kg/Ha)**	**Area (Ha)**	**Production (tons)**	**Average yield (kg/Ha)**
Satkhira	59,054	24,571	416	9,378	8,647	922
Bagerhat	52,550	18,049	343	19,960	17,623	883
Cox's Bazar	42,028	13,343	317	129	279	2163
Khulna	32,996	11,317	343	19,016	11,446	602
Chattogram	2,924	786	269	278	191	687

Jashore	1,612	354	220	15,178	8,102	534
Other districts	800	285	356	7,122	4,462	627
Total	**191,964**	**68,704**	**358**	**71,062**	**50,750**	**714**

Source: DoF (2022).

Note: Satkhira, Bagerhat, Khulna and Jashore are southwestern districts under Khulna division. Cox's Bazar and Chattogram are the south-eastern coastal districts of Chattogram division.

2.3.3 Production systems

Brackish water aquaculture activities are primarily carried out in southwest Bangladesh in paddy fields *(ghers)*, modified to make them suitable for shrimp and prawn farming by constructing peripheral trenches to provide deeper habitats for stocking aquatic animals that do not generally dry out, and building dikes to prevent flooding or escape (Belton et al. 2011). *Ghers* used for prawn and shrimp farming are usually located within land protected from the sea by polders and are usually connected to estuaries and canals through channels and sluice gates allowing farmers to manage the flow of brackish or tidal water (Belton et al. 2011; USAID 2006).

Traditional (extensive) systems

Shrimp farms in Bangladesh have historically been small (i.e., less than two hectares), although they average 4.5 hectares overall given the much larger farm sizes in Chattogram and Cox's Bazar. Extensive farming systems employ traditional techniques, coming about because of adequate year-round water salinity, stable temperatures, good supply of post-larvae and cheap, readily available labor. These traditional farms require minimal inputs, but also have low yields. They used to trap shrimp post-larvae flowing into *ghers* during high tides using bamboo barriers at water entry and exit points, but this step has now largely been replaced by the artificial stocking of shrimp and prawn PL collected from the wild or sourced from hatcheries (USAID 2006).

Modified traditional (improved-extensive) systems

Most farms now use modified farming methods (following assistance from government and donor-led projects, as well as some private enterprises) to increase yields and improve water management techniques. These modifications may include the use of nursery-grown post-larvae for better survival rates, electric pumps to control saline water flow, land preparation to enrich the soil with lime, deepening *ghers* to better simulate natural conditions and prevent shrimp deaths due to high temperatures, co-culture of both *bagda* and *golda* in the same *gher*, gradual introduction of PL over one-month intervals to maximize continuous production, polyculture of shrimp and other fish, mixed crop production of *golda* prawn and rice, and production process intensification. These farms average 2.5 hectares in size, with yield rates of around 600 kg/Ha per year (USAID 2006).

Semi-intensive systems

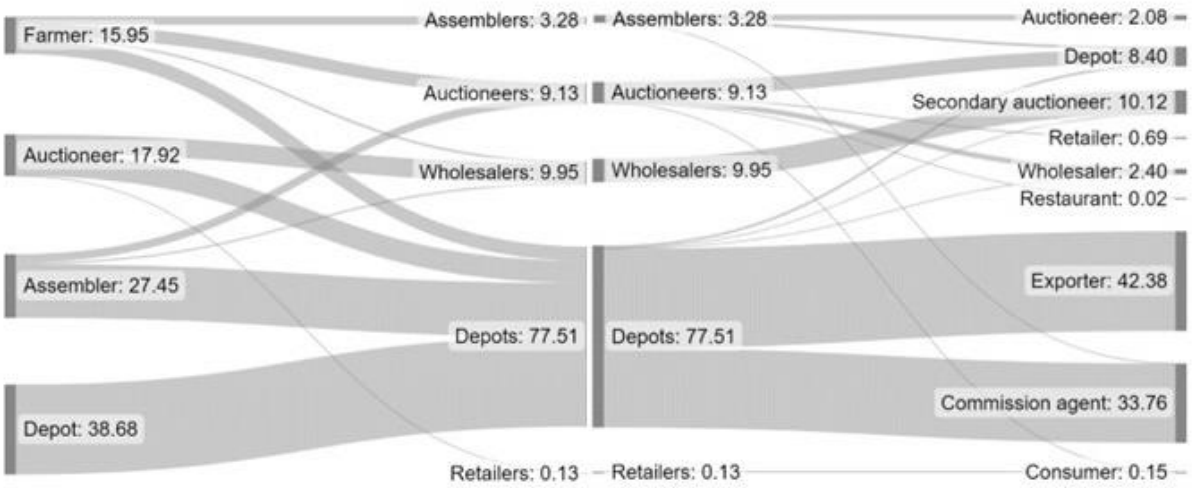
These are the rarest types of shrimp farms in Bangladesh, with less than 125 hectares under semi-intensive systems as of 2006. These systems are characterized by aeration, pumping, water exchange and intensive feeding, and are found mostly in Khulna district, with a few in Chattogram and Cox's Bazar. Semi-intensive farms are capable of yield rates of around 2,000 kg/Ha per year, and average around 3 hectares in size. They are also characterized by shrimp monoculture and improved adherence

to biosecurity protocols. Stocking densities are high, and the PL are sourced almost exclusively from hatcheries.

2.4 Domestic production and processing channels

The shrimp marketing channels in Bangladesh are a complex network comprising upstream hatcheries and farmers, various midstream traders, and downstream processors cum exporters. These traders include: (1) *aratdars*, or auctioneers, who facilitate and negotiate shrimp sales between sellers and buyers through an open bidding system; (2) wholesalers, who buy shrimp from *aratdars* and other suppliers for onward sales to distal domestic markets; (3) depots, who aggregate shrimp and prawn sourced from farmers and assemblers and sell to processors cum exporters; (4) *farias* and *beparis* (assemblers), who buy small quantities of shrimp from farms and aggregate to sell to *aratdars* and depots; and (5) retailers, who buy small quantities of shrimp from other traders for direct sale to consumers (Figure 5). The marketing channels differs slightly between *bagda* shrimp and *golda* prawn, such that most *bagda* is sold by farmers to assemblers and depots, whereas golda is primarily sold by farmers to *aratdars*, and then on to depots.

Figure 5: Share of crustaceans traded (%) by marketing channel



Source: Ali et al. (2023). Forthcoming.

Note: 'Crustaceans' refer to the two most important species traded by volume, which in nearly all cases are bagda shrimp and golda prawn.

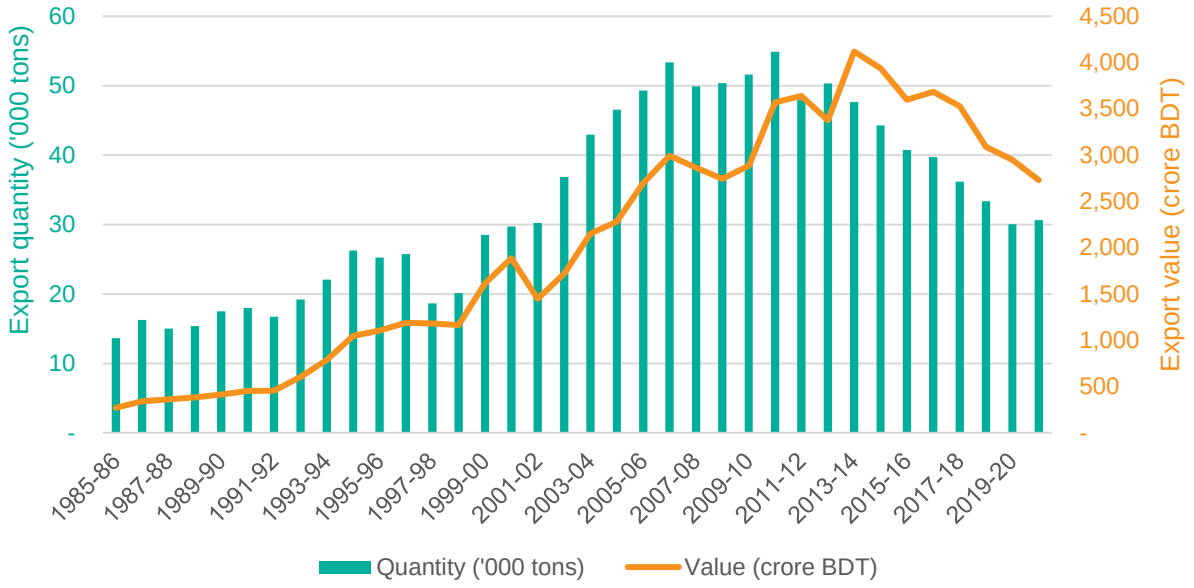
Depots are the main aggregators, with Ali et al. (2023) reporting that around 78% of all traded crustaceans flow through them. Depots mainly buy shrimp from auctioneers (18%), assemblers (27%), and other depots (39%). Depots then sell onwards to processors/exporters (42%) and commission agents working on behalf of exporters (34%). Only around 10% of farmed shrimp goes to secondary wholesalers in domestic markets, with the rest (90%) presumably headed to international markets. Exported shrimp and prawn supply foreign buyers, primarily located in Europe and the United States.

2.5 Bangladeshi shrimp and prawn exports

Export quantities of Bangladeshi shrimp and prawn have fallen by 45 percent in the last decade, from a peak of around 55,000 tons in 2009-10 to around 30,000 tons in 2019-20. The value of annual exports

has also fallen by around 28 percent since 2013-14, from around BDT 4,119 crore to around BDT 2,949 crore in 2019-20 (Figure 6).

Figure 6: Annual frozen shrimp and prawn exports from Bangladesh, 1985-86 to 2020-21



Source: Yearbook of Fisheries Statistics of Bangladesh, DoF, several years.

Note: Quantities and values are reported by fiscal year. In Bangladesh, the fiscal year runs from July to June.

Of total shrimp exports, *bagda*'s share in total export value averaged 71%, *golda* 22% and other varieties around 7% between 2009-10 and 2020-21 (Around 90% of Bangladeshi shrimp and prawn exports to the EU in 2021 were accounted for by the five largest buyers: the Netherlands (21%), Belgium (21%), Germany (20%), the United Kingdom (18%) and France (9%) (Figure 9).

For the Netherlands, Belgium, Germany and the UK, Bangladesh is the largest supplier of black tiger shrimp. In 2020, the four countries (and France) imported over 19,000 tons of Bangladeshi tiger shrimp worth US $262 million, accounting for 70% of total black tiger shrimp imports for these countries. Rotterdam (Netherlands), Antwerp (Belgium) and Hamburg (Germany) are strategically located ports that serve as interconnected markets. Germany is the biggest consumer market, but the Netherlands and Belgium serve equally important roles in terms of imports (Center for the Promotion of Imports [CBI] 2022).

Figure 7, panel a). Likewise, in terms of the share of total quantity exported, *bagda* averaged 73%, *golda* 15%, and other shrimp around 12% over the same period (Around 90% of Bangladeshi shrimp and prawn exports to the EU in 2021 were accounted for by the five largest buyers: the Netherlands (21%), Belgium (21%), Germany (20%), the United Kingdom (18%) and France (9%) (Figure 9).

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Belgium serve equally important roles in terms of imports (Center for the Promotion of Imports [CBI] 2022).

Figure 7, panel b).

The primary markets for Bangladeshi shrimp exports are the European Union (EU), the United States, Japan and Russia (Figure 8). Exports to the EU averaged 79% of the total annual export value between 2012 and 2021 (ITC 2012-2021). The competitiveness of Bangladeshi shrimp in EU markets stems from its relatively low price, which in turn is a result of a 10% subsidy afforded to seafood exporters by the Government of Bangladesh (GoB) (van der Pijl and van Duijn 2012).

Around 90% of Bangladeshi shrimp and prawn exports to the EU in 2021 were accounted for by the five largest buyers: the Netherlands (21%), Belgium (21%), Germany (20%), the United Kingdom (18%) and France (9%) (Figure 9).

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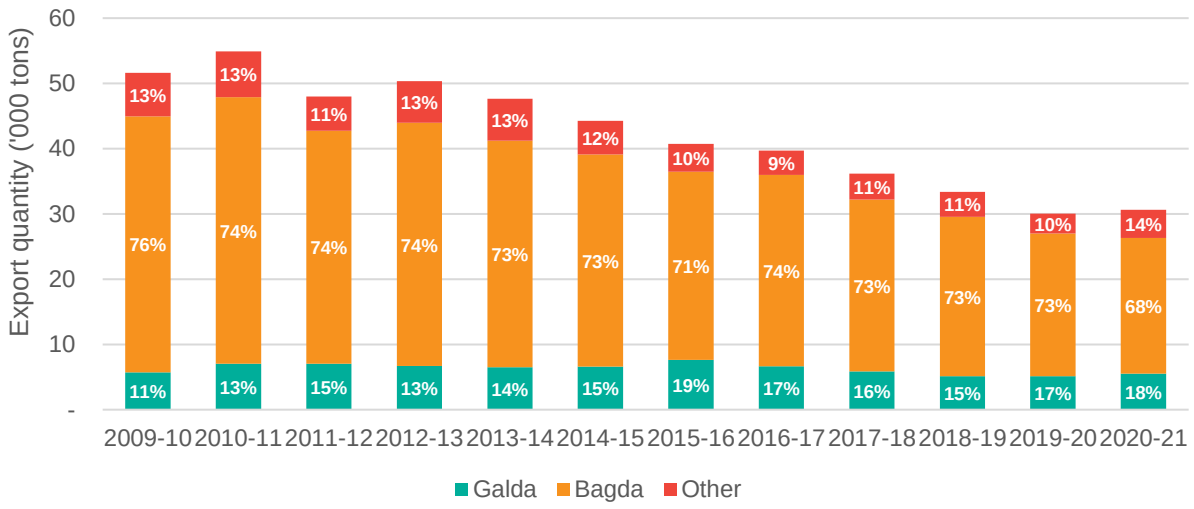
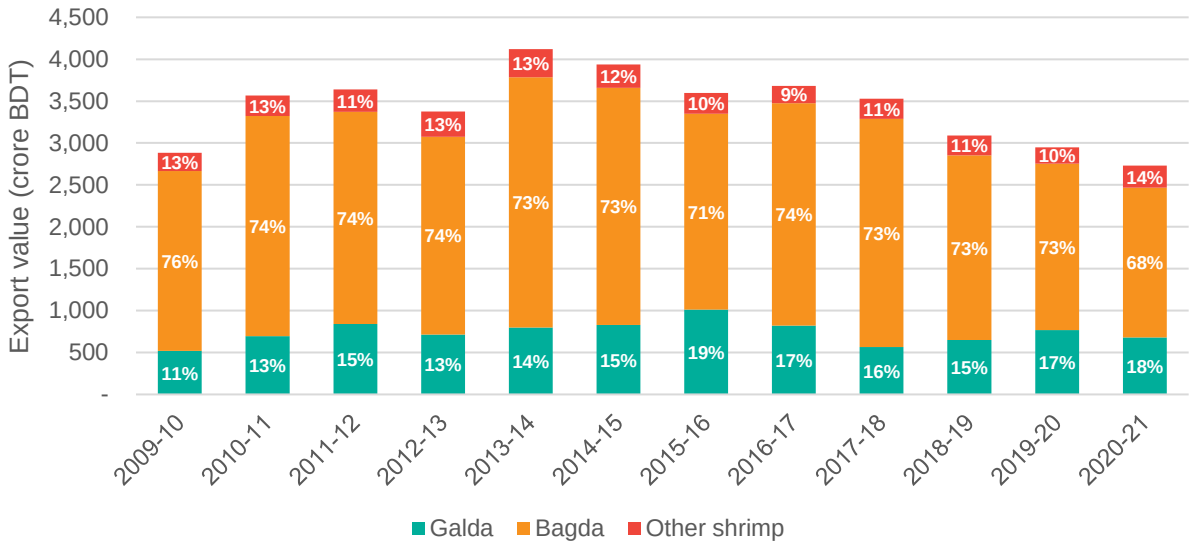
Figure 7: Annual frozen shrimp and prawn exports from Bangladesh by species, 2009-10 to 2020-21

(a) Export quantity

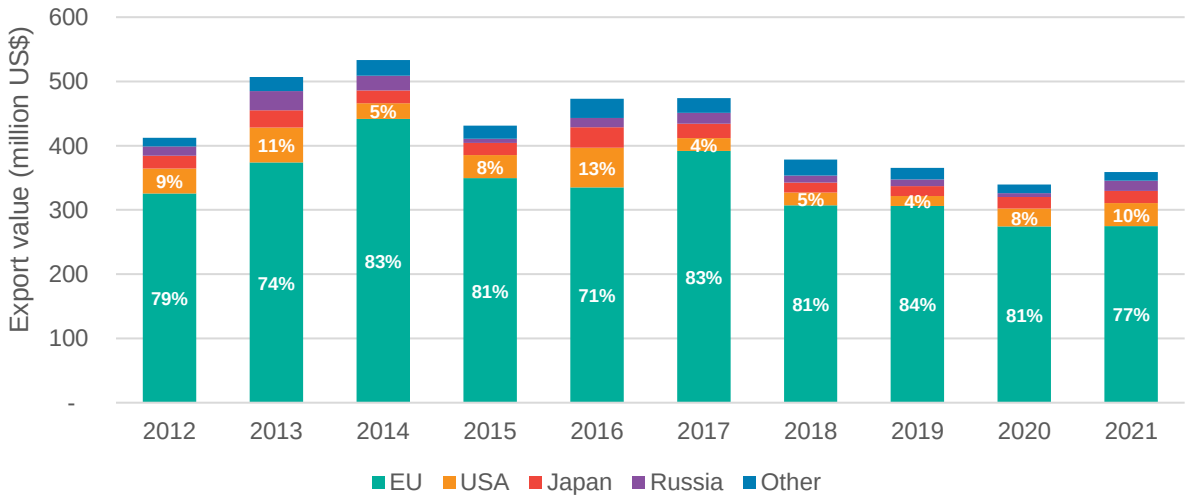


(b) Export value



Source: Yearbook of Fisheries Statistics of Bangladesh, DoF, several years.

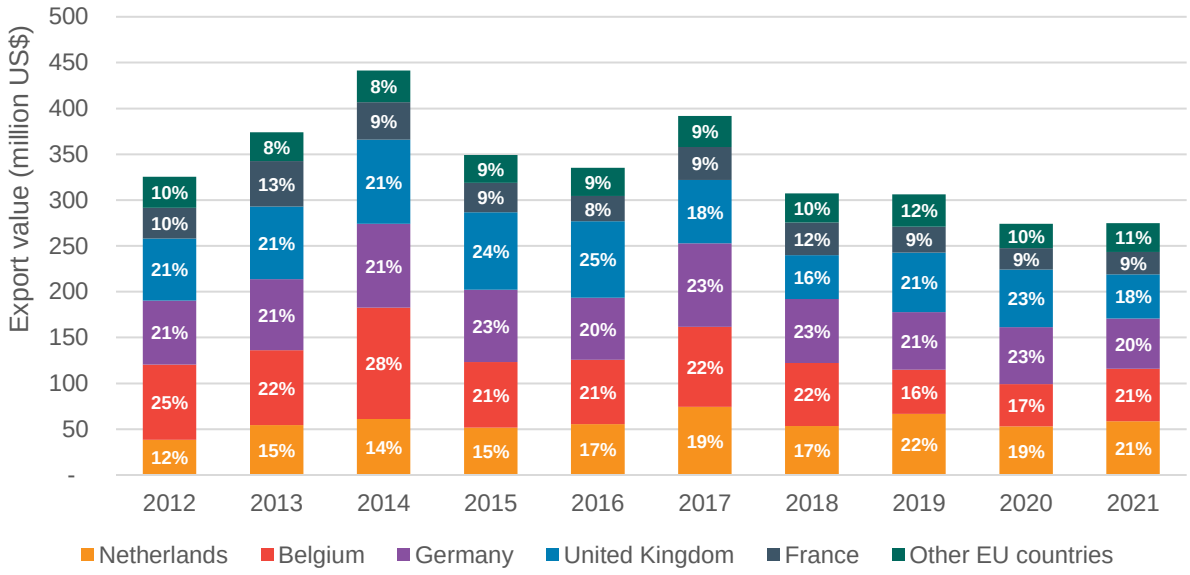
Figure 8: Annual Bangladeshi shrimp exports by destination, 2012-2021



Source: International Trade Centre (ITC) Trade Statistics, 2012-2021.

Note: (1) Percentage values refer to the destination's share in total shrimp export earnings. (2) EU data includes the United Kingdom for all years, even though the UK left the EU in 2020. (3) Data are collated at the 6-digit Harmonized System (HS6) level (030617). The tariff line (8-digit) HS code for *P. monodon* is 03061792, which includes products having undergone only one processing step, such as raw peeled and deveined (PD) or head-on shell-on (HOSO) cooked products.

Figure 9: Value of Bangladeshi shrimp exports to EU markets, 2012-2021



Source: ITC Trade Statistics, 2012-2021.

Note: EU markets include the 27 member states plus the United Kingdom, even though the UK left the EU in 2020.

Black tiger shrimp has an apparently stronger position in Europe's ethnic Asian wholesale markets than in the broadline wholesale market, owing to the preference of Asian restaurants for the species relative to cheaper Pacific white shrimp. The larger sizes of head-on shell-on (HOSO) black tiger shrimp in particular still have and are expected to maintain a strong position in Asian wholesale markets in the Netherlands, Germany and Belgium (CBI 2022).

In the UK, black tiger shrimp has a relatively strong position in both broadline food service and retail. However, certification requirements mean that black tiger shrimp for retail is sourced from Vietnam. Importers interested in importing Bangladeshi shrimp need to wait for ASC certification on the part of Bangladeshi exporters. Since leaving the EU in 2020, it has also become important for exporters to know that the EU and UK now regulate their own separate food safety standards (CBI 2022).

2.6 Gender and inclusion

Women employed in the sector appear to largely be involved in the labor-heavy activities with little room for upward mobility or better pay. Islam (2008) notes that women are involved at both the bottom end of the value chain, where they gather shrimp larvae from the sea, and at the end stage at processing plants, where they are involved in cleaning the shrimp, removing the heads and final preparation prior to shipping. These largely informal jobs (i.e., without an employment contract and its associated rights) are vulnerable, and are characterized by low employment security, low pay, and poor working conditions. The seasonal nature of shrimp production and irregular supply to processors also contributes to this informal labor structure (Belton et al. 2011). Table 2 outlines women's involvement in various segments of the shrimp value chain in Bangladesh.

Halim (2004) also notes that poor women engaged in harvesting PL and working as labor on shrimp farms are vulnerable to exploitation and sexual harassment. Likewise, Haque et al. (2022) find that

marginalized households are primarily involved in the shrimp value chain as laborers. They identify financing, the ability to lease land, technical training, and self-initiative as important factors for these households to be able to participate either as shrimp farmers or other formal value chain actors.

Table 2: Women's participation in different segments of shrimp aquaculture

Value chain segment	Women's involvement (% of total)
Collection of wild PL	70
Labor in shrimp ponds (e.g., embankment, weeding)	40
Management in processing centers	1
Casual jobs in processing factories (e.g., de-heading, counting, peeling)	80
Food processing, snail collection, snail breaking for freshwater prawn	80
Shrimp pond owners/farmers	1-2
Shrimp business (e.g., trading, contractors, middlemen)	3-4

Source: Belton et al. (2011), which in turn was modified from Islam (2008).

2.7 Sustainability

2.7.1 Impacts of wild prawn PL harvesting

Wild prawn PL harvesting started in southwestern Bangladesh in the 1970s. The activity provides a major source of year-round income for marginalized populations in the region, especially women, poor families, and other vulnerable groups. Ahamed et al. (2012) note that, while wild prawn PL harvesting provides an essential source of income, it is also characterized by high levels of by-catch of non-target finfish, shellfish, and other pelagic species. The by-catch is rarely of any significant value and is therefore discarded on the banks and shores of the harvested water bodies. It also results in the reduction of larvae and juveniles of these species, leading to negative effects on the aquatic biodiversity of the region.

2.7.2 Environmental impacts of shrimp farming

In general, discharge water from shrimp and prawn farms have lower phosphorus and nitrogen loads relative to inflowing water. There is evidence suggesting that effluent discharges from shrimp farms do not contribute to negative impacts on local waterbodies (Seafood Watch 2021).

A life cycle assessment of the environmental impacts of aquaculture in over 2,600 Bangladeshi ponds by Henriksson et al. (2018) concluded that the intensification of aquaculture ponds had no significant impact on carbon dioxide emissions; however, the largest contributor to these emissions were extensive shrimp *ghers* (8,200 to 186,000 kg CO_2 eq per ton, 68% CI). In terms of acidification, however, shrimp and rice farms (1.7 to 11 kg SO_2 eq per ton, 68% CI) and shrimp *ghers* (1.7 to 47 kg SO_2 eq per ton, 68% CI) had some of the lowest measured impacts. Overall, shrimp farms contributed the least on average to eutrophication as a result of effluent runoff, but contribute highly to freshwater ecotoxicity due to the use of methylene blue – although these effects are far smaller when compared to those of products used in agriculture. Shrimp ghers also continue to be highly water-intensive relative to other

forms of aquaculture. Alongside shrimp and rice farms, these systems also use up the most land, as shrimp culture in the country remains primarily extensive.

Relative to other aquaculture systems in Thailand, China and Vietnam, another study by Henriksson et al. (2015) noted that *bagda* shrimp farming in southwest Bangladesh makes insignificant contributions to global warming, eutrophication and freshwater ecotoxicity, due to limited feed and fertilizer use in what are primarily extensive systems. However, more intensive farms in the eastern part of the country exhibited poor eutrophication and ecotoxicity outcomes, while combined shrimp and prawn systems contributed the most towards negative environmental impacts; the authors note that this is likely the result of using agricultural products (which use pesticides) as feed in these farms.

3 POLICY ENVIRONMENT AND PROGRAMS

3.1 Major supporting policies

Two major national policies supporting shrimp sector in Bangladesh are the National Fisheries Policy and the National Water Policy. The National Fisheries Policy supports shrimp production, while acknowledging the concerns related to biodiversity and risks associated with intensive cultivation. It advocates for the role of the private sector in developing hatcheries and in promoting improved production through demonstration. The policy also acknowledges the need for defining zones where shrimp production should be considered in conjunction with the Ministry of Environment (MoE).

Meanwhile, the National Water Policy (NWP) reflects the need for special consideration to be given to brackish shrimp production, with respect to water resource planning, formulating multipurpose water resources projects, and confining brackish aquaculture to specific zones.

Table 3 lists a range of policies, laws, rules, acts, and ordinances relevant to the shrimp sector in Bangladesh. Some of these are noted in the discussions on policy issues below.

Table 3: Policies relevant to the fisheries sector in Bangladesh

Policy / law / rule / act / ordinance	Year	Aspects covered
Forest Act	1927	Allocation of fisheries management responsibilities to the Forest Department in mangrove areas
The Protection and Conservation of Fish Act	1950	Conservation of fisheries resources as a whole
Embankment and Drainage Act	1953	Legal protections against seawater intrusion and damage to farmland due to shrimp farming
The Government Fisheries Protection Ordinance	1959	Protection of government-owned water bodies against unauthorized fishing
Bangladesh Water and Power Development Board Ordinance	1972	Develop water management infrastructure for shrimp farming
Territorial and Water Maritime Zone Act	1974	Conservation of marine fisheries
The Marine Fisheries Ordinance	1983	Conservation of marine fisheries
Fish and Fish Product (Inspection and quality control) Ordinance	1983	Quality control of fish and shrimp, mainly targeting export

Policy / law / rule / act / ordinance	Year	Aspects covered
The Protection and Conservation of Fish Rules	1985	Farming rules for enforcement of various provisions of the Fish Act 1950
Land Management Manual	1990	Allocate unused state *(khas)* land to the landless poor
Shrimp Estate *(Mohal)* Management Policy	1992	Allocate suitable state *(khas)* land for shrimp culture
Shrimp Farm Taxation Law	1992	Imposing higher tax on shrimp land to cover cost of polder infrastructure
FAO Code of Conduct for Responsible Fisheries (Marine)	1995	Marine fisheries best practices
FAO Code of Conduct for Responsible Fisheries (Aquaculture)	1995	Aquaculture best practices, especially with respect to production and land management
Bangladesh Environment Conservation Act	1995	Conservation of natural resources and ensure eco-friendly development
Bangladesh Environment Conservation Rules	1997	Conservation of natural resources and ensure eco-friendly development
Fish and Fish Product (quality control) Rules	1997	Quality control of fish and shrimp, mainly targeting export
National Fisheries Policy	1998	Conservation, management, exploitation, marketing, quality control and institutional development
National Water Policy	1999	Water resource planning and multipurpose projects, and specific zones for brackish water aquaculture
Fish and Animal Food Act	2010	Sale fish and animal feed production, processing, quality control, import, export, marketing and transportation
Hatchery Act	2010	Hatchery development to ensure quality fish and shrimp seed

Source: Compiled from DoF (2006) and Ahamed et al. (2012).

3.2 Policy issues

3.2.1 Poor governance in land allocation

Two policies are relevant for the shrimp sector in terms of farmland allocation: (1) the Land Management Manual (LMM) dealing with the (permanent or temporary) allocation of unused *khas* land[4] to the landless, and (2) the Shrimp *(Mohal)* Estate Management Policy (SEMP), which governs the allocation of *khas* land suitable for shrimp production. However, enforcement of both policies has been subject to poor governance. In the case of the LMM, allocation requires the endorsement of the District Commissioner, a process which has historically favored influential local elites and displaced the landless poor. Likewise, the allocation of *khas* land designated for shrimp under SEMP favors those able to finance investment and those with technical knowledge, rather than the poor (DoF 2006).

[4] *Khas* land refers to government-owned fallow land, where nobody has property rights. It is land deemed to be owned by the government and available for allocation according to government priorities. [S. 2(15) of the State Acquisition and Tenancy Act, 1950 (E. B. Act XXII of 1951)]

3.2.2 Water usage, effluent discharge, and land salinization

A significant constraint to *bagda* cultivation is access to and release of water, and the requisite need for inflow and outflow canals. However, the primary rationale for construction of the embankments around the polders in the southwest was to prevent saltwater intrusion in the first place. Given the economic importance of shrimp production, the Bangladesh Water Development Board (BWDB) has now been tasked with improving the regulated flow of salt water into the polders. While the National Water Policy now recognizes the need to define brackish water shrimp farming zones, there are still no mechanisms in place to declare such areas. Farm effluent does not appear to differ significantly from inflowing water in terms of nutrient levels, but there remains the issue of disease transfer from one transfer to the other, as many shrimp farms continue to use water passed on from other farm outflows. The Embankment and Drainage Act of 1953 allows impacted farmers to take legal action against shrimp farmers if farmland becomes contaminated by seawater. There are no other environmental support measures and no requirements for Environmental Impact Assessments, nor any form of monitoring of existing holdings (FAO 1995).

3.2.3 Fiscal support to the sector

Most financial support to the sector has flowed to the hatchery and export/processing segments of the value chain, resulting in over-expansion of actors in these segments. Hatcheries and processors can easily secure loans and are offered several direct and indirect tax incentives. Some of these include accelerated depreciation on machinery, exemptions from advance income tax (AIT) on exports, nil import duties and value added tax (VAT) for exporters and working capital loans at low interest rates (resulting in an implicit subsidy of 40%), among others (DoF 2006).

By contrast, financial support for the production, post-harvest, and marketing segments of the value chain has been low. Financial support for infrastructure development in polders is provided through donor loans and is coordinated by BWDB and the Department of Fisheries but concerns over equity have slowed these disbursements.

3.2.4 Poor government capacity to enforce regulations and policies

While there are several policies in place to manage and regulate the sector, there appears to be little capacity on the part of the government to enforce these policies, due to a shortage of skilled staff and resources. There are no mechanisms in place to ensure the quality of exported shrimp, check adherence to land management guidelines under the FAO Code of Conduct for Responsible Fisheries (Aquaculture) or protect other farms from the negative effects of shrimp farming. The fisheries sector largely does not comply with the restrictions placed on shrimp fry trawling under the Marine Fisheries Ordinance (MFO).

3.3 Programs supporting the shrimp sector in Bangladesh

3.3.1 Ongoing government projects

There are currently 12 fisheries projects under the auspices of the Ministry of Fisheries and Livestock (MoFL). One is run by the Bangladesh Fisheries Research Institute (BFRI), two by the Bangladesh Fisheries Development Corporation (BFDC), and nine projects fall under the Department of Fisheries (DoF). Two DoF projects—the Sustainable Coastal and Marine Fisheries Project and the Climate-Smart

Agriculture and Water Management Project—are co-financed by the World Bank, and it is these two that are relevant to the shrimp sector.

The ***Sustainable Coastal and Marine Fisheries Project (SCMFP)*** is a five-year project expected to run until June 2023 worth US $281.60 million, of which US $240 million is in the form of International Development Assistance (IDA) credit. The project conceives a range of interventions across the fisheries sector in southwest Bangladesh, several of which are relevant and/or specific to shrimp. Some of these include the construction of diagnostic and quarantine labs, renovation of existing PCR labs, canal rehabilitation planning and salinization mapping alongside hydrological surveys, and crucially, establishing 600 shrimp production clusters totaling around 15,000 marginal shrimp farmers. Some interventions in these cluster farms include conditional matching grants in the form of feed in exchange for the farmers' investment in deepening ponds, training in good agricultural practices (GAP), motivating farmers to increase uptake of SPF PL, and assisting in the preparation of an annual cluster business plan. Other value chain interventions include the development of e-traceability mechanisms, establishing an aquaculture challenge grant facility for private sector investment in commercializing SPF hatcheries, and supporting the construction of a dedicated SPF broodstock facility (World Bank 2018).

The second of these World Bank-financed projects is the ***Climate-Smart Agriculture and Water Management Project*** running from 2021 to 2026. The project cost is US $155.31 million, of which US $120 million is financed by an IDA scale-up window credit facility. Activities relevant to the shrimp sector include support for improved climate resilience of flood control and drainage infrastructure, the promotion of integrated rice-fish/shrimp farming, establishment of cold storage facilities and improving local market infrastructure, training on quality assurance, aggregation and forward linkages to buyers, and improving access to market information (World Bank 2021).

3.3.2 Donor-funded projects

The largest relevant donor project for the sector is the United States Agency for International Development (USAID)'s Feed the Future Bangladesh Aquaculture and Nutrition Activity (BANA), envisioned as a follow-up to the Aquaculture for Income and Nutrition (AIN) project. While not targeted specifically towards shrimp, this five-year aquaculture sector project began in 2018 and was planned to run until February 2023. The project had three main objectives: (1) increased productivity of aquaculture production systems through increased availability of affordable, high-quality feed and the adoption of best pond management practices; (2) strengthened market systems by increasing private sector engagement in aquaculture markets; and (3) increased awareness and practice of nutrition-related behaviors by improving access to diverse and nutritious food, including fish.

3.3.3 Past interventions in the sector

There have been several initiatives in the shrimp value chain with varying degrees of success, outlined comprehensively in van der Pijl (2014). Some of these interventions have included farmer capacity development focusing on GAP, organic shrimp farming projects, supply chain simplification pilots involving premium collection centers, and e-traceability projects, among others. These initiatives have involved a range of stakeholders, including the government's Department of Fisheries, industrial bodies such as the Bangladesh Frozen Foods Exporters' Association (BFFEA) and the Bangladesh Shrimp and Fish Foundation (BSFF), European shrimp importers such as WAB Trading International, and international donors/organizations such as the United Nations Industrial Development Organization (UNIDO), the European Union (EU), Solidaridad and WorldFish.

It appears, however, that none of these past initiatives targeting either production or marketing channels have resulted in significantly changing the prospects for the shrimp sector overall, and many have now been discontinued. In most cases, the problems lay with both the design and implementation of these interventions. The following chapter describes a problem identification exercise conducted with industry stakeholders by the study team; it is interesting to note that many of the issues noted and solutions proposed were those that had already been flagged and supposedly worked on.

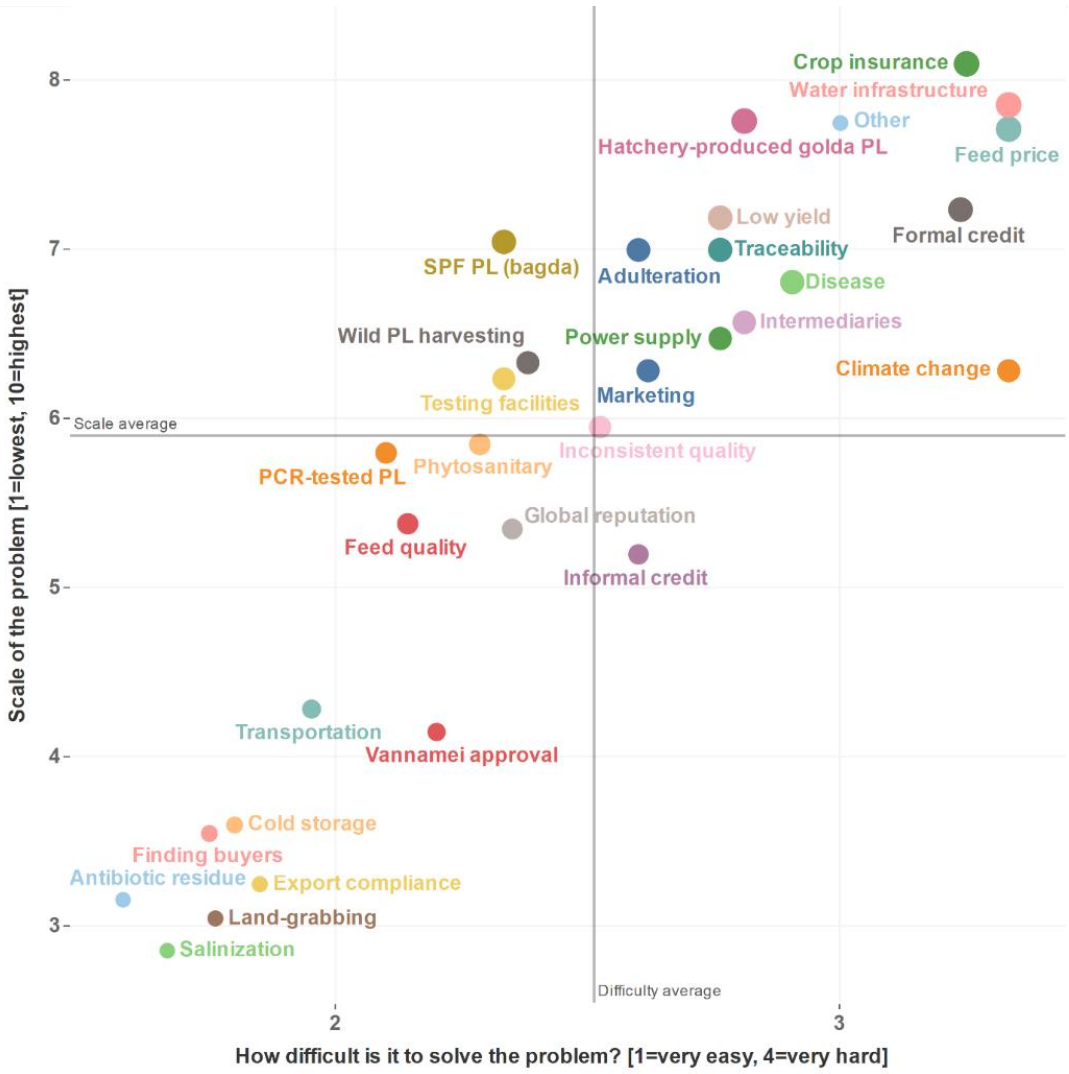
4 DIAGNOSIS OF PROBLEMS AFFECTING THE SHRIMP VALUE CHAIN

To help identify critical problems in the shrimp value chain, the study team conducted a series of one-on-one interviews with relevant sector stakeholders. The results of these consultations were then presented to an audience of these stakeholders, academia, and other industry personnel in January 2023.

Preliminary findings from the stakeholder interviews noted that despite some improvements in yields and farmer adoption of modern technical practices, including farm and feed management, significant structural problems continue to plague the sector. “Big, difficult to solve” problems, as perceived by these key informants, include the lack of crop insurance and formal credit support for farmers, poorly planned water infrastructure, and high feed prices, among others. Other perceived “big, but relatively easier to solve” problems include the limited availability of Specific Pathogen-Free Post-Larvae (SPF PL), poor access to farm-level testing facilities, and unsustainable harvesting of wild PL.

The bulk of the challenges, according to these experts, would appear to be at the production end. Small farm ponds and rearing shrimp in shallow *ghers* constrain the survival of shrimp and productivity of the farms. There is a pressing need for infrastructure, especially for deepening ponds and structures for improving water management. Yet, farmers have little or no financial support, especially from formal institutions, in the absence of collateral.

Figure 10: Ranking problems facing the shrimp sector in Bangladesh



Source: Authors' calculations using data from expert consultations.

There was consensus that growing shrimp needs more technical knowledge than other species. In the absence of such knowledge and the inputs required to do this (for example, availability of disease-free PL), shrimp farming becomes a high-risk venture for small farmers. There is also an associated challenge of ensuring that the farmed shrimp is free from disease. However, the present extensive shrimp farming systems limit the ability of farmers to maintain biosecurity of farms.

While such farms prevent farmers from specializing and cultivating shrimp intensively, this strategy protects the farmers from the high risks associated with shrimp farming. Farmers, many felt, need to see a demonstration of successful shrimp farm models that will incentivize them and bolster their confidence in shrimp farming in general.

Although *vannamei* approvals and trials exist, most believe that Bangladesh's best opportunities remain in *bagda*, with a focus on market development and branding internationally. Here, ensuring that up-

stream actors can pursue certification credentials such as Best Aquaculture Practices (BAP) and Aquaculture Stewardship Council (ASC), among others, that are requirements for entry/access to certain markets/buyers, is crucial. Thus far, a few processors have obtained the necessary certification, but farms continue to remain uncertified. Experts also pointed to a growing domestic market for shrimp and prawn, such that exports need not be the only objective. There may also be additional opportunities to target niche markets for organic shrimp and appeals to consumers who want to consume local shrimp that are based on sustainable production practices.

Most industry stakeholders felt that there is a need for a holistic policy for shrimp and a dedicated agency committed to developing the shrimp industry. These would enable focused attention on shrimp and enable current efforts of the government and private sector, and identification of specific coastal zones. Some felt that thus far, policies supporting the shrimp sector had been more exporter-centric and that it was time to build a farmer-focused policy that enabled farmers to overcome the many constraints they face.

4.1 Problem #1: Limited availability and farmer uptake of PCR-tested and/or SPF PL

Shrimp farms in Bangladesh continue to be plagued by high mortality rates in ponds, owing to both inadequate pond depth and disease outbreaks. It is widely believed that increasing the availability and uptake of SPF and/or PCR-tested PL can minimize disease problems and associated losses.

Three hatcheries at present (MKA Hatchery in Cox's Bazar, FishTech Hatchery, and Desh Bangla Hatchery in Khulna) produce SPF PL locally. Another eight hatcheries have recently been granted permission for SPF production by the government. However, the degree of SPF PL penetration remains very low; Belton et al. (2022) reported that less than 2% of shrimp farmers used SPF PL. The reasons behind this low uptake appear to be a lack of knowledge regarding SPF PL and its benefits, its limited availability, and high price. Farmers also reportedly tend to mix SPF and non-SPF PL in the same grow-out pond. There is scant research on the effectiveness of PCR-tested/SPF PL in the extensive systems that predominate the grow-out regions.

Another area of concern surrounding improved PL adoption is traceability in terms of the quality of PCR-tested/SPF PL available to farmers. At present, the PL are transported over long distances to the grow-out areas, but there are no regulations or certification bodies in place regarding quality assurance once it reaches the farmer.

4.1.1 Intervention #1: Traceable SPF PL

We propose a set of three complementary, bundled, interventions: (1) introducing systems to ensure traceability/accreditation for disease free PL; (2) assessing WTP for disease free PL, with or without accreditation; and (3) assessing effects of disease-free PL use on disease/yield/incomes. We will explore, along with our potential implementation partners, a randomization design that can be implemented on a scale that has enough statistical power for testing each arm or combination of treatments. If not, we will explore using difference-in-differences design combined with propensity score matching or explore spatial discontinuity designs.

One possible intervention in the area of traceability could be the use of blockchain technology, such that farmers are able to scan a QR code on a smartphone and receive information on the origin hatchery of the PL they buy, and whether or not it has been "certified" as being PCR-tested or SPF.

A potential partner for this in Bangladesh is SourceTrace (https://www.sourcetrace.com). Farmers could check the "authenticity" of the SPF/PCR-tested PL through an Android app. On the PL supply side, we could potentially partner with one or more hatcheries, to implement the blockchain traceability app. Other hatcheries could act as comparison groups. Possible implementation challenges include correctly assessing the level of smartphone penetration among the target shrimp farmers, identifying who the certifying body would be (whether the government or a third-party certification authority), and finding a willing hatchery to implement the blockchain traceability technology. As part of the intervention, it may be possible to test farmers' willingness to pay (WTP) for "certified" vs. "non-certified" PCR-tested/SPF PL. Finally, it would be important to measure the effect of using these disease-free PL on shrimp yields. One possibility is to embed a randomized experiment within the larger evaluation, that exogenously varies the price (via discount vouchers).

This intervention could shed light on an under researched issue that is also recognized as a key impediment to building shrimp value chains for export in Bangladesh.

4.2 Problem #2: Complex value chains

The shrimp value chain in Bangladesh at present is complex and comprised of many intermediaries, who essentially act as product aggregators, auction facilitators, and, in some cases, informal credit sources for farmers. While they do perform the critical functions of aggregation and managing transport of shrimp from farms to processors, the concerns surrounding plural intermediaries boil down to price gouging practices, maintenance of biosecurity protocols, hygiene, food safety and increased opportunities for product adulteration to artificially increase the weight of shrimp.

4.2.1 Intervention #2: Value chain disintermediation

Firm B is currently in the process of engaging farmers from whom they plan to directly purchase shrimp, bypassing midstream value chain actors (and added potential for product adulteration) to ensure traceability and quality. Their target areas are in Satkhira district and Firm B's timeline for procurement appears to be 2024, at which point they will have leased a processing plant. They aim to have all their farmers ASC certified prior to export operations. Their disintermediation intervention also includes a training component to educate farmers on biosecurity protocols and certification.

Given our evaluation window and the firm's timeline, an RCT may not be feasible, but there is potential for longer-term research and scope for learning. Our approach here would be to set up a difference in differences and spatial discontinuity designs, while ensuring enough statistical power to evaluate the independent and combined effect of disintermediation, training, and certification.

4.2.2 Intervention #3: Upgrading farm clusters

The Department of Fisheries currently leads an ambitious project led by its Coastal Aquaculture Authority. Operating in Khulna, the project tackles key production challenges in shrimp farming through multiple components that address multiple constraints. The first is an infrastructure development component that incentivized farmers to deepen shrimp ponds, by providing free SPF seed and feed for one year. The second is to develop these as clusters, with contiguous ponds to enable better control over biosecurity and to enable the benefits of aggregation of many small farmers. So far, the Government has promoted a few pilot clusters and intends to expand this over the next two years. The proposed plan is to also provide direct market linkages with processors.

Here as with the previous candidate intervention, a randomized control trial would be infeasible. We would therefore consider, depending on the Department's willingness to set up a research design that admits difference in differences techniques while allowing for the evaluation of each of the components of the bundled innovation.

5 CONCLUSIONS

Shrimp is Bangladesh's main agricultural export and makes a substantial contribution to the economy of southern Bangladesh, but the sector has a checkered history; beset by struggles over land and water governance, salinization of agricultural croplands, persistent problems with shrimp disease, and overcapacity in the processing and shrimp hatchery sectors. Bangladesh's shrimp production and exports have been in steady decline, since peaking in the early 2010's. This decline has been driven by a shift among farmers to producing greater quantities of less-risky fish for the burgeoning domestic market, contributing to underutilization of processing capacity. Most shrimp exports from Bangladesh are used by the food service and niche ethnic markets in Europe.

The complex nature of shrimp supply chains in Bangladesh, comprised of hundreds of thousands of small farms and tens of thousands of small traders, make it difficult to implement traceability and certification initiatives – now a prerequisite for entry into most supermarket supply chains. Previous interventions aimed at upgrading production practices (such as promoting stocking of disease-free shrimp seed) and facilitating disintermediation and transparency in the supply chain (such as by establishing producer groups, shrimp collection centers, and contracts with processors), have met with limited success.

The consensus among industry stakeholders consulted during the preparation of this document is that issues related to the supply and quality of shrimp seed represent some of the most pressing, yet relatively simple-to-solve challenges currently faced by the sector. Given this diagnosis, we propose to test a set of three complementary, bundled interventions: (1) Introducing systems to ensure traceability/accreditation for disease free shrimp PL; (2) Assessing WTP for disease free PL, with or without accreditation; and (3) Assessing effects of disease-free PL use on disease/yield/incomes.

In addressing these three issues concurrently we hope to establish: a) An effective mechanism for differentiating disease-free and conventional PL in the marketplace and assuring the provenance of disease-free seed; b) The level of effective farmer demand for disease-free shrimp seed; c) The impact of disease-free shrimp seed on farm productivity and profitability, with each component informing and reinforcing the others.

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