Sub-Project ID: 036

Program Based Research Grant (PBRG)

Sub-project Completion Report on

Post-harvest Losses, Supply and Value Chain Analysis of Fisheries Sub-sector in Bangladesh

Sub-project Duration
27 December 2017 to 20 December 2021

Coordinating Organization
Fisheries Division
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1213

Project Implementation Unit
National Agricultural Technology Program-Phase II Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

November 2021

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Abbreviation and Acronyms

ADB	:	Asian Development Bank	IFLAM	:	Informal Fish Loss Assessment Method
BARC	:	Bangladesh Agricultural Research Council	kg	:	Kilogram
BAU	:	Bangladesh Agricultural University	LoA	:	Letter of Agreement
BBS	:	Bangladesh Bureau of Statistics	LTM	:	Load Tracking Method
BDT	:	Bangladesh Taka	Max.	:	Maximum
BFDC	:	Bangladesh Fisheries Development Corporation	MT	:	Metric Ton
Cell	:	Cellphone	NATP-2	:	National Agricultural Technology Program- Phase II Project
Co-PI	:	Co- Principal Investigator	NGO	:	Non-Governmental Organization
DoF	:	Department of Fisheries	NRI	:	Natural Resources Institute
e.g.	:	For example	P&D	:	Peeled and Deveined
Etc.	:	Et cetera	PBRG	:	Program Based Research Grant
EU	:	European Union	PCR	:	Project Completion Report
FAO	:	Food and Agriculture Organization	PHL	:	Post-Harvest Loss
FIQC	:	Fish Inspection and Quality Control	PI	:	Principal Investigator
FQC	:	Fish Quality Control	PIU	:	Project Implementation Unit
GAP	:	Good Agricultural Practices	PSTU	:	Patuakhali Science and Technology University
GDP	:	Gross Domestic Product	QLAM	:	Questionnaire Loss Assessment Method
GHP	:	Good Hygienic Practices	SIS	:	Small Indigenous Species
GoB	:	Government of Bangladesh	SOP	:	Standard Operating Procedure
HACCP	:	Hazard Analysis and Critical Control Points	SSOP	:	Sanitation Standard Operating Procedure
ID	:	Identification	USA	:	United States of America
IFAD	:	International Fund for Agricultural Development	Viz.	:	Videlicet
			WB	:	World Bank

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Executive Summary

Food losses are of great attention in the efforts to combat hunger, raise income, and improve food security in developing countries to meet sustainable development goals (SDGs). Food losses have an impact on food security for poor people, on food quality and safety, eventually on economic development. However, post-harvest loss (PHL) is one of the inevitable parts of food loss. This entails that noticeable emphasis should be taken in action not only on the production but also on the post-harvest operations to minimize the PHL and ensure food security. The fisheries sub-sector of Bangladesh undergoes serious PHL every year due to ignorance and oversight in the processing and handling throughout the supply chain from the harvest to retail distribution. It also brings out a severe economic loss for the fishers, fish farmers, and actors of the supply chain. Therefore, it is imperative to generate policy recommendations for taking legitimate interventions to reduce fisheries' PHL. Besides, policy options and strategy formulation can be formed by determining the PHL of inland and marine fisheries at different supply chain stages in terms of different actors, species, sources, and causes. To this end, this study aims to generate in-depth information on PHL, supply, and value chain in the fisheries sub-sector of Bangladesh.

This study has covered 64 districts, 173 upazilas, and 1463 markets of Bangladesh. However, this is the first empirical study of fisheries sector in Bangladesh considering a massive primary data of 24672 stakeholders of which 21575 from inland and 3097 from marine fisheries. Among the sample of inland fisheries, 3850 fishers, 4656 fish farmers, and 13069 traders were interviewed. Among the sample of marine fisheries, data were collected from 889 marine fishers and 2208 marine fish traders throughout the country. Total four interview schedules were developed for fisher/fish farmers and traders in the case of inland and marine fisheries. Alongside the primary data collection, 87 Focus Group Discussions (FGDs) were arranged to validate the collected data. However, this study considered 202 inland species and 86 marine species to estimate the PHL. To summarize the outcomes of assessing the PHL of fishes, the Questionnaire Loss Assessment Method (QLAM) and descriptive technique based on field-level data were used. Besides, to evaluate the supply chain performance at different stakeholders and markets (spot, contract, relational and cooperative), this study has collected data based on six indicators, namely, efficiency, effectiveness, quality, reliability, flexibility, and capability, using a five-point Likert scale. Shephard method, Acharya and Agarwal method, Marketing Efficiency Index Method, and Composite Index Method were employed to investigate the efficient value chain of different fish species.

The findings of this study revealed that the estimated overall PHL in capture fisheries was 59.70 kg/MT, which is comprised of physical loss (3.31 kg/MT) and market loss (56.39 kg/MT). On the other hand, the estimated overall PHL in culture fisheries was 6.74 kg/MT, including physical loss of 0.99 kg/MT and market loss of 5.75 kg/MT. The medium quality fish loss was a major concern in inland fisheries, and it was 40.30 kg/MT and 3.91 kg/MT for both capture and culture fisheries, respectively. Substantial amount of PHL was found in the marine fisheries, which was around 36.53 kg/MT, including total market and physical loss of 26.00 kg/MT and 10.53 kg/MT, respectively. Consequently, the fisheries sub-sector of Bangladesh lost about BDT 2940 core every year in terms of PHL. Regarding the different inland water bodies, the highest amount of PHL emanated from the river (10.69 kg/MT), while it was 6.66 kg/MT for pond culture. The PHL varied according to the fish species, and the higher PHL was observed for Hilsha, which was 2.93 kg/MT among high-value species in capture fisheries. In contrast, among low-value species in capture fisheries, the higher PHL occurred for Punti, which was 1.52 kg/MT. In culture fisheries, the calculated PHL was higher for Rui (high-value species) and Mrigal (low-value species), which were 1.14 kg/MT and 0.86 kg/MT, respectively. Specie-wise, higher physical losses were observed for Mola, Kachki, and Chanda (10.98-14.98 kg/MT) due to small indigenous species (SIS). Similarly, species like Chanda, Kachki, Bighead carp, and Mola had higher market loss. The PHL was found at a different stage of the supply chain; the highest PHL was observed at the selling stage for both inland and marine fisheries. The predominant causes for the physical loss of capture and culture fisheries were delay

in marketing the fish and higher temperature, followed by the causes of inappropriate harvesting method and longer harvesting duration. The excess supply and delay in marketing of the fish were the main reasons for the market loss in both capture and culture fisheries. However, the most significant issue of marine fishes' physical loss at the fishers' stage was more time attached with the net, while the imbalance of demand and supply was the main reason for market loss at the traders' level.

This study also assessed the supply chain network and mapping of inland and marine fisheries along with the PHL. Besides, this study also measured the performance of supply chains. Twelve channels were identified for culture fisheries, fifteen channels for capture fisheries, and ten channels for marine fisheries through which fishes flowed from producers to consumers. In backward and forward linkage, all actors maintained a contractual/ managed/ not managed relationship with the fellow actors in capture, culture and marine fisheries sub-sector. To evaluate the supply chain performance at different stakeholders and markets, we have analyzed six supply chain performance indicators: efficiency, effectiveness, quality, reliability, flexibility, and capability. The performance score of quality was dissatisfactory for fishers and fish farmers. The overall performance of efficiency and capability were not satisfactory among the entire stakeholders. This study also unveiled that the comprehensive performance of effectiveness, reliability, and flexibility were good in the entire market arrangement.

The study also provided a brief outlook of value chain analysis framework for different species of capture, culture, and marine fishes to identify the most efficient chain. The value chain of carp fishes indicated that around 1.63 times value addition took place in the process of retail distribution (from fish farmers to consumers), while it was 1.49 times for Pangas in terms of monetary value. Local agents (*faria*) added the most value among the value chain actors in the capture fisheries sector, while wholesalers (*bepari*) added the maximum value in case of culture fisheries. Besides, processing (salting) added up the highest value for marine fisheries. Based on the above findings, following policy measures are suggested:

- Capture and marine fisheries need more emphasis to reduce PHL and maintain quality through improved infrastructure facilities in landing center, use of adequate quality ice and maintain the standard of procedures along the supply chain.
- At selling stage, fish seller/retailer should use insulated container which can reduce the post-harvest market loss. In that case, motivation, training and institutional support (financial and technical) need to be ensured from different relevant department of Bangladesh.
- During peak harvest period, storage capacity needs to be enhanced specially for capture fishes. Entrepreneurs should come forward for developing fish storage capacity and diversified ice packaging of fish.
- Supply chain performance need to be enhanced to reduce the PHL in terms of capacity and efficiency of the stakeholders. Stakeholders' capacity of storing the unsold fish and much volume transport capacity are to be accelerated. Therefore, adoption of fish/aquaculture mechanization and development of cooperative system for transportation are suggested for the small-scale fisher/fish farmers and other stakeholders.
- Training on awareness and skill development for reducing PHL should be conducted for all supply and value chain actors.
- Effective enforcement of legal regulatory frameworks like DoF/FIQC, GAP, GHP, SOP, and SSOP should be ensured.

Keywords: Post-harvest loss, Supply chain, Value chain, Capture fisheries, Culture fisheries.

PBRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the PBRG sub-project : Post-harvest Losses, Supply and Value Chain Analysis of Fisheries Sub-sector in Bangladesh**

2. **Implementing organization (s)**

   Bangladesh Agricultural University (BAU), Mymensingh-2202 and Patuakhali Science and Technology University (PSTU), Babugonj, Barishal-8201

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4. Sub-project budget (Tk):

4.1. Total (In Tk. as approved): Tk. 3,63,45,140.00

a. Coordination Component: Tk. 30,00,000.00
b. Component- 1 (BAU): Tk. 1,38,12,020.00
c. Component- 2(PSTU): Tk. 1,95,33,120.00

4.2. **Latest Revised (if any):** Not applicable

5. Duration of the sub-project

5.1.1 Start date (based on LoA signed): 27 December 2017
5.1.2 End date : 20 December 2021

6. Background of the sub-project

In Bangladesh, fisheries sector plays an important role to ensure stable food fish supply, income generation and employment opportunities, earn foreign exchange, supply nutrition and contribute to livelihood improvement and poverty reduction. This sector contributes 3.50% to the Gross Domestic Product (GDP), 26% to agricultural GDP and 1.23% to the foreign exchange earnings (BBS 2019; DoF 2018-2019). With annual fish consumption of about 22.52kg/person (DoF, 2018-19), fish contributes 60% of the animal protein consumed by the population, and also provide essential vitamins, minerals and fatty acids (DoF, 2018-19). Around 1.3 million people are directly employed and 12 million people are indirectly involved in this sector. The domestic demand for fish has increased with the rapid population growth of 1.8% annually on average and has reached to 169 million in 2021 (BBS 2021). The fisheries sector comprises of inland capture, inland culture and marine fisheries contributing 28%, 57% and 15% of total fish production respectively (DoF 2018-19). Inland capture fisheries include river & estuaries, Sundarbans, beels, Kaptai Lake and floodplain which comprise of about 4.03 million hectares of area.

In spite of these economic, social and nutritional benefits, concerns are raised about the sustainability of fisheries sector in maintaining their role of filling the gap of fish demand and supply.Actors across the fisheries value chain are facing several challenges. The common challenges are decreasing profit margin due to rise in costs, falling prices, and post-harvest loss (PHL) (Gyan et al., 2020). Existing literature (Torell et al., 2020; Gyan et. al., 2020; Rashid and Sarkar, 2020; Nowsad et al. 2015 and Nowsad, 2010) pointed that, losses from harvest to consumption are one of the reasons for the loss of considerable economic benefits across the value chain. Furthermore, Ambler et al. (2018) and Tesfay and Teferi (2017) pointed that PHL is inadequately valued and recognized in policies. However, minimizing PHL across the fisheries value chain has been identified as a policy instrument improving the livelihoods of the actors of the value chain and its contribution to improving poverty, food security, and employment (Rashid and Sarkar, 2020 and Odoli et al., 2019).Though there are numerous threatening factors on fisheries, securing post-harvest benefits through measuring post-harvest fish loss, control has long been a concern of development practitioners committed to improving the livelihoods of fishermen, processors and traders.Fish is an extremely perishable food commodity and its quality cannot be kept unaffected for human consumption for a long time. Therefore, the most obvious means of increasing supply of fish, even without increased landings, is by reducing post-harvest losses of what is presently caught.

It has been estimated that 10 percent by weight of world fish catch is lost by poor handling, processing, storage and distribution. However, losses in small-scale fish processing are said to be particularly high and figures as high as 40 percent are sometimes reported (FAO, 1984; Mills, 1979; Moes, 1980). Regardless of all positive measures taken towards increment of production, post-harvest loss of fish in Bangladesh is also enormous. About 20- 30% in different fish and fishery products losses after harvesting, and 50 % reduction of such loss can save Tk.8,000-10,000 crore per annum (Nowsad *et al.*, 2015, Nowsad, 2010). A problem in the supply chain for fish in Bangladesh is that the knowledge about post-harvest handling is limited and post-harvest losses are high. Losses occur in all post-harvest activities such as handling, storage, processing, packaging, transportation and marketing.Longdistancebetween production and consumption areas is also one of the main causes of post-harvest losses.

Post-harvest losses occur within the whole supply chain due to limited resources such as post-harvest technology, knowledge and infrastructure (Parfitt *et.al* 2010). In order to increase the food security, it is not enough to increase only productivity or catch but also need to lower the losses. The amount of losses within a supply chain is dependent on activities such as handling, storage, processing, packaging, transportation and marketing. It is though not only the activities undertaken by the actors within the supply chain that affect the performance but also the interactions between actors and external factors such as governance structure, market access, infrastructures and information flow that have impact on performance and level of efficiency in a supply chain.

Accurate assessment of post-harvest loss of fish in developing countries is an important challenge. Since fish production in Bangladesh is increasing over the years, its disposal pattern is very important as growers, wholesalers, retailers and consumers- all are affected due to value addition in the marketing process. For the sustainability of these stakeholders, fish marketing studies are very necessary. Farmer/fisher[1]needs to better engage with supply and value chains in order to gain added value, reducing risks and increasing resilience. Systematic and effective post-harvest techniques as well as supply and value chain management and governance can reduce the fish perishability and distribution problem. Analysis of post-harvest losses, supply chain and value chains require detailed micro-level data. But there is no countrywide in-depth study on these issues. Previous research works provide only the amount of losses and supply chain of some specific species in a specific area. Thus, the present study was conducted to generate countrywide information on post-harvest losses, supply chain and value chain structure of capture, culture and marine fisheries which will enhance production, processing and marketing of different species of fishes and reduces post-harvest losses of fish in Bangladesh.

7. Sub-project general objective (s)

To generate information on postharvest losses, supply and value chain structure of fisheries sub-sector in Bangladesh

[1]Fisher/fisherman: A person who catches fish from the different natural sources of inland capture and marine fisheries for leading their livelihood.

8. Sub-project specific objectives (Component wise)

Coordination component (BARC)

a) To ensure smooth and efficient implementation of sub-project activities to achieve desired sub-project outputs within the stipulated timeframe under strengthened capable research management system;
b) To coordinate sub-project implementation efforts and integration of activities to generate desired information /technology as per methodology of the sub-project;
c) Identify operational deviations and addressing constraints/problems (if any) under a process of strong and regular monitoring of the sub-project activities;
d) To upgrading the level of output of the sub-project through reviewing of yearly technical progress;
e) Collect and collate sub-project data, finding and observation and production of compiled sub-Project Completion Report (PCR).

Component 1 (BAU)

a) Assessing post-harvest losses (quantitative) and causes of losses in capture and culture fisheries of Bangladesh;
b) Analyzing existing supply chain structure of capture and culture fisheries of Bangladesh;
c) Analyzing value chain structure, and extent of value addition of specific fish species.

Component 2 (PSTU)

a) Assessing postharvest losses (quantitative) and causes of capture, culture and marine fisheries losses of Bangladesh;
b) Analyzing existing supply chain structure of capture, culture and marine fisheries of Bangladesh
c) Analyzing value chain structure and extent of value addition of specific fish species.

9. Implementing location (s) : Sixty-four (64) districts of Bangladesh.

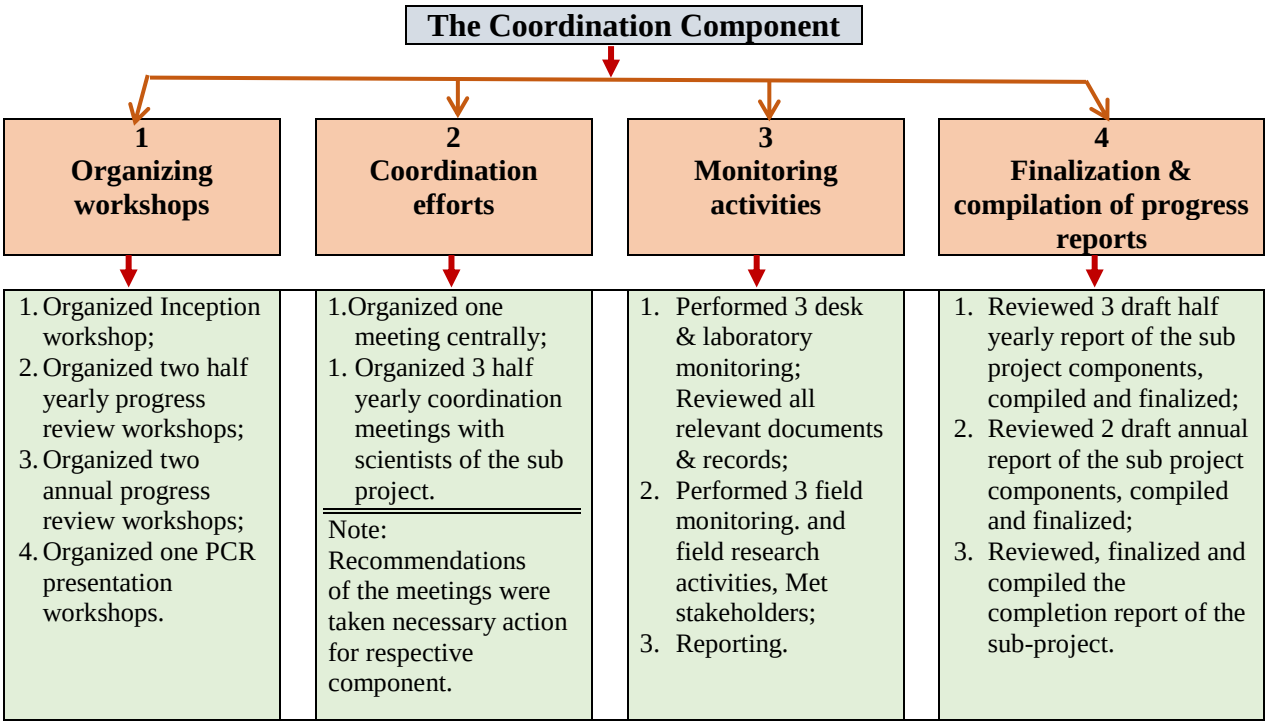
10. Methodology in brief

10.1. Activity Implementation Approach of the Coordination component

The Coordination component as the responsible unit of the sub-project to initiate all potential efforts in the process of implementation of each component under the sub-project so that the general objectives and goal of the sub-project can be achieved through smooth and successful completion of each of the specific objectives as per activity time plan of the sub-project document. To ensure that, the Coordination component, taken into consideration its own activity and objectives and duration of the sub-project, thus accordingly designed its own plan of activity (approach) for the proposed period. Following are the major activities carried out by the Coordination component under the plan:

a. Organizing of seminars/workshops.
b. Monitoring of the sub-project activities (specifically financial and research activities);
c. Coordination of activities within the componentsof sub-project.
d. Review and compilation of half yearly and annual research progress reports;

The implementation approach and activities thereunder for the Coordination component of the sub-project shown in the following diagram:

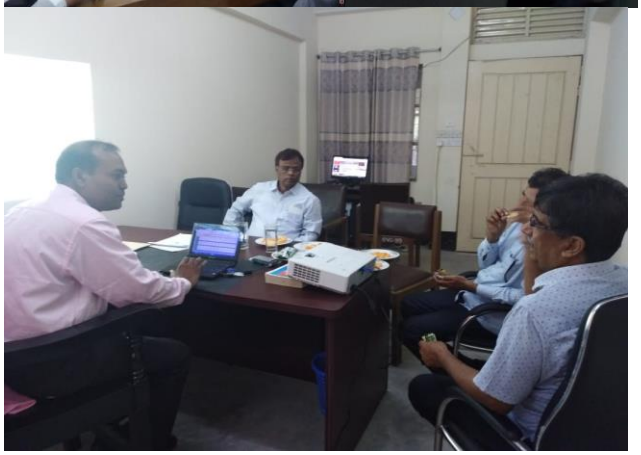


Recommendations of the inception, half yearly and annual research progress review workshops and different coordination meetings are furnished hereunder in **Appendices- BARC: A - D.**

Following table presenting the summary statement of achievements performed by the Coordination component of the sub-project:

Summary statement of achievements		
Name of activities	**Performance against each Sub-project**	**Remark**
Inception workshop	Organized centrally at BARC in November' 2018	Attended all PI, Co-PI & expert members.
Revision of PP	Done as per recommendations of Inception workshop	
Half yearly progress review Workshop (Date)	Organized centrally at BARC in March' 19, January'20.	Attended all PI, Co-PI & expert members
Ann. Prog. review workshop (Date)	Organized centrally at BARC in July' 19 & in September' 20	Attended all PI, Co-PI & expert members.
Coordination meeting (No)	03 *07.02.19, 19.10.19 & 25.06.20*	One Coordination meeting held centrally.
Monitoring of field and Lab activities	04 *(BAU & PSTU)*	Covered all components under sub-project.
Financial achievement *(Upto March'21)*	100% of released money & 99.5% of total approved budget	Delay in Proc. Plan approval and Covid-19 incidence hampered desired progress
Reporting performance	Provided sub-project inception report, SoE, Half yearly and Annual compiled progress reports of all sub-project components as per planned time frame.	Major reports are: • Inception report (1 no); • Compiled half yearly progress report (3 no); • Compiled annual progress report (2 no); • Monitoring reports (3 no);

Pictorial views of different workshops, coordination meetings and field monitoring activities



10.2. Study Area, Data and Sample Size

Since the aim of the study was to generate countrywide information on the post-harvest loss, supply chain, and value chain of inland, and marine fisheries, therefore; the sub-project covered 173 upazila of 64 districts under eight divisions. The sub-districts were selected based on the production level (high, medium, and low), intensity (extensive, semi-intensive, intensive, and highly intensive), the scale of operation, sources of fish, environmental heterogeneity, geographical characteristics, water availability, etc. Random sampling technique was followed to select fisher, fish farmers[2], and fish processing plants, while traders were selected through snowball sampling technique. A total of 24672 samples were designated from the chosen areas, of which 21575 from inland fisheries and 3097 from marine fisheries. The detailed sample size of inland and marine fisheries according to stakeholders and division is shown in Table1 and 2.The study covered 1463 market throughout the country. Total 202 fish species were identified in capture and culture fisheries while 86 fish species were identified in marine fisheries during the data collection.

Table 1. Division wise sample size of inland fisheries

Name of Divisions	Fisher	Fish farmer	Traders							Grand Total
			Faria[3]	*Bepari*[4]	*Paiker*[5]	*Aratdar*[6]	Commission agent[7]	Retailer[8]	Total traders	
Chattogram	538	433	173	220	397	210	197	806	2003	2974
Khulna	642	823	216	321	554	349	138	914	2492	3957
Mymensingh	608	812	93	358	205	46	382	707	1791	3211
Dhaka	820	992	100	420	392	75	372	989	2348	4160
Rajshahi	393	676	27	283	186	17	341	723	1577	2646
Barishal	412	398	243	236	215	135	110	787	1726	2536
Sylhet	321	164	8	97	62	11	60	212	450	935
Rangpur	116	358	2	132	102	11	153	282	682	1156
Total	3850	4656	862	2067	2113	854	1753	5420	13069	21575

Table 2. Division wise sample size of marine fisheries

Name of Divisions	Fisher	Traders*								
		Bepari	*Paiker*	*Aratdar*	Retailer	Processor (Freezing)	Processor (Dry)	Processor (Salting)	Trader total	Grand total
Chattogram	460	183	167	131	480	53	102	20	1136	1596
Barishal	429	119	272	154	432	32	33	30	1072	1501
Total	889	302	439	285	912	85	135	50	2208	3097

*Traders' data were collected from all over the country following snowball sampling

[2] Fish farmer: Someone who farming/culture fish in the pond, seasonal culture water bodies, *baor*, etc. for commercial purposes.
[3]*Faria*: The middleman who contacts to the buyer i.e., *paiker*, *bepari*, commission agents, and retailer to sell the fish of others. A certain amount of commission is given to those middlemen for selling the fish of fisher and fish farmers, especially in the local area.
[4]*Bepari*: *Bepari* is one kind of wholesaler who transacts a big volume of fish from one district to another.
[5]*Paiker*: *Paiker* is another one kind of wholesaler who transacts the fishes within a particular district/area.
[6]*Aratdar:Aratdar* is a person who is capable to store the purchased fishes for the next sale.
[7]*Commission agent:* Commission agent is a person who transacts fishes on commission. The sellers sell fish to the buyers through the commission agent. Generally, the commission agent arranges auction and takes commission from the sellers (in some locations, they receive commission from both of the sellers and buyers). Also, the commission varies area to area, and normally it is from 2% to 6%.
[8] Retailer: Retailer is a person who sells fishes to the public in relatively small quantities for ultimate consumption.

The interview schedule was organized with the information on PHL in terms of different sources of fish (i.e., capture**:** river, haor, beel, and canal; culture**:** pond, gher[9], seasonal water body, and baor, and marine), fish species, season, different value-adding stages (fishing/harvesting, landing, processing, transport, storage, and selling), and causes were emphasized in the interview schedule. The information on supply chain performance measuring indicators (i.e., efficiency, effectiveness, quality, reliability, flexibility, and capability), nature of the fish transaction, and market activities were also incorporated into the interview schedule. We asked the respondents about the fish quantity traded, fish price, and different cost items (fixed and variable cost) to measure the value-added throughout the chain.A separate interview schedule was developed for fisher/fish farmers and traders.

Enumerators' training at BARC

Face to face data collection from fish traders

Pre-testing was carried out using the developed interview schedule to see whether the information is appropriate or not. Then the required changes were made to the questionnaire to improve the accuracy level of data. Finally, direct interview method was followed in collecting the primary data by using a well-structured questionnaire. About 22 trained and educated enumerators collected the data for 30 consecutive months.However, before going to data collection, all enumerator had been provided with several training on the way of data collection. During the survey, a brief (i.e., post-harvest loss, supply chain, and value chain) was delivered to the respondents[10] on the purpose of the research.

Conducting FGD at traders' level

[9]*Gher*: The term '*gher'* refers to the modification of a rice field to enable operation of fish farming. The middle of the '*gher'* is surrounded by high and wide dikes with canals dug at the inner periphery of the dikes. The whole area of '*gher'* is filled with rain-water during monsoon season, specifically from June to December, and closely resembles a typical pond.

[10]*Respondents is the person who would response to the question of the enumerators during data collection using the questionnaire*

In addition, 87 Focus Group Discussion (FGD) and 52 Key Informant Interviews (KII) were conducted to examine the consistency of data and policymaking. Two identical checklists were developed to facilitate the FGD for a fisher/fish farmer and trader. Also, two forms of KII's interview schedule were generated, one was for fisher/fish farmer, and the other was for traders. FGD was arranged in different markets, and different locations. However, separate FGDs were arranged for fisher, fish farmers and traders.

Conducting FGD at fisher level

Data collection from fisher

10.3 Analytical techniques

10.3.1 Post-harvest loss assessment

The accuracy and reliability assessment of the PHL process is often influenced by how data is collected. The Food and Agriculture Organization (FAO) and Natural Resources Institute (NRI) described and validated three leading methods of fish loss assessment, i.e., Informal Fish Loss Assessment Method (IFLAM), Load Tracking Method (LTM), and Questionnaire Loss Assessment Method (QLAM). The study adopted QLAM, which is suitable if the survey area is vast and can accommodate enormous variation in the selected samples regarding species, types of losses, and factors influencing PHL (Ward and Jeffries, 2000; Diei-Ouadi and Mgawe, 2011). The QLAM method for assessing physical and market loss is depicted in Fig 1.This loss occurs due to the several causes throughout the value-adding activities such as fishing, landing, processing, transport, storage, and selling fishes in capture and culture fisheries.

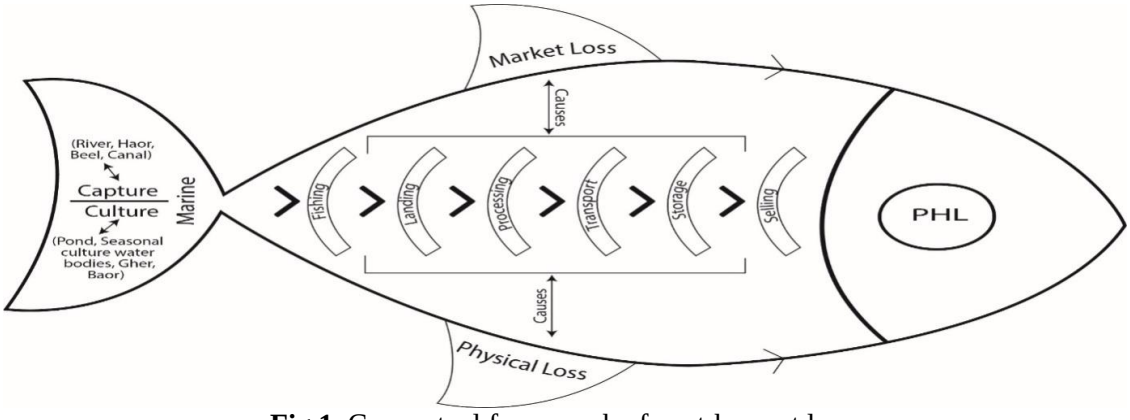


Fig 1. Conceptual framework of post-harvest loss.

However, this study considered physical loss as a form of the discarded (not edible or saleable) fish quantity, while losses due to quality and market forces loss were considered as market loss. The monetary value of discarded fishes was calculated based on the market price of particular species of good quality fish. The following equation was applied to estimate the physical loss:

$$Q_{pl} = \frac{Q_d}{Q_t} \times 1000 \ldots\ldots\ldots\ldots \quad (i)$$

and

$$M_{pl} = \frac{(Q_d \times P_m)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots \textit{(ii)}$$

Where,

Q_{pl}= Quantity of physical loss (kg/MT); M_{pl}= Monetary value of physical loss in (BDT/MT); Q_d= Quantity of discarded fishes (kg); Q_t= Quantity of total harvested fishes (kg); and P_m = Market price of good quality fish (BDT/MT).

Initially the study calculated the quantity sold at reduced price due to the quality defect and unexpected demand and supply imbalance of the fishes. Later, the study identified the differentiated price from the actual market price and lower selling price to estimate the price loss. Based on the quantity sold at reduced price and price loss, the monetary value loss of market loss was estimated. Finally, the study deliberated the actual quantity of market loss based on the monetary value loss at the actual market price of respective good quality fish.

However, the monetary value of the market loss was measured based on the price loss due to the quality deterioration or market dynamics, which is expressed as:

$$L_p = P_m - P_s \ldots\ldots\ldots\ldots \textit{(iii)}$$

Where,

L_p = Per kg price loss of the fishes and P_s= Reduce price (per kg fish) due to the quality deterioration or market dynamics. In this study, the market loss was calculated by summing up losses due to quality deterioration and market forces loss. The quality loss was categorized into three types and ordered as medium, poor, and poorest quality of fishes based on the extent of the quality defects, which are often sold at a lower price than the market price. The actual loss for "medium quality" is defined if the price drops by less than or equal to 50% than the market price, and the following equation was used to calculate it:

$$M_m = \frac{(Q_m \times L_p)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

$$QL_m = \frac{M_m}{P_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (v)$$

Where, M_m = Loss at monetary value due to selling the medium quality of fish (BDT/MT); Q_m= Quantity of medium quality fish (kg), QL_m = Quantity loss on market price due to the selling of medium quality fish[11] (kg/MT).

[11] Medium quality fish: If the fish price drops by less than or equal to 50% of actual market price, then we termed it as a medium quality fish.

If the price of fish dropped by more than 50% than the market price, then it is called "poor quality" and was estimated using the equation:

$$M_p = \frac{(Q_p \times L_p)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

$$QL_p = \frac{M_p}{P_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vii)$$

Where, $M_p = \text{Loss at monetary value}$ due to selling the poor quality of fish (BDT/MT); QL_p = Quantity loss on market price due to the selling of poor-quality fish (kg/MT) and Q_p =Quantity of poor quality of fish (kg).

On the other hand, the actual loss for " poorest quality" is defined as the fishes that cannot be eaten but sold at the lowest price for different purposes, and it was calculated by the equation given below:

$$M_s = \frac{(Q_s \times L_p)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (viii)$$

$$QL_s = \frac{M_s}{P_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ix)$$

Where,

$M_s = \text{Monetary value loss}$ due to selling the poorest quality of fish (BDT/MT); QL_s = Quantity loss on market price due to the sold of poorest quality fish[12] (kg/MT) and Q_s =Quantity of poorest quality of fish (kg).

Besides, operators often have to sell at a lower price even of good quality fishes may be due to the excess supply during peak season and lower demand during religious festivals (Wibowo et al., 2017). The losses due to such a fall in price were considered as market forces loss. The loss due to excess supply was calculated using the following equations:

$$M_e = \frac{(Q_e \times L_p)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (x)$$

$$QL_e = \frac{M_e}{P_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xi)$$

Where, QL_e = Quantity loss on market price due to excess supply of good quality fish (kg/MT), $M_e = \text{Monetary value loss}$ due to excess supply of good quality fish (BDT/MT) andQ_e =Quantity of excess supply of good quality fish (kg).

The loss from lower demand was estimated as follows:

$$M_l = \frac{(Q_l \times L_p)}{(Q_t)} \times 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xii)$$

$$QL_l = \frac{M_l}{P_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xiii)$$

Where, $M_l = \text{Monetary value loss}$ due to lower demand of good quality fish (BDT/MT) QL_l = Quantity loss on market price due to lower demand of good quality fish (kg/MT) and Q_l =Quantity of lower demand of good quality fish (kg).

[12]Poorest quality fish: Fishes those cannot be consumed but sold for using other purposes such as preparing fish feeds.

10.3.2 Supply chain structure analysis

10.3.2.1 Supply chain mapping and networking

The mapping of a supply chain is crucial in the fisheries sub-sector since it depicts the way how fishes are traded from producers to consumers through different intermediaries. First, the study identified the actors who were engaged in the fish transaction from harvesting to ultimate consumption. Then the study sketched the supply chain to see the transaction volume of fish among the stakeholders for capture, culture, and marine fisheries. The study emphasized the major chain of fish transactions among the stakeholders.

Further, the study developed the supply chain network for inland and marine fisheries. The supply chain networking system was developed mainly based on the focal distributor of fish transactions. The study evaluated how the focal actor was linked with the other traders and institutions through backward and forward linkages. In addition, the study investigated whether the focal traders were connected with the manage and not-mange system, as well as any contract and relational management prevail.

10.3.2.2 Supply chain performance measurement

The progress of fish production achieved a remarkable position nowadays. But the distribution system of fish is still in a complex situation. Besides, supply chain performance measurement received little attention in the field of the fisheries sector in Bangladesh. Therefore, the study focused on supply chain actors considering the different market arrangements to evaluate the performance. However, the study emphasizes six indicators: efficiency, effectiveness, quality, reliability, flexibility, and capability to measure supply chain performance.

The interview schedule was developed based on six supply chain indicators (efficiency, effectiveness, quality, reliability, flexibility, and capability), stakeholders (fisherman, fish farmer, *chalani paiker*[13], commission agent, and retailer), and market arrangements. The study focused on the stakeholders who traded the capture, culture, and both sources of fishes in inland fisheries. For convenience, the study incorporated the *bepari* and *paiker* into *chalani paiker* into one category. In addition, the *faria* and *aratdar* were incorporated into commission agents. The market arrangements, i.e., spot, contract, relational and cooperative market, were identified based on the significant transaction mode of the stakeholders. The factors of each indicator were categorized to the different scales in the interview schedule. However, before analyzing the data, the scales were given equal weight (five points of Likert scale). The study emphasized simple descriptive statistics to see the performance among the actors and in the different market arrangements by the indicators. At the same time, the mean score represents the performance of each market participant in different market arrangements. When the mean score of an indicator is highest, the position of that particular indicator is better. The performance was assessed applying the following equation:

[13]*Chalani Paikar:* The *chalani paikar* is a wholesaler who play dual role to transact the fishes. Generally, they transact the fishes from one district to another or transact within a particular district.

$$\text{Mean score (M)} = \frac{M_j}{N_j} \ldots\ldots \ldots\ldots \ldots\ldots (XIV)$$

Where,
M_j= Sum of score and N_j= Number of respondents.

10.3.3 Value chain analysis

10.3.3.1 Value chain mapping

The study sketched the value chain map of the major fishes, i.e., carp fish (rohu), Pangas, shrimp, and Hilsha in inland fisheries. In the case of marine fisheries, the study sketched the value chain map for Bombay duck, Hilsha, and shrimp. The study evaluated the value chain from the fisher folks up to the consumers based on the price spread.

10.3.3.2 Marketing cost, profitability, and value addition

The marketing cost was calculated based on the monetary value due to performing the marketing activities by the actors for buying and selling various fishes, e.g. the capture, culture, and marine fish. The study calculated the profitability by subtracting the total cost from the gross return. Further, the value addition or net margin was measured by subtracting themarketing cost from the total marketing margin.

Marketing cost

Marketing costs items such as loading and unloading, grading, sorting, transportation, basket, ice, toll, etc., are very crucial after harvesting to sell the fishes. The study considered all particulars for estimating the total marketing cost by applying the following equation given below:

$$T_c = \sum M_c \ldots\ldots \ldots\ldots \ldots\ldots (XV)$$

Where,T_c= Total cost and M_c= Marketing cost by the actor

Marketing margin

The marketing margin was calculated based on the selling price, purchase price, and marketing cost of fishes. It means the subtraction of the summation of buying price and marketing cost from the selling price. The following equation was applied to calculate the marketing margin:

$$M_m = P_s - (P_b + M_c) \ldots\ldots \ldots\ldots \ldots\ldots (XVI)$$

Where, M_m= Marketing margin, P_s= Selling price (Consumer purchase price), P_b= Buying price (Price received by the seller) and M_c = Marketing cost.

Percentage of producer share

Producer's share refers to the ratio between the price received by the producer and the price paid by consumers. The greater the proportion, the higher is the efficiency and vice-versa. The following equation of percentage of producer share are given below:

$$P_s = \frac{P_p}{P_c} \times 100 \ \ldots\ldots\ \ldots\ldots\ \ldots\ldots\ (XVII)$$

Where, P_s= Producer share, P_p= Price received by producer and Pc= Price paid by the consumer.

Price spread

Price spread refers to the difference between the price paid by consumers and the price received by the producer for an equivalent quantity of goods.

$$P_{sp} = P_c - P_p \ \ldots\ldots\ \ldots\ldots\ \ldots\ldots\ (XVIII)$$

Where, P_{sp} =Price spread, P_c=Price paid by the consumer and P_p= Price received by the producer.

Rate of return

The rate of return means the ratio between marketing margin and marketing cost. The higher the percentage means the higher efficiency and vice-versa. The equation of rate of return are given below:

$$R_r = \frac{M_m}{\mathrm{M_c}} \ \ldots\ldots\ \ldots\ldots\ \ldots\ldots\ (XIX)$$

Where, R_r= Rate of return, M_m= Marketing margin and M_c = Marketing cost.

10.3.3.3 Marketing efficiency measurement

The study evaluated the performance by assessing the level of efficiency. Five indicators, i.e., total marketing cost, total marketing margin, price spread, producer share, and rate of return, were considered to estimate efficiency. The study assessed the efficiency method by using several methods, i.e., Shephard method, Acharya and Agarwal's method, Marketing efficiency index method, and Composite index methods. Each of the efficiency method was applied to identify the most efficient channel.

Shepherd method

Shepherd (1965) suggested the ratio of the consumer purchase price and marketing cost as a measure of marketing efficiency. The equation of this method is given below:

$$\mathrm{M_s} = \left(\frac{\mathrm{P_c}}{\mathrm{T_c}}\right) \ \ldots\ldots\ \ldots\ldots\ \ldots\ldots\ (XX)$$

Where, $\mathrm{M_s}$= Shepherd method, P_c=Price paid by consumer and T_c= Total marketing cost.

Acharya and Agarwal's method

Acharya and Agarwal (2007) considered producer selling price, marketing cost, and marketing margin to evaluate the marketing efficiency. The given equation by Acharya and Agarwal was:

$$M_{aa} = \frac{P_p}{(T_c + M_m)} \ldots\ldots\ldots\ldots\ldots\ldots (XXI)$$

Where, M_{aa} =Acharya and Agarwal's method,P_p=Price received by the producer, T_c=Total marketing cost and M_m= Net marketing margin.

Marketing efficiency index method

In this method, marketing cost and margin were considered for assessing marketing efficiency. The following equation calculated the marketing efficiency index method:

$$M_i = 1 + \left(\frac{M_m}{T_c}\right) \ldots\ldots\ldots\ldots\ldots\ldots (XXII)$$

Where, M_i=Marketing efficiency index method, M_m= Net marketing margin and T_c=Total marketing cost.

Composite index method

The composite index method refers to the ratio of the total ranks of indicators and the number of indicators. The equation of this method is given below:

$$\mathrm{R} = \frac{R_i}{N_i} \ldots\ldots\ldots\ldots\ldots\ldots (XXIII)$$

Where, R= Composite index method, R_i= Sum of ranks of indicators and N_i =Number of indicators.

11. Results and discussion

11.1 Post-harvest loss of fisheries sub-sector

11.1.1 Background

Although Bangladesh has attained impressive growth in terms of productivity, efficiency, and production technology both in culture and capture fisheries, the innovations across the value chain are partly explored due to the substantial amount of PHL. Therefore, effective measurement of PHL must be taken into consideration to realize maximum potential economic benefits and welfare (i.e., nutrition and livelihoods) from the fisheries sub-sector. It indicates that efficient control over PHL will support the ways to increase the quantity and quality of fishes in the market, which in turn, have an economic and social consequence on people's livelihood in developing countries (Akande and Diei-Ouadi, 2010). Besides, reducing these losses would increase the amount of fish available for human consumption and enhance global food security, a growing concern with rising fish prices due to growing consumer demand (Ahmed, 2008). The post-harvest losses of fish do not merely reduce the availability of fish for human consumption but also cause negative externalities to society through waste management costs and loss of scarce resources used in their production. This chapter demonstrates the findings of the PHL at different stages and stockholders' level of fisheries sub-sector in Bangladesh. Before discussing the PHL of fisheries sub-sector, initially we show the division-wise inland fish harvest and trade in percentage for comprehensive understanding about the overall scenario of capture and culture fisheries in Bangladesh. This study utilizedsubstantial amount of primary data (24672 stakeholders from 64 districts covering 1463 markets) collected from all over the country to disclose the information on fish production and harvest even though the Department of Fisheries (DoF) has reported this.

11.1.2. Division-wise harvest of capture and culture fish species

The amount of fish harvested in capture fisheries varies according to the division due to geographical location. Spatial characteristics influence the availability of capture fish in particular regions. Data in Table 3 demonstrate the division-wise harvested fish in Bangladesh as percentage. Results revealed that a substantial portion of the major carp fish (Rui, Catla, and Mrigal) was harvested in Khulna (40.82%), followed by Dhaka (37.35%). This finding supports the national scenario of Bangladesh (DoF, 2019). On the other hand, the lowest amount of major carp fish was harvested in Barishal that was only 0.23%. The highest other carp fishas Kalibaus, Bata, and Ghania were harvested in the Chattogram division covering 36.51% of the total catch in Bangladesh, followed by Khulna (23.97 %). The lowest amount of other carp was produced in the Rangpur division. Besides, the study showed that more than half (53.24%) of the exotic carp (Silver carp, Grass carp, Common carp, Mirror carp, Bighead carp, and Black) wasproduced in the Khulna division because of the vast water bodies and cultured fishes flowed away every year due to flooding, consequently fishers catch those fishes from open waterbodies. The lowest harvested exotic carp was in the Barishal division (0.11%). Bangladesh produces abundant *Pangasius* and it is one of the most prevalent catfishes species. However, *Pangasius* also found in the open waterbodies, and it was observed that about 44.84% of Pangas was produced in the

Dhaka division due to the presence of Padma, Meghna, and their estuary. Live fish (Koi, Singh, and Magur) stay alive for a long time, even after harvest. Results revealed that most of the live fish (39.05%) was harvested in the Sylhet division due to presence of vast areas under haor, baor, and other water bodies. The harvested amount of Hilsa was the highest in Barishal (40.64%), followed by Chattogram (35.89%). This is because during the monsoon, Hilsha comes in the river's estuary from the Bay of Bengal for breeding purpose. In case of Shrimp, about 28.96% of total catch belong to Chattogram, and followed by Dhaka (25.98%), Barishal (13.56%) and Khulna (13.35%) (Table 3). Although Tilapia has become a popular aquaculture species, this fish is harvested from different rivers and other water bodies. The highest proportion of Tilapia was harvestedfrom Dhaka division (48.94%), followed by Khulna (29.14%), and Chattogram (18.02%). Finally, the Dhaka division has the highest amount of harvest of other fish (26.22%). Similarly, 16.97% and 15.94% of total other fishes was captured from Mymensingh and Chattogram, respectively.

Table 3. Division-wise harvest of different capture fish species (in percentage)

Percentage (%) of total catch									
Division	**Major carp**	**Other Carp**	**Exotic Carp**	**Pangas**	**Live Fish**	**Hilsha**	**Shrimp**	**Tilapia**	**Other Fish**
Dhaka	37.35	20.39	30.08	44.84	16.01	14.73	25.98	48.94	26.22
Mymensingh	3.68	2.54	2.66	0.00	13.95	0.03	5.57	0.07	16.97
Khulna	40.82	23.97	53.24	23.48	16.86	1.38	13.35	29.14	6.46
Barishal	0.23	1.80	0.11	5.56	0.23	40.64	13.56	0.11	7.91
Rangpur	2.49	0.30	7.00	0.00	1.99	0.12	2.18	2.86	4.16
Rajshahi	4.44	4.98	4.73	0.78	5.40	7.16	6.98	0.69	7.87
Chattogram	8.23	36.51	1.73	25.34	6.52	35.89	28.96	18.02	15.94
Sylhet	2.76	9.50	0.47	0.00	39.05	0.06	3.41	0.16	14.46
Total	100	100	100	100	100	100	100	100	100

Note: Major Carp - Rui, Catla, Mrigal; Other Carp - Kalibaus, Bata, Ghania; Exotic Carp - Silver Carp, Grass Carp, Common Carp, Mirror Carp, Big Head Carp, Black Carp; Live Fish - Koi, Singhi, Magur; Other Fish - Includes all other fishes except those mentioned above.

Likewise, the culture fish production scenario across the divisions is illustrated in Table 4. In terms of fish culture at the farm level, the maximum amount of major carp fisheswas produced in the Rajshahi division (31.77%). On the other hand, Sylhet, Rangpur, Barishal, and Mymensingh divisions had lower major carp production covering only 1.44%, 2.73%, 2.82%, and 3.96%respectively of total cultured major carp fishes in Bangladesh. Exotic carp species were grown highest in Dhaka (31.65%) and Rajshahi (23.50%) division. Contrarily, the Sylhet division had the lowest exotic carp production (0.96%). Again, the farmers of the Mymensingh division prominently produce Pangas and live fish species. Approximately 45% of Pangas was produced in Mymensingh district. Besides, more than half of total live fish production was found in Mymensingh, while farmers of Rajshahi and Dhaka division produced 16.92%, and 11.71% of the total, respectively.

Table 4. Division-wise production of different culture fish species (in percentage)

Percentage (%) of total production								
Division	**Major carp**	**Other Carp**	**Exotic Carp**	**Pangas**	**Live Fish**	**Shrimp**	**Tilapia**	**Other Fish**
Dhaka	24.92	53.78	31.65	14.54	11.71	0.35	25.25	26.70
Mymensingh	3.96	2.43	3.07	44.60	53.86	0.04	3.86	15.44
Khulna	9.41	14.02	15.99	4.74	3.31	97.50	8.99	7.27
Barishal	2.82	0.23	3.22	1.85	2.67	0.68	2.80	2.38
Rangpur	2.73	6.21	5.19	1.22	4.84	0.00	2.47	6.35
Rajshahi	31.77	9.61	23.50	13.21	16.92	0.45	6.24	17.02
Chattogram	22.96	13.28	16.43	18.76	6.41	0.02	48.45	22.80
Sylhet	1.44	0.44	0.96	1.08	0.28	0.97	1.94	2.03
Total	100	100	100	100	100	100	100	100

Khulna division alone had 97.50% shrimp production through *gher* practice. However, the commercialization of Shrimp and wide acceptance of *gher* culture among the farmers of the Khulna division can be entitled beyond this scenario. Almost half (48.50%) of the total tilapia production was contributed by the Chattogram division, followed by Dhaka (25.25%). Other fish species (all fish except those mentioned above) were produced primarily in Dhaka, Chattogram, Rajshahi, and Mymensingh divisions.

11.1.3 Overall post-harvest loss of fisheries sub-sector in Bangladesh

In order to ensure the highest quality of fish products for the consumer, care must be taken from the time of harvesting or capturing to the time it reaches the consumer. It is easy to lose fish value in terms of physical and market loss as it can be spoiled rapidly, and there are many points in the supply chain where fish is exposed to hazards. Physical loss of fish refers to that, after capture or landing, is not used. It is either thrown away accidentally, or as authorized. Physical loss can be caused by theft, by insects eating the fish, or by bird or animal predation (Diei-Ouadi, & Mgawe, 2011). Data in Table 5 highlight the overall post-harvest loss in capture, culture, and marine fisheries of Bangladesh, considering the quantity and monetary value loss. In capture fisheries, the estimated overall PHL was 59.70 kg/MT, which comprised of 3.37 kg/MT of physical loss and 56.33 kg/MT of market loss. However, the market loss categorized into quality and market force loss. Regarding quality loss, farmers sold 112.07 kg/MT fish at less than or equal to 50% reduced price (referred as medium quality loss),which is estimated as 40.30 kg/MT fish loss at actual market price.

The total monetary loss estimated as BDT 10205.60/MT for selling medium quality capture fish. Besides, BDT 3142.83/MT was lost due to excess supply in the market. In the peak season, the excess supply of fish remains in the market because fishers did not have adequate storage facilities. They were eager to sell their fish immediately after capturing. It is obligatory to establish a sufficient storage facility at the right place to ensure the year-round uninterrupted flow of fish in the market.

Moreover, overall PHL in culture fisheries was 6.74 kg/MT, including physical loss of 0.99 kg/MT and market loss of 5.75 kg/MT. In culture fisheries, 43.48 kg/MT of fish sold at less than or equal to 50% reduced price (referred as medium quality loss) and this loss was equivalent to 3.91 kg/MT at actual market price. Like the capture fisheries, fish farmers were losing their fish value regarding the market forces due to the excess supply in the market rather than the lower demand in the market. Therefore, demand from the consumers is not a burning issue but excess supply in the peak season, which becomes a burden for the fisheries sub-sector in Bangladesh. However, farmers incurred the total PHL of BDT 1278.73/MT in culture fisheries.

Post-harvest loss at market level

Additionally, marine fisheries are the most potential segment to explore; however, due to some technical constraints, this segment has not been thoroughly scrutinized yet. There is a substantial amount of PHL in the marine fisheries, which was around 36.53 kg/MT. In the total PHL of marine fisheries, physical and market were 10.53 kg/MT and 26.00 kg/MT, respectively. Besides, loss regarding excess supply and medium quality fish sale contributed substantially to the market loss, 19.64 kg/MT and 27.07 kg/MT at the reduced price, whereas the monetary value of these losses was BDT 1826.52/MT and BDT 2165.60/MT, respectively. On the other hand, the actual loss at the prevalent market price was 6.76 kg/MT and 8.02 kg/MT for medium quality fish and excess supply, respectively. In a nutshell, a significant amount of PHL of fish resulted from the excess supply and medium quality fish sale.

Table 5. Overall post-harvest loss of capture, culture, and marine fisheries in Bangladesh

PHL types	Capture fisheries		Culture fisheries		Marine fisheries	
	kg/MT()*	**BDT/MT()****	**kg/MT**	**BDT/MT**	**kg/MT**	**BDT/MT**
A. Physical loss	3.37	1330.76 (0.32)	0.99	210.46 (0.10)	10.53	2843.10
B. Market loss						
i) Quality loss						
Medium [a]	40.30 (112.07)	10205.60 (5.94)	3.91 (43.48)	756.30 (4.34)	6.76 (19.64)	1826.52
Poor [b]	3.12 (5.36)	516.16 (0.220)	0.73 (1.82)	92.83 (0.14)	4.77 (7.80)	1287.00
Poorest[c]	0.11 (0.15)	11.17 (0.004)	0.02 (0.04)	1.94 (0.002)	0.32 (4.32)	90.72
ii) Market forces loss						
Excess supply	10.48 (43.34)	3142.83 (2.391)	0.81 (12.67)	161.44 (1.27)	8.02 (27.07)	2165.60
Lower demand	2.32 (11.07)	725.14 (0.641)	0.28 (3.86)	55.76 (0.39)	6.13 (22.05)	1653.75
Total market loss (i+ii)	56.33	14600.9	5.75	1068.27	26.00	7023.59

	(172.00)		(62.87)		(80.88)	
C. Total PHL (A+B)	59.70 (175.37)	15931.65	6.74 (63.86)	1278.73	36.53 (91.41)	9866.69
Loss at national level (quantity in MT and BDT in Crore)	73771.83	1968.69	16773.17	318.22	24106.55	651.11
Total national loss (BDT in crore/year)	**2938.02**					

Note:()* shows the sold quantity (kg.ton^{-1}) due to the price reduction than the market price; ()**indicates the percentage of monetary value loss on total capture and culture harvest.[a] If the fish price drops by less than or equal to 50% of actual market price, [b]If the fish price drops by more than 50% of its actual market price, [c] Fish can't be consumed but sold. Loss at the national level is measured through the country's total harvest (according to DoF, 2018-2019) multiplied by the estimated PHL of capture and culture fisheries.

Besides, the monetary value of PHL was calculated BDT 9866.69/MT for marine fisheries. However, it was found that the overall PHL represented BDT 1968.69 crore, BDT 318.22 crore, and BDT 651.11 crore for capture, culture, and marine fishery, respectively at the national level. In total, Bangladesh lost about BDT 2938.02 crore from the fisheries sector each year, which should be a concerning issue for the economy. Therefore, the overall PHL should be kept as minimum as possible to obtain the sustainable goals target of Bangladesh by 2030.

The loss in percentage was calculated based on the total capture, culture and marine loss showed in Fig 2. Results revealed that the physical loss was the highest (28%) out of total PHL for marine fish. However, the loss for medium quality fish was 64% and 59.14% out of total loss for capture and culture, respectively, which were higher among the market loss.

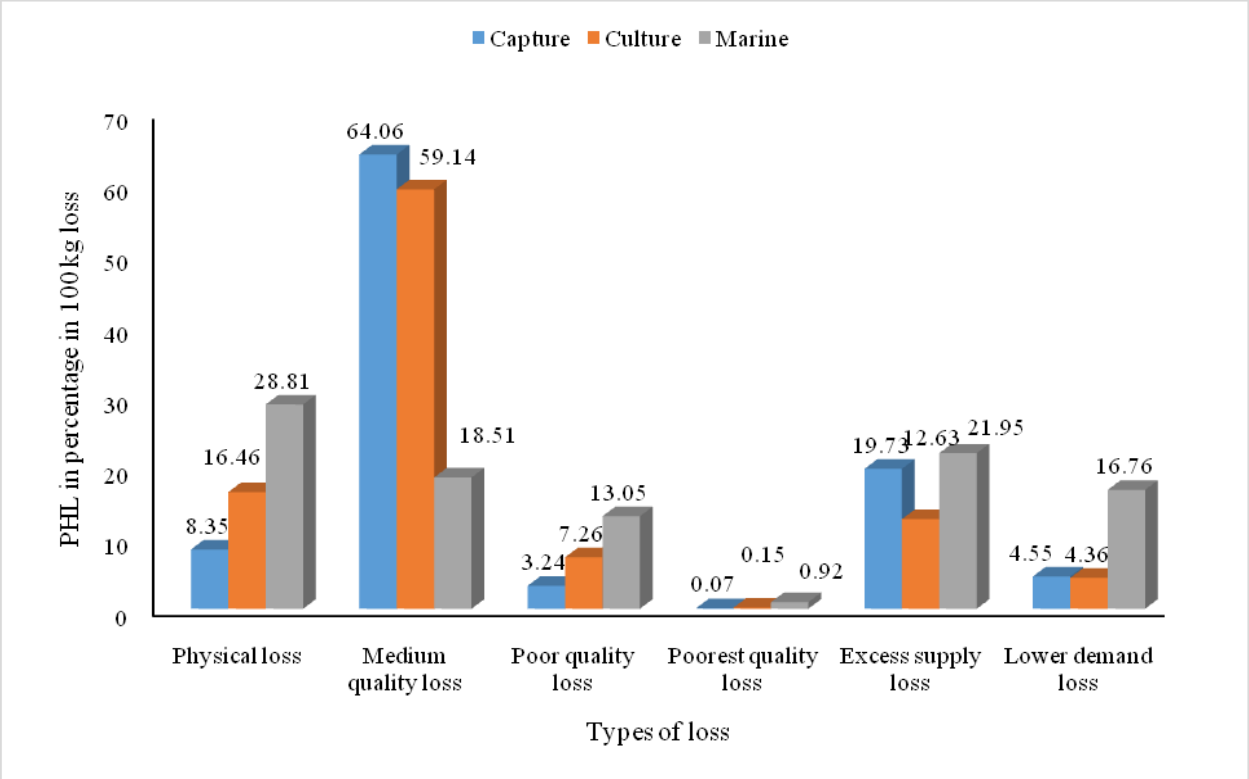


Fig 2. Different types of post-harvest loss in capture, culture, and marine fish (per 100 kg loss).

11.1.4 Mapping the severity of post-harvest loss

Fig 3 demonstrates the overall PHL severity across different districts of Bangladesh. This study categorized all districts into three, i.e., low PHL areas, medium PHL areas, and high PHL areas marked by three different colors in the map. Dhaka, Tangail, Mymensingh, Gazipur, Kishoreganj, Netrokona, Habiganj, Sylhet, Pabna, Rajshahi, Natore, Bogura, Chapainawabganj, Noakhali, and Chattogram were the region where PHL was severe. From the results, it is worth mentioning that high PHL was observed at the high-intensity fish culture or capture region or where fishes were traded most. Therefore, efficient and effective marketing, storage, and transportation system should be incorporated to reduce the overall PHL in different regions. On the other hand, all stakeholders should lead forward to minimize the PHL at the farm and traders' level.

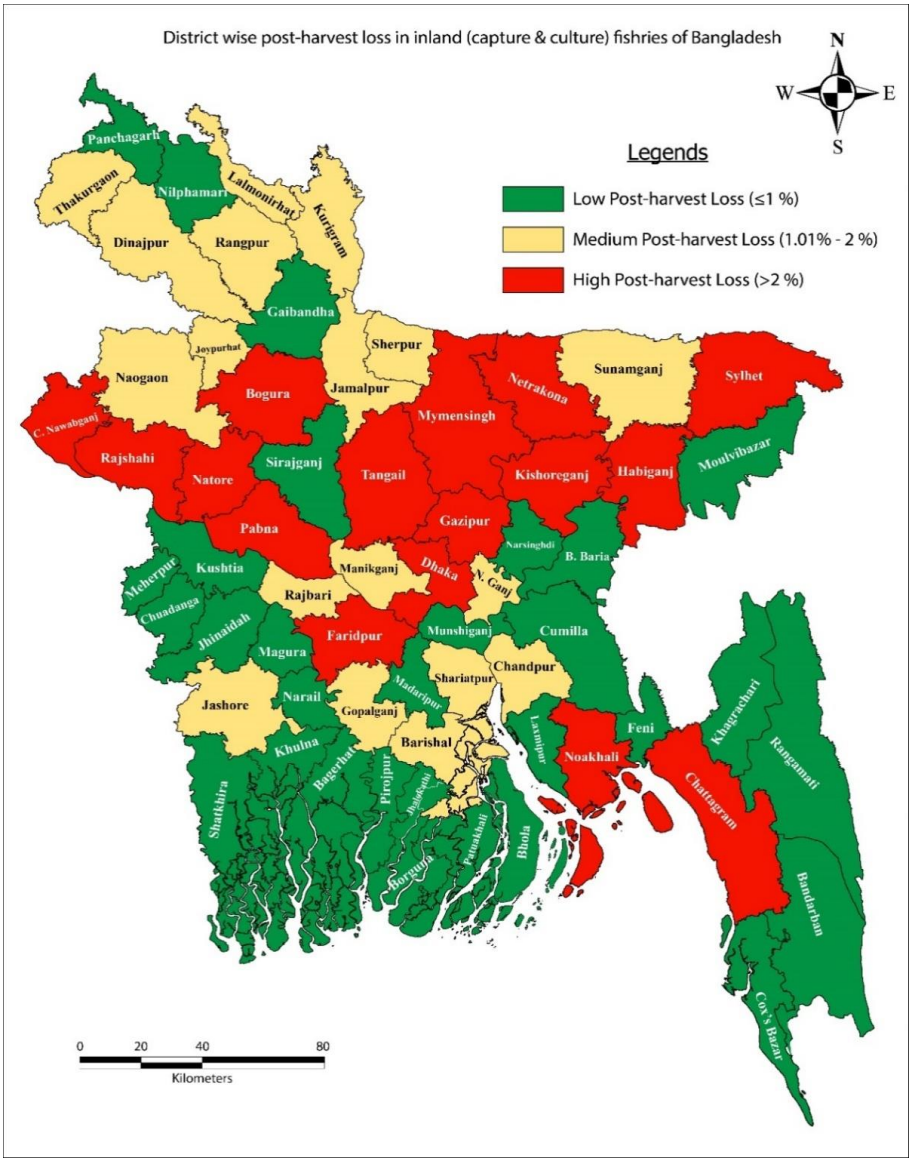


Fig 3. District wise severity of post-harvest loss (PHL) in Bangladesh.

11.1.5 Source-wise post-harvest loss in capture and culture fisheries at farm level

In this subsection, results on PHL by sources in capture and culture fisheries were described and data/result reported in Table 6. The results indicated that the highest PHL emanated from the river and floodplain (i.e., haor), which were 51.32% (10.69 kg/MT) and 36.25% (7.55 kg/MT), respectively. The observed physical loss in the case of the river was 2.10kg/MT,and market loss was 8.59 kg/MT. While the physical loss and market loss for haor was 2.49 kg/MTand 5.06 kg/MT, respectively. Furthermore, the highest market loss was observed in the pond was 97.37% (6.66 kg/MT). The calculated PHL was negligible in the seasonal cultured water body, gher, and baor. The monetary value of PHL in the case of river and haor were BDT3664.08/MT and BDT2426.68/MT, respectively. In contrast, it was BDT1706.88/MT for the pond in culture fisheries. It may happen because of the improved management practices in the case of culture fisheries.

Table 6. Sources-wise post-harvest loss of capture and culture fisheries at farm level

Sources of fishes	**Physical loss**		**Market loss**		**Total PHL**	
	kg/MT	**BDT/MT (%)***	**kg/MT ( )****	**BDT/MT (%)***	**kg/MT (% loss on total loss)**	**BDT/MT (%)***
Capture fisheries						
River	2.10	727. 4(0.20)	8.59(31.55)	2936.6(0.79)	10.69(51.32)	3664.08(0.98)
Haor	2.49	686.3 (0.18)	5.06(20.54)	1730.4(0.46)	7.55(36.25)	2416.68(0.65)
Beel	0.62	173.9 (0.05)	1.70(10.36)	581.28(0.16)	2.32(11.14)	755.16(0.20)
Canal	0.06	15.96(0.01)	0.21(1.16)	73.08(0.02)	0.27 (1.30)	89.04 (0.02)
Capture total	5.26	1604.4 (0.43)	15.57(63.6)	5322.2(1.43)	20.83	6925.8(1.86)
Culture fisheries						
Pond culture	1.53	314.16 (0.16)	5.13(38.26)	1392.7(0.72)	6.66(97.37)	1706.88(0.88)
Seasonal cultured water body	0.01	0.84 (0.01)	0.13 (0.73)	34.44 (0.02)	0.13 (1.90)	35.28 (0.02)
Gher (Shrimp farm)	0.02	2.52(0.01)	0.03 (0.14)	9.24(0.01)	0.05 (0.73)	11.76(0.01)
Baor	0.00	0.00 (0.00)	0.01 (0.04)	1.68 (0.01)	0.01 (0.15)	1.68(0.01)
Culture total	1.54	316.68 (0.16)	5.30 (39.17)	1438.9(0.75)	6.84	1755.6(0.91)

Note: ( )*Value in the parenthesesindicatesthe percentage of monetary value loss on total capture and culture harvest; ( )**indicates the sold quantity (kg/MT) due to the price reduction than the market price.

11.1.6 Species wise post-harvest loss in capture and culture fisheries at farm level

The PHL observed by fish species has been described in this section and results were reported in Table 7. This study identified 202 capture and culture species during the survey. In case of capture and culture fish 89 and 32 species were observed respectively for physical loss, while 111 capture and 64 culture fish species were observed for market loss. However, 14 species in capture and 11 species in culture were considered as major species of loss. It is because these species among observed species were accounted for the highest physical and market losses in both capture and culture fisheries.

Post-harvest loss at harvest level

The PHL for the rest of the species was not individually sizable; however, if aggregated across many species it is sizable. Therefore, the rest of the capture and culture fish species were taken together measuring the PHL as "other fish species". Further, the study categorized the observed fish species as high and low value based on its market price per kilogram. The results found a typical variation of losses across the species.

The results showed that in capture fisheries, the higher PHL occurred in case of Hilsha, which was 2.93 kg/MT among high-value species. However, the estimated physical loss for Shrimp and market loss for Hilsha were higher, which were 0.52 kg/MT and 2.67 kg/MT, respectively. Besides, among low-value species, the higher PHL occurred for Punti, which was 1.52 kg/MT, and for this species both physical and market losses were also higher. Furthermore, in culture fisheries, the calculated PHL was higher for Rui (high-value species) and Mrigal (low-value species), which were 1.14 kg/MT and 0.86 kg/MT, respectively (Table 7). Thus, even both physical loss and market loss was higher for these species in culture fisheries. Nowsad *et al.* (2015) reported that the quality loss of Rui was higher as estimated by the sensory assessment tool in Bangladesh.

Moreover, BDT 1037.4/MT for Hilsha and BDT 479.64/MT for Punti in capture fisheries was the highest total monetary loss. But the higher monetary value of physical loss and market loss was estimated for Shrimp and Hilsha, respectively. The estimated monetary loss of Punti was higher for physical and market loss among the low-value species, which were BDT 201.6/MT and BDT 278.04, respectively. In the case of culture fisheries, Rui (BDT 285.6/MT) and Mrigal (BDT 219.24/MT) were identified as species causing the highest total monetary loss among high-value and low-value fish species. In addition, the monetary value of physical loss, and market loss of these species were also higher in case of culture fisheries.

Table 7. Species-wise post-harvest loss of inland capture and culture fisheries at farm level

Local name (Scientific name)	Physical loss		Market loss		Total PHL	
	kg/MT	BDT/MT (%)*	kg/MT( )**	BDT/MT (%)*	kg/MT	BDT/MT (%)*
Capture fish species						
High-value fish						
Hilsha (*Tenualosa ilisha)*	0.26	126 (0.03)	2.67 (5.59)	911.4 (0.25)	2.93	1037.4 (0.28)
Shrimp (*Acetes chinensis)*	0.52	178.9 (0.05)	1.88 (2.76)	642.6 (0.17)	2.40	821.52 (0.22)
Baem (*Mastacembelus armatus)*	0.43	154.6 (0.04)	0.85 (2.79)	290.64 (0.08)	1.28	445.2 (0.12)
Balia (*Awaous guamensis)*	0.24	73.92 (0.02)	0.76 (2.38)	259.56 (0.07)	1.00	333.48 (0.09)
Rui (*Labeo rohita)*	-------	-------	0.41 (3.94)	141.12 (0.04)	0.41	141.12 (0.04)
Tengra (*Macrones vittalus)*	0.32	109.2 (0.03)	-------	-------	0.32	109.2 (0.03)
Boal (*Wallago attu)*	0.29	77.28 (0.02)	-------	-------	0.29	77.28 (0.02)
Total high-value fish	2.06	719.04 (0.19)	6.57 (17.45)	2246.16 (0.60)	8.63	2965.2 (0.80)
Low-value fish						
Puti (*Puntius chola)*	0.71	201.6 (0.05)	0.81 (5.58)	278.04 (0.08)	1.52	479.64 (0.13)
Taki (*Channa punctate)*	0.52	124.32 (0.03)	0.43 (3.85)	146.16 (0.04)	0.95	270.48 (0.07)
Chanda (*Brama brama)*	0.35	71.4 (0.02)	-------	-------	0.35	71.4 (0.02)
Chela (*Salmostoma acinaces)*	0.17	43.68 (0.01)	-------	-------	0.17	43.68 (0.01)
Mrigel (*Cirrhinus cirrhosis)*	-------	-------	0.14 (2.57)	47.88 (0.01)	0.14	47.88 (0.01)
Silver carp (*Hypophthalmichthys molitrix)*	-------	-------	0.07 (2.28)	25.2 (0.01)	0.07	25.2 (0.01)
Tilapia (*Oreochromis mossambicus)*	-------	-------	0.06 (4.22)	21.84 (0.01)	0.06	21.84 (0.01)
Total low-value fish	1.74	441 (0.12)	1.52 (18.50)	519.12 (0.14)	3.26	959.28 (0.26)
Others fish (high and low)	1.47	444.36 (0.12)	7.48 (27.66)	2556.96 (0.69)	8.95	3001.32 (0.81)
Capture total	5.26	1604.4 (0.43)	15.57 (63.61)	5322.24(1.43)	20.83	6925.8 (1.86)
Cultured fish species						
High-value fish						
Rui (*Labeo rohita)*	0.35	72.24 (0.04)	0.79 (7.03)	213.36 (0.11)	1.14	285.6 (0.15)
Katla (*Catla catla)*	0.21	39.48 (0.02)	0.43 (3.76)	116.76 (0.06)	0.64	157.08 (0.08)
Singh (*Amblyceps mangois)*	0.10	31.08 (0.02)	0.30 (1.54)	81.48 (0.04)	0.40	112.56 (0.06)
Pabda (*Callichrus pabda)*	0.08	30.24 (0.02)	0.15 (0.74)	40.32 (0.02)	0.23	70.56 (0.04)
Gulsha (*Mystus cavasius)*	0.03	8.4 (0.01)	-------	-------	0.03	8.4 (0.01)
Total high-value fish	0.78	181.44 (0.09)	1.67 (13.06)	452.76 (0.24)	2.45	634.2 (0.33)
Low-value fish						
Mrigel (*Cirrhinus cirrhosis)*	0.14	24.36 (0.01)	0.72 (4.44)	194.88 (0.10)	0.86	219.24 (0.11)
Silver carp (*Hypophthalmichthys molitrix)*	0.16	24.36 (0.01)	0.53 (5.05)	142.8 (0.07)	0.69	167.16 (0.09)
Tilapia (*Oreochromis mossambicus)*	0.14	21 (0.01)	0.25 (3.90)	67.8 (0.04)	0.39	89.04 (0.05)
Pangas (*Pangasius pangasius)*	0.08	12.6 (0.01)	0.24 (4.89)	63.84 (0.03)	0.32	76.44 (0.04)
Big-head carp (*Hypophthalmichthys nobilis)*	0.08	10.92 (0.01)	0.07 (0.94)	20.16 (0.01)	0.15	30.24 (0.02)
Mirror carp (*Cyprinus carpio)*	-------	-------	0.10 (1.53)	27.72 (0.02)	0.10	27.72 (0.02)
Total low-value fish	0.60	93.24 (0.05)	1.90 (20.76)	515.76 (0.27)	2.50	609.84 (0.32)
Others fish (high and low)	0.16	42 (0.02)	1.73 (5.35)	469.56 (0.24)	1.89	511.56 (0.27)
Culture total	1.54	316.68 (0.16)	5.30 (39.17)	1438.92 (0.75)	6.84	1755.6 (0.91)

Note: ( ) *indicates the percentage of monetary value loss on total capture and culture harvest; ( ) **indicates the sold quantity (kg/MT) due to the price reduction than the market price.

11.1.7 Post-harvest loss of major capture and culture fish species

The PHL for culture and capture fisheries included physical and market loss. Species-wise, higher physical losses were observed for Mola, Kachki, and Chanda (10.98-14.98 kg/MT) due to being small indigenous species (SIS). Corresponding market losses (BDT/MT) were also higher for the particular species (Table 8). Individually SIS species are tiny in size, and smaller body constituents result in more physical losses. High-valued species such as Hilsa, Rui, Catla, Poa,

and Shrimp (Galda) have observed much lower PHL (<1 kg/MT). Fishers usually maintain good handling practice and been use of ice results lower physical loss and minimized the PHL of the mentioned high valued culture and capture fishes. Catfish species such as Pangas, Shing, Pabda, and Boal had moderate physical PHL within the range of 1-5 kg/MT. The catfish species usually transported in a live condition where minimum physical and monetary loss occurred.

Table 8. Species wise post-harvest loss in inland fisheries (all actors level)

Species Local name (Scientific name)	Physical loss		Market loss		Total	
	kg/MT	BDT/MT	kg/MT	BDT/MT	kg/MT	BDT/MT
Chanda *(Brama brama)*	10.98	2254.25	43.79 (174.41)	8818.59	54.77	11072.84
Mola *(Amblypharyngodon mola)*	14.98	4400.32	37.12 (170.20)	10944.99	52.11	15345.31
Big-head carp *(Hypophthalmichthys nobilis)*	4.38	817.00	41.98 (152.22)	8653.76	46.36	9470.75
Kachki *(Corica soborna)*	14.21	3889.91	28.92 (186.17)	8524.30	43.14	12414.20
Singh *(Amblyceps mangois)*	5.15	1948.73	33.45 (107.65)	12629.13	38.60	14577.86
Taki *(Channa punctate)*	9.22	2048.8	27.83 (177.52)	5928.42	37.05	7977.22
Balia *(Glossogobius giuris)*	9.63	3970.55	23.41 (110.59)	9246.87	33.04	13217.42
Other small shrimp/prawn	6.36	2992.31	22.82 (115.09)	10666.89	29.18	13659.20
Tengra *(Batasio batasio)*	5.61	1721.29	22.67 (96.97)	5543.72	28.28	7265.01
Rui *(Labeo rohita)*	0.77	199.36	27.12 (96.20)	7052.92	27.89	7252.28
Mrigel *(Cirrhinus cirrhosis)*	2.14	380.43	23.13 (110.84)	4067.11	25.28	4447.55
Puti *(Puntius chola)*	1.87	377.83	22.81 (71.59)	4163.77	24.68	4541.61
Koi *(Anabas testudineus)*	3.08	776.12	21.05 (94.10)	5362.11	24.13	6138.23
Bata *(Labeo bata)*	3.52	951.30	18.73 (98.39)	5041.51	22.26	5992.82
Silver carp *(Hypophthalmichthys molitrix)*	2.46	381.88	19.65 (118.12)	3000.31	22.11	3382.19
Pabda *(Ompok pabda)*	2.95	1159.97	18.29 (79.84)	7313.37	21.23	8473.34
Tilapia *(Oreochromis mossambicus)*	1.83	258.91	18.80 (87.56)	2663.72	20.63	2922.63
Boal *(*Wallago attu)	4.61	2033.22	12.41 (82.33)	5348.27	17.02	7381.49
Katla (*Catla catla)*	0.59	184.33	16.08 (76.16)	4908.85	16.68	5093.18
Pangas *(Pangasius pangasius)*	1.08	226.19	14.17 (90.38)	2953.52	15.25	3179.71
Poa *(Otolithoides pama)*	0.69	184.38	9.57 (74.72)	2567.46	10.26	2751.84
Hilsha *(Tenualosa ilisha)*	0.72	422.21	8.72 (67.17)	4853.85	9.45	5276.06
Bagda Chingri *(Penaeus monodon)*	0.09	46.66	2.51 (14.43)	1325.58	2.60	1372.24
Golda Chingri *(Macrobrachium rosenbergii)*	0.25	142.40	1.86 (14.38)	1046.24	2.12	1188.64

*Value in parentheses ( )represent the quantity of fish sold at a reduced price

Irrespective of inland fish species, market losses (kg/MT) and their corresponding monetary loss (BDT/MT) were much higher than physical losses, which varied from species to species. Likewise, species specifically Chanda, Kachki, Bighead carp, and Mola had a higher market loss

(kg/MT). Considering the total loss (physical loss and market loss), the species mentioned above also had higher total loss as well as monetary loss. Again, smaller size fish are more susceptible to spoilage and quality loss during post-harvesting handling and transportation. Thus, higher market losses might occur. Causes and variations in PHL among the inland capture and culture fishes might be due to differences in biological/physical structure and size of fish, fish body constituents, fishing methods, fishing season, and post-handling process and preservation facilities applied for the respective species. The PHL was mainly because of physical loss caused by the loss of small size fish and spoiled fish due to lack of inadequate ice supply, storage, and transportation facilities.

11.1.8 Species-wise post-harvest loss in marine fisheries

The PHL for marine fish included physical and market loss. The average market loss was 26 kg/MT which was more than double of the physical losses (10.53 kg/MT) for marine fish, and this also varied by species (Table 9). Irrespective of fish species, market losses were two to three times higher than physical loss. Considering the major marine fish species, physical losses were within the range of 5.74 to 16.75 kg/MT and on average it was 10.53 kg/MT. Maximum physical loss was observed for Lottiya (16.75 kg/MT) due to its highly soft physical structure/body constituents that contain more than 90% water (Nordhagen et al. 2020). Higher percentages of body water make this species more susceptible to physical losses. Loittya, Sardine, Pomfret, Shrimp, Croaker, Flat/Sole fish, Mackerel, Tular dati, Mud Crab, and other categories fish had more than 10 kg/MT (10.15- 16.75 kg/MT) physical PHL, which was the highest quantity of physical loss. Physical losses were 7-9 kg/MT for other listed marine fishes, except Hilsa. Hilsa had the lowest post-harvest physical loss of 5.74 kg/MT. Hilsa is the most commercially important marine fish and targeted species by the fishers. Although the physical loss (in quantity) was the lowest for Hilsa,butthe respective monetary loss was the third highest (BDT 4386.21/MT) due to being high-valued commercial marine fish.The highest monetary loss was found for shrimp (BDT 6284.64/MT) and followed by Indian salmon BDT 6063.86/MT. The physical loss inevitably involves a loss in value, as fishers, processors, and traders have less quantity or weight to sell. Thus, commercially important fish species such as Hilsa, had a maximum monetary market loss (BDT 23364.04/MT) followed by Shrimp, Indian Salmon, and Snapper at BDT 15827.16, 10919.4, and 10656.80/MT, respectively. To maintain the quality and avoid post-harvest losses of commercially important fish, fishers usually take care of Hilsa with smooth handling, ice use, and discard even smaller in size and low quality, resulting in lower physical loss.

On the other hand, the average total PHL in marine fishes was 36.53 kg/MT, which was BDT 9866.69/MT in monetary value. Species-wise total losses were maximum in the case of shrimp (47.48 kg/MT) than Hilsa (38.15 kg/MT). Shrimp species are mixed of different varieties between these two species, and all are much smaller in size than Hilsa. In addition, all Shrimp are shellfish containing carapace, and swimming and walking legs, which usually become soften and losses during rough handling and delayed preservation results more significant physical losses occurred in case of Shrimp than Hilsa. Shark and Rays also had a greater total loss (47.27 kg/MT) than other marine fish due to lower consumer preference/food habit. The fishers usually discard skates and Rays due to fishing regulation restrictions and lower market/consumers' demand. Total monetary loss for Pomfret was also higher (BDT 18316.67/MT) since it is a

commercially important high market valued fish. The cuttlefish/squid had the lowest PHL because it is not under the fish or shellfish category but Mollusca, a different hard structure body constituent named chitin or chitosan.

Table 9. Species wise post-harvest loss in marine fisheries

Species	Physical loss		Market loss		Total	
	kg/MT	BDT/MT	kg/MT	BDT/MT	kg/MT	BDT/MT
Shrimp *(Penaeus monodon)*	12.54	6284.64	34.94 (78)	15827.16	47.48	22111.8
Shark/Rays *(Carcharhinus limbatus)*	9.4	2285.21	37.87 (67.95)	6222.05	47.27	8507.26
Mackerel *(Rastrelliger kanagurta)*	10.34	3099.29	35.32 (65.36)	9735.59	45.66	12834.88
Marine catfish *(Rita rita)*	8.77	2815.71	36.24 (128.07)	9020.55	45.01	11836.26
Sardine *(Gudusia chapra)*	15.62	2094.36	26.54 (88.03)	4791.55	42.16	6885.91
Mud Crab *(Scylla serrata)*	15.32	450	26.71 (78.19)	2704.39	42.03	3154.39
Croaker *(Otolithoides pama)*	10.76	2691.71	30.63 (92.47)	6872.32	41.39	9564.03
Tuna *(Euthynnus lineatus)*	8.66	2445	32.37 (89.54)	8431.31	41.03	10876.31
Indian Salmon *(Eleutheronema tetradactylum)*	7.81	6063.86	31.68 (108.81)	10919.47	39.49	16983.33
Hilsha *(Tenualosa ilisha)*	5.74	4386.21	32.41(110.18)	23364.04	38.15	27750.25
Tular dati *(Sillaginopsis panijus)*	10.15	2553.79	27.62 (76.05)	4832.39	37.77	7386.18
Saytan *(Priacanthus Sagittarius)*	9.32	681.21	28.36 (82.26)	2067.68	37.68	2748.89
Loitta *(Harpadon nehreus)*	16.75	1528.57	19.6 (101.8)	3099.03	36.35	4627.6
Snapper *(Lates calcarifer)*	9.12	10493.2	26.51 (75.56)	10656.80	35.63	21150
Ribbon *(Trichiurus haumela)*	9.86	2959.43	25.22 (78.87)	7182.37	35.08	10141.8
Chandona *(*Tenualosa toil)	8.86	1550.71	26.18 (75.58)	3535.66	35.04	5086.37
Faisha *(Setipinna phasa)*	9.63	1259.57	24.86 (53.93)	4338.44	34.49	5598.01
Flat/Sole fish *(Soleichthys heterorhinos)*	10.64	426.71	23.23 (84.77)	4852.58	33.87	5279.29
Topse *(Sarotherodon melanotheron heudelotii)*	8.63	2617	24.5 (98.97)	6548.11	33.13	9165.11
Lakkha *(Eleutheronema tetradactylum)*	9.83	207.1	21.61(89.26)	1196.27	31.44	1403.37
Pomfret *(Stromateus chinensis)*	13.05	10042.1	17.33 (79.43)	8274.57	30.38	18316.67
Scads *(Megalaspis cordyla)*	9.54	889.79	18.32 (89.78)	9287.06	27.86	10176.85
Redfish/Rupban *(Lesiostomus xanthurus)*	9.55	1795.4	17.89 (32.76)	2033.62	27.44	3829.02
Cuttle fish/Squid *(Sepia apama)*	8.73	724.59	3.53 (10.04)	478.43	12.26	1203.02
Others	14.65	732.3	20.65 (86.25)	9318.37	35.30	10050.67
Average	10.53	2843.10	26.00 (80.88)	7023.59	36.53(91.41)	9866.69

Note: The value in the parenthesis represents the quantity of fish at a reduced price

The causes and variations in PHL among the marine fishes might be due to differences in biological/physical structure of fish body constituents, fishing methods, and post-harvest handling process and preservation facilities applied for the respective species. However, PHL was mainly due to by-catch that is usually thrown out, multi-day fishing, over-catch that exposed under pressure in the fishing gear and/or no-board fishing vessel without preservation, fish falling from the net, forced washing/bruising of fish, fish stuck too long in the net and getting spoiled, lack of ice/chilling and storage facilities onboard.

11.1.9 Actor wise post-harvest loss in capture fisheries

There are many actors involve in the fish supply chain, and the PHL varies among actors depending on their nature of activities. Actors play a vital role in capture fisheries, and their efficiency drives the physical and market loss of fish. Data inTable 10 represent the different categories of PHL in capture fisheries of Bangladesh by different actors. Results revealed that the physical loss in case of *beparies* was the highest (5.99 kg/MT) among all the actors, followed by fishers (5.30 kg/MT). *Beparies* buy fish from one district and sell to another, involving various activities such as transportation, loading, and unloading, storing, etc. During these activities, fish get physically damaged. The average amount of fish discarded by all actors was 3.37 kg per MT. Some of the damaged fish cannot be eaten but sold (poorest quality), which is used to prepare livestock and fisheries feed. This loss was 0.11kg/MT, where *beparies* and *paikar* incur 42.22% and 41.11%, respectively (Fig 4). In terms of quantity, approximately 0.32 kg/MT and 0.31 kg/MT of fish were sold at reduce price for *beparies* and *paikar*, respectively (Table 10). It is evident that the highest PHL is incurred in the medium quality loss category, where most loss was made by the *beparies* (60.98 kg/MT). Similarly, the highest loss in poor quality fish[14]was found for*paikar*(6.15 kg/MT) and retailers(5.27 kg/MT). *Beparies, paikers*, and retailers usually have higher holding period, which causes deterioration of fish quality. The medium quality fish loss was found lowest in case of *farias* (25.29 kg/MT). The poor-quality fish was lowest for *farias* (0.52 kg/MT), followed by commission agents(1.15 kg/MT) since their holding period of fish is lower compared to other actors. Results also showed that about 12.05 kg/MT of capture fish were sold at reduced price due to market force (excess supply and lower demand), where*beparies*incurred the highest portion among all the actors (26.88 kg/MT). It may happen due to the lack of proper information about the market situation.

Table 10. Actor-wise post-harvest of capture fish (kg/MT)

Actors	**Physical loss**	**Medium quality**	**Poor quality**	**Poorest quality**	**Market force loss**
	Quantity (kg/MT)	**Quantity (kg/MT)**	**Quantity (kg/MT)**	**Quantity (kg/MT)**	**Quantity (kg/MT)**
Fisher	5.30	41.03	1.76	0.06	16.40
Faria	2.56	25.29	0.52	0.00	12.02
Bepari	5.99	60.98	5.14	0.32	26.88
Paikar	3.26	32.67	6.15	0.31	9.32
Aratdar	1.93	38.01	1.85	0.00	3.73
Commission agent	0.60	29.63	1.15	0.00	6.71
Retailer	3.94	54.50	5.27	0.07	9.29
Average	**3.37**	**40.30**	**3.12**	**0.11**	**12.05**

[14]Poor quality fish: If the fish price drop by more than 50% of its actual market price, then we called those fishes are poor quality fishes.

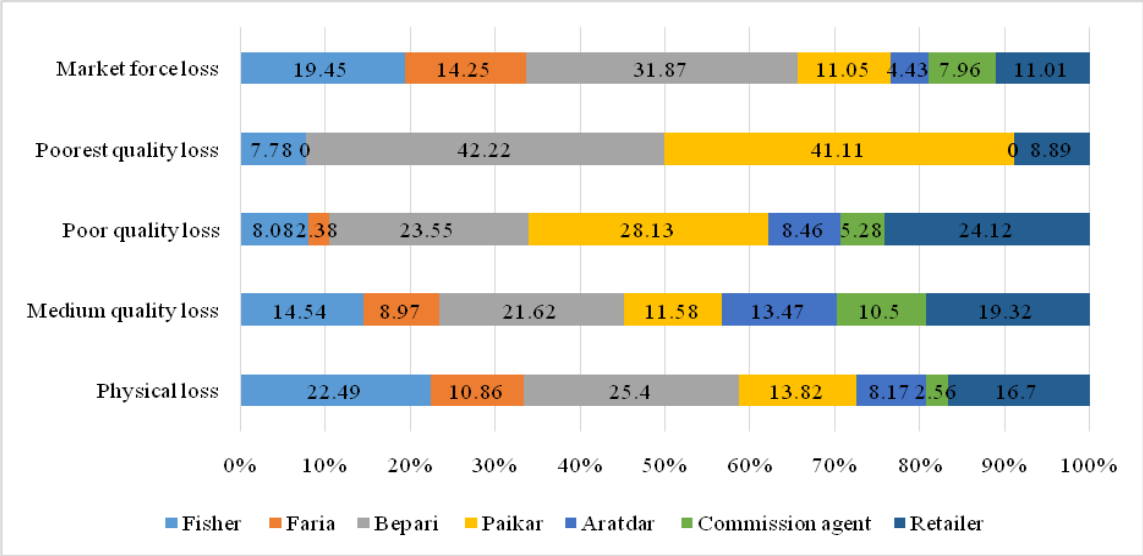


Fig 4. Actor-wise post-harvest of capture fish (percentage).

11.1.10 Actor-wise post-harvest loss of culture fish

It was observed that culture fish species have less PHL compared to capture fishes. Actor wise PHL scenario of culture fish, as illustrated in Table 11, indicates that *aratdar* and fish farmers incurred the highest physical loss of 1.66 kg/MT (23.97%) and 1.55 kg/MT (22.45%), respectively. At farm level, the physical loss of culture fisheries was significantly lower compared to capture fisheries because culture fisheries were harvested with adequate care. At the commission agent level, the loss was the minimum (0.13 kg/MT) as they do not hold any fish between their purchase and sale period rather only use their place for buying and selling activity. The portion of fish that cannot be sold but eaten (poorest quality loss) came maximum from the *paikars*(41.94%) and *bepari* (29.03%) (Fig 5). However, the maximum medium quality fish loss occurred at *Aratdars*level, which was 10.76 kg/MT (39.32%). The minimum amount of medium and poor-quality fish loss was incurred by *Faria*, while maximum poor-quality loss occurred at *paikar*level. Considering excess supply and lower demand in the market, the maximum amount of market force loss was incurred by*bepari* (30.89%) while it was minimum for *faria* (3.72%).

Table 11. Actor-wise post-harvest loss of culture fish (kg/MT)

Actors	**Physical loss**	**Medium quality loss**	**Poor quality loss**	**Poorest quality loss**	**Market force loss**
	Quantity (kg/MT)	**Quantity (kg/MT)**	**Quantity (kg/MT)**	**Quantity (kg/MT)**	**Quantity (kg/MT)**
Fish farmers	1.55	1.09	0.37	0.03	0.66
Faria	0.14	0.47	0.02	0.00	0.28
Bepari	1.25	4.19	0.79	0.05	2.36
Paikar	0.98	3.24	1.37	0.07	1.18
Aratdar	1.66	10.76	1.18	0.00	1.35
Commission agent	0.13	2.13	0.19	0.00	0.61
Retailer	1.20	5.49	1.19	0.02	1.19
Average	0.99	3.91	0.73	0.02	1.09

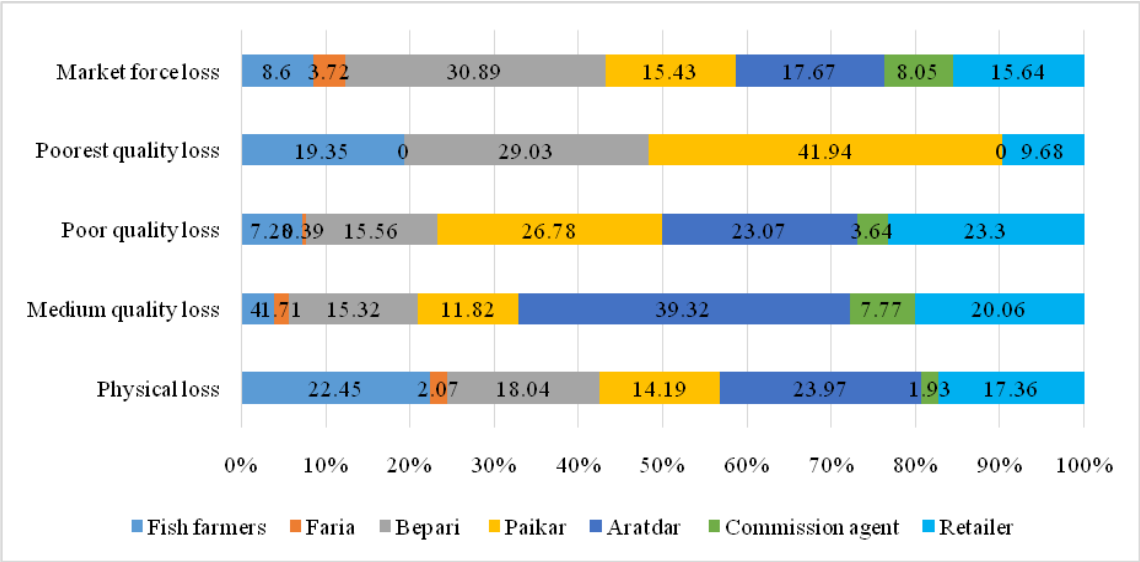


Fig 5. Actor-wise post-harvest loss of culture fish (percentage).

11.1.11 Actor-wise post-harvest loss of marine fish

Marine fisheries involve several actors along their value chain. The scenario of PHL by different actors of marine fisheries is depicted in Table 12. Results revealed that the processors (salting) discarded the highest amount of fish (39.19%), followed by retailers (28.62%). Processors (salting) have to depend on the weather and temperature for salting fish which is challenging during summer and rainy seasons. The average amount of physical loss in marine fisheries by all actors was 10.53 kg/MT. In marine fisheries, poorest quality loss was found at fisher level among all actors, which was 36.96% of total poorest quality fish loss. Fish sometimes get damaged by being stuck with the net for a more extended period. This damaged fish can often be used in the feed of livestock and fishes. *Paikers* incurred the highest medium quality fish loss (22.83%), followed by fishers (18.33%). Besides, *aratdars* have the highest poor-quality fish loss (25.54%), followed by the retailers (20.80%). These actors have a higher holding period compared to others which causes loss of fish quality. Market force loss was found about 14.15 kg/MT, which is the highest among all the types of losses (Table 12). It was also observed that fishers incurred most (25.62%) of the market force loss, followed by *beparies* (24.71%) (Fig 6).

Table 12. Actor-wise post-harvest of marine fish

Actors	**Physical loss**	**Medium quality**	**Poor quality**	**Poorest quality**	**Market force loss**
	Quantity (kg/MT)				
Fisher	13.60	9.91	4.04	0.95	29.00
Bepari	9.00	7.64	6.05	0.41	27.97
Paiker	3.10	12.34	2.73	0.05	12.64
Aratdar	0.20	5.77	9.75	0.34	14.47
Retailer	24.10	9.68	7.94	0.60	13.91
Processor (Freezing)	0.00	2.00	1.17	0.15	7.52
Processor (Dry fish)	1.20	2.30	1.17	0.07	4.59
Processor (Salting)	33.00	4.41	5.32	0.00	3.10
Average	**10.53**	**6.76**	**4.77**	**0.32**	**14.15**

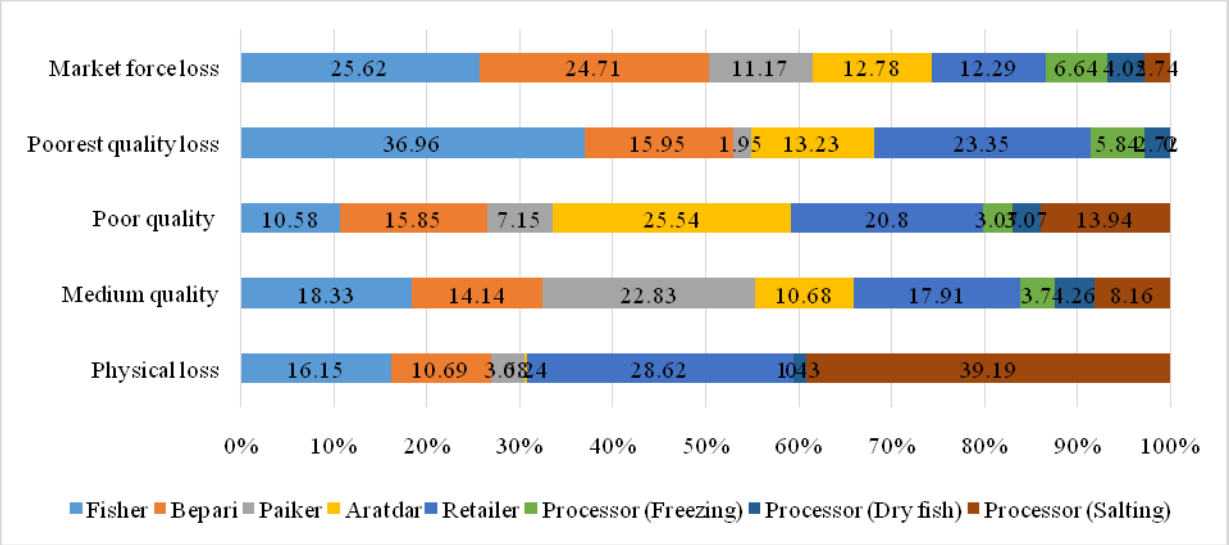


Fig 6. Actor-wise post-harvest loss of marine fish (percentage).

11.1.12 Stage wise post-harvest loss in capture and culture fisheries at farm level

The degrees of PHL vary across the value-adding activities performed at the farm level. Therefore, the results were estimated and organized across six value-adding activities (stages) at the farm level, such as fishing, landing, processing, transport, storage, and selling. To assess the extent of PHL at these stages, the respondents were asked about the discarded quantity for estimating physical loss and the quantity sold relatively at a lower price than the market price for estimating market loss. The estimated PHL were 3.87 kg/MT at fishing, 0.70 kg/MT at landing, 0.57 kg/MT at processing, 0.70 kg/MT at transport, 1.22 kg/MT at storage and 13.79 kg/MT at selling stages in capture fisheries (Table 13). In case of culture fisheries, estimated PHL were 0.81 kg/MT, 0.38 kg/MT, 0.91 kg/MT, 0.58 kg/MT, 0.33 kg/MT and 3.83 kg/MT at fishing, landing, processing, transport, storage and selling stage, respectively. However, physical loss (1.93 kg/MT in capture and 0.55 kg/MT in culture fisheries) was higher at the harvesting level, while the market loss (12.67 kg/MT in capture and 3.55 kg/MT in culture) was higher at the selling stage. For both the fisheries sub-sector, the overall monetary loss (BDT 4662.84/MT in capture and BDT 1018.9/MT in culture) was higher at the selling stage than that of all other stages of value addition. Moreover, physical loss in monetary value was higher at the fishing stage for both the capture and culture fisheries. However, the total PHL was BDT 6925.8/MT in capture fisheries, while it was BDT 1755.6/MT in culture fisheries.

Table 13. Stages of post-harverst loss in capture and culture fisheries at farm level

Stages	Capture fisheries						Culture fisheries					
	Physical loss		Market loss		Total		Physical loss		Market loss		Total	
	kg/ MT	BDT/ MT (%)*	kg/MT ()**	BDT/ MT (%)*	kg/ MT	BDT/ MT (%)*	kg/ MT	BDT/ MT(%) *	kg/ MT( )**	BDT/ MT (%)*	kg/ MT	BDT/ MT (%)*
Fishing/harvesting	1.93	573.72 (0.15)	1.94 8.55)	663.6 (0.18)	3.87	1237.3 (0.33)	0.55	110.04 (0.06)	0.26 (1.73)	70.56 (0.04)	0.81	180.6 (0.09)
Landing	0.47	146.16 (0.04)	0.23 (1.14)	78.96 (0.02)	0.70	225.12 (0.06)	0.15	33.6 (0.02)	0.23 (2.23)	62.16 (0.03)	0.38	95.76 (0.05)
Processing	0.12	39.48 (0.01)	0.44 (2.23)	151.2 (0.04)	0.57	190.68 (0.05)	0.05	11.76 (0.01)	0.86 (6.78)	232.68 (0.12)	0.91	244.44 (0.13)
Transport	0.65	182.28 (0.05)	0.05 (0.43)	17.64 (0.01)	0.70	200.76 (0.05)	0.21	45.36 (0.02)	0.37 (3.21)	99.96 (0.05)	0.58	145.32 (0.08)
Storage	0.98	326.76 (0.09)	0.24 (1.50)	82.32 (0.02)	1.22	409.32 (0.11)	0.29	59.64 (0.03)	0.04 (0.29)	10.92 (0.01)	0.33	70.56 (0.04)
Selling	1.11	335.16 (0.09)	12.67 (49.76)	4327.7 (1.16)	13.79	4662.8 (1.25)	0.29	56.28 (0.03)	3.55 (24.94)	962.64 (0.50)	3.83	1018.9 (0.53)
Total	5.26	1604.4 (0.43)	15.57 (63.61)	5322.2 (1.43)	20.85	6925.8 (1.86)	1.54	316.68 (0.16)	5.30 (39.17)	1438.9 (0.75)	6.84	1755.6 (0.91)

Note:* Value in the parentheses indicatesthe percentage of monetary value loss on total capture and culture harvest.
** Value in the parentheses indicates the sold quantity (kg/MT) due to the price reduction than the market price.

11.1.13 Stage wise post-harvest loss in inland fisheries considering all stakeholders

Data in Table 14 present PHL scenarios at different stages of the capture and culture fisheries value chain in Bangladesh. Results showed that most of the physical loss occurred at the time of harvesting and fishing, which was 2.82 kg/MT (Table 14). Approximately 22.81% of the physical loss at selling stages (1 kg/MT) may happen due to discarding damaged fish for delayed marketing, temperature, or poor handling. Thus, total physical loss at different stages was 4.36 kg/MT occupying about 8.28% of the total PHL in inland fisheries. The total physical in monetary term was BDT 1541.22 per MT.

Table 14. Scenario of stage-wise post-harvest loss in inland (capture and culture) fisheries (kg/MT)

Stages	Physical loss		Market loss		Total	
	kg/MT	BDT/MT	kg/MT	BDT/MT	kg/MT	BDT/MT
Fishing/harvesting	2.82	997.52	4.81	1568.72	8.28	2507.21
Landing	0.07	27.87	2.66	870.78	2.71	784.92
Processing	0.13	46.52	4.78	1568.42	4.88	1409.95
Transport	0.11	37.05	5.23	1711.29	5.27	1503.86
Storage	0.24	80.73	0.65	214.78	0.94	276.29
Selling	1.00	351.50	33.27	10883.18	33.98	10728.14
Total	**4.36**	**1541.22**	**62.02**	**15669.17**	**66.44**	**17210.38**

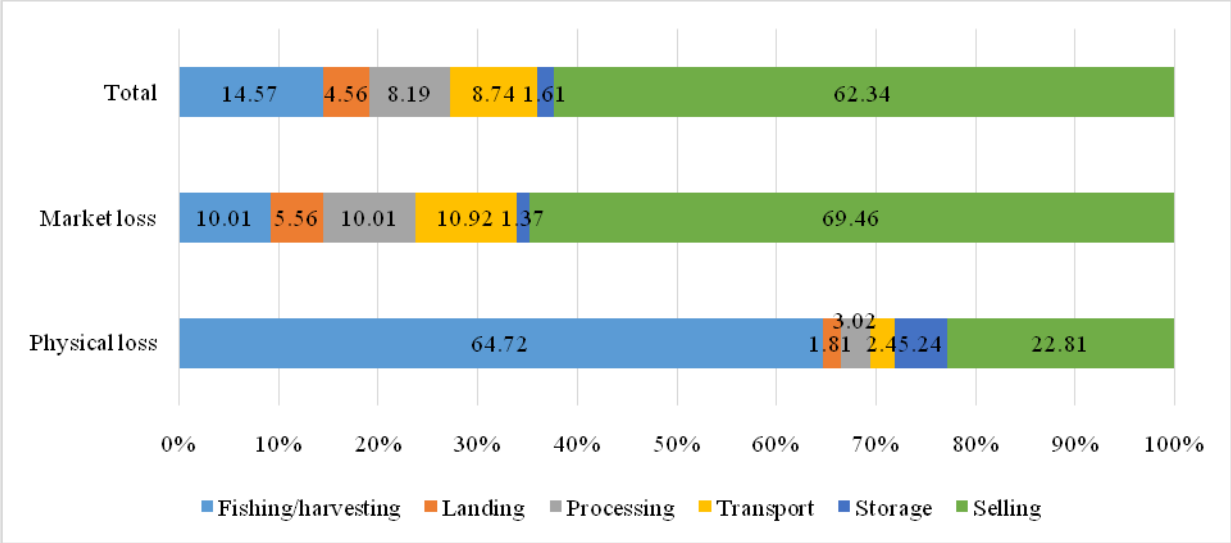


Fig 7. Stage-wise post-harvest loss in inland (capture and culture) fisheries (percentage).

The highest market loss occurred at the selling stage (33.27 kg/MT) of the fish value chain in inland fisheries. The main reason behind this is quality loss of fish due to delayed marketing, temperature, or poor handling, for which fish is being sold at a lower price. Besides, some portion of market loss occurs at the stage of fishing or harvesting (4.81 kg/MT), processing (4.78 kg/MT), and transport (5.23 kg/MT). The estimated total market loss was 62.02 kg/MT (91.72%) of the total PHL of inland fisheries in Bangladesh. The monetary value of this loss was BDT 15669.17 per MT.

However, the findings further reveal that most of the PHL in inland fisheries in Bangladesh occurred at the selling stage of the value chain, which was33.98 kg/MT. Following selling, 8.28 kg/MT of fish was lost during fishing or harvesting, covering 14.57% of the total PHL of the sector (Fig 7). The least amount of loss was found at the storage stage, where 0.94 kg/MT of fish was lost. Finally, the estimated total PHL in inland fisheries in Bangladesh was 66.44kg/MT annually. In terms of monetary value, BDT 17210.38/MT was lost in Bangladesh during the post-harvest stage of inland fish.

11.1.14 Stage-wise post-harvest loss in marine fisheries

Data in Table 15 present the stage-wise PHL including physical and market loss of marine fisheries in Bangladesh. Similar to the inland fisheries, six stages, namely fishing, landing, processing, transport, storage, and selling, were also identified in the value chain of the marine fisheries. Results reveal that the physical loss at the fishing or harvesting stage was 7.77 kg/MT, which was the highest among all the stages, and it comprises 73.79% of the physical loss in marine fisheries. Around 1 kg/MTof fish was discarded or lost during transportation. The estimated total physical loss in marine fisheries in Bangladesh was 10.53 kg/MT, which was BDT 2843.1/MT in monetary value. Physical loss shared 28.83% of the total PHL in marine fisheries.

Table 15 revealed that 13.29 kg/MTof marine fish was lost at the selling stage, and it was 51.12% of the total market loss. This loss occurs mainly because of the quality loss due to the

delayed marketing or poor handling. Besides, 8 kg/MTof marine fish was lost at the fishing stage, where fish might lose quality due to faulty management. As a result, the total market loss in marine fisheries was71.17% (26 kg/MT) of the total PHL in this category. The monetary value of this loss was BDT 7023.59 per metric ton.

Table 15. Stage-wise post-harvest loss of marine fisheries

Stages	Physical loss		Market loss		Total	
	kg/MT	BDT/MT	kg/MT	BDT/MT	kg/MT	BDT/MT
Fishing/harvesting	7.77	2097.9	8.00	2160	15.77	4257.9
Landing	0.80	216	0.33	89.1	1.13	305.1
Processing	0.32	86.4	0.12	32.4	0.44	118.8
Transport	1.00	270	2.63	710.34	3.63	980.34
Storage	0.29	78.3	1.63	443.45	1.92	521.75
Selling	0.35	94.5	13.29	3588.3	13.64	3682.8
Total	**10.53**	**2843.1 (28.83)**	**26.00**	**7023.59 (71.17)**	**36.53**	**9866.69 (100)**

Note: Value in parentheses are percentages of loss

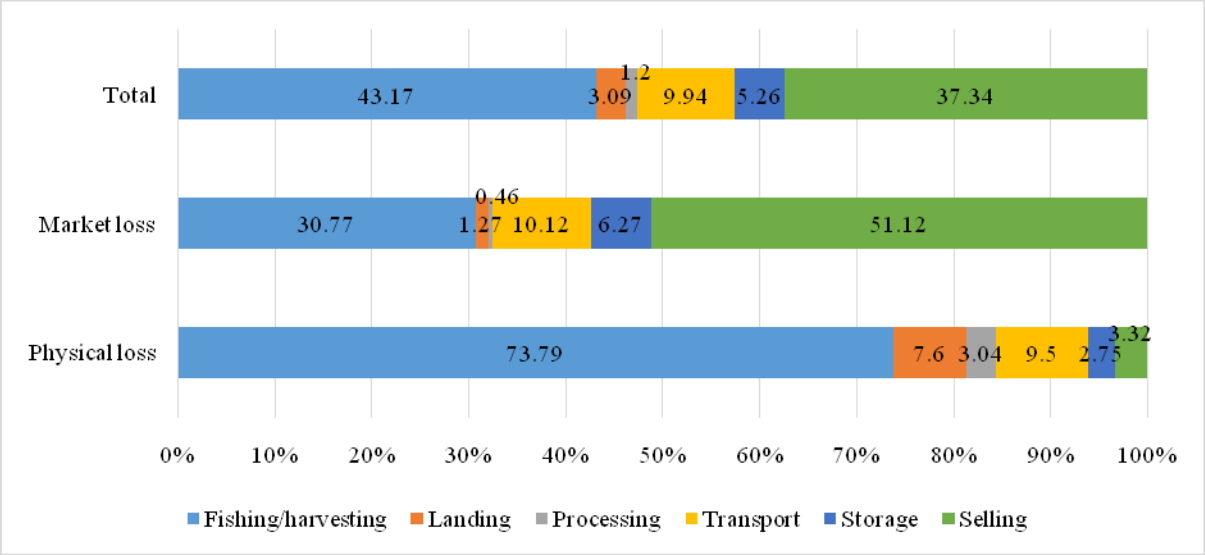


Fig 8. Stage-wise post-harvest loss of marine fisheries (percentage).

The study showed that most of the PHL in marine fisheries in Bangladesh occurred at the fishing/harvesting stage, which was 15.77 kg/MT,and comprising 43.17% of the total loss in the sector. Following fishing, 13.64 kg/MTof marine fish was lost at the selling stage, which occupied 37.34% of the total PHL. Besides, the amount of fish loss at the transport and storage stage was 3.63 kg/MT(9.94%) and 1.92 kg/MT (5.26%), respectively. The least amount (1.20 %) of marine fish was lost during processing stage (Fig 8). Finally, the study revealed that a total of 36.53 kg/MTof fish was lost annually at various post-harvest stages in marine fisheries in Bangladesh which was BDT 9866.69 per MT in monetary value.

11.1.15 Seasonal physical loss at farmer and traders' level in inland fisheries

In this section, seasonal variation in PHL of inland fisheries was estimated and presented. The following figures depict the month-wise physical loss of fish at the farm and traders' level of Bangladesh. It revealed that the amount of physical loss in capture fisheries was higher than culture all over the year irrespective of level (Fig 9 and 10). *Boishakh (Apr-May), Joishtho (May-Jun),* and *Chaitra (Mar-Apr)* months were the highest months in terms of physical loss in capture fisheries at both farm and trader levels. Physical loss at farm level in *Boishakh (Apr-May), Joishtho (May-Jun),* and *Chaitra (Mar-Apr)* month was 10.58 kg/MT, 10.41 kg/MT, and 10.14 kg per MT, respectively, while at traders' level 5.69 kg/MT, 5.82kg/MT, and 5.59kg/ MT, respectively (Fig 9 and 10). At the farm level of culture fisheries, higher physical loss was found in the month *Chaitra (Mar-Apr), Boishakh (Apr-May),* and *Sravon (Jul-Aug)*which were 4.05 kg/MT, 2.35 kg/MT, and 1.61 kg/ MT, respectively. At the traders' level, this happened in *Vadro (Aug-Sep), Joishtho (May-Jun),* and *Chaitra (Mar-Apr)* accounting of 1.48 kg/MT, 1.12 kg/MT, and 1.10 kg/ MT, respectively (Fig 10). *Boishakh (Apr-May), Joishtho (May-Jun),* and *Chaitra (Mar-Apr)* months are considered the summer season in Bangladesh. In this season, it becomes difficult for fishers, farmers, and other traders to manage the fish due to the higher temperature. Besides, a shortage of ice arises in this period which also causes to discard fish. It is further confirmed since, in both fisheries, the lowest physical loss of fish occurs in *Poush(Dec-Jan)*and *Magh (Jan-Feb)*months, (in winter seasons) in Bangladesh. So, the physical loss of fish is highly influenced by variation in seasonal temperature. Besides, fish discarding also increases in the *Vadro (Aug-Sep)* and *Ashwin (Sep-Oct)*months for both levels.

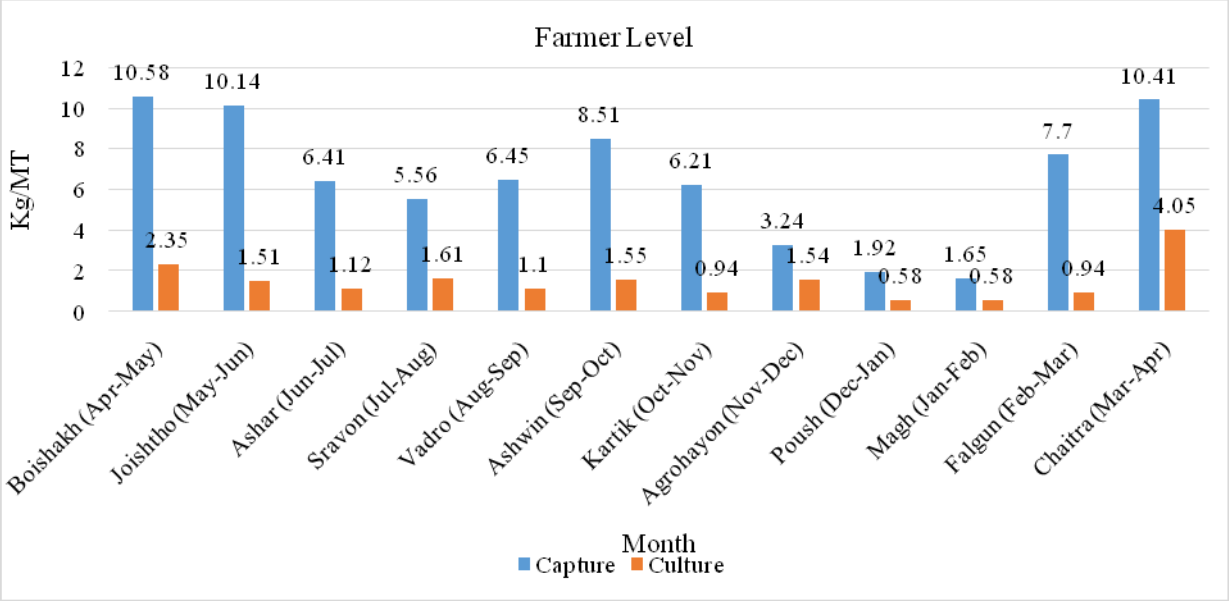


Fig 9. Month-wise physical loss at farm level (kg/MT).

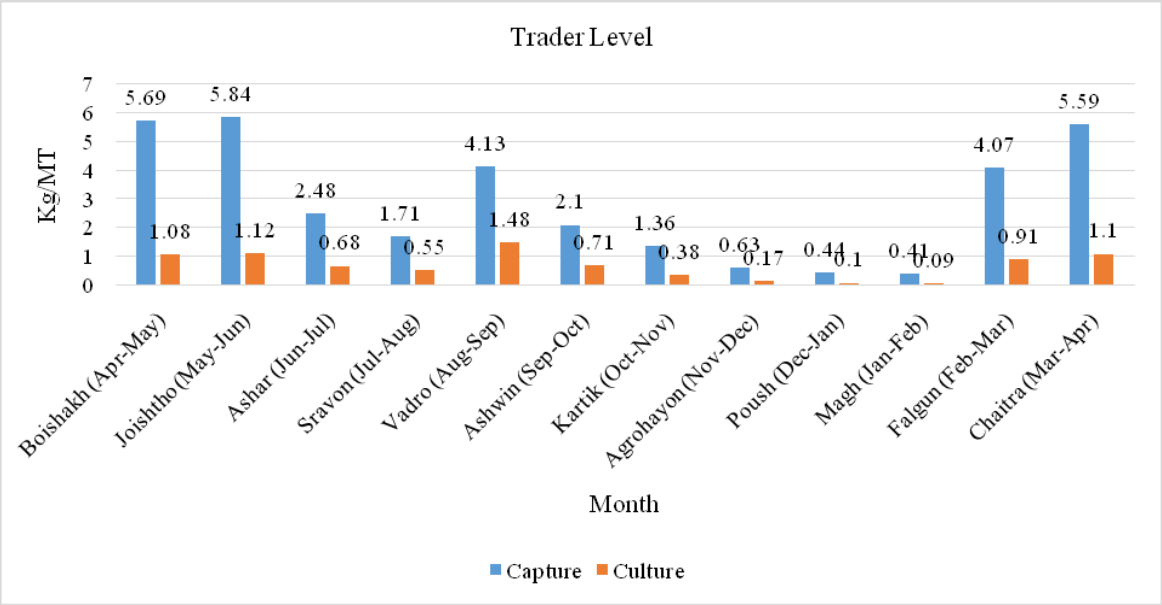


Fig 10. Seasonal physical loss at trader level (kg/MT).

11.1.16 Actor wise seasonal physical loss in inland fisheries

Seasonal variation is associated with the physical loss of fish in inland fisheries of Bangladesh. This study calculated the month-wise physical loss by the traders which are presented in Table 16. Results revealed that about 3.01 kg/MTof fish was discarded or lost in the month of *Chaitra (Mar-Apr),* which has the highest physical loss in inland fisheries. Following *Chaitra (Mar-Apr), the* physicalloss of inland fisheries in*Boishakh (Apr-May)*and *Joishtho (May-Jun)*were calculated as 2.56 kg/MTand 2.43 kg/MT, respectively. These three months are considered the summer season of Bangladesh. During summer, the physical loss is expected to increase due to higher temperatures, shortage of ice, or delayed marketing. The lowest physical loss was found in *Magh (Jan-Feb)*and *Poush (Dec-Jan)* month, which are 0.38 and 0.43 kg/MT,respectively, these are the months of winter season in Bangladesh.

Table 16. Actor wise seasonal physical loss by the traders in inland fisheries (kg/MT)

Trader Type	**Different months**												
	Boishakh (Apr-May)	***Joishtho (May-Jun)***	***Ashar (Jun-Jul)***	***Sravon (Jul-Aug)***	***Vadro (Aug-Sep)***	***Ashwin (Sep-Oct)***	***Kartik (Oct-Nov)***	***Agrohayon (Nov-Dec)***	***Poush (Dec-Jan)***	***Magh (Jan-Feb)***	***Falgun (Feb-Mar)***	***Chaitra (Mar-Apr)***	***Average***
Fishers	10.57	10.14	6.41	5.56	6.45	8.51	6.22	3.24	1.92	1.65	7.70	10.41	6.57
Fish Farmer	2.34	1.51	1.12	1.61	1.10	1.55	0.94	1.54	0.58	0.59	0.94	4.05	1.49
Aratdar	0.79	0.70	0.16	1.24	0.84	1.13	3.62	0.69	0.12	0.10	2.11	1.69	1.10
Bepari	1.05	1.20	1.55	1.15	6.67	2.10	0.97	0.32	0.22	0.19	1.18	1.13	1.48
Commission Agent	0.19	0.21	0.11	0.09	0.14	0.19	0.12	0.06	0.03	0.03	0.10	0.17	0.12
Local Agent	0.08	0.14	0.02	0.03	0.20	0.06	0.32	0.06	0.14	0.07	0.01	0.71	0.15
Paiker	1.21	1.49	0.73	0.53	1.06	0.73	0.46	0.20	0.27	0.26	1.13	1.55	0.80
Retailer	4.22	4.05	1.81	1.42	1.29	0.88	0.46	0.33	0.17	0.15	3.50	4.40	1.89
Average	**2.56**	**2.43**	**1.49**	**1.45**	**2.22**	**1.89**	**1.64**	**0.81**	**0.43**	**0.38**	**2.08**	**3.01**	

11.1.17 Species-wise seasonal physical loss in inland fisheries (top ten fish species)

Over the last decade, as the world fishery pushes toward maximum sustainable yields, discard/physical losses in commercial fisheries have become an increasingly important concern in fisheries management.Data in Table 17 provides an update of the quantity of physical loss of the top ten fish species at the farm level based on a month-by-month approach. Yearly average of physical losswasestimated at 22.12 kg/MT for Punti which wasthe highest among the species.It was observed that the highest physical loss of 34.95 kg/MT in the month of*Jaistho (May-Jun)* followed by *Vadro (Aug-Sep), Boishaakh (Apr-May), Ashar (Jun-Jul),Ashwin (Sep-Oct), Srabon (Jul-Aug),* and *Falgun (Feb-Mar).* However, it is understandable that Punti fish were more discarded in the summertime due to hot temperature, the inadequacy of ice, delay in freezing, etc. Moreover, Punti is a small fish with a lower survival rate and can be disposed of within a short duration. However, it was found that small fish were more discarded than big size fish because large sized fish have the highest market value and easy to manage. For that reason, high-value fish species such as Ruiwere discarded less compared to the other small species. On average, it was estimated that 0.63 kg/MT of Rui fish was discarded, for which the physical loss was highest in *Chaitra (Mar-Apr).*

Table 17. Species wise seasonal physical loss in inland fisheries (top ten species)

Species	Losses in kg/MT by months												
	Boishakh (Apr-May)	***Joishtho (May-Jun)***	***Ashar (Jun-Jul)***	***Sravon (Jul-Aug)***	***Vadro (Aug-Sep)***	***Ashwin (Sep-Oct)***	***Kartik (Oct-Nov)***	***Agrohayon (Nov-Dec)***	***Poush (Dec-Jan)***	***Magh (Jan-Feb)***	***Falgun (Feb-Mar)***	***Chaitra (Mar-Anr)***	***Average***
Punti (*Puntius chola*)	27.37	34.95	25.83	24.49	29.8	24.83	22.4	13.31	8.93	8.74	22.7	22.11	22.12
Taki (*Channa punctata*)	15.87	33.29	26.42	19.82	20.48	22.51	17.02	8.85	3.72	2.98	12.52	13.64	16.43
Singh (*Amblyceps mangois*)	4.3	3.6	2.67	2.04	2.88	13.73	3.57	2.42	1.42	2.7	2.8	9.16	4.27
Bata (*Cirrhinus reba*)	3.62	2.59	2.25	4.2	3.59	2.31	0.77	2.04	0.5	2.65	2.39	15.63	3.55
Silver carp (*Hypophthalmichthys molitrix*)	3.15	1.55	1.79	2.55	2.4	1.81	2.27	3.26	1.26	0.8	1.51	5.2	2.30
Mrigel (*Cirrhinus cirrhosis*)	4.43	3.73	1.67	1.97	1.79	1.85	1.91	1.32	0.45	0.4	1.57	3.98	2.09
Tilapia (*Oreochromis mossambicus*)	3.38	1.46	2.28	1.36	1.37	2.51	1.41	2.03	0.65	0.42	0.79	4.05	1.81
Rui (*Labeo rohita*)	0.86	0.41	0.29	0.9	0.27	0.28	0.27	0.96	0.54	0.5	0.64	1.65	0.63
Small shrimp/prawn	13.14	10.72	7.88	7.07	6.52	5.45	3.42	1.14	0.92	1.1	11.35	15.5	7.02
Average	**6.34**	**7.69**	**5.92**	**5.37**	**5.76**	**6.27**	**4.42**	**2.94**	**1.53**	**1.69**	**4.69**	**7.58**	**5.02**

11.1.18 Species wise seasonal physical loss in marine fish

Month and species-wise PHL for marine fishes are presented in Table 18. Regardless of the fish species, the average PHL was comparatively lower during the months from *Karthik (Oct-Nov)* to *Magh (Jan-Feb)* than the rest of the year. The periodsi.e. *Karthik*(Oct-Nov) to *Magh (Jan-Feb)* covered the winter season indicating the lower atmospheric temperature. *Chaitra (Mar-Apr), Boishakk (Apr-May),* and *Joaistha (May-Jun)* months covering the summer season represent higher temperature which might cause comparatively higher PHL of the marine fish. In addition, during *Ashar (Jun-Jul)* and *Sraban (Jul-Aug)* months (covering the rainy season), the higher marine catch was observed, and fishers and traders might face difficulties for proper post-harvest management of large catch with their limited resources and unavailability of ice to preserve fish.

Table 18. Species wise seasonal physical loss in marine fish (kg/MT)

Species	Losses in kg/MT by months												
	Boishakh (Apr-May)	***Joishtho (May-Jun)***	***Ashar (Jun-Jul)***	***Sravon (Jul-Aug)***	***Vadro (Aug-Sep)***	***Ashwin (Sep-Oct)***	***Kartik (Oct-Nov)***	***Agrohayon (Nov-Dec)***	***Poush (Dec-Jan)***	***Magh (Jan-Feb)***	***Falgun (Feb-Mar)***	***Chaitra (Mar-Apr)***	***Average***
Tular dandi (*Sillaginopsis panijus*)	17.6	17.42	18.44	16.81	18.83	15.38	9.8	9.48	11.73	17.56	11.71	18.68	15.29
Topse (*Sarotherodon melanotheron heudelotii*)	17.06	9.93	9.47	22.51	22.75	21.7	9.53	9.31	7.93	8.59	17.51	22.31	14.88
Chandona (*Tenualosa toil*)	15.19	18.8	12.81	12.93	18.12	13.86	12.98	15.4	13.98	14.38	13.69	15.39	14.79
Scads (*Megalaspis cordyla*)	13.04	15.28	14.09	16.71	15.11	14.46	12.37	12.93	13	12.97	12.76	12.86	13.80
Loitta (*Harpadon nehreus*)	17.91	14.09	13.23	13.95	14.85	12.22	14.45	17.48	11.08	12.38	11.98	11.05	13.72
Catfish (*Rita rita*)	13.79	16.2	17.07	15.87	13.7	13.75	11.78	12.93	12.43	11.75	11.28	13.64	13.68
Mud Crab (*Scylla serrata*)	11.73	0	0	15.57	14.86	10.38	11.61	11.42	22.66	24.52	15.85	24.08	13.56
Sardine (*Gudusia chapra*)	12.28	14.05	12.52	12.55	12.22	12.96	10.73	17.87	11.63	14.65	15.5	15.75	13.56
Croaker (*Otolithoides pama*)	13.71	15.43	16.04	11.65	12.29	10.96	8.15	13.01	13.53	13.21	13.89	13.2	12.92
Mackerel (*Rastrelliger kanagurta*)	15.11	13.51	14.16	13.34	14.41	13.28	8.88	10.84	9.95	10.44	11.64	14.35	12.49
Ribbon (*Trichiurus haumela*)	11.84	13.01	13.01	13.7	12.75	12.6	9.5	10.06	9.76	9.84	11.69	13.33	11.76
Shrimp (*Penaeus monodon*)	14.6	4.2	6.92	14.71	11.88	11.32	10.63	10.66	10.33	9.72	10.97	14.69	10.89
Hilsha (*T. ilisha*)	12.02	14.38	13.11	10.88	10.53	9.85	9.3	9.61	8.55	8.12	11.2	11.68	10.77
Shark/Rays (*Carcharhinus limbatus*)	10.77	11.54	9.15	9.63	10.11	12.14	9.5	8.8	10.21	9.72	10.81	11.9	10.36
Faisha (*Setipinna phasa*)	10.21	11.06	10.45	9.58	9.09	9.37	9.92	10.18	9.89	10.18	10.21	10.43	10.05
Saytan /Pori (*Priacanthus Sagittarius*)	10.25	10.47	9.45	9.28	9.45	9.23	10.2	10.23	10.22	9.69	10.25	10.17	9.91
Indian Salmon (*Eleutheronema tetradactylum*)	13.6	7.47	3.87	11.07	14.08	13.41	7.51	7.15	7.05	7.36	11.4	14.4	9.86
Pomfret (*Stromateus chinensis*)	8.03	9.87	8.25	8.62	8.38	8.65	5.54	2.23	11.53	12.46	9.84	9.59	8.58
Tuna (*Euthynnus lineatus*)	8.72	8.37	5.13	5.81	5.71	6.08	7.05	6.07	5.92	6.3	7.7	7.74	6.72
Snapper (*Lates calcarifer*)	5.73	1.26	0.77	5.15	4.83	4.46	6.32	3.95	4.67	3.93	5.25	5.45	4.31
Flat/Sole fish (*Soleichthys heterorhinos*)	5.69	4.44	4.76	4.58	7.58	4.14	2.46	1.88	1.85	1.84	5.98	6.11	4.28
Cuttle fish/Squid (*Sepia apama*)	11.43	0	0	0	0	0	0	0	0	0	12.86	12.86	3.10
Redfish/Rupban (*Lesiostomus xanthurus*)	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Lakkha (*Eleutheronema tetradactylum*)	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Others	21.96	20.05	19.7	45.39	27	27.52	17.64	19.69	22.79	21.75	22.38	20.87	23.90
Average	11.69	10.03	9.30	12.01	11.54	10.71	8.63	9.25	9.63	10.05	11.05	12.42	10.53

However, species-wise the average PHL was between 0 to 15.29 kg/MT and on an average of 10.53 kg/MT. Among the species, Ladyfish (*Tular dadi*), *Chandona*, and *Topse* had the higher (14.79 to 15.29 kg/MT) average PHL throughout the year. The smooth and soft body structure of Ladyfish might result in a higher loss of body fluids due to pressure of ice and fish overloading consequence higher PHL. The species are not commercially essential and mostly locally consumed; thus, fishers or traders may not maintain proper post-harvest preservation that makes higher PHL of the respective species. The PHL was 10.77 kg/MT and 10.89 kg/MT for commercially important species like, Hilsa and Shrimp, respectively. The higher fat content of these two species might undergo oxidation due to higher temperatures during the summer of the year. Improper and insufficient post-harvest management due to bulk catch, lack of ice, inept handling, poor packaging, inadequate storage facilities and natural calamity might cause variation in PHL for all the marine fish species.

11.1.19 Actor wise seasonal physical loss of marine fish

Scenario of month and actor-wise physical loss of marine fish is presented in Table 19. Actor-wise, the lowest physical losses of marine fish were observed at the processor (freezing) level. During processing, the head, carapace/shell, leg, vein, etc., are removed from Shrimp which are further used to prepare the fish meal, gelatin, chitin, chitosan, and other value-added fisheries by-products; thus, shrimp processor had very negligible physical loss. The physical loss was also comparatively lower (0.18 – 3.48 kg/MT) at *Aratdar, paiker*, drying and salting fish processor level. For the drying and salting process of fish, as a part of pre-processing steps, i.e., gutting, eviscerated/removal intestine, gill, scale is removed; thus, this loss could occur. However, a relatively higher physical loss occurred at *bepari* (10.17 kg/MT) and retailer (24.82 kg/MT) stage. The actors (*bepari* and retailers) might apply deficient post-harvest preservation, handling, packaging, transportation system, and lack of technical knowledge; as such the higher physical loss occurred in their cases.

In general, the month-wise lower physical loss occurred during the month from *Kartik (Oct-Nov)* to *Magh (Jan-Feb),* i.e., the winter season when the atmospheric temperature is lower than other months of the year. Among the month, the retailer has higher physical loss during *Falgun (Feb-Mar)* to *Ashwin (Sep-Oct),* are the time of summer and rainy season and comparatively high temperature observed. Retailer and retail markets are not well facilitated with improved infrastructure and sufficient ice supply; thus, higher PHL occurred at this stage in the before said months.

Table 19. Actor wise seasonal physical loss of marine fish (kg/MT)

Months	Different actors						
	Bepari	***Paiker***	***Aratdar***	**Retailer**	**Processor (Freezing)**	**Processor (Dry fish)**	**Processor (Salting)**
Boishakh	22.01	6.00	0.29	26.23	0.00	1.20	0.01
Jaishtho	16.56	5.01	0.35	33.23	0.00	1.26	0.02
Ashar	3.65	0.00	0.19	37.23	0.00	5.26	0.56
Srabon	5.01	4.01	0.09	29.22	0.00	29.34	10.21
Vadro	5.01	4.04	0.18	25.23	0.00	1.79	25.21
Ashwin	6.56	5.03	0.11	28.90	0.00	0.95	25.03
Kartik	10.11	1.57	0.11	19.11	0.00	0.69	18.02
Agrohayon	7.12	1.01	0.14	16.23	0.00	0.92	17.54
Poush	7.01	1.01	0.14	17.12	0.00	0.82	1.21
Magh	7.01	2.02	0.12	18.11	0.00	0.86	0.01
Falgun	15.01	6.03	0.19	26.11	0.00	1.15	0.01
Chaitra	17.01	6.02	0.22	21.11	0.00	0.89	0.21
Average	**10.17**	**3.48**	**0.18**	**24.82**	**0.00**	**3.76**	**8.17**

11.1.20 Channel-wise post-harvest loss in capture and culture fisheries

Different actors of the supply chain have different extent of PHL. Hence, different channels involving these actors of fish supply chain vary in terms of losses. However, we explored the channel-wise PHL in capture fisheries. We identified the nine most prominent supply channels in capture fisheries, then estimated the channel-wise PHL. Among them, when fish transformation is done through channel I, on average, 34.96kg/MT of fishes lost (Fig 11). The highest amount of fish loss was estimated at channel VII which was 68.01 kg/MT. Out of ten channels, the lowest amount of fish loss happened in channel VIII, since it includes only two actors i.e., fishers and local agents (*faria*) to reach the consumers. Fish is transformed in this channel from the fishers to consumers directly through local agents (*faria*), but a negligible amount of fish. However, the highest amount of fish losses at the wholesaler (*bepari*) stage (27.32 kg/MT). Because the wholesaler (*bepari*) conveys fishes from one district to another district, the quality of fish may be affected during transportation. Besides, the physical condition of fish gets involved, which affects the market loss of fish. However, the damage caused to the fish due to improper transportation facilities, handling, careless loading and unloading.

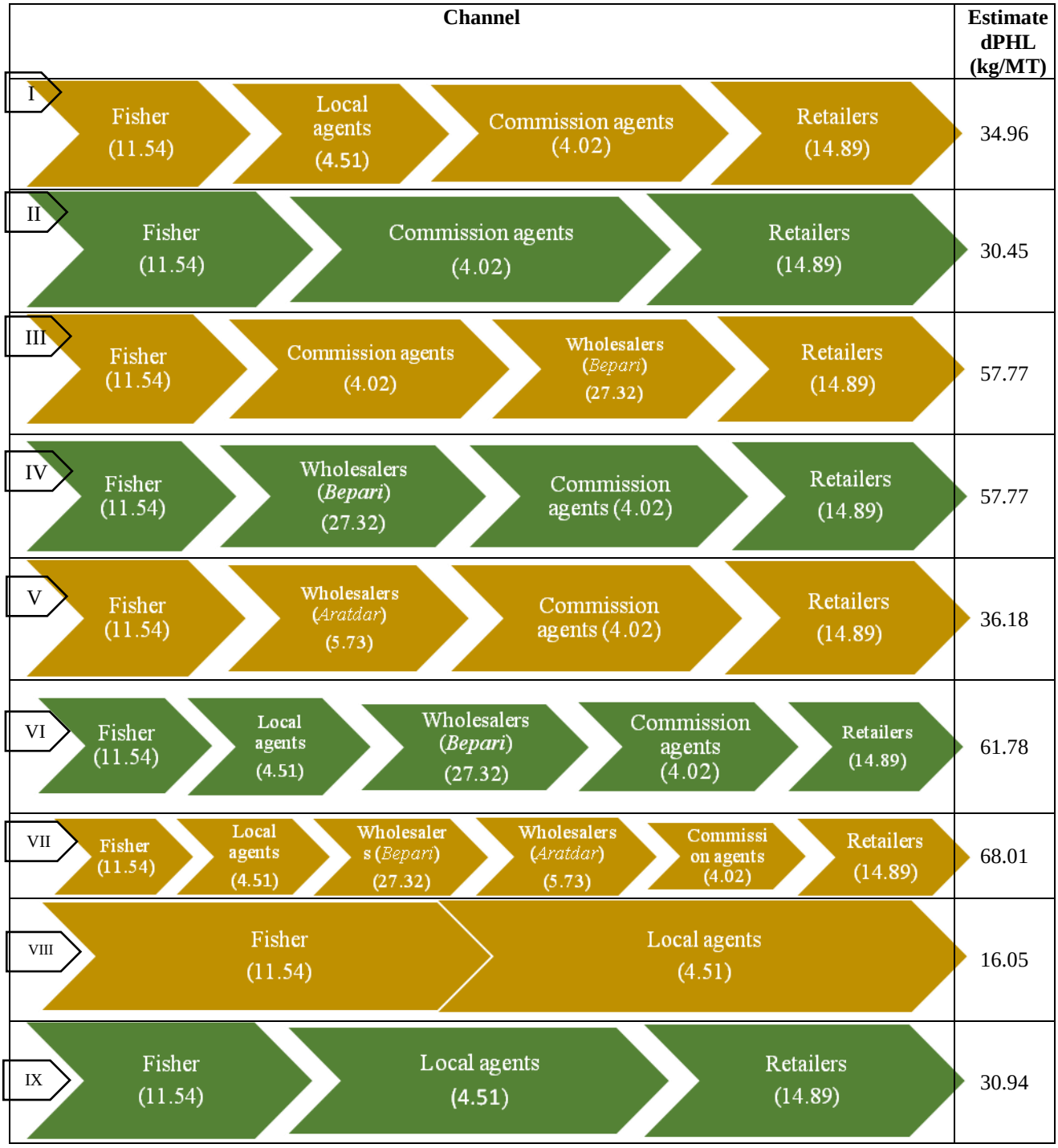


Fig 11. Channel-wise average post-harvest loss of capture fisheries.

All the discards and market loss were treated as total losses since they were not either marketed further or lost market value due to physical injury and quality loss. However, transit injury from field to assembly market was comparatively low in culture fishes over the capture fishes. Supply chain-wise analysis revealed that the PHL were higher during retailing compared to other stages

of marketing. However, the highest amount of losses was found at channel VII which was 9.98 kg/MT (Fig 12). In contrast, the lowest amount of PHL was found at channel II, which was 2.59 kg/MT. However, substantial losses were observed for wholesalers (*aratdar*) due to their flawed storage system. Sometimes wholesaler (*aratdar*) tried to store fish for a long time and sold in the lean season when the price upsurge. During the storage time, the physical quality of fish might deteriorate, and the market value of fish may reduce. Therefore, when the supply channel includes wholesalers (*aratdar*), the overall cost of the supply chain was augmented. It should be noted that the fish farmers should follow channel I to avoid the overall PHL.

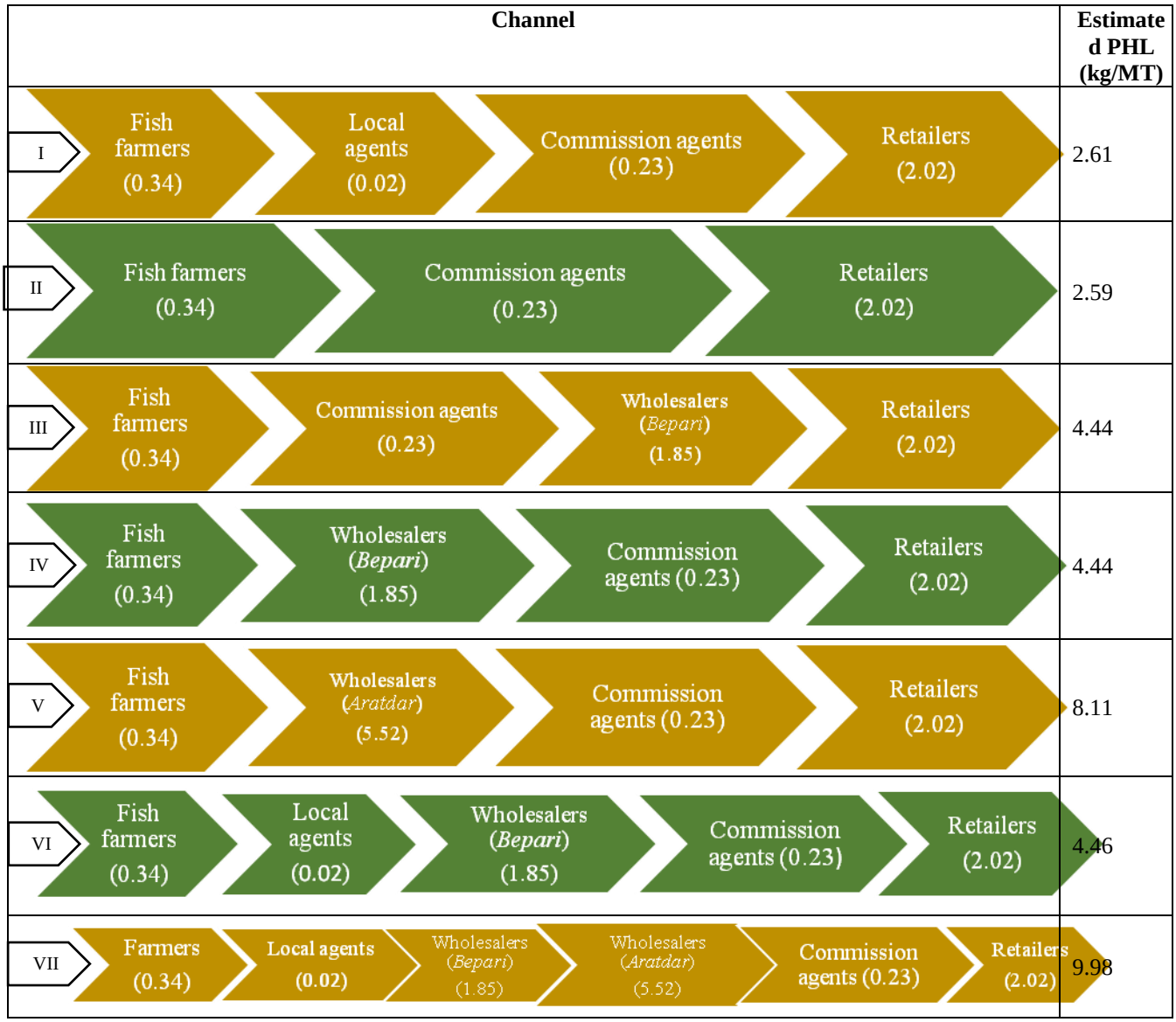


Fig 12. Channel-wise average post-harvest loss of culture fisheries.

11.1.21 Channel-wise post-harvest loss in marine fisheries

In case of the inland fisheries, this study also explored the channel-wise PHL of the marine fisheries. The supply chain of marine fisheries includes different identical traders such as processors (salting, freezing, and drying), unlike the supply chain of inland fisheries. Since the marine fishes are traded in the nationwide and overseas market from the ten marine fish landing centers, the fishes need to be processed through proper salting, freezing, and drying. Various species of the marine fishes are export such as Ribbon, Cuttle, Shrimp, Red Jew, Pomfret (white/silver, gray and black) Sardine and Maceral etc. Among the different stakeholders, fisher faces the several problems of PHL for instance, long time for grading after harvest, apply fishing gear for long duration, temperature more than 30^0C and at a time huge amount of fish jammed in the gear. Industrial marine fisher reported that use of chill water and automation the grading to reduce the PHL. We have identified the five most prominent supply channels through which a substantial amount of fishes were traded. Among the five channels, the least amount of fishes was lost in channel 1, which was 28.59 kg/MT. In contrast, the highest amount of fish was lost when fishes were traded through channel IV, (43.48 kg/MT on average). However, it is clearly understood that a massive amount of fishes loss occurred at the *bepari* stage and at the retailer's stage (Fig 13). Because the *beparies* are traded fish to distant market which causes a significant fish loss. Therefore, when *beparies* were included in the channel, the overall PHL was robotically augmented.

Channel	Estimated PHL (kg/MT)
I: Fisher (12.66) → *Aratder* (3.66) → Retailer(12.37)	28.59
II: Fisher (12.66) → *Aratder* (3.66) → Wholesaler (*Bepari*) (10.21) → Retailer (12.37)	38.9
III: Fisher (12.66) → Processor (Freezing) (0.43) → Wholesaler (*Bepari*) (10.21) → Retailer (12.37)	35.67
IV: Fisher (12.66) → Processor (Salting) (8.24) → Wholesaler (*Bepari*) (10.21) → Retailer (12.37)	43.48
V: Fisher (12.66) → Processor (Dry) (0.37) → *Aratder* (3.66) → Wholesaler (*Bepari*) (10.21) → Retailer (12.37)	39.27

Fig 13. Channel-wise average post-harvest loss of marine fish.

11.1.22 Causes of physical loss in inland fisheries at farm level

There were several causes for PHL at the farm level across the value-adding activities, from fishing to selling the fishes. To better understand and measure the extent of loss, the causes were

identified, and the quantity was estimated as per causes. Sources and species may cause the variation in the factors influencing PHL, and its impacts on physical loss and market loss may be different, which could help generate source-specific information for policy insights. The physical and market loss specific to factors were measured based on information provided during the interview and reported in the following section.

In the case of capture and culture fisheries, results showed that the predominant factor identified as the first rank of the physical loss was delaying marketing fish and higher temperature, followed by the causes of inappropriate harvesting method and longer harvesting duration (Fig 14). It was estimated that the physical loss due to delaying marketing and the temperature was 20.88% of total losses in capture and 21.15% of total losses in culture fisheries. About 18.99% and 17.64% monetary value loss in capture and culture fisheries respectively were estimated for the causes of inappropriate harvesting methods.

In addition, due to the longer harvesting duration, the physical loss was calculated about 16.80% of total loss in capture and 13.55% of total losses in culture fisheries. Besides, inadequate cold-storage facilities, contamination with poisoning, rodents, and animals accelerated the physical loss (Fig 14a and 14b), which also supported the study of Gyan *et al*. (2020), Adelaja *et al*. (2018), and Torell *et al*. (2020).

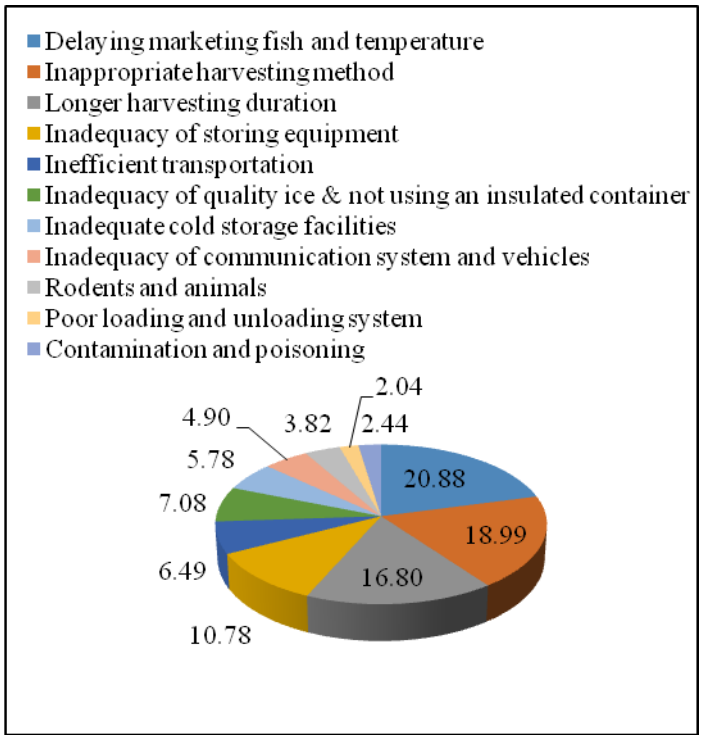


Fig 14a. Causes of physical loss in capture fisheries (%) due to the causes of physical loss in total capture loss.

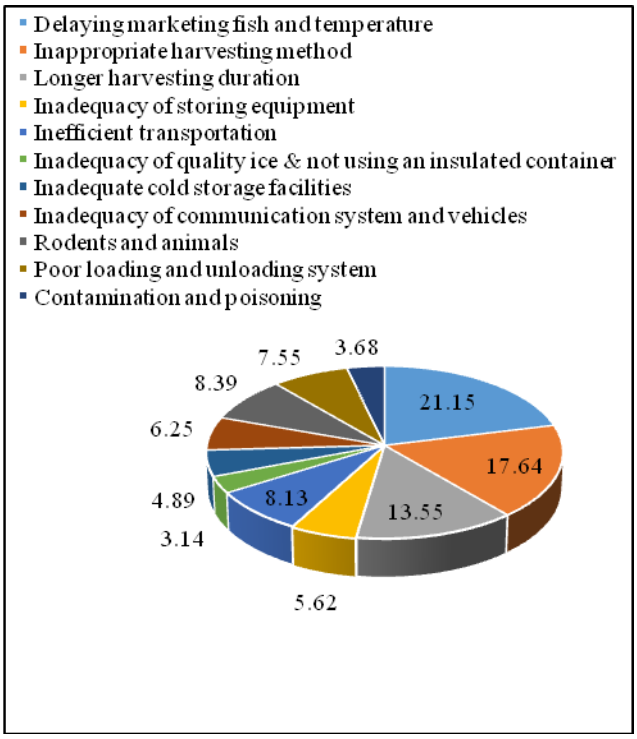


Fig 14b. Causes of physical loss in culture fisheries (%) due to the causes of physical loss in total culture loss.

11.1.23 Causes of market loss in inland fisheries at farm level

The factors for market loss were also measured and organized similarly and found that the excess supply ranked first, followed by the causes of delaying marketing the fish and temperature in both capture and culture fisheries. Furthermore, based on total monetary value loss in capture and culture fisheries, the influential factors of market loss were calculated in percentage (%) and shown in Fig 15. The result revealed that the market loss due to the excess supply was 34.97% of total loss in capture and 23.26% of total loss in culture fisheries. On the other hand, the market loss due to delayed selling and the high temperature was about 23.52% and 19.76% of total monetary loss in capture and culture fisheries, respectively.

Thus, lower demand in capture and culture fisheries was another critical factor for market losses. The calculated market loss due to lower demand was 17.65% and 11.79% of total loss in capture and culture fisheries, respectively. Furthermore, longer harvesting duration, insect infestation, poor market infrastructure, and multiple handling were identified as the main reasons for the market loss. The study of Ahmed (2008), Gyan *et al.* (2020), and Torell *et al.* (2020) mentioned a similar findingfor PHL. On the other hand, poor loading and unloading system, inefficient transportation, the inadequacy of good quality ice, and inadequate insulated container were other concerns for physical loss and market loss simultaneously in both capture and culture fisheries.

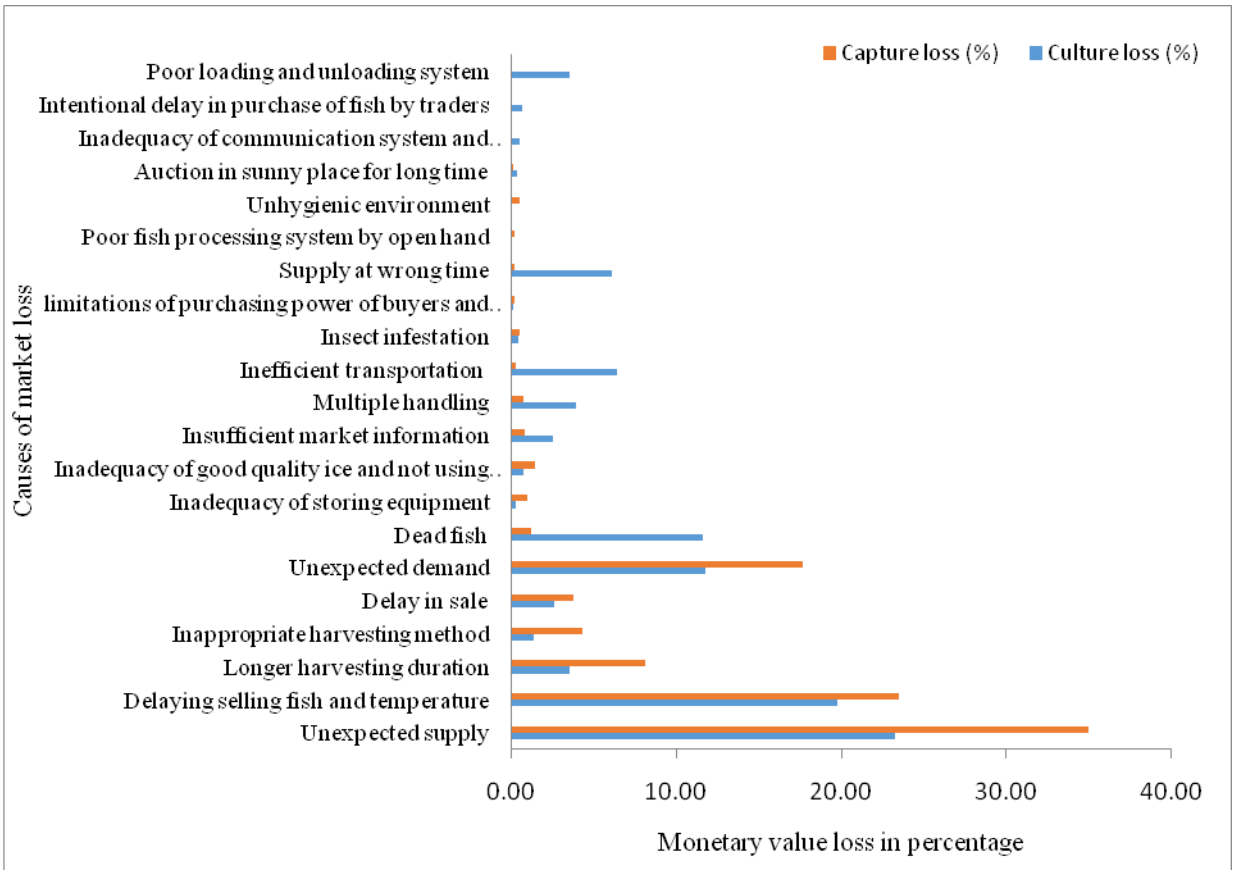


Fig 15. Causes of market loss in capture and culture fisheries at farm level.

11.1.24 Causes of physical loss in inland fisheries at traders level

There are several causes across the value-adding activities, from fishing to marketing the fish. To better understand and measure the extent of loss, the reasons are identified, and the quantity is estimated as per causes. Fig 16 illustrates the proportion of physical loss due to the identified causes in inland fisheries of Bangladesh. It showed that about half (49.49%) of the total discarded fish is caused by delayed delivery. Delay in the delivery at sales point occurs due to various reasons such as poor road communication, inadequate transport facilities, the longer receiving process, etc. Following this, about 22.62% of the physical loss in inland fisheries happened by the inadequacy of storing equipment during peak season. Besides, approximately 10.76% and 4.47% of fish discarded because of an unhygienic environment and delay in selling, respectively. Other major causes of physical loss in inland fisheries include quality loss during transportation due to high temperature (3.35%), insect and pest infection (2.22%), inadequate ice use and non-use of insulator containers (1.85%), bidding under the extreme heat of the sun (0.58%), fish quality loss due to pressure during inexperienced transportation system (0.18%) and fish discarded during loading and unloading (0.04%).

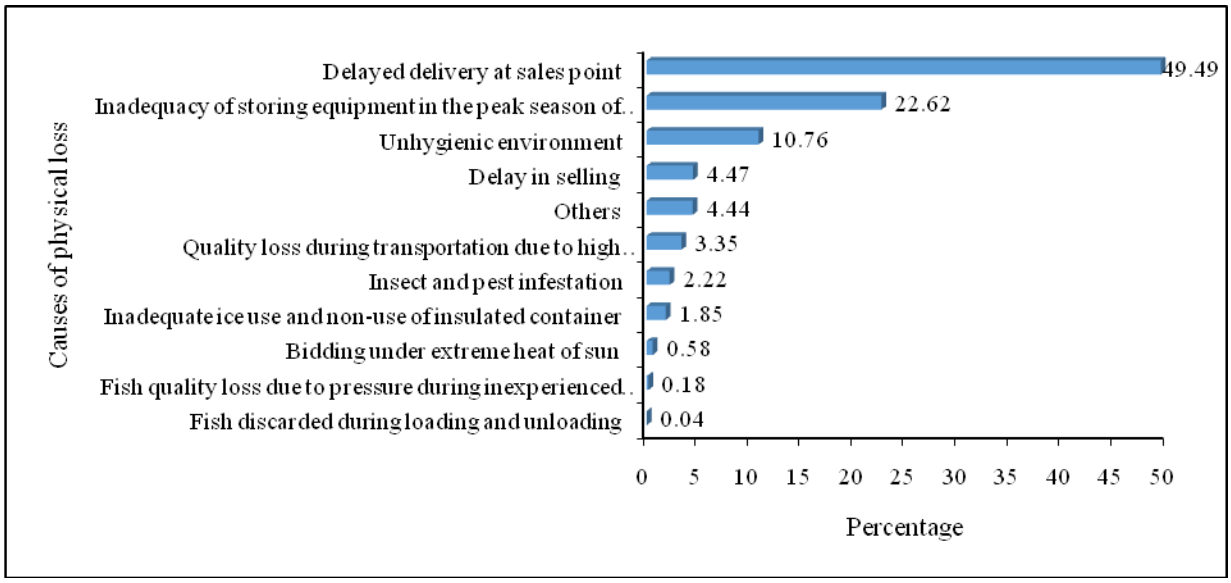


Fig 16. Causes of physical loss in inland fisheries at traders level in Bangladesh.

11.1.25 Causes of market loss in inland fisheries at traders level

The percentages of market loss at traders level by different causes are depicted in Fig 17. Results revealed that about 21.69% of the quality deterioration happens due to the delay in selling which was the highest among all causes. Traders often sell fish in delay because of various reasons such as time consumed in biding or expectation of better price. Following this, quality loss during transportation due to high temperature causes 16.67% of the market loss in inland fisheries. Besides, delay in the delivery at sales point and fish quality loss due to pressure during inexperienced transportation system led to a lower price due to deterioration in quality by 15.44% and 10.67%, respectively. Other important causes were fish discarded during loading

and unloading (9.79%), dead fish (9.51%), inadequate ice use and non-use of insulator containers (2.46%), etc.

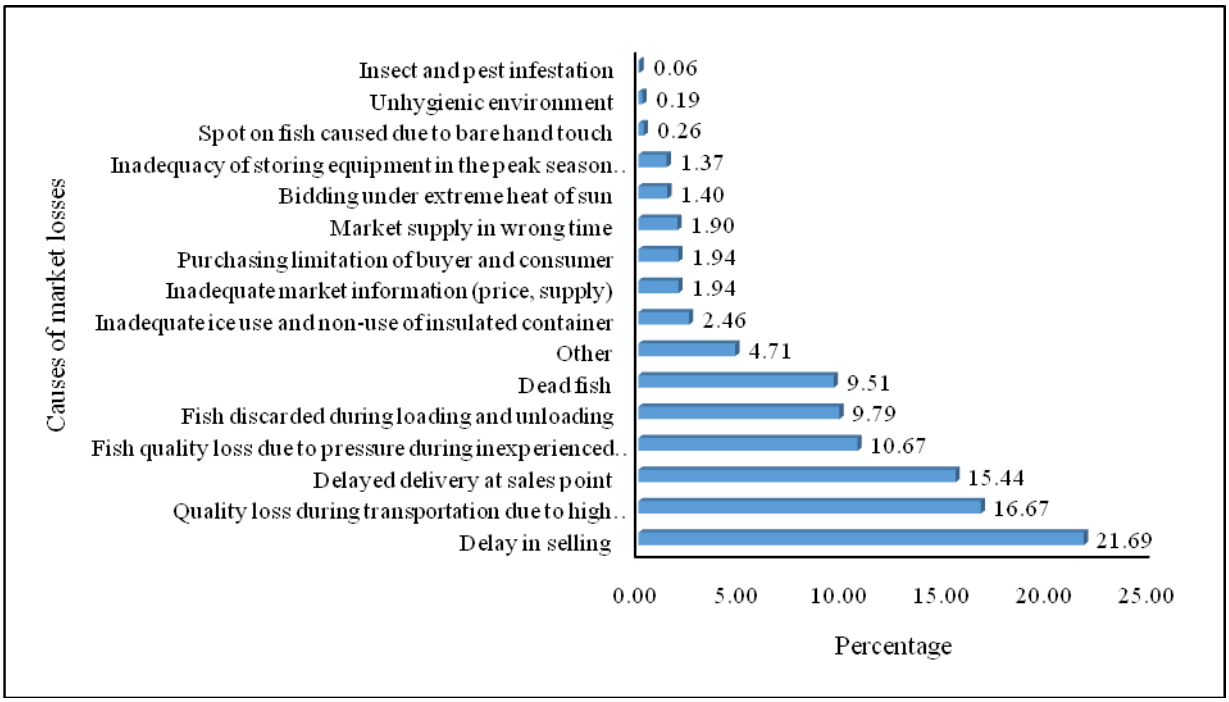


Fig 17. Causes of market loss in inland (capture and culture) fisheries at traders level.

11.1.26 Causes of physical loss of marine fishes at fisher level

In Bangladesh, the fisheries sector suffers from severe year-round quantitative and qualitative PHL at a different stages(in harvesting, handling, and processing) of the supply chain from the harvest to retail distribution.However, physical loss at the fisher stage is one of the major concerning issues to solve.This study identified several reasons of physical loss at the harvesting stage. Common constraints identified in the marine fish distribution channel at fisher stage were inadequate storage facilities and ice, more time attachment with net, delayed in marketing, fish handling, loading and unloading problems, fish damaged during transportation, and damaged by net or hock. The most significant issue of physical loss was more time attached with the net since fish are trying to escape from the trap and put pressure on the net; thus, the physical damage occurred on the fish body surface. It caused almost one-third of total physical loss (Fig 18). Besides, selling fish at lapse time also resulted in nearly 16% of total physical loss of marine fish, alongside shortage of ice and insulated container caused 15% of total physical loss. When the fish is harvested and sold to the nearer market within a few hours of harvest, the post-harvest loss was negligible. The longer the distance between harvest place to market, the higher the amount of physical loss since fishes remained at the under level of the trawler. And, it almost causes approximately 14% of total physical loss. More ice is also required to freeze fishes for a long-time transport to long distances. However, adequacy and uniformity in the icebox design was prerequisite to reduce the physical loss of marine fish. On the other hand, loading and unloading of fish by fishers properly since it caused minimum loss at the fishers' stage of marine fish.

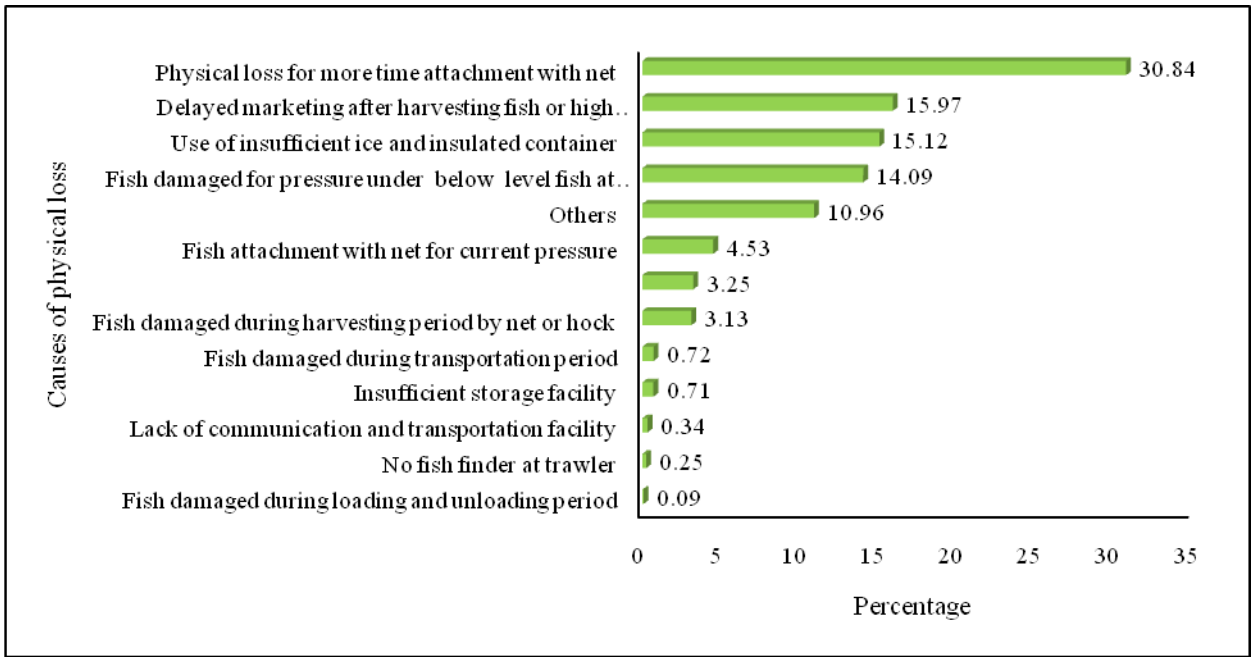


Fig 18. Level and Causes of physical loss at fisher stage in marine fisheries.

11.1.27 Causes of physical loss of marine fishes by traders

The physical loss at the traders' levelof marine fish, also shares a substantial amount of fish loss. Common problems related to the physical loss for traders were inadequate ice and insulated container, high temperature, insufficient storage facilities, transportation, and improper or rough communication system etc. (Fig 19). It is pointed that one-fourth of physical loss was estimated due to an insufficient amount of ice. Each trader required a massive amount of ice to store fishes for a long time or convey the fish from one trader to another.

Regarding commission agents, they store fish overnight to call an auction on the following day, requiring extensive ice. Besides, due to more temperature, more amount ice is needed to facilitate the smooth storage facility. It is calculated that 20% and 14% of the total physical loss resulted from the hot and humid temperature and deficient storage facility.Besides, transportation was one of the concerning issues for the marine fish trader as they brought fish from one place/market to another market or location. It has been estimated that due to transportation problems, almost 10% of total physical loss occurred.

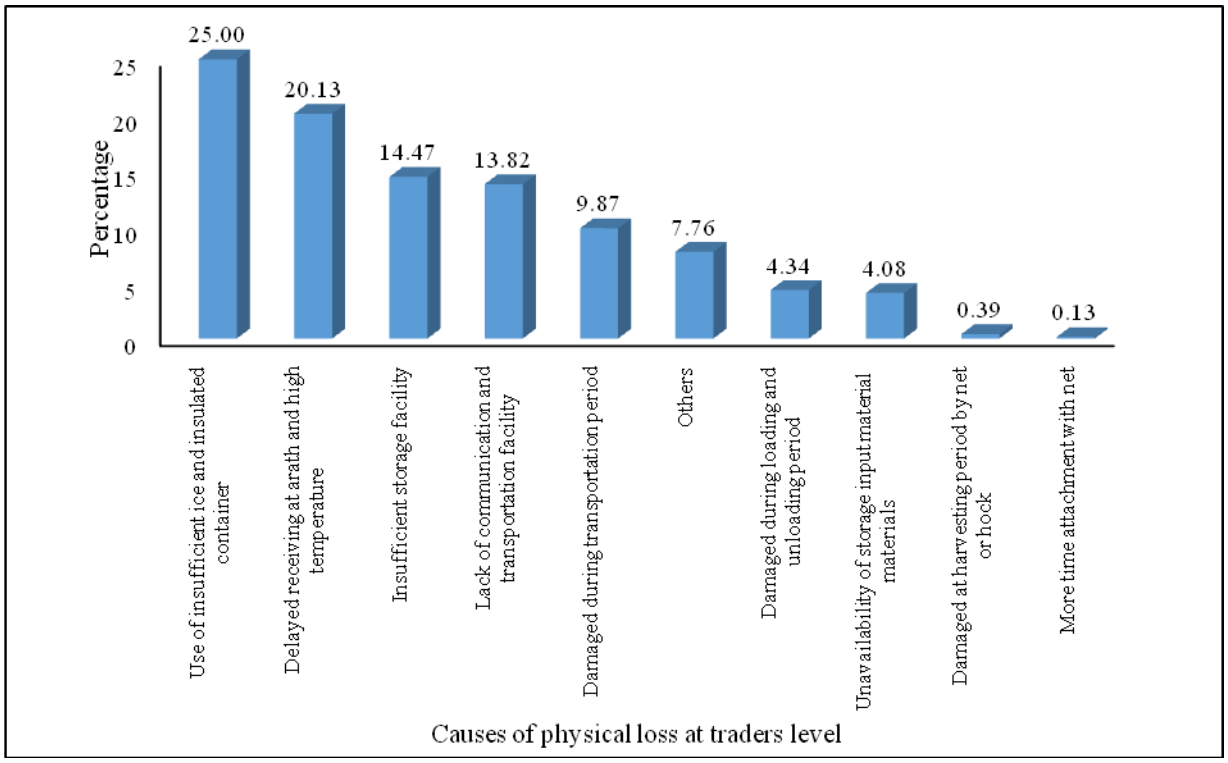


Fig 19. Causes of physical loss by traders of marine fish.

11.1.28 Causes of market loss at fishers level of marine fishes

In marine fisheries, several causes are responsible for the market loss. This study identified the major 21 causes and estimated quantity of loss by fishers as per causes presented in Table 20. Results showed that fishers lost 21.10 kg per MT of marine fish due to excess supply, which was the highest loss (18.00%) among all other causes. Increased supply during the peak season may overwhelm the market with the fish, causing the price to fall regardless of its quality. Lower demand of fish caused 19.71 kg per MT of market loss, covering 16.81% of total loss by marine fishers. Demand shortage creates surplus lead to loss of the price and quality of fish. Delayed marketing of fish causes deterioration of quality leading to price reduction which caused loss of12.89 kg/MT. Use of sufficient ice and the insulated container is necessary to prevent quality loss during storage and transportation. However, this study found that insufficient ice and insulated container causes loss of marine fish by 11.47 kg/ MT which was 9.79% of the total market loss by fishers. The quality of fish falls when it remains in the fishing gear for a longer time. Results show that more prolonged use of fishing gear causes loss of 10.29 kg/MT fish at farm level (8.78%).

Moreover, other significant causes of market loss in marine fisheries included fish damaged during transportation period for pressure (6.15%), lengthy bidding time in high temperature (4.63%), damaged during loading and unloading period (4.63%), delayed receiving at *ara*t after harvesting fish or high temperature (4.53%), wrong icing procedure (1.86%), etc. Among the identified major causes, intentionally delayed purchasing fish by a businessman (0.04 %) appear

as the most minor market loss by marine fishers. Fishers lost about 9.16 kg/MT of marine fish due to all the other causes combined that covers 7.81% of the total market loss.

Table 20. Causes of market loss by fishers of marine fish

Causes of market loss	**Amount and share**	
	kg/MT	**%**
Excess supply	21.10	18.00
Lower demand	19.71	16.81
Delayed marketing	12.89	11.00
Use of insufficient ice and insulated container	11.47	9.79
Long time use of the fishing gear	10.29	8.78
Fish damaged during transportation period for pressure	7.21	6.15
Lengthy bidding time in high temperature	5.43	4.63
Fish damaged during loading and unloading period	5.43	4.63
Delayed receiving at *arat* after harvesting fish or high temperature	5.31	4.53
Wrong icing procedure	2.18	1.86
Attack by insects	1.72	1.47
Use of banded current jal[15], behundi jal, and hock	1.69	1.44
Unhealthy environment	1.15	0.98
Insufficient market information such as supply, price, etc.	0.63	0.54
Discolor of fish for open hand handling	0.56	0.48
Limitation of buyers and sellers purchasing power	0.56	0.48
Unavailability of storage input material (ice and processing materials)	0.36	0.31
Wrong time market supply of fish	0.2	0.17
Lack of communication and transportation facility	0.12	0.10
Intentionally delayed purchasing fish by businessmen	0.05	0.04
Others	9.16	7.81
Total		**100.00**

11.1.29 Causes of market loss of marine fish by traders

The market losses of marine fish at the traders' level deprive the marine fish actors of gaining economic benefit from their business. Marine fish traders communities face multiple problems such as: social, economic, institutional, technical, and infrastructural.A substantial amount of market loss occurred due to an imbalance of supply and demand. The market price of marine fish unquestionably decreases in the peak season when the government lifts the banned period on marine fish catch. The uninterrupted and adequate flow of fish in the market prompts the reduction in fish prices. On the other hand, during the banned period, none of the fisher can catch fish in the sea, and traders do not have enough fish in their store to meet the market demand. Hence, the inequality of supply and need arises, resulting in a rise or fall in the market price of fish and economic loss for traders. It is estimated that 66.76% of total market loss at traders' level occurred due to excess supply and lower demand (Table 21).

[15] Current *jal*: Rectangular in size which is mainly made by mono-filament synthetic fibre, nylon rope, floats, coin shape soil-made sinker and pieces of narrow bamboo poles.

The Bangladesh Fisheries Development Corporation (BFDC) operates six fish landing centers in the coastal districts, namely, Chattogram, Cox's Bazar, Khulna, Barishal, Pathorghata, and Khepupara. All these centers are provided with landing platforms, auction halls, ice plants, cold storage, drinking water and accommodation, and other storage inputs facilities for fish traders. However, the fish landing centers, and their facilities are minimal compared to the number of marine fish traders. About 6.47% of the total market loss was responsible for the poor ice and insulated container facilities. Besides, the unavailability of storage material inputs was responsible for 1.35% of total market loss at traders' level. However, most of the marine catches are marketed at fresh level. Some are frozen for export; some are dried, and a small portion is salted. The transport arrangements are inferior and remarkable shares of the catch are spoiled due to lack of quick and better transport facilities as fish is one of the most perishable products. Also, within a short time, fish are spoiled, and their quality also deteriorate. It was estimated that 5.13% of the total market loss of marine fish was damaged during transportation for heavy pressure. Besides, almost 12% of the total market loss of marine fish at traders' level was occurred due to delayed marketing. Traders kept fish for several hours even for several days, which in turn reduce the quality of fish. Often high temperature is one of the major reasons to concern about, and marketing delay to reach at *arat;*altogether it caused almost 2% of total market loss of marine fish traders. However, in most cases, there were lack of auction sheds, packing sheds, landing terminals, gangways, pontoons, and proper drainage or hygienic facilities. Among the identified causes, unhealthy environment, and intentionally delayed purchasing fish by businessmen were the least imperative reason for market loss of marine fish traders.

Table 21. Causes of market loss by traders of marine fish

Causes of market loss	**Amount and share**	
	kg/MT	**%**
Excess supply	16.83	37.79
Lower demand	12.90	28.97
Delayed marketing	5.33	11.97
Use of insufficient ice and insulated container	2.88	6.47
Fish damaged during transportation period for pressure	2.28	5.13
Delayed receiving at *arat* after harvesting fish or high temperature	0.80	1.80
Unavailability of storage input material (ice and processing materials)	0.60	1.35
Fish damaged during loading and unloading period	0.39	0.87
Wrong time market supply of fish	0.28	0.62
Insufficient market information such as supply, price, etc.	0.23	0.51
Use of banded current jal, behundi jal, and hock	0.20	0.45
Lack of communication and transportation facility	0.20	0.45
Lengthy bidding time in high temperature	0.13	0.29
Attack by insects	0.09	0.19
Discolor of fish for open hand handling	0.09	0.20
Limitation of buyers and sellers purchasing power	0.05	0.12
Long time use of the fishing gear	0.03	0.06
Intentionally delayed purchasing fish by businessman	0.02	0.05
Unhealthy environment	0.01	0.02
Others	1.20	2.69
Total		**100.00**

11.2 Supply chain structure

11.2.1 Introduction

Supply chain measurement is an important issue for each and every commodity to ensure control over organizational behaviors, thereby saving the farm and actors from revenue loss and poor long-term growth. Therefore, from sales, finance, human resources, productivity, quality, and the entire product life cycle, measuring the supply chain performance can help a sector achieve its short- and long-term goal. To keep the sector in track, it is vital to implement the primary strategies for measuring supply chain performance. This study analyzed fisheries supply chain structure of Bangladesh through micro-level data where existing supply chain mapping, supply chain network and supply chain performance are discussed with problems and challenges.

Inland capture fish landing at Chattogram

11.2.2 Supply chain mapping of capture fisheries

Because of high demand, scarcity of riverine fishes, and improved communication methods, the marketing system of capture fishes is changing rapidly. The livelihoods of fishers and other actors engaged in fishing and marketing fish from the rivers are affected due to the lack of proper marketing system and are not getting fair price (Amin & Nabi, 2019).With this view in mind, attempts were taken to investigate the supply chain analysis of capture fishes in Bangladesh. This study identified fifteen supply channels through which the capture fishes flow from fishers to consumers. Among the fifteen channels, ten channels were shown in Fig 20, and these channels flow almost 81% of the total captured fishes in Bangladesh.

Fishers were the primary actors in the fish marketing channel in capture fisheries. Several types of fishers were identified in the capture fisheries, viz. permanent fishers, subsistence fishers, and seasonal fishers. The permanent fishers were entirely relying on income from fishing to sustain their livelihood around the year. Some fishers do not catch fish around the year known as seasonal fisher, but they depend on fishing from open water sources in the peak season. They generally go for fishing during the monsoon when the availability of fish in the river augments, and they have no work with their primary profession to do at that time. Fishers sold most of the total catch fish (48.63%) to the commission agents (Fig20). *Aratdars* sell the fish on the commission they collect from fishers, and they usually have an excellent connection to the wholesalers. Besides, fishers also sold to local agents (*farias*) (18.47%), wholesalers (*bepari*) (18.33%), wholesalers (*aratdar*) (12.70%), and a small amount to spot consumers (1.87%). Some consumers buy fish from the fishers' boat on a required amount basis.

Unloading fish at Chattogram Fishery ghat

Local agents (*farias*) are fish traders who were moving to different fishing groups with the boat or without a boat searching for captured fish. They bought any amount of fish from the fishers on the spot of capture and carried it to the wholesale market at the nearest district or Upazila level. In most of the cases, local agents (*farias*) have their preselected wholesaler (*bepari*), wholesalers (*aratders*), or *aratdar* (commission agents) to whom they sell the collected fish. Besides, local agents (*farias*) often sell captured fish directly to consumers on a small amount basis at the daily marketplace. Local agents sold a significant share of their purchase (55.37%) to *aratdar* (commission agents), whereas they sold 1.01% of their total purchase to the ultimate consumers.

Wholesaler (*bepari*) purchased fish directly from the fishermen and local agents (*farias*) or *aratdar* (commission agents) who came to the landing centers. Then, the wholesalers (*bepari*) took the collected fish to the wholesale market at the district level or another district and sold it to the destination marketsdirectly or through *aratders* (commission agents). As a result, wholesalers (*bepari*) sold 80.53% of the total purchase to the *aratdar* (commission agents). However, they also sold 10.53% of their total purchase to the retailers.

Wholesalers (*Aratdar*) were the one of the main actors in the fish marketing process at the fish landing centers and wholesale markets. Wholesalers (*Aratdar*) purchased fish from fishers and wholesalers (*bepari*), which they sold to the commission agents (Fig 20). The *aratdars* (commission agents) who have fixed establishment to help the fishers, local agents (*faria*), wholesalers (*bepari*), and wholesalers (*aratdar*) to sell their fish and charged a fixed amount of commission of 3 to 5 percent of the selling price. The aratdars (commission agents) often provided the loan to the fishermen, local agents (*farias*), and wholesalers (*bepari*) on the condition to sell fish through them. As a result, *aratdar* sold the lion's share of their purchased (77.33%) fish to the retailers and the rest amount to the wholesaler (*bepari*), who supply fishes to other districts.

Retailers were the last intermediaries of the fish supply channel who did not have any permanent establishment, but they have fixed places in the market. The retailers bought fish directly from local agents (*farias)* or *aratdars* (commission agents) and sold it instantly to the consumers. Primarily they purchase fish on cash or credit. Credit means retailers repay the money on that day or next day after selling the fish. However, in the case of very large-sized fish, the retailers often cut it into pieces and sold it to the consumers as per their requirements.

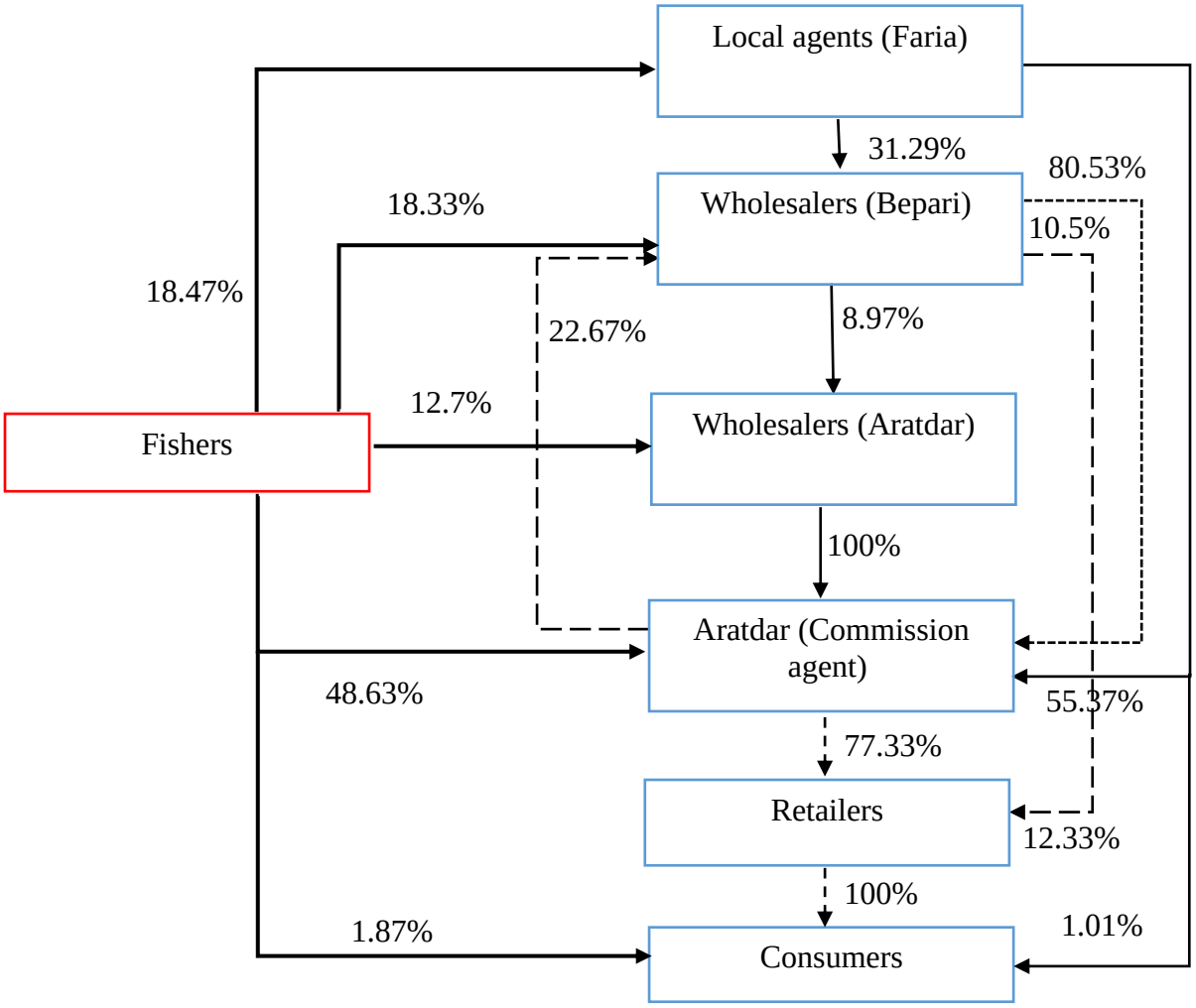


Fig 20. Supply chains mapping of capture fisheries in Bangladesh.

11.2.3 Supply chain mapping of culture fisheries

Fish farming in Bangladesh is rapidly evolving along with its supply chain structure (Hernandez *et al.*, 2018). The supply chain mapping of culture fish species in Bangladesh can be perceived in terms of who takes part in the chain from producers to ultimate consumers and what activities are being performed throughout the chain. This binary focuses on actor and action create avenues for the dual perspective of the supply chain in Bangladesh. The supply chain actors of culture fisheries include fish farmers, local

Fish loading to a vehicle

agents (*faria*), wholesaler (*bepari*), wholesaler (*paikar*), wholesaler (*aratdar*), *aratdar* (commission agent), retailer, and consumers. We have identified 12 channels through which fish is supplied from producers to consumers. The Fig 21 showhow these different actors are interlinked with each other in the supply chain process. Most of the culture fishes (82%) are supplied from producers to consumers through seven supply chain. Farmers who are the primary actor in these chains grow fish by nourishing fry to marketable sizes. The sources of fry for farmers include nursery, hatchery, fry *aratdar*, and fry commission agent. Households who practiced commercial fish farming converted their cultivable and fallow land into pond or lease land and get involved in fish farming. Fish farmers mainly sell their fishes to commission agents (56.23%), followed by wholesalers (*bepari*) (27.43%). Sometimes they also sell to local agents (*faria*) or directly to the wholesalers (*aratdar*), which is 9.47% and 6.87% of the total fish sale, respectively, when they overproduce or have a shortage of buyer. They face challenges in pricing culture fish due to monopsony and their inability to store fish for deferred selling at a better price.

The local agents (*faria*) bought fish from farmers and sold mostly to commission agents (63.17%), followed by wholesalers (*bepari*). They generally trade round the year. However, they are not able to preserve fish for a long time and therefore need to sell on the same day. The wholesaler (*bepari*) were professional traders who purchased fish directly from producers. They also bought from local agents (*faria*) and commission agents who collect from fish farmers. On the other hand, wholesalers (*bepari*) sold 81.55% of their total purchased fish to commission agents, 10% to wholesalers (*aratdar*), and 8.45% directly to retailers. Sometimes, there are multiple wholesalers (*aratda*r) where one *aratdar* sells fish to another *aratdar*, but the portion of fish being sold through this channel is negligible.

Generally, *aratdar* (commission agents) purchase fish from wholesalers (*aratdar*), fish farmers, wholesalers (*bepari*), and local agents (*faria*). However, they sold most of the fish to retailers (83.17%) who sold it to ultimate consumers. The commission agents sold the rest of the fish to wholesalers (*beparies*), which was 16.83%. Thus, they generally enjoy superior power, as they are the only link between backward and the forward entities. In addition, the commission agents often use a platform for auction selling which is famous for all kinds of fish irrespective of source and species. This auction selling can ensure a better price for the fish sellers.

Retailers sell fish to ultimate consumers either in the local marketplace or selling through walking in the semi-urban and urban areas. Fish retailers have low scale but regular sale. They generally buy fish from various sources, including commission agents and wholesalers (*bepari*). But they sell 100% of the total purchased fish to consumers. Besides this, retailers also offer various services to customers, such as cutting and packaging fish, sorting and grading, etc. They enjoy a power position in fixing sales prices, which they decide based on the size of the fish. However, local buyers comprise their clientele who have minimal bargaining power. Almost all retailers purchase fish from the retailers in the local market.

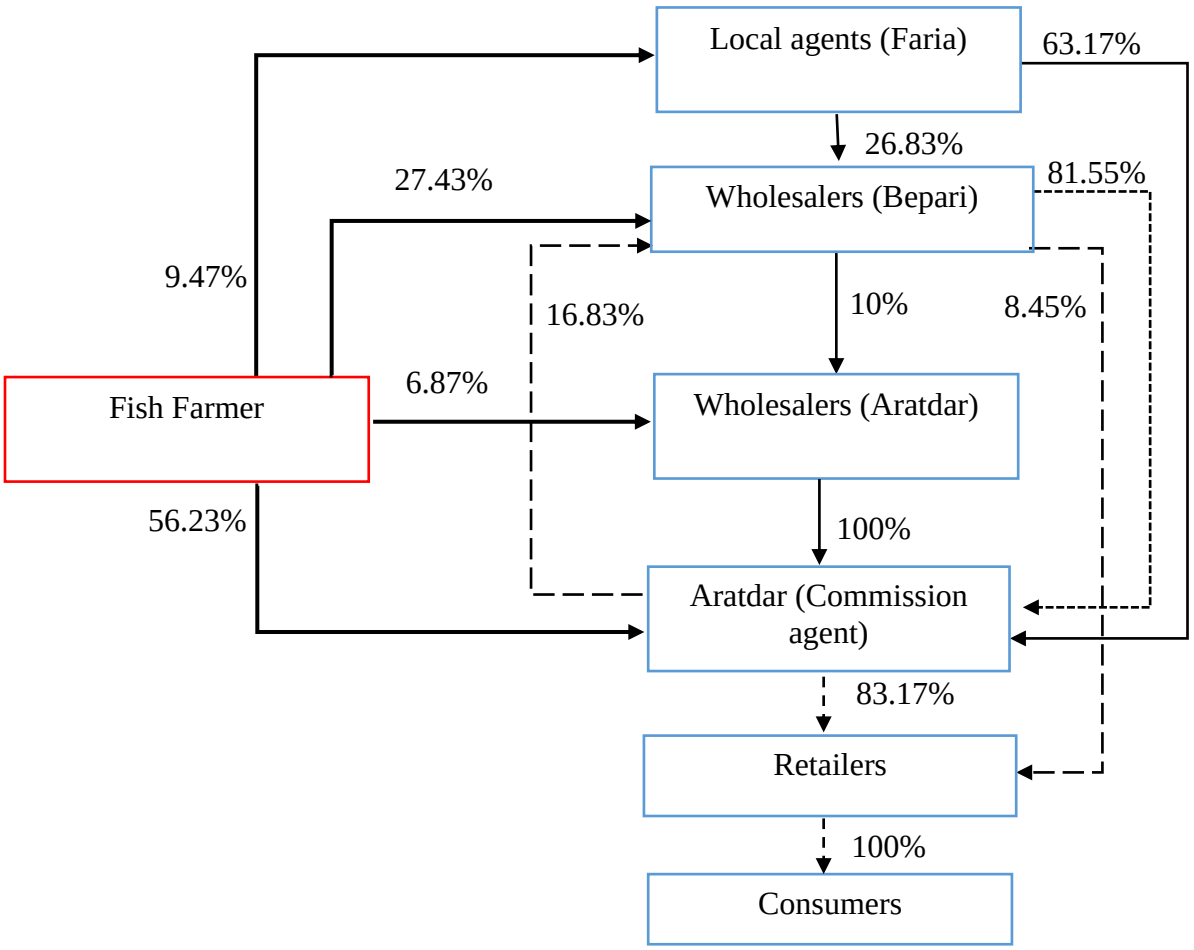


Fig 21. Supply chain mapping of culture fisheries in Bangladesh.

11.2.4 Supply chain networking of inland fisheries

The supply chain network analysis is very useful in understanding any marketing system (Ribas *et al*., 2018). A supply chain network framework consists of all the major participants of the supply chain, the focal agent; the participants acting as a backward linkage of the focal agent; the actors of forwarding linkage (from focal agent to his next participant); and finally, some associated institutions who cooperate all the participants for performing as a whole entity (Chopra and Meindl 2007). A supply chain involves a series of steps involved to get a product or service to the customer. The steps include moving and transforming raw materials into finished products, transporting them, and distributing them to the end-user. The supply chain networking channel of different actors in fish supply chain of Bangladesh is described below where different arrangement (supportive, contract, manage, and not manage) between the actors is shown.

11.2.4.1 Supply chain networks of the fishers

A fisher is someone who captures fish from theopen water body. These fishers are connected to different participants through backward and forward linkage of the supply chain for various activities presented in Fig 22. In backward link, fishers get financial help, training, extension, or input supports from different NGOs, Department of Fisheries (DoF) of Ministry of Fisheries and Livestock, money lenders, and cooperatives. *Aratdar* or retailers often provide financial, or input supports on condition of future fish trade. Fishers bought different inputs for fishing such as boats, fishing net, and other equipment primarily based on the business relationship with the provider, or they often practiced price negotiation. In forward linkage, fishers had contractual arrangements with *aratdars* (commission agent) who sold the fish to other traders and got a 3 to 5 percent commission. Fishers sold their fish to other *aratdars* (commission agents), retailers, and consumers at open market, based on price, which does not manage arrangement. However, fishers also sell some of the fish to specific customers and retailers. The repetitive transaction of fish creating an understanding of business. Besides, customers or retailers also bought fish directly from farmers due to better quality and lower price.

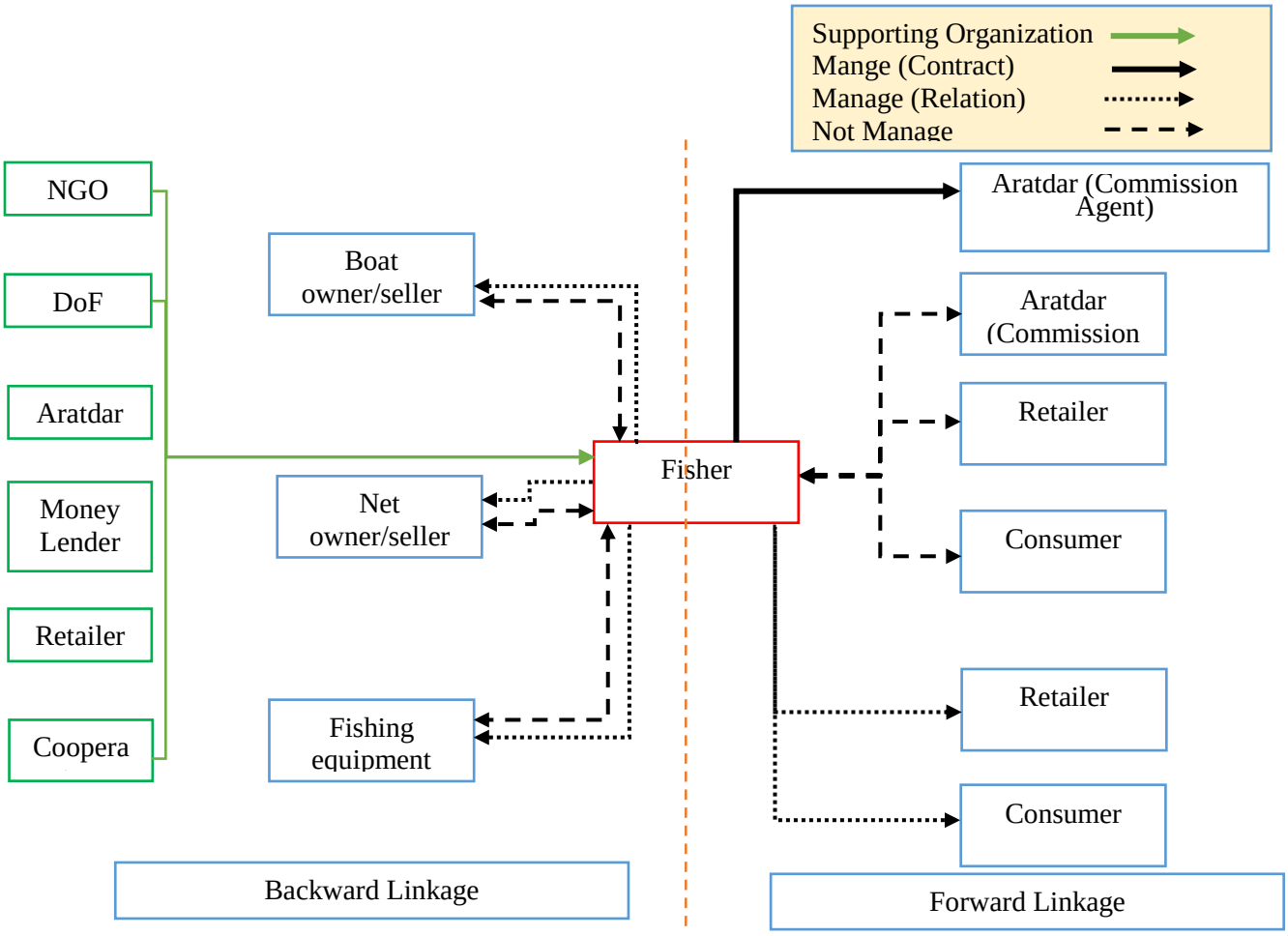


Fig 22. Structure of supply chain network for fishers.

11.2.4.2 Fish farmers supply chain network

A fish farmer is someone who rears fish for commercial purposes. Fish farmers are involved with various actors in the supply chain of fish through backward and forward linkage. The supply chain network of fish farmers is illustrated in Fig 23. Farmers get financial, training, extension, and input support from banks, NGOs, DoF, and money lenders in the supply chain network. Fish farmers had a contractual or relational arrangement with the feed mills or shops. Due to buying feeds from the same shops, they build business relationship with the feed suppliers.

Similarly, they procured other inputs such as fingerlings, medicines, fertilizers, fishnet, and other equipments based on price as well as business liaison. In forward linkage, farmers often sell fish on contractual agreement with *aratdar* (commission agent) and wholesaler (*bepar*i) and managed arrangement. They also sold their fish for a competitive price which is not managed. For the storage of fish, farmers sometimes bought ice from the market when needed. *Aratdars* provided storage facilities to farmers when they did not sell fish right after harvesting. Sometimes, fish was sold in the market through auction also. Here, auctioneers provided support in the bidding process of the fish. Besides, different transportation facilities were used by farmers for moving fish to markets.

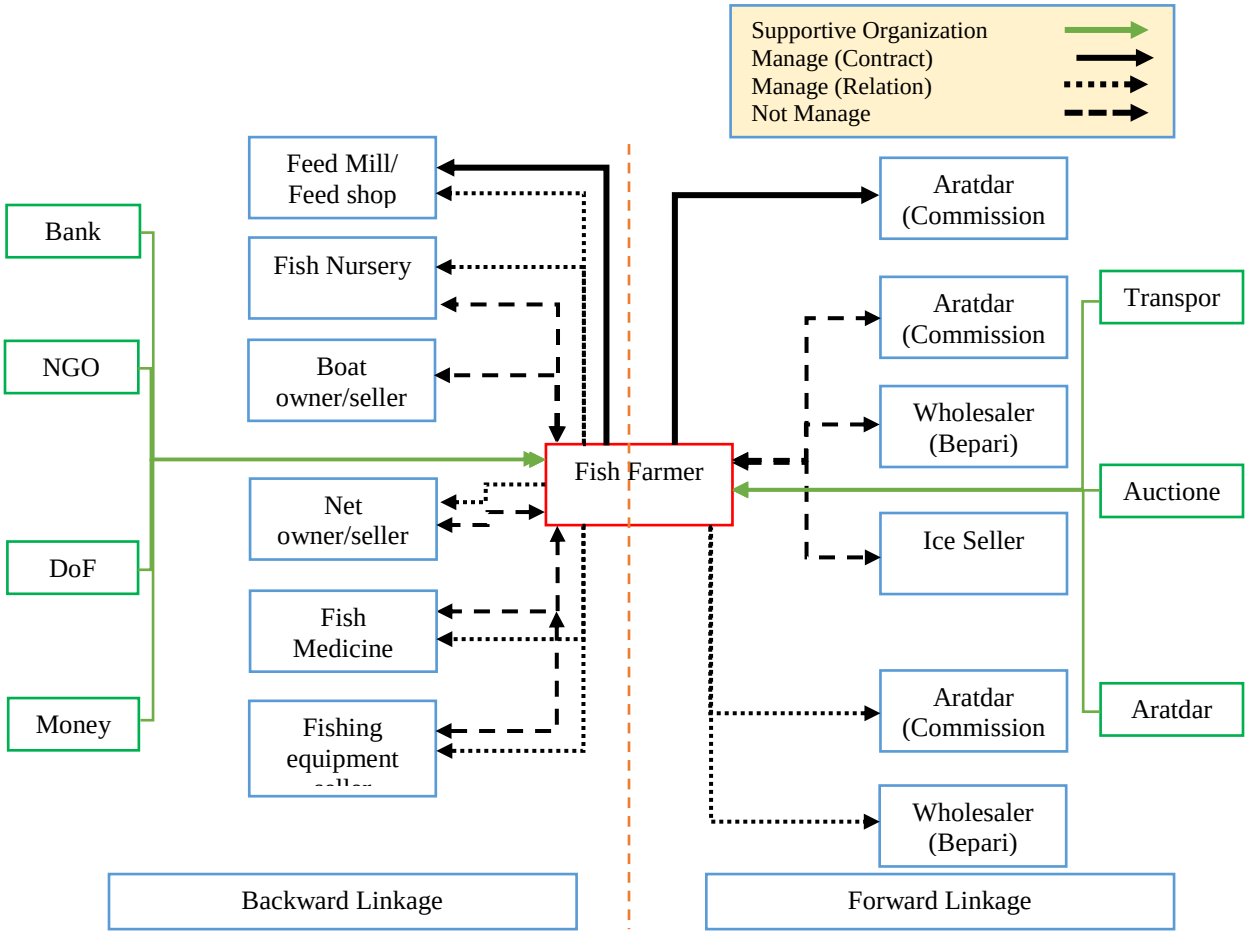


Fig 23. Structure of supply chain network for fish farmers.

11.2.4.3 Wholesaler (Bepari) supply chain network

Wholesaler (*bepari*) is the inter-district intermediary who buys fish from farmers/fishers, local agents (faria), or commission agents of one district and sells to wholesalers or retailers of another district. Their supply chain network is depicted in Fig 24. Here, *beparies* got financial support from other *aratdars* and relatives. *Aratdars* often sold fish to *beparies* on credit to repay when they got cash from selling fish to other districts. In the backward linkage, *beparies* bought fish from *aratdars* and necessary equipment from various sellers based on business rapport and reasonable market price. The forward chain of *beparies* included*aratdars* (commission agent), equipment sellers, water suppliers, and ice suppliers. Here, *beparies* sold fish to aratdars, who often sold it to others for a commission. During the fish selling, suppliers provided water, ice, and different equipment for storing and managing the fish. These arrangements were managed and not managed depending on the situation or preferences of the *beparies*.

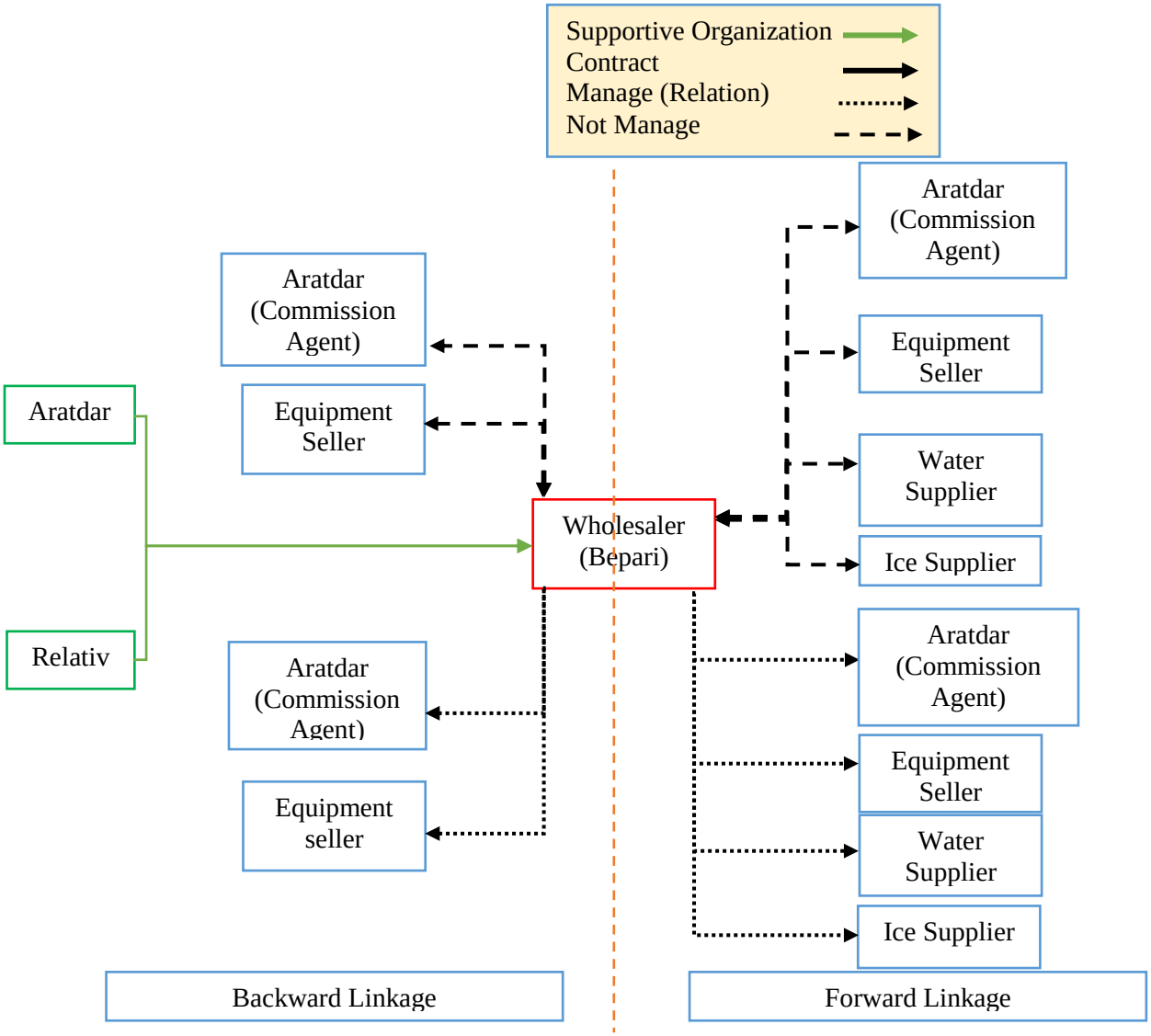


Fig 24. Supply chain network analysis for wholesaler (*beparies*).

11.2.4.4 Wholesaler (Paikar) Supply Chain Network Structure

Wholesaler (*paiker*) is the intra-district intermediary who buys fish from farmers/fishers, local agents (*faria*), or commission agents and sells to wholesalers or retailers within the same district. Fig 25 presents the structure of supply chain network of wholesalers (*paiker*) in this study. It shows that *paikers* received financial and other supports from different NGOs and their relatives. They bought fish from *aratdar* (commission agent) and necessary equipment from other sellers in backward linkage. Both linkages were based on prior business liaison as well as price negotiation in the competitive market. They often bought their fish from the same *aratdar* for an extended period due to better service and quality, which led to good business relations. *Paikers* sold their fish to retailers both in relational arrangement and competitive market. They had similar agreements with different suppliers who provided equipment, water, and ice used to store and manage fish while selling it. Long-term business relations were built in these arrangements due to repetitive purchases for customer service or product quality.

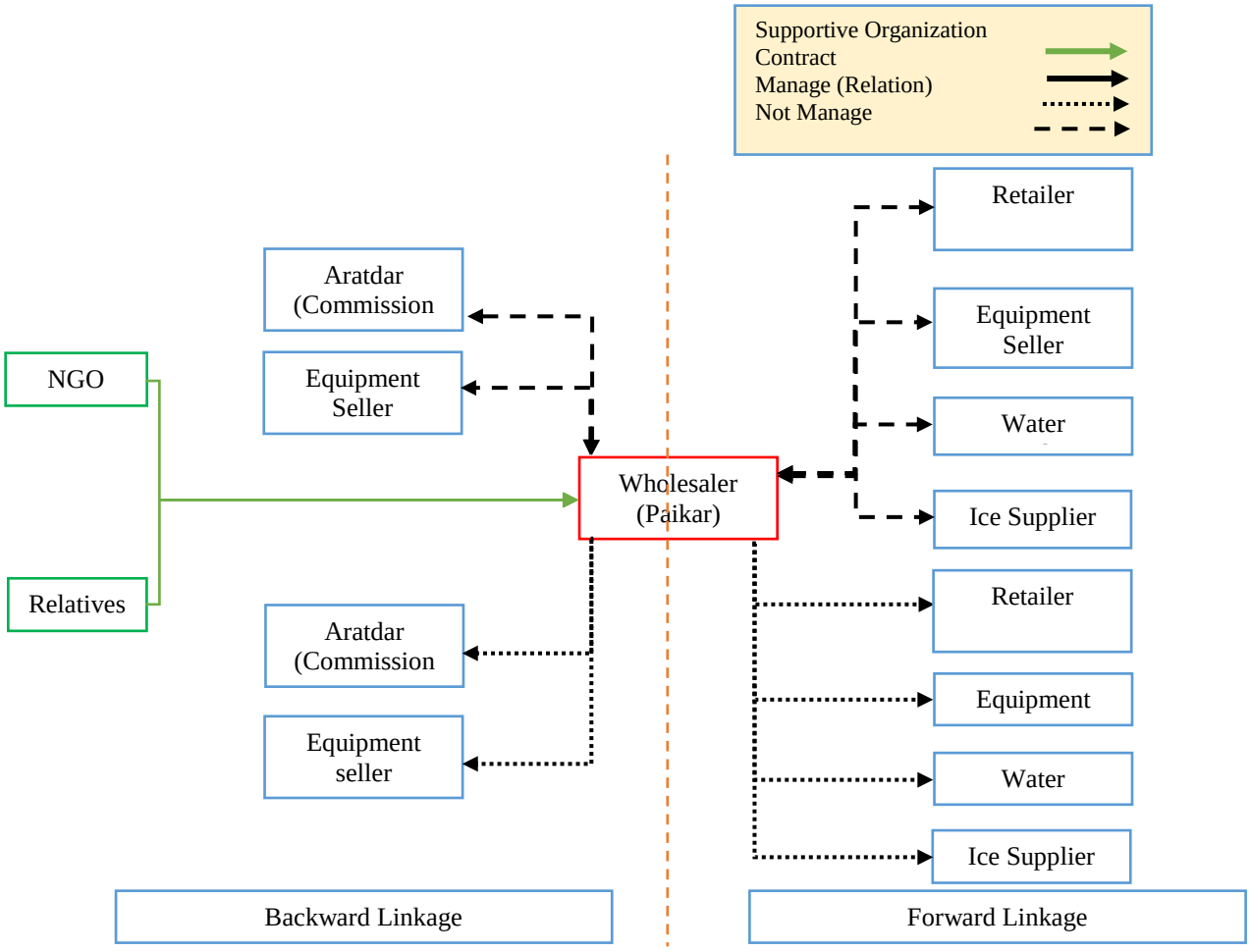


Fig 25. Structure of Supply chain network for wholesaler (*paikers).*

11.2.4.5 Aratdar (Commission Agent) Supply Chain Network Framework

Aratder acts as a commission agent who often buys fish sells to retailers or other traders. They get a commission on selling the fish from farmers, fishers, or other traders. Fig 26 illustrates the structure of supply chain network of *aratdar* (commission agent) in this study. *Aratdars* gathered financial support for their operation from banks and relatives in the form of loan. In backward linkage, they had a contractual arrangement with beparies to sell their fish, for which *aratdar*s receive commission of 3 to 5 percent of the sale. Besides, *aratdars* maintained linkages with fish farmers, beparies, and equipment sellers who provided them fish and equipment needed to manage the fish. On the forward side, *aratdars* sold fish to *beparies* and retailers based on business liaison as well as at a competitive market price. A similar arrangement was found with water and ice suppliers at the time of selling fish. Often, they bought from certain providers for better services.

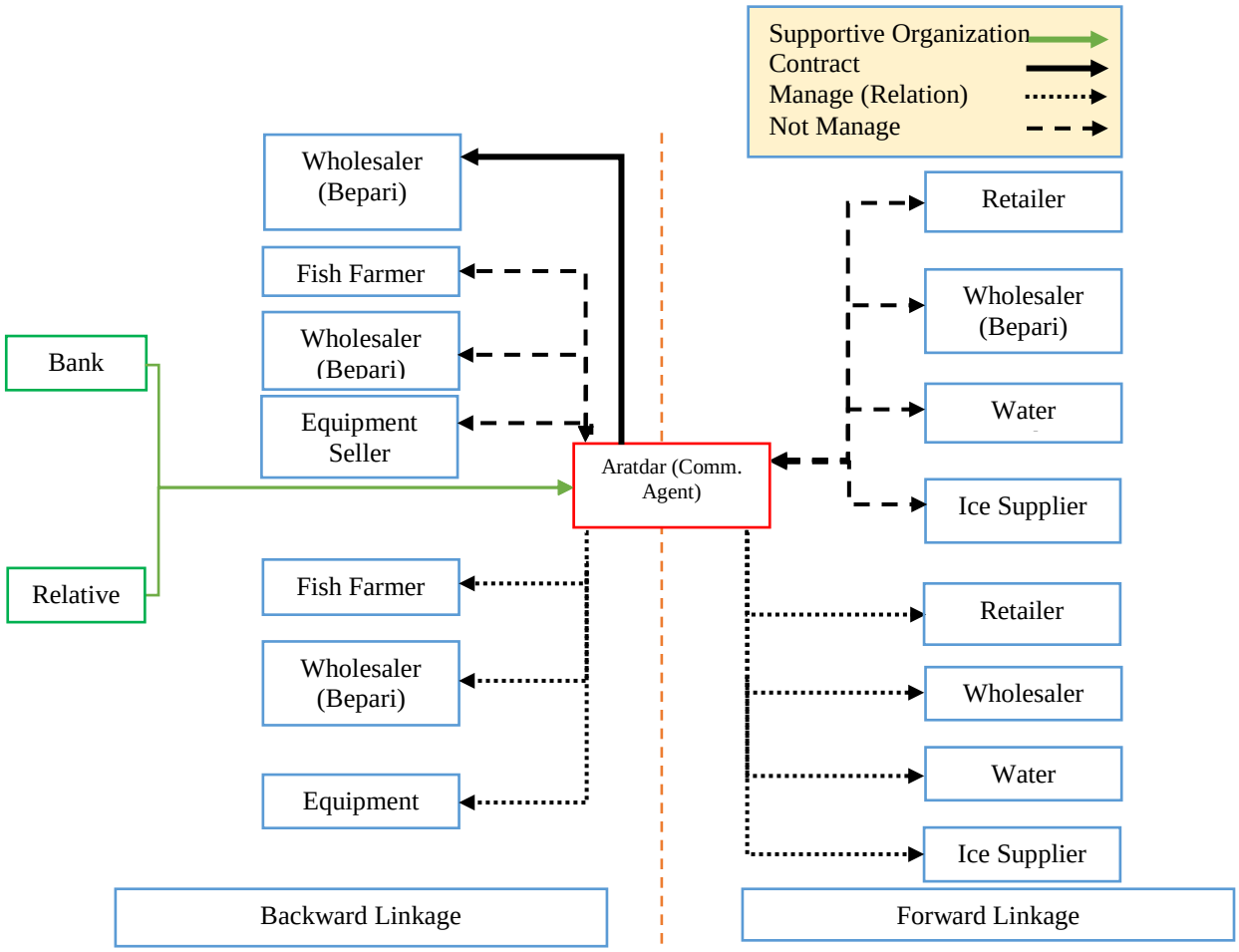


Fig 26. Scenario of supply chain network for *aratdar* (commission agent).

11.2.4.6 Retailers' Supply Chain Network Structure

The supply chain network of retailers in the fish marketing system is shown in Fig 27. Retailers maintained forward and backward linkage with consumers, facilities providers, fish suppliers, and inputs suppliers. In forward linkage, retailers managed long-term relationship with the

consumers, equipment sellers, water and ice suppliers etc. Sometimes a customer buy fish from the same retailers over the times and develop relationship with the retailers. On the other hand, retailers also had a not manageable relationship with the customers who bought fish from different retailers rather than the same retailers. It depended entirely on the behavior, negotiation of fish price, availability of different fish species as per consumer demand, and fish selling of retailers. Like the customers, retailers also bought different inputs from the same suppliers such as equipment sellers, ice and water suppliers, or purchase from different suppliers based on the suppliers' inputs price, facilities, and behavior.

Retailers maintained necessary relationships with the *aratdar* (commission agents) and equipment sellers in the backward linkage. Most retailers purchase fish from the preselected *aratdar* (commission agents) due to maintaining a continuous supply of fish. However, they often bought fish from other *aratdars* when they could not manage fish from their regular supplier. The *aratdars* got a commission in both cases. However, retailers had to pay higher amount to other *aratdars* compared to their preselected ones. On the other hand, retailers sometimes purchased fish from different *aratdar* (commission agents) due to the advantage of price reduction where retailers developed not manageable relation. NGO and relatives provide support (loan), while auctioneers offer logistic support to the retailers.

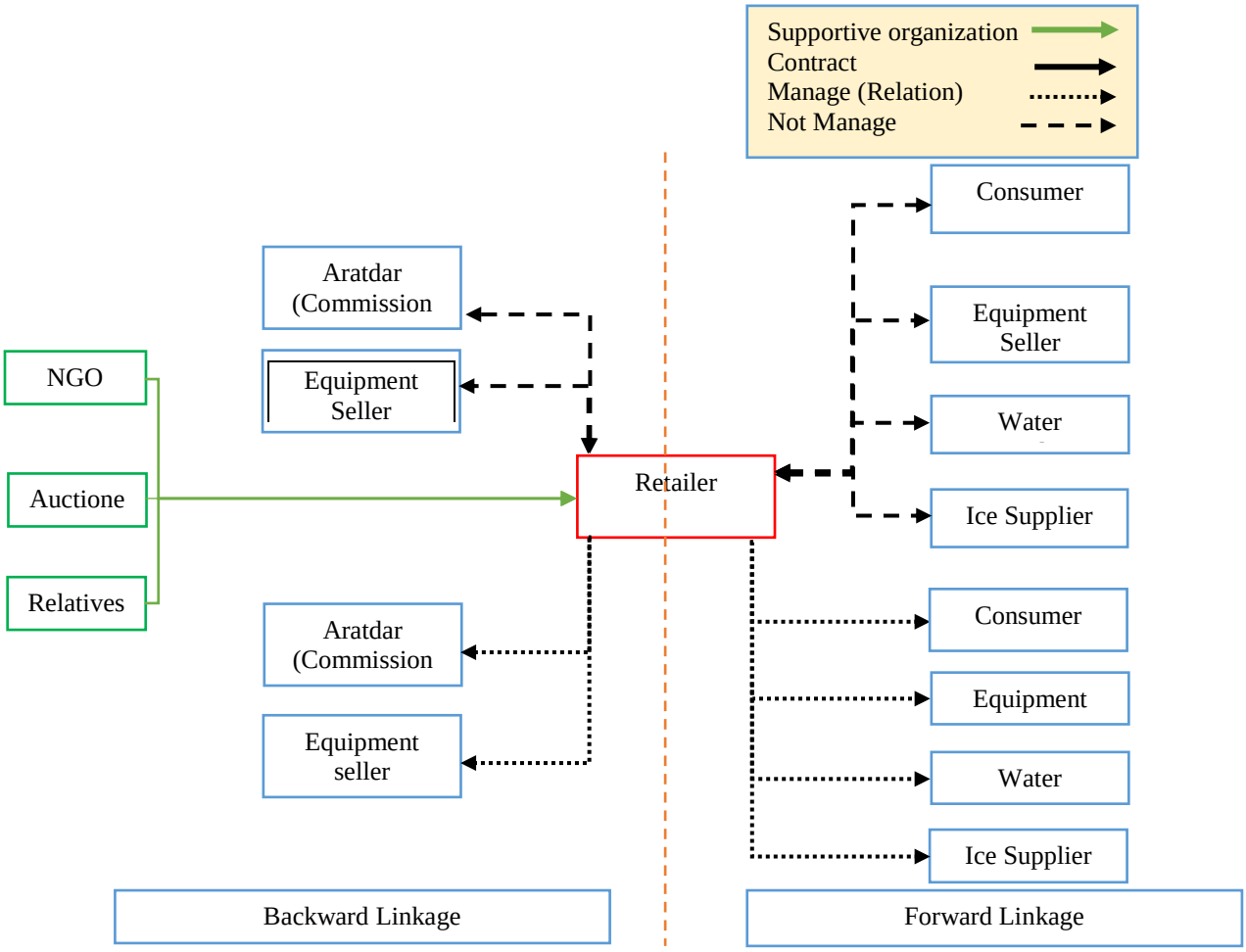


Fig 27. Structure of supply chain network for retailers.

11.2.5 Supply chain mapping and networking of artisanal marine fisheries

Artisanal is a kind of subsistence fishing that provides food directly to the concerned family or community (Akhtar *et al.*, 2017). It requires minimum capital and simple technology or traditional techniques prevailing generation to generation. The supply chain mapping and networking of artisanal marine fisheries are presented in Fig 28. Artisanal marine fisheries maintain both backward and forward linkage. Along the supply chain, fishers are the main central actor who established supply chain networks (both backward and forward linkage) in various ways like the contract, managed (relation), and not managed. In backward linkage, artisanal fishers maintained a contract network with DoF, NGOs, banks, *aratdar*, money lenders, and cooperatives to get training/capacity building, financial or relevant input supports. Fishers also managed and/or not managed linkage with boat owners, net owners, and fishing equipment sellers for the fishing boat, net, and other equipment. Boat owner/mahajan provides financial support (loan) to the fishers under contract networking.

In forward linkage, fishers mostly sold their fish to *aratdars* (78%) and suppliers/dalal (10%) based on their given financial support. The primary/major fish supply chain was fishers>*aratdar*>retailer>consumer, where *aratdars* held the major supply chain share and had established contract linkage with wholesalers to supply 77% fish. They also managed relations for the rest 23% of fish supply, reaching consumers via retailers under the same networking. *Aratdars* take the responsibility and control of each sale when fish comes to the wholesale markets and sell the fish through the auctioning system. Supplier/dalal further had contract linkage with exporter (30%) and drying processor (70%) for their inputs supplies and financial support. Fishers sold 4% of fish to the commission agent under managed networking and reached the consumers via retailers. However, fishers also sold some fish (1-5%) directly to the different processors (freezing, drying, and salting), which went to the final consumer under not-managed supply chain networking.

11.2.6 Supply chain mapping and networking of industrial marine fisheries

The industrial marine fisheries have a massive potential in Bangladesh, and its supply chain network is critical as it involves various crucial intermediaries. Therefore, the actors in this sector established backward and forwarded supply chain linkage/networks in multiple ways like the contract, managed (relation), and not managed, shown in Fig 29.

In backward linkage, industrial fishers/captains-maintained contract networking with the marine academy, marine fisheries department of DoF, Bangladesh Navy, and banks to get legislative supports, training/capacity building, and financial supports. Managed and/or not managed linkage also followed with net seller and fishing equipment sellers who imports these to provide net and other fishing equipment. Fishers/captains also procured fishing vessels under contract and managed backward networking.

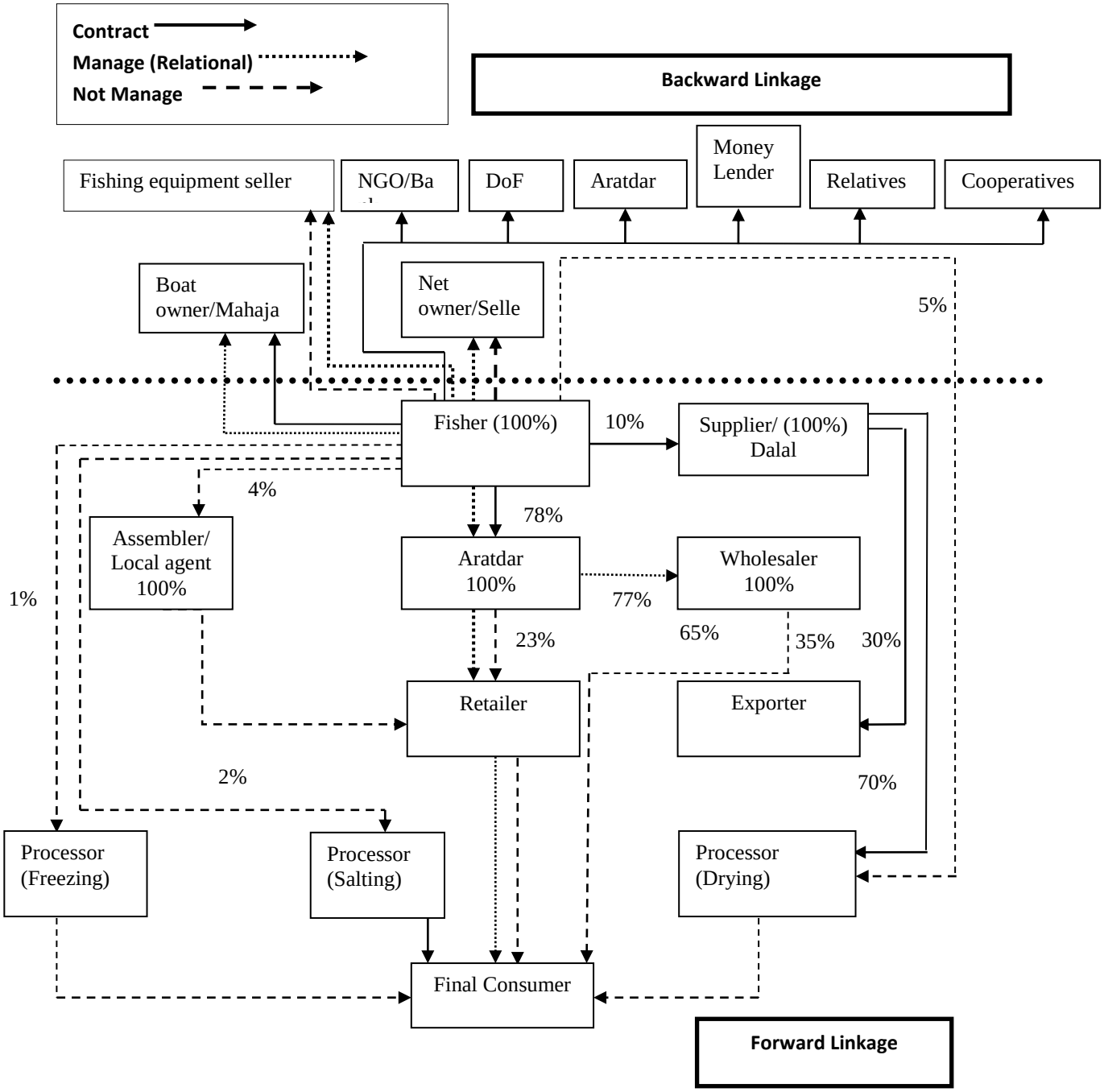


Fig 28. Supply chain and network of artisanal marine fisheries in Bangladesh.

In forward linkage, fishers and captains sold all the harvested fish to the fish party (company) following an online tender process under contract and not managed linkage. The large industrial fish catch per trip could not pass to the next step/actors without 'fish part/company' that holds the single power in the supply chain actors. The principal industrial marine fish supplychain was fishers>fish party/company>cold storage>*aratdar* (at district level)>*paiker*>consumer. Fish

party/company supply 85% fish to the cold storage, of which 85% go to the consumers via *aratdar* and *paikers* under contract supply chain linkage. Only 9% fish are supplied directly to the final consumer from *aratdar*. Fish party/company sell 7% and 3% fish directly to the poultry feed or trash fish processors and dried fish processors under managed and contract networking, respectively. In addition, 2% of fish are supplied to the exporter following managed and contract linkages, where 3% goes via suppliers under the same supply chain networking.

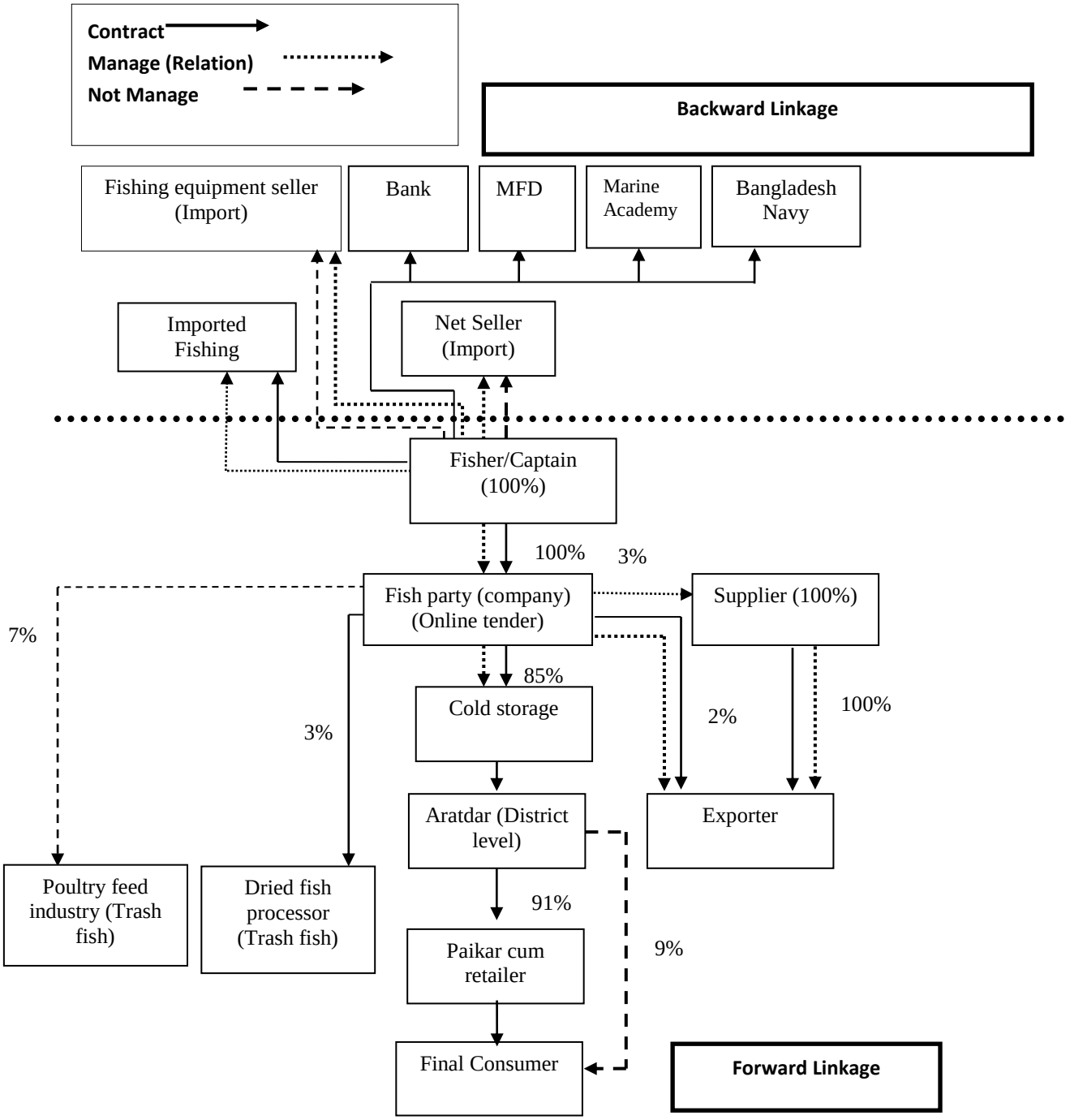


Fig 29. Supply chain and network of industrial marine fisheries in Bangladesh.

11.2.7 Supply chain mapping and networking of dried fish

The drying of marine fish is widespread in the entire coastal areas of Bangladesh, and these dried fishes have demand both in domestic and international markets (Hossain & Masud, 2012). The supply chain of dried fish involves various actors who are connected in different arrangements such as contract, manage and not manage across the backward and forward linkage. The supply chain mapping and networking of dried fish in Bangladesh are presented in Fig 30, which involves seven major supply channels identified in the dried fish marketing system.

In backward linkage, the dried fish processors received different supports such as financial, inputs, training, capacity building from NGOs, DoF, banks, money lenders, and relatives, usually contractual arrangements. They y procured fish from raw fish *aratdars* and often directly from fishers. Both transactions were contracted and manage to backward linkage. That means though they usually had contracts with their suppliers, they often collect fish based on relational arrangements whenever needed. In forward linkage, dry fish processors sold 90 percent dried fish to dry fish *aratdar* directly through relational linkage. Very few of their fish went to suppliers who proceeded to the exporter, usually based on contracts. The *aratdars*made 67 percent sell to district-level wholesalers who supply it to *paiker* cum retailers, which is a manage arrangement. Dry fish *aratdars* had managed and not manage linkage with *paikers* cum retailers and contractual linkage with suppliers who supply dried fish to the exporter. Final consumers mainly bought dried fish from the *paikers* or retailers in addition to other actors.

11.2.8 Supply chain networking of shrimp processing plant

The shrimp industry in Bangladesh is crucial for the economy as it occupies the second-largest export industry. Shrimp processing plants are the most vital part of this industry. They are linked with various actors in their supply chain in backward and forward linkage, which is illustrated in Fig 31. It reveals that they had contractual arrangements in their backward linkage with account holders/commission agents/local agents, depot owner/*aratdars*, banks, DoF, and ice suppliers who provided them with financial, training, capacity building, or input supports. Shrimp processing plants procured their shrimp directly from farmers with whom they usually have necessary contract. However, they sometimes bought shrimp from farmers and *farias* in not managing arrangements where they paid competitive prices. In forward linkage, shrimp processing plants get connected to the exporter as their main target is the customers in foreign markets. For which, they maintain a certain quality of the product following the rules and regulations of the customs of the targeted country.

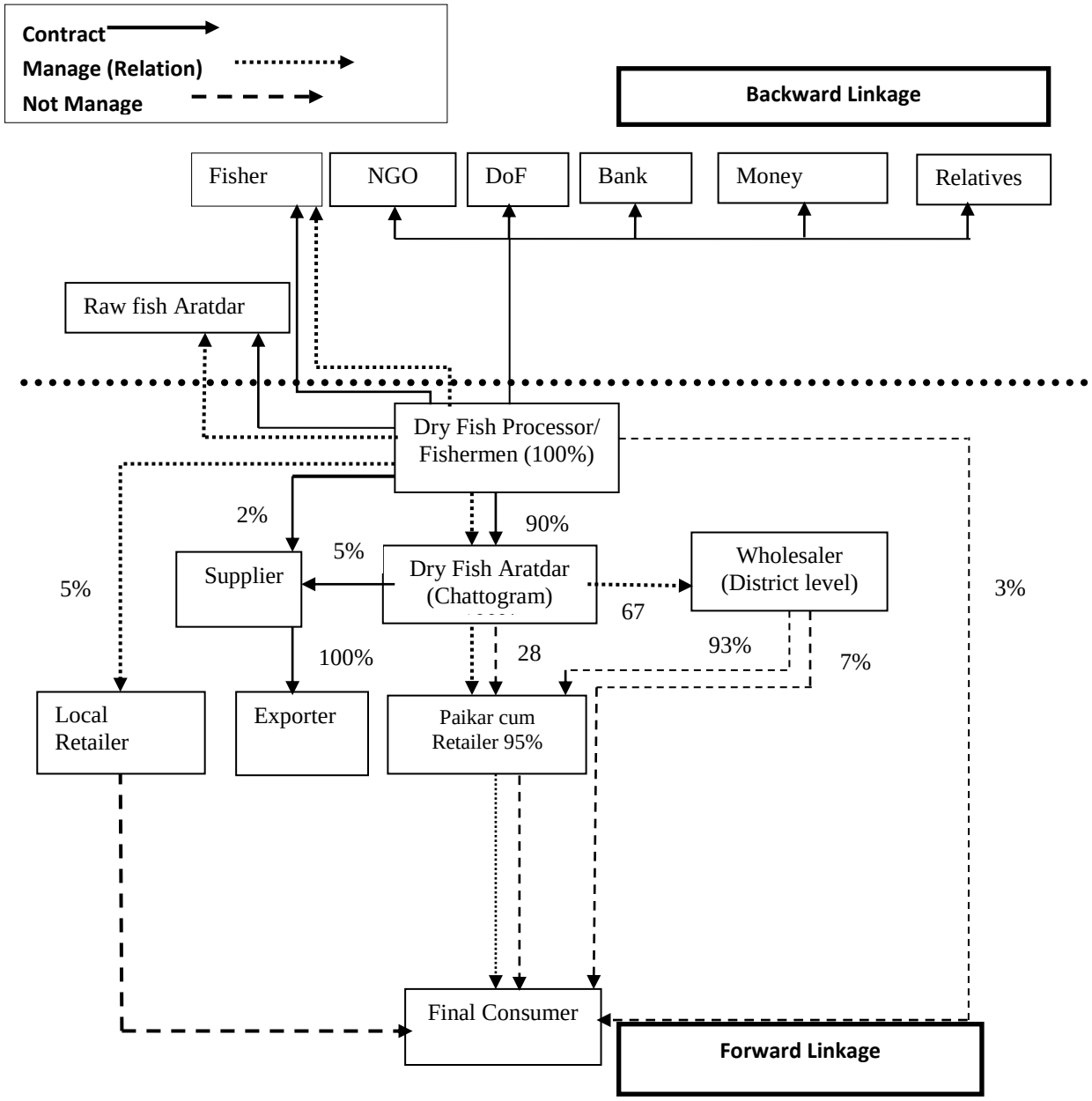


Fig 30. Marine dry fish processor supply chain in Bangladesh.

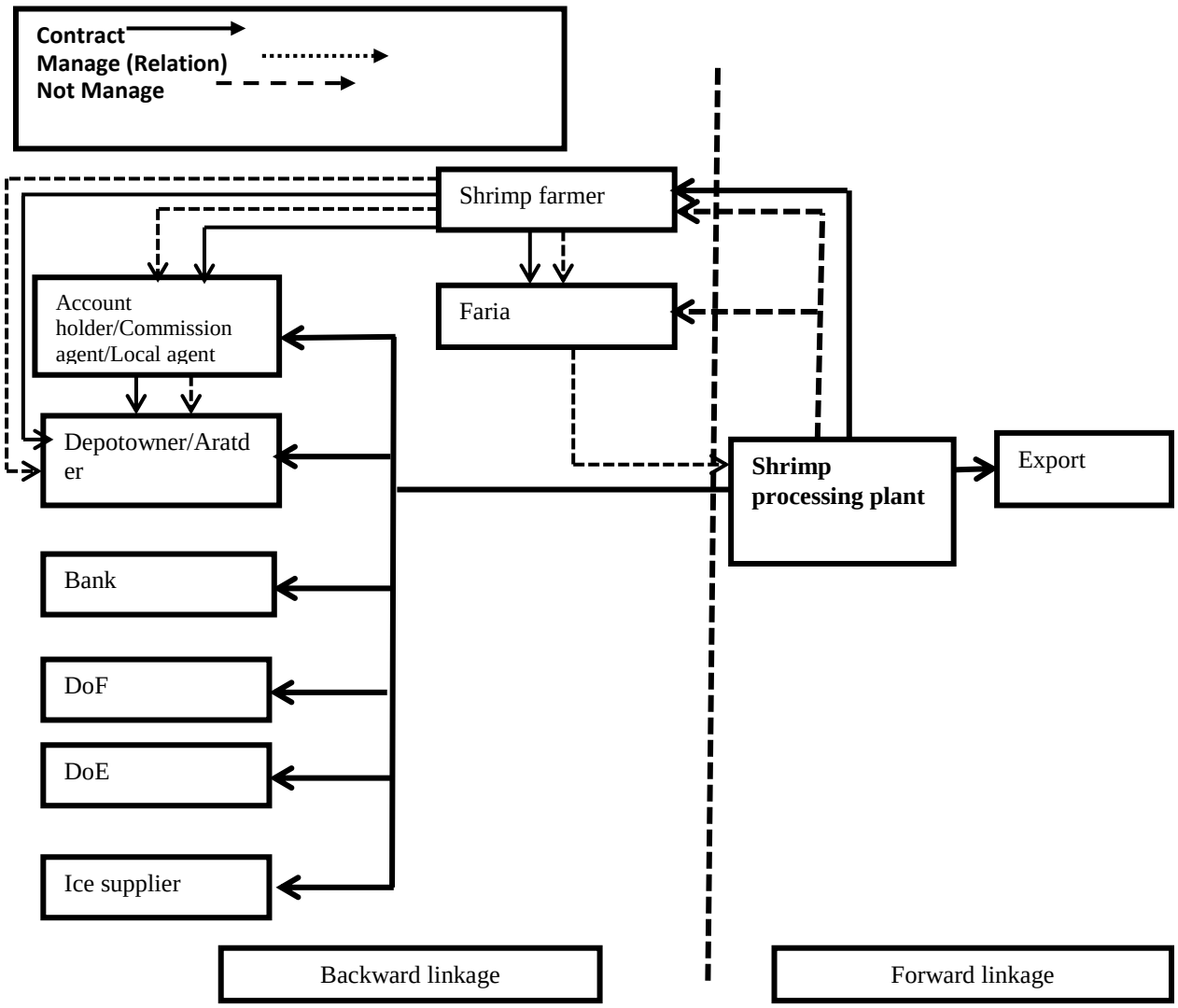


Fig 31. Structure of Supply chain network of the shrimp processing plants.

11.2.9 Supply chain performance measurement

The progress of fish production achieved a remarkable position nowadays. But the distribution system of fish is still in a complex situation (Rahman *et al.,* 2013). Besides, supply chain performance measurement received little attention in the field of the fisheries sector in Bangladesh. This section focuses on supply chain actors (fisher, fish farmer, *chalani paiker*, commission agent, and retailer) considering the different market arrangements, i.e., spot, contract, relational and co-operative market[16], to evaluate the performance using a five-point Likert scale. Six indicators, namely efficiency, effectiveness, quality, reliability, flexibility, and capability are taken into account to assess the performance.

[16]Co-operative market: is a market where sellers sell their fishes to the buyers to meet their common goal in a certain period.

11.2.9.1 Supply chain performance at stakeholders' level

The study identified four stakeholders, i.e., fishers/fish farmers, *chalani paiker*, commission agent, and retailer, to measure whether the supply chain performance is good or not. It is worth mentioning that a person who catches fish from different natural sources of inland capture and marine fisheries for leading their livelihood is known as fishers, while someone who is farming fish in the pond is called fish farmer. The *chalani paikar* includes wholesalers (*bepari*) and wholesalers (*paikar*), whereas the commission agents include *faria*, and *aratdar* who transacts fishes on commission. Ultimately, a retailer is a person who sells goods to the public in relatively small quantities for ultimate consumption. The supply chain performance may vary from actors to actors due to their nature and extent of business operation. The study reveals that the overall performance of effectiveness, quality, reliability, and flexibility are satisfactory. In contrast, the overall performance of efficiency and capability is not satisfactory among the entire stakeholders. However, the specific performance indicators of the supply chain are discussed below:

Efficiency

The factors of assessing the efficiency to measure supply chain performance at the stakeholder level are shown in Fig 32. The stakeholders are asked six (6) questions for determining the efficiency. The study revealed that the overall efficiency score is poor, indicating the lower performance of the supply chain. However, the study showed that the stakeholders can sell fish without their fixed buyer because of the availability of buyers in the market, but the stakeholders could not sell their fish at the right time. It was observed that the *chalani paiker* faces so many obstacles such as bad weather, flawed communication system, unexpected situation, etc., to reach at their purchased fishes in the desired market. But in the case of the commission agent, poor market environment and poor infrastructure lead to delaying selling the fishes. Sometimes, an excess supply of fishes in the market causes muchproblem in selling the fish for the retailers. Therefore, due to the lesser demand situation, the retailer cannot sell their fishes at the right time. On the other hand, the stakeholders are not able to reduce transportation costs yet, though the transportation facilities are developed much. As such, stakeholders are paying higher fare with the minimum carrying volume of fish. In addition, sometimes, they need to pay toll fees while carrying the fish from one place to another. However, it is promising that the transportation cost is zero for the commission agents.

Effectiveness

The study considers various factors of effectiveness which are shown in Appendix-I. To evaluate the performance on effectiveness, the study considered seven (7) items. It was found that the overall performance of effectiveness is better among the supply chain actors. The results showed that the hired labor by the stakeholders is punctual. In fact, the stakeholders pay a higher amount to the labor. Besides, the stakeholders show positive attitude and maintain good relationship with the hired labor. Therefore, the laborers are also obliged to the stakeholders.

Furthermore, the stakeholders could not get their expected price despite the shortage of buyers indicating the lower supply chain performance. Moreover, the demand for fish is less at different religious festivals such as Eid-Ul-Fitr, Eid-Ul-Azha, and Lakshmi puja compared to meat. Therefore, the stakeholders have to sell the fishes at a lower price. But, only the *chalani paiker*

who sell capture fish get their expected price despite shortage of buyers. Because the *chalani paiker* does not sell their fish to the consumer. Instead, they sell the fishes to the commission agent and the retailer. Therefore, in most cases, they are able to sell the fishes at their expected price.

Quality

Quality is another aspect of measuring the supply chain performance among the actors. There are eight (8) important factors of quality which are shown in Appendix-I. Though the overall performance of quality was satisfactory, there are some dissatisfactory factors as well. The study assesses whether the stakeholders use insulated containers or not to ensure the quality of fish. It was evident from the survey that the stakeholders are discouraged for using of insulated containers. Because most of the time, the stakeholders are buying and selling the fresh fish, and they are able to sell all the fishes. Therefore, they need not to use the insulated container. On the other hand, some stakeholders are uninterested to use the insulated container to store the unsold fishes. As a result, the quality of fish deteriorates, as said by the respondents. Thus, the item influences the supply chain performance of the capture and culture fisheries sector.

Invariably, the stakeholders transact the fresh fish (live or just dead fish). Because maintaining the quality of fish is possible only for buying or selling fresh fish. Besides, the demand of fresh fish is higher than for frozen. The belly shape, color of eyes, color of gills, and slime of gills remain the same in the fresh fish. Therefore, everyone wants to buy fresh fish. Thus, buying or selling fresh fish indicating the higher performance of supply chain actors. In addition, quality judgment during buying and selling of fish by the stakeholders is another crucial item of measuring quality. It is reported that the quality judgment of the stakeholders was good in this study. It is because of their prolonged engagement with the fish business. The stakeholders are able to identify the quality fish by the physical inspection of fish.

Reliability

The factors of reliability that indicate the supply chain performance are shown in Appendix-I. The study indicated several influential factors of reliability. The study reports that the overall performance of reliability on the supply chain is more satisfactory among the other indicators. Further, it is promising that there was no item of reliability that is accounted for the poor performance of the supply chain. The study assesses whether the stakeholders are buying and selling the disease-free fish or not. It was evident that the fish supply chain actors are always buying and selling the disease-free fish of capture and culture fisheries. Because every stakeholder transacts the better-quality fish to ensure reliability with their customer. For instance, the fisher and fish farmers maintain the sorting process.

Furthermore, *chalani paiker*, commission agent and retailer also do the supply activitiesduring buying and selling the fishes. Before selling, they pick out the diseased fish. Besides, it is more profitable to transact the disease-free fish. Thus, buying or selling disease-free fish means the higher performance of the reliability in the chain.

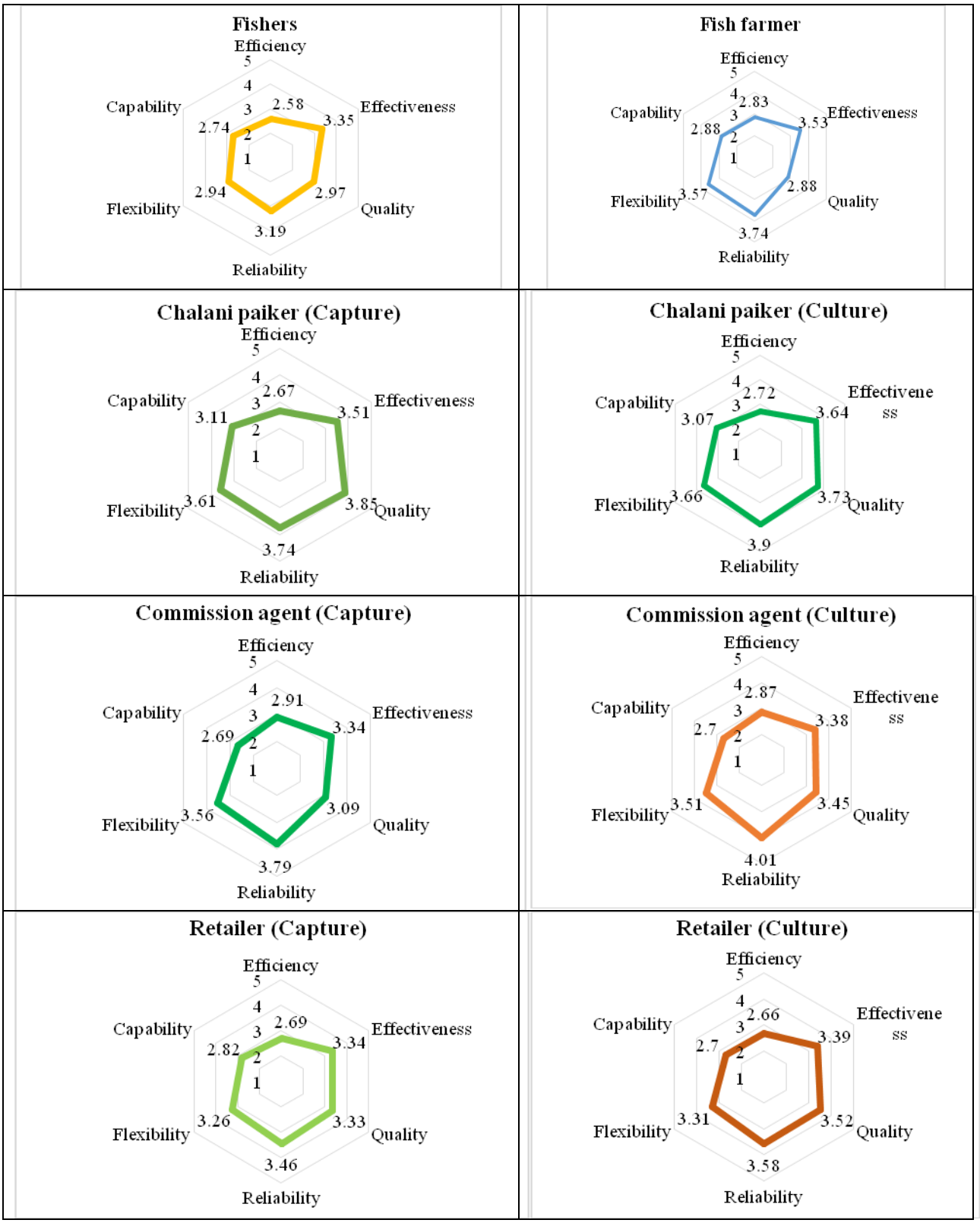


Fig 32. Supply chain performance indicators of different stakeholders.

Note: The score of 3 in the Likert question indicates a neutral attitude. The score which are larger than 3 reflects better performance and the score which are smaller than 3 reflects poor performance.

Similarly, the study evaluated the stakeholders' trustworthiness on sellers and buyers. The result showed that the trustworthiness on seller and buyers are sufficiently good. The fishers and fish farmers trust their buyer, especially the commission agent and *chalani paiker*. It is because the commission agent and *chalani paiker*follow their commitment to the fishers and fish farmers and vice-versa. Besides, the trustworthiness enhances due to the long-term transaction among the stakeholders. For example, they do not cheat with each other. Thus, trustworthiness improves the supply chain performance in the fisheries sector.

Flexibility

Flexibility is a vital part of measuring the supply chain performance among the stakeholders. The study considered some influential factors of flexibility which are shown in Appendix-I. These are whether the laborers are available or not during the peak and lean seasons, whether it is challenging to switch to other traders or not, transportation facilities, and whether it is not easy to enter the fish market for new traders or not. The results reveal that the overall performance of these factors of flexibility is satisfactory. It was observed that the hired labor by stakeholders during the lean season is available. During the lean season (December to June), the volume of fish supply was limited because of less catching fish by the fishers. In the case of fish farmers, they harvest limited fish from their pond during the lean season (December to February). In the lean season, the *chalani paiker*, commission agent, and retailer transact a lower amount of fish than the peak season. Therefore, the stakeholders do not need much labor in the lean season. As a result, the availability of labor is higher, even, the labor who engage themselves, especially for fish marketing activities, does not want to do the other works.

Further, the study evaluated whether the stakeholders could move from one to another for buying and selling their fish. The study observed that except fisher,other stakeholders cannot easily move from one to another for the fish transaction. Because the fish farmer, *chalani paiker*, commission agent, and retailer are linked in the management system at the backward and forward point for buying and selling the fish. In most cases, they are involved in contractual and relational management systems for the transaction of fish. The contractual management varied, such as verbal and written format. Therefore, they do not move easily from one to another. On the other hand, most of the fisher is linked with a not-manage system. They are not bound to sell the fishes to the same buyer. They change the buyers when they get lower market price from the buyer. So, they can sell the fishes to different buyers as their wish.

Capability

Capability is also another important indicator to assess supply chain performance. Six (6) items of capability are taken to consider the supply chain performance shown in Appendix Table-I. The overall performance of stakeholders on capability is not satisfactory yet. However, the results reveal that the stakeholders are pleased with the supply of fish according to the need. It is because of linking with each other of the stakeholder. The buyers contact the seller in advance for the required quantity of fish. For instance, sometimes, the fish farmers are confirmed by the *chalani paiker* and commission agent in advance. They fix a specific time locally named *haat bar* (the day of a week when market setting is arranged) for the transaction of fish. On that day, farmers provide required quantity.Furthermore, the road and transportation facilities and the equipment facilities tend to help to deliver the required quantity of fish of the stakeholders to the respective customer. The study also assesses whether the business scope accelerates or not. In

this case, except for the fisher, a satisfactory response was measured for all stakeholders who buy and sell the capture, culture, and fishes. The skill for doing the business, strategy, behavior, and the market environment promotes the stakeholders' business scope except fisher. It mainly happened because of their financial crisis, which was reported by the fisher during the survey.

Furthermore, the poor performance of supply chain actors was observed during the survey. The study revealed that the stakeholders cannot store the unsold fishes for the next sale because of their insufficient storage facilities.As a result, despite having high-quality fish, they have to sell fish at a lower price. Thus, the performance of the supply chain affects inversely.

11.2.9.2 Supply chain performance at market level

The study exposed how the performance indicators are associated with the different market arrangements for trading the inland fish (Fig 33). We identified four different markets: the spot market[17], relational market[18], contract market[19], and co-operative market. The products are exchanged between multiple buyers and sellers at a given time in a fixed place at the spot market. On the other hand, a written or verbal agreement between seller and buyers at a given time occurs in the contract market. However, the concept of the relational market is quite different, where the products are exchanged between buyers and sellers based on their relationship, regular purchase from the same seller make such kind of relationship. The co-operative market is a dynamic type of market, where sellers trade their fish to the buyers to meet their common goal in a certain period. The members of farmer's co-operative market lease in the government property and enjoy as common property for all members as well as get benefited from this. It was observed from the study that the comprehensive performance of effectiveness, quality, reliability, and flexibility are good in the entire market arrangement. Besides, the overall efficiency and capability score indicate the poor performance of the market arrangements. However, the indicators of measuring supply chain performance are illustrated below:

Efficiency

The respondents were asked whether they can sell the fish without fixed buyers or not, whether they consult with other traders or not and whether they are able to sell the fish at the right time. In addition, the study investigated that whether they are able to reduce the labor, transportation, and processing cost or not. These important factors were considered to leverage the overall efficiency, one of the elements of measuring the supply chain performance. The study reported that the overall mean score of efficiency is poor in the different markets for the transaction of capture and culture fishes. Therefore, the performance was not gratifying to the different market arrangements. It is evident from the result that the respondents (actors) were often able to sell the fish through all market arrangementsbecause of their convincing power. Except for the spot market, consulting with successful fish traders in contract, relational and co-operative market increases the business performance. The buyers and sellers are not familiar with each other in the spot market arrangement, like other market arrangements. Therefore, they do not get the proper counsel from the other. In addition, the actors were not able to sell their fish at the right time.

[17] Spot market: means where the fishes are exchanged between multiple buyers and sellers at a given time.
[18] Relational market: means the market in where the fishes are exchanged between buyers and sellers based on their relationship.
[19] Contract market: means a written or verbal agreement of seller's output with their buyers in a given time.

During the peak season, the supply of fish is excessive in the market, but the volume of fish transaction is large compared to the buyers. Therefore, the transportation facilities are fragile during the peak season. As a result, the sellers cannot sell their fish at the right time. The results affirmed that the sub-indicators, i.e., labor, transportation, and processing costs, are relatively low; thus, they are forced to shrink the overall mean efficiency score. The labor cost was higher because the actors had to pay higher wages for efficient labor. The transportation cost was higher for carrying minimum volume of fish. In addition, the price of the necessary equipment for processing and packaging the fish was also higher. Therefore, the actors faced higher costs for buying and selling the fishes. The results observed that the seller in the spot and co-operative markets require better ability to routinely transact the capture and culture fish because regular buyers usually purchase from contract and relational markets. However, irrespective of the market type, appropriate attention on business consultation and suitable time to fish sale must be in place to augment the efficiency of fish sellers. The study further suggests for selling the fishes timely and need intervention to reduce transportation costs for transacting the capture, and culture fishes in all marketing arrangements.

Effectiveness

The effectiveness comprises of several factors in the different market arrangements, including market competitiveness, modern facilities, avail the expected price and profit, and punctuality of hired labor. The findings indicated that higher market competitiveness prevails in all the markets of capture and culture fishes since multiple sellers tried to captivate buyers to trade their fishes, bringing the market competitiveness. However, sellers in the spot market do not get the expected price when the challenges of shortage buyers endure. It was also a typical phenomenon in all other markets since the market price supported the theory of demand. In addition, oversupply was a significant problem for all the market arrangements. This was because the customers make their presence to purchase fish, but when they find ample scope to negotiate the price with multiple sellers, then the asking price is dropped significantly. In addition, the punctuality of the hired labors was at satisfactory level to the trader in all market arrangements.

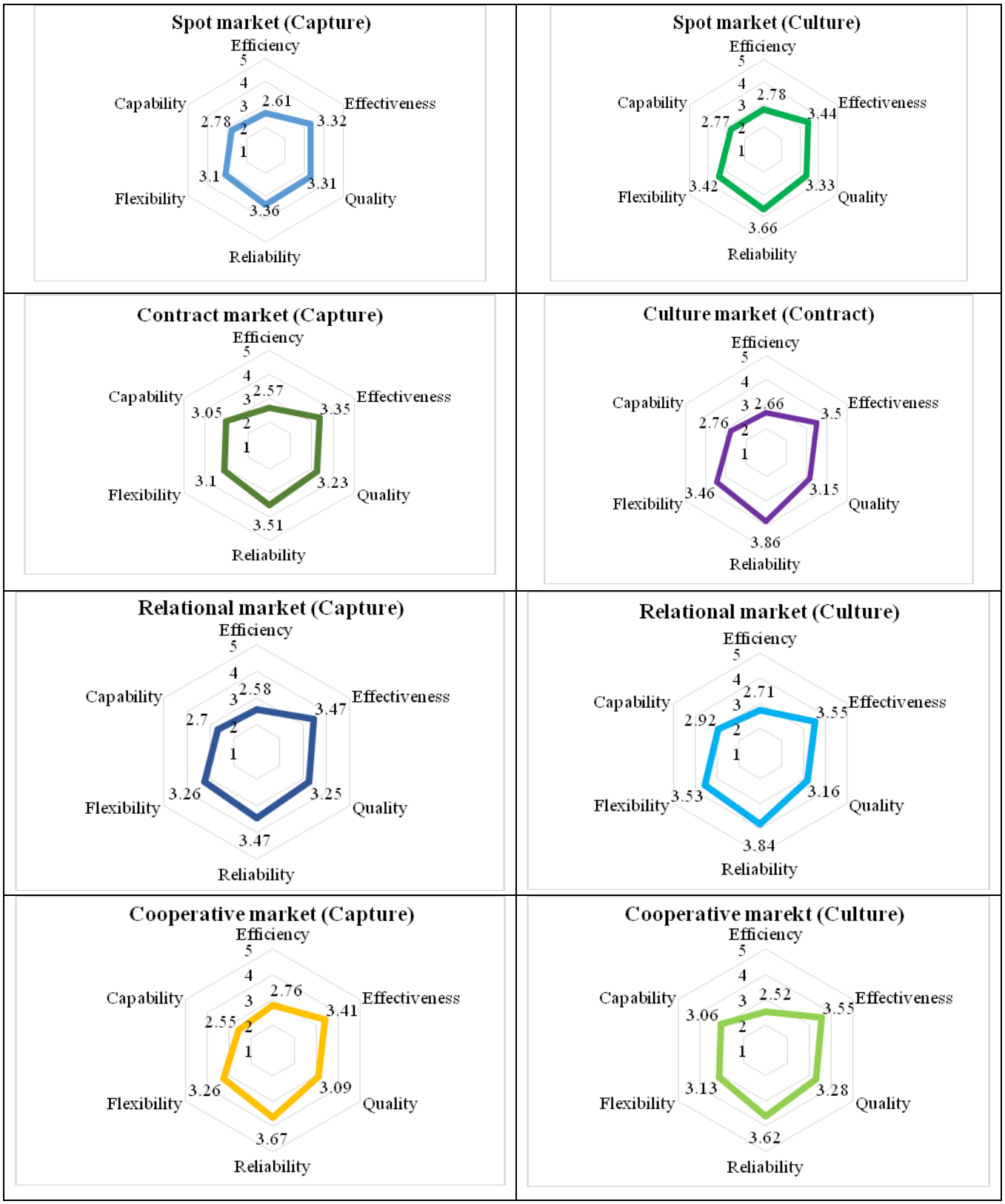


Fig 33. Supply chain performance indicators at different markets.

Note: The score of 3 in the Likert question indicates a neutral attitude. The score which are larger than 3 reflects better performance and the score which are smaller than 3 reflects poor performance.

Quality

Quality is another vital factor of measuring the performance of different markets. The overall mean score of quality was satisfactory across all market arrangements. The study reported that the factors of measuring quality, i.e., trading fish in an eco-friendly place, sufficient electricity facilities, use of good quality ice, the quality judgment, and trading live fish are satisfactory across all the market arrangements. But the quality judgment and trading live fish was more satisfactory across the market arrangements. Their perceptiveness of identifying the good or bad quality fishes was excellent due to the higher discretion. Fish trading experience was another crucial factor in judging whether the fish was good in quality or not. Transaction of live fish was in favorable condition across all market arrangements. During the field survey, the customers (buyers and sellers) were willing to buy and sell the live fish compared to the other form.In the case of contract market, the buyers and sellers were settled in an arrangement for transacting the fish as their pre-agreement. Therefore, they can easily transact the iced fish. Similarly, the actors were able to sell the iced fish in terms of the relational market because of their long-term bonds with the fellow actors. In the case of spot and relational markets, the buyer and seller try to avoid transacting the iced fish. Because these market arrangements were not like the contract and relational market. The actors of the spot and co-operative market were willing to sell live fishes instead of iced. However, a poor condition was observed in terms of using the insulated containers across the markets because of actors' apathies to use an insulated container. They do not use insulated containers since it was expensive and primitive. In contrast, there was lack of insulated containers for marketing the fish.

Reliability

The reliability measurement is entirely based on the information about market supply, demand, price, and labor. Besides, it also encompassed the trustworthiness of buyers, sellers and trading of disease-free fish. The mean score of reliability was comparatively superior for culture fish transactions in the contract market than other markets. Because the actors of this market settle an agreement for the transaction. Therefore, the buyers and the sellers became transparent to transact the fish compared to the other market arrangements. The reliable information about the market condition may bring confidence to sellers' mind which ultimately affect the performance. However, the information on supply, demand, price, credited money, and trustworthiness was gratified in all the market arrangements. Also, the transaction of disease-free fish was satisfactory to the markets. If the disease-affected fish are traded in the market, that may affect the future business activity of sellers. In this sense, the issue of trustworthiness raised among the market participants. If trustworthiness and integrity prevail among buyers and sellers, then the fish sale on credit happens.

The overall reliability score rises along with the performance of markets. It is noticeable from the findings that hired labor was not sincere in the spot market for the transaction of capture, culture, and both sources of fishes. Usually, spot market sellers transact fish by themselves without hiring much labor. The perception was that the hired labor plays a poor role in fish trading, even higher wage paid to them.

Flexibility

The study investigates some factors of measuring flexibility as an indicator of supply chain performance (Appendix-J). Although the overall scenario of flexibility was satisfactory, a few

indicators of flexibility were dis-satisfactory. The study revealed that, except for the contract and relational market for only the transaction of culture fish, the transportation facilities during excess supply were poor in spot and co-operative markets. In the contract and relational market arrangement, the actors were benefited from each other. For instance, the sellers provide vehicles to the buyers for carrying a large volume of fish. But the actors involved in buying and selling the capture and both sources (capture and culture) of fish also fall in a challenging situation in case of getting the transportation facilities on the spot and co-operative market arrangements. This is because the responsibility or friendly relations between buyers and sellers were not maintained in this type of market arrangement.

Furthermore, it was asked to the respondents whether the laborers were available or not during the peak season. The results revealed that the laborers are available in all market arrangements during peak season. It was because the actors pay higher wages to the laborers. In addition, some fisheswere given to the hired labor for their household consumption as an extra benefit. Thus, the availability of labor affects the flexibility and the performance of the supply chain.

Capability

The factors of measuring capability in all market arrangements are shown (Appendix-J).The study examined whether these factors affect the supply chain performance or not among the market arrangements. The results revealed that the overall performance of capability was not satisfactory. However, the study observes that the sellers were able to supply the required quantity of fish to the buyersduring the peak season. The business scope of actors was also accelerated in the contract and co-operative market due to its transaction nature. In addition, the volume of capture fish transactions was not satisfactory in the case of spot, contract, and relational markets except co-operative market arrangement. The study reported that the co-operative business was found among the fisher, fish farmer and retailer where co-operative members can easily manage the marketing technique, i.e., harvesting, processing, packaging, and selling. On the other hand, the stakeholder who buys and sells fishes in spot, contract, and relational market arrangements cannot perform alike.

Furthermore, the study investigated whether the actors were able to store the unsold fishes in the different market arrangements. It was found that the actors were not able to store the unsold fishes because of their insufficient storage facilities. Further, the study examined whether the actors fall into a financial crisis or not. The results indicated that the actors often face financial crisis for doing their business. They faced financial crisis during the large volume of fish transactions. Also, the marketing cost (i.e., transportation cost, market toll and so on)was much higher nowadays. In this situation, they take loan at high interest from the moneylender. As a result, they cannot run their business smoothly. Thus, the factor hampers the supply chain performance among all market arrangements.

11.3 Value chain analysis

11.3.1 Introduction

To many people, 'value chain' is an interchangeable term of the 'supply chain' (Min, 2015). They use similar terminology but have different implications in understanding the business situation. However, the value chain analysis assists a business to discern how it adds value to every stage of the chain and subsequently how the business can trade its product and service for higher than the value-added cost, thereby provoke a profit margin. Moreover, value chain analysis has scrutinized and figured out the value addition from specific products or services of a particular business or within firms (Zamora, 2016). The purpose of this chapter is to provide a brief outlook of value chain analysis frameworks for different species of capture, culture, and marine fishes in order to identify the most efficient chain.

11.3.2 Value Chain Mapping

Value chain mapping is a process of illustrating all the activities involved in a product supply chain, including actors' performance at each level (Mooney, 2014). For example, in the fisheries sector (capture, culture, and marine), multiple actors at different stages are involved in the efficient supply of captured or cultured fishes from the source to consumer plate. Quantitative value addition identification of different fish species (inland and marine) at multiple stages would contribute at the policy level.

11.3.2.1 Value chain mapping of carp fishes

In the whole value chain of Rui fishes (Appendix box 1), between the fish farmer (source) and consumer (end), four active market participants were involved, i.e., wholesaler (*bepari*), *aratdar* (commission agent), wholesaler (*paikar),* and retailer. Three major value chains of Rui fishes were identified comprising these market actors, as illustrated in Fig 34. Through these chains, approximately 71% of total Rui fish sales take place in Bangladesh. Wholesaler (*bepari*) and *aratdar* (commission agent) are the primary link in the value chain with fish farmers. In this regard, fish farmers sell about 60.73% and 39.27% of their Rui fishes to *aratdar* (commission agent) and wholesaler (*bepari*) at BDT 176.65 and 160.68//kg, respectively. First, wholesalers (*bepari*) sell the fish to *aratdar* (commission agent) at BDT 186.14/kg. Then, about 69.21% of fish of *aratdar* (commission agent) is sold to another wholesaler (*paikar*) at BDT202.69/kg, which they again sell to retailers for BDT 215.09/kg. Then, *aratdars* (commission agent) sell the rest of the fishes directly to retailers at BDT 219.52/kg. Finally, consumer purchases carp fishes at BDT 275.83/kg from retailers. As identified here, the value chain of Rui fishes indicates that around 1.63 times value addition took place in the process (from fish farmers to consumers) in the monetary value.

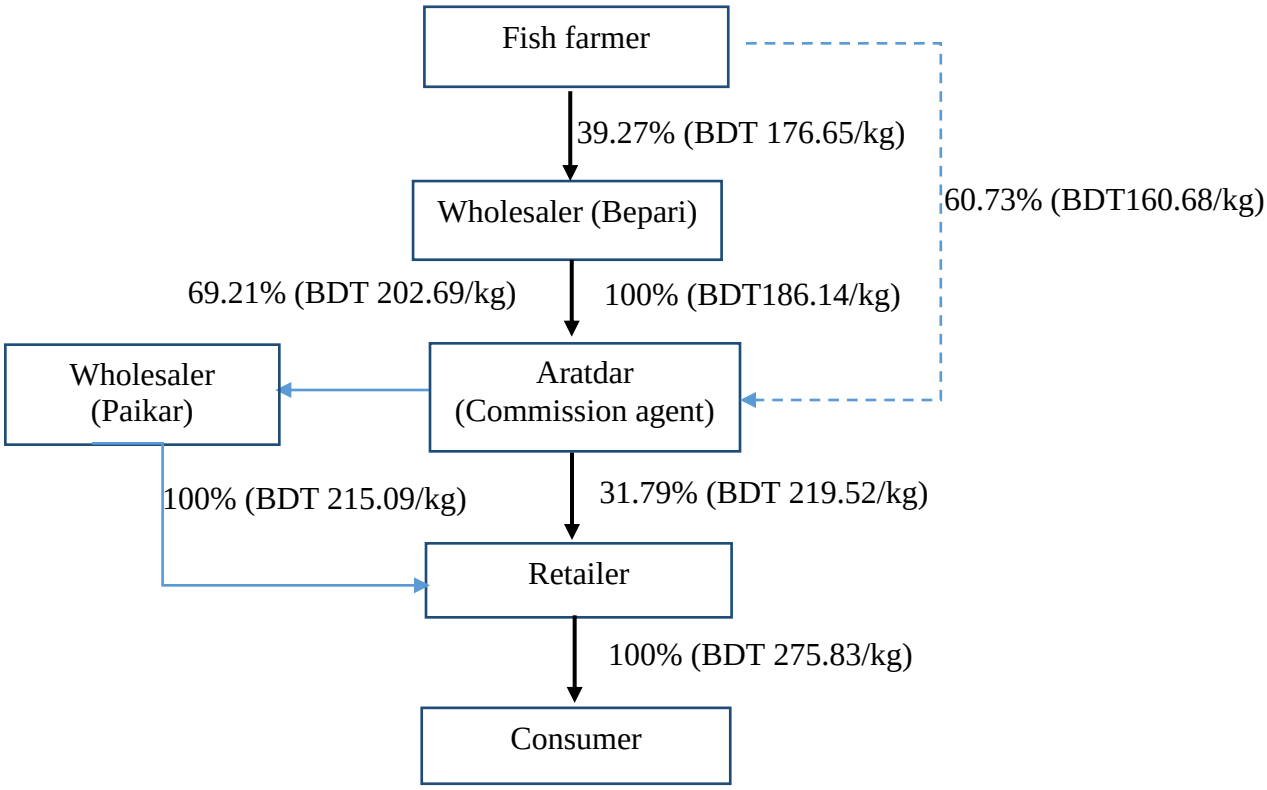


Fig 34. Value chain of Rui fishes in Bangladesh.
Note: The value in the parenthesis indicates the selling price (BDT/kg) of each market participant.

11.3.2.2 Value chain mapping of Pangas

Value chain mapping of Pangas appears to have different market participants, i.e., local agent (*faria*), *aratdar* (commission agent), wholesaler (*paikar)*, and retailer in between fish farmer and consumer (Appendix box 2).The principal value chain of pangas includes local agent (*faria*) and *aratdar* (commission agent) as the primary linkage in the process. Fig35 demonstrates that approximately 68.17% of total Pangas fish sales in Bangladesh occurred through these top three channels.

Of the total Pangas fishes, 24.61% reached to *aratdar* (commission agent) indirectly through local agents (*faria*)at BDT 99.82/kg, and the remaining 75.39% of Pangas fishes were sold directly to them by fish farmers (at BDT 93.88/kg). *Aratdars* (commission agent) is the central player of the value chain process who sold a substantial portion of their purchased fishes (63.75%) to the wholesaler (*paikar*), which again transacted to retailers at a higher price (BDT 119.89/kg). Contrarily, retailers can purchase at a lower (BDT 112.45/kg) from *aratdars* (commission agent) directly than wholesalers (*paikar*). Consumers purchased the Pangas fish at the local market for BDT 133.64/kg, which was 1.49 times higher than the farmer's price. For Pangas, the value addition takes place at different market actors at different rates.

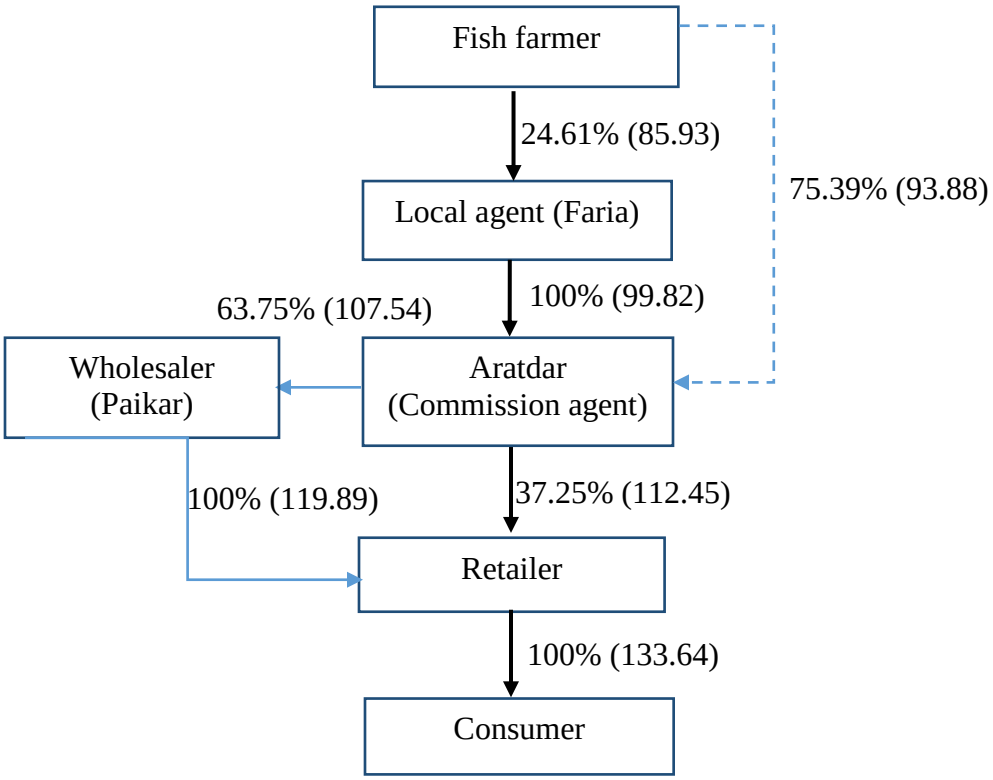


Fig 35: Value chain of Pangas in Bangladesh.
Note: Figures in the parenthesis indicates the selling price (BDT/kg) of each market participant.

11.3.2.3 Value chain mapping of inland Shrimp

Freshwater shrimp is widely available in the markets of Bangladesh, and the supply is well ensured by fishers or fish farmers along with other intermediaries (i.e., local agents, wholesalers, commission agents, and retailers) (Appendix box 3). The supply takes place in different channels, but three prominent channels are presented in Fig 36. Approximately 67% of the total shrimp sale took place materialized through illustrated channels. Of the total shrimp sale, *aratdar* received 72.5% directly from fish farmers and/or fishers, while over a quarter (27.5%) was accumulated through local agents (*faria*). In direct selling to *aratdars*, farmers and fishers get benefit as they can sell at a higher price (BDT 484.51/kg), but *aratdars* have a low-cost advantage in the indirect purchase through local agents (BDT/kg 475). At this stage, *aratdar* (commission agent) sold most of their Shrimp (68.75%) directly to retailers at BDT 487.27/kg, and the remaining quantity was sold to wholesalers (*bepari*) at BDT 491.69/kg. However, wholesalers (*bepari*) sold to retailers at BDT 525/kg. Finally, consumers bought shrimp from retailers at BDT 550/kg from their local markets.

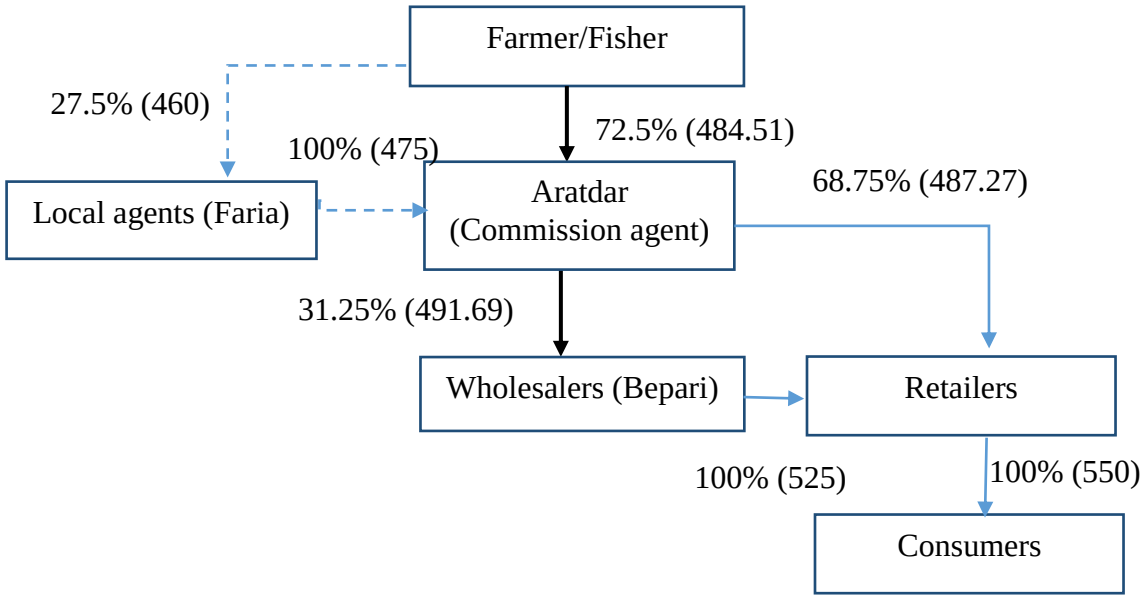


Fig 36. Value chain of Shrimp (inland) in Bangladesh.
Note: Value in the parenthesis indicates each market participant's selling price (BDT/kg).

11.3.2.4 Value chain mapping of Hilsha (inland)

Inland or freshwater Hilsha has upward demand across the country and internationally because of its flavor, palatability, and shiny appearance. (Wahab *et al.*, 2019; Haldar *et al.*, 2004). Among all the available channels of Hilsha (Appendix box 4) across the country, the top three value-adding channels were illustrated in Fig 37. These three value chains encompass information regarding Hilsha sales in Bangladesh. Firstly, fishers sold 58.75%, 15.75%, and 25.5% of their total catch to wholesalers (*aratdar*), wholesalers (*bepari-1*), and *aratdar* (commission agent) at BDT 553.04, 550, and 567.81/kg, respectively.

Wholesalers (*aratdar*) sold their fish to the wholesaler (*bepari-1*) at BDT 571.25 per kg, who again sold their fish to *aratdar* (commission agent) at BDT 585.74 per kg. Then, *aratdars* (commission agent) sold 72.5% of the Hilsha to wholesalers (*bepari-2*) at BDT 593.29 per kg, who actually covey fishes from one district to another. They sold the rest of the fish to retailers at BDT 609.91 per kg. Wholesaler (*bepari-2*) again sold their Hilsha to retailers at BDT 611.25 per kg. Finally, consumers purchased Hilsha from retailers at BDT 648 per kg. However, it is worth mentioning that this average price of Hilsha fish includes all available graded fish, irrespective of size. So, the average price may not reflect the actual market price of larger-sized and medium-sized (graded) Hilsha.

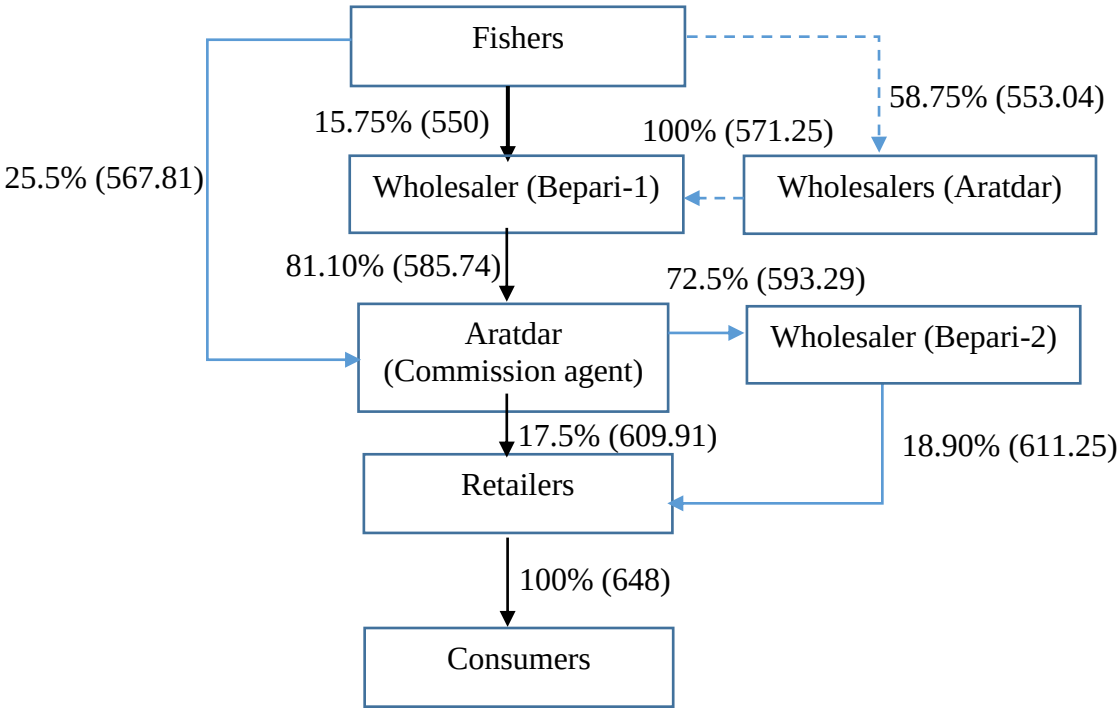


Fig 37. Value chain of Hilsha (inland) in Bangladesh**.**
Note: The figures in the parenthesis indicate the selling price (BDT/kg) of each market participant.

11.3.2.5 Value Chain Mapping of Bombay Duck (Lottiya)

Among the various marine fish species, Bombay duck is important, especially for its dried item. This fish is transported to different parts of the country through several marketing channels. The marine fish marketing system is traditional and complex. Still, it plays a vital role in connecting the fishers and consumers, where consumers have to depend on an effective fish marketing system to get fresh fish at the quickest possible time (Chowdhury, 2004). Major value chains of Bombay duck were identified and presented in Fig 38. It is evident that, fishers sold 76% and 24% of the Bombay Duck to raw fish *aratdars* and dry fish processors, respectively, at an average of BDT 66/kg. Raw fish *aratdars* sold most of the fishes (82.89%) at BDT 66/kg to dry fish processors indirectly through raw fish wholesalers who sold at BDT 71 per kg, whereas the direct selling price was at BDT 70 per kg.

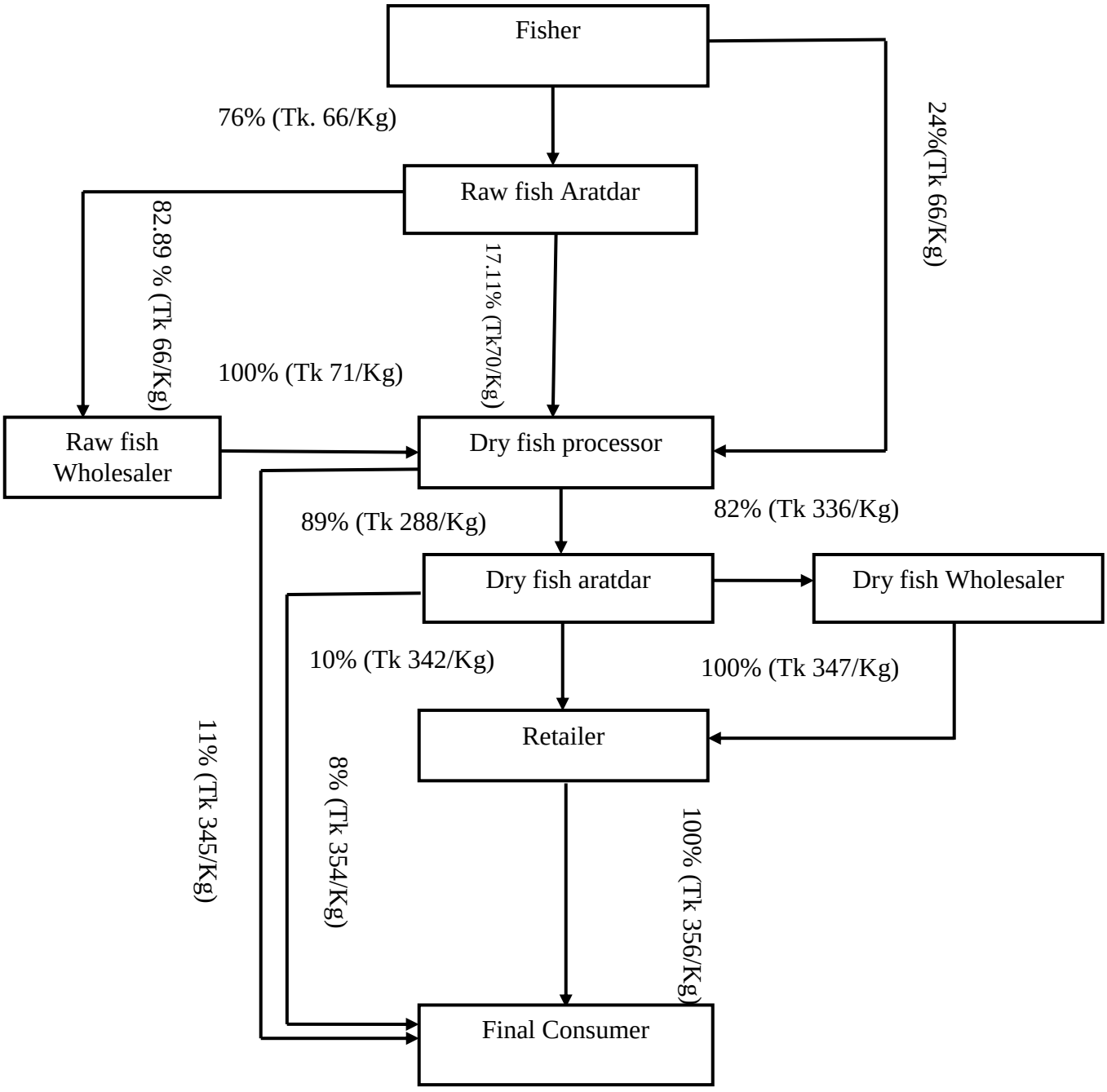


Fig 38. Bombay duck value chain mapping.
Note: The value in the parenthesis indicates the selling price (BDT/kg) of each market participant.

It is evident that dry fish processors buy Bombay duck from wholesalers as they purchase in bulk. However, some of the predetermined fishers and *aratdars* who can supply fish directly at an enormous stock. However, the processors are primarily involved in adding value to dried Bombay duck by transforming it into dried products. The Bombay duck processing sector quickly turns into an emerging industry in the study areas due to abundant production (in the

rainy season), low price, and easy drying method. Compared to frozen fish marketing, dry fish marketing incurs more costs since the fishes are being marketed dried up and processed to sell it in good and hygienic condition. After processing, processors sell the dried Bombay duck to dry fish *aratdars* at BDT 288 per kg, around 89% of their products. The rest (11%) are sold directly to consumers at BDT 345 per kg. These consumers might purchase Bombay duck in larger volume, which could be restaurants or spot consumers. Retailers purchase dried Bombay duck at an average price of BDT 345.5 per kg. However, *aratdars* often perform a direct transaction with some retailers (10%) and consumers (8%), and in most cases, they are spot consumers and retailers who have a business rapport with the *aratdars*.

11.3.2.6 Value chain mapping of marine Hilsha

In the southern part of Bangladesh, marine Hilsha is a vital source of income and cultural identity. The mapping of the major value chain of marine Hilsha is illustrated in Fig 39. Approximately 88% of the total marine Hilsha fish in Bangladesh flows in these channels. Fishers are the primary producers or suppliers in the Hilsha value chain.Fishers tend to sell their fish as soon as they land, primarily to pre-agreed contracts with intermediaries like *aratdars*. After harvesting, fishers sell most (88%) of their Hilsha to *aratdars* at BDT 640 per kg, mainly to wholesalers. Wholesalers distribute the Hilsha to retailers (73%) from different locations at BDT 658 per kg.They also sell some fish (9%) directly to consumers at BDT 666 per kg. These are mainly the spot consumers. However, fishers sell 1% of the Hilsha directly to processor (freezing) and processor (salting) at BDT 666 and 286 per kg, respectively.

Low-quality Hilsha fishes are sold to processors (salting) after sorting out at a lower market price. Lastly, approximately 9% of the Hilsha flows to suppliers/brokers from fishers at BDT 679 per kg, and ultimately reaching to exporters at BDT 706 per kg. The exporters usually collect good quality exportable bigger size (at least 1 kg/fish) Hilsha fish. According to customs guidelines, the quality of Hilsha is maintained; hence fishes were traded at a higher price. Before exporting, the quality of the fish is tested by the Department of Fisheries (DoF) Fish Quality Control (FQC) laboratory and should fulfil the criteria set by intending country's quality control criteria and regulatory bodies (Porras et al., 2017).

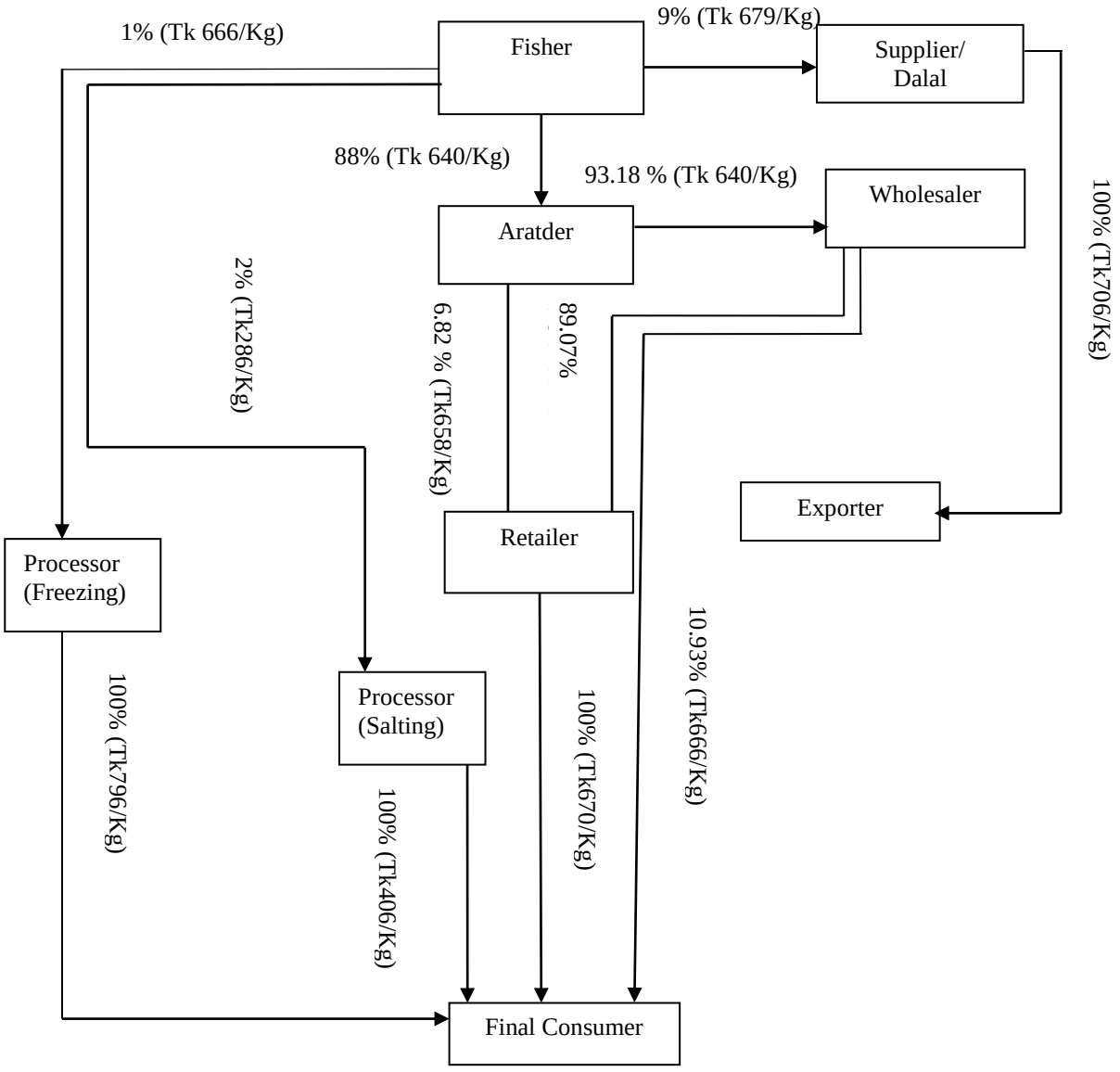


Fig 39. Marine *Hilsha* value chain mapping.
Note: The value in the parenthesis indicates the selling price (BDT/kg) of each market participant

11.3.2.7 Value chain mapping of marine Shrimp

Both inland and marine Shrimp are the leading exportable products in Bangladesh. Almost all the marine Shrimp harvested in Bangladesh are transacted through market actors, as illustrated in Fig 40. Fishing vessels are required to harvest the marine Shrimp of both artisanal and industrial categories. After harvesting, they sell their catch to *aratdars* or depot owners or fish companies and local agents or account holders or commission agents at BDT 389 and BDT 398 per kg, respectively (Fig 40). Large-sized and good-quality shrimps are collected by processing plants from local agents, account holders, or commission agents at BDT 410/kg. *Aratdars* or depot owners or fish companies sell most of the Shrimp (73%) to wholesalers at BDT 428.5 per kg,

and they consecutively sell to retailers at BDT 658 per kg. *Aratdars* or depot owners or fish companies also sell a portion (11%) of good quality exportable more giant shrimps to processing plants at the same price.

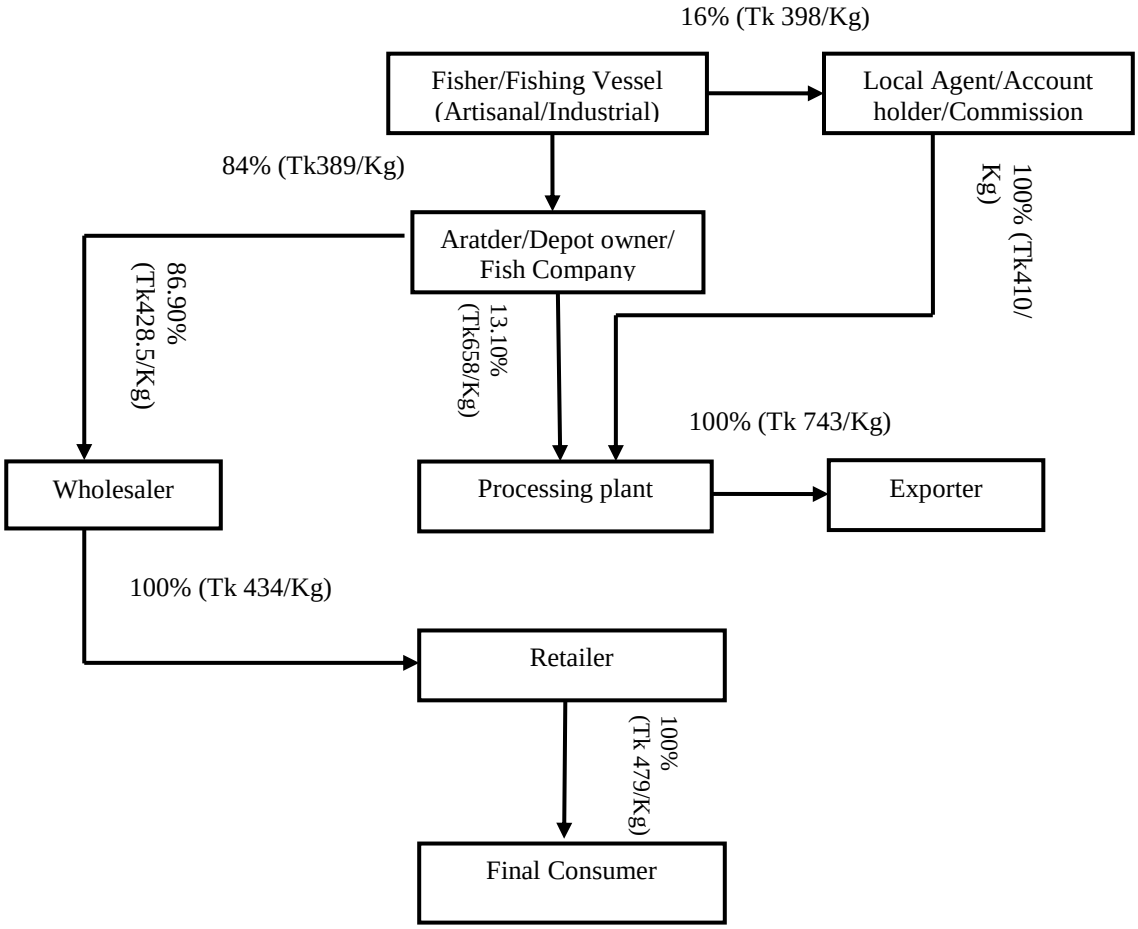


Fig 40. Marine shrimp value chain mapping.
Note: The value in the parenthesis indicates the selling price (BDT/kg) of each market participant

In contrast, processing plants export marine Shrimp abroad at BDT 743 per kg. Consumers buy marine Shrimp from retailers at BDT 479 per kg from their local domestic market. Shrimp is processed for exporting following Hazard Analysis and Critical Control Points (HACCP) procedures guided by EU and USA suggested traceability regulation. However, maintaining a traceability system is particularly difficult for Bangladesh due to many small-scale suppliers (farmers, *aratdar*, local agents, and commission agents) and their informal processing, which varies and also complex. Processor- need to conform the required compliance guidelines and get approval from both local and foreign buyers' representative quality checkers (Muzareba & Khondkar, 2019).

11.3.3 Marketing cost, profitability and value addition of inland and marine fisheries

Different costs are associated with varying stages for completing this process in the capture, culture, and marine fisheries sector. Marketing costs are considered as these costs are incurred to present all these fishes to the prospective customer in different forms (raw or processed). Therefore, the profitability of a fish sector refers to a situation where active participants in the marketing process can generate revenue from available production. Value addition is a form that usually takes place through actors involved in the marketing channel. Every market participant in the fisheries sector aims to add value to the fish and sell at higher prices.

11.3.3.1 Marketing cost of capture and culture fisheries at farm level

The cost items of capture and culture fisheries at the farm level are indicated in Table 22. The total marketing cost of capture and culture were estimated at BDT 41550.67/MT and BDT 21130.80/MT, respectively. Fish farmers or fishers incurred the highest marketing cost in both sectors by paying commission to *aratdars*, about 41.11% and 41.28% for capture and culture, respectively. *Aratdars*take commission of BDT 1 to 3 per kg from fish farmers and fishers after selling their fishes. Transportation cost is the second-highest cost for fish farmers, and they spend about 22.01% of their total marketing cost for them. However, the transportation cost for culture (BDT 4650.50/MT) was higher than capture fish (BDT 3132.29/MT). A large portion of the expenses is associated with the commission of local agent/*faria*/*dalal* (broker), which was about 9.80% shared by the fishers. Using ice for storing fishes for a particular time is crucial, and ice is the third most expensive item for both capture and culture fish, which were about 9.26% and 7.12%, respectively. Besides these, the cost of loading and unloading, market cleaning, personal expenses, hospitality cost for wholesalers or *bepari*, etc., are the important marketing costs for both capture and culture fishes.

Table 22. Marketing cost of capture and culture fisheries at farm level (BDT/MT)

Cost Items	**Capture**		**Culture**	
	Cost (BDT/MT)	**Share (%)**	**Cost (BDT/MT)**	**Share (%)**
Loading and unloading	1036.81	2.50	1364.01	6.46
Grading	482.41	1.16	371.82	1.76
Auction cost	542.79	1.31	329.92	1.56
Market cleaning cost	546.64	1.32	454.19	2.15
Mobile bill	456.34	1.10	177.58	0.84
Transportation cost	3132.29	7.54	4650.00	22.01
Commission of aratdar	17083.36	41.11	8722.69	41.28
Commission of Local agent/faria/dalal	4072.84	9.80	1010.24	4.78
Personal expenses	3146.62	7.57	443.85	2.10
Plastic/Bamboo basket	486.19	1.17	268.47	1.27
Water	993.77	2.39	209.19	0.99
Ice cost	3848.86	9.26	1503.63	7.12
Disinfectant materials	532.05	1.28	365.63	1.73
Hospitality cost for wholesaler or bepari	2711.94	6.53	609.20	2.88
Market tool/rent	702.20	1.69	68.86	0.33
Fisher cooperative cost	577.55	1.39	81.29	0.38
Other cost	1198.02	2.88	500.25	2.37
Total	**41550.67**	**100**	**21130.82**	**100**

11.3.3.2 Profitability of capture and culture fishery at farm level

The gross return, fixed cost, variable cost, marketing cost, and profitability of both culture and capture fisheries are presented in Table 23. The gross return of capture and culture fisheries in Bangladesh is BDT 360790 and BDT 202100 per metric ton. Of the total cost per ton in capture (BDT 170010/MT) and culture (BDT 136778/MT) fisheries, fixed costs were BDT 25458.79 and 26182.34 per metric ton, and variable costs BDT 103000.14 and 89464.59 per metric ton, respectively.

Table 23. Profitability of capture and culture fisheries (BDT/MT) (considering all species).

Items	Capture	Culture
Gross return	360790	202100
Fixed cost	25459	26182
Variable cost	103000	89465
Marketing cost	41551	21131
Total cost	170010	136778
Profitability	190780	65322
BCR(Full cost basis)	2.12	1.48

After incurring the marketing cost of BDT 41550.67 and 21130.8 per metric ton for capture and culture fisheries, the estimated profit gained BDT 190780.40 and 65322.27 per metric ton from capture and culture fisheries, respectively. It indicated that the fishers of capture sector get higher profits than the fish farmers of culture fisheries. Obtaining higher average price of capture fish might be the reason behind higher profit. Besides, the capture fishes have greater market demand over the culture fisheries. However, the average price includes all species irrespective of high-valued and low-valued fish species.

11.3.3.3 Marketing cost of traders in capture and culture fisheries

The most common market actors in inland fish marketing channels are the local agent (*faria*), wholesaler (*bepari*), wholesaler (*paikar*), wholesaler (*aratdar*), *aratdar* (commission agent), retailer, and exporter. The marketing costs of these traders are illustrated in Table 24.

Local agent (faria)

Local agents (*faria*) act as intermediaries between farmers/fishers and wholesalers (*bepari)* and usually perform within the district. They sell the fish of farmers/fishers to wholesalers in different markets and derive a commission on the sold prices. During the process, local agents incur some marketing costs. Their total marketing cost incurred was estimated at BDT 2486.25 per ton. They spend the highest portion on labor purposes (BDT 901.15/MT), 36.25% of their total marketing cost. During the fish transaction, some labor is needed for wholesalers (*beparies),* usually involved in packaging, cleaning the office or market space. Other significant expenses include transportation and ice, which were 20.29% and 14.64% of their total marketing cost, respectively. In addition, local agents have some other expenses such as rent of office/market space (4.01%), personal expenses (4.66%), mobile bills (1.22%), cost of water (3.49%), cost of weighing scale (3.65%), miscellaneous cost (2.07%). However, wholesalers often pay a certain amount of commission to the local agents for negotiating prices with the fish

farmers, which affects the pricing of fish. Sometimes, local agents act as selling agent where the farmers/fishers bear all the expenses.

Wholesaler (Bepari)

Wholesaler (*bepari*) is one of the inter-district intermediaries who buy fish from farmers/fishers, local agents (*faria*), or commission agents of one district and sell to wholesalers or retailers of another district. Their two most marketing cost items are commission to *aratdar* (32.67%) and local agents/*farias*/*dalal*(broker) (15.87%). *Beparies* usually sell or buy their fish through commission agents and local agents who take the commission for arranging the wholesaler or retailer of another district. Besides, they spend 9.97% and 9.05% of their marketing costs on permanent labor and ice. The transportation cost incurred by the *beparies*was BDT 1272.40/MT which was 7.59% of the total marketing cost. Some other expenses, including temporary labor (5.07%), loading and unloading (5.22%), market rent (1.98%), personal expenses (1.93%), cost of weighing machine (1.49%), are associated with the process. The total marketing cost of wholesalers (*bepari*) is BDT 16774.6 per MT, the second highest among all traders.

Wholesaler (Paikar)

Like wholesaler (*bepari*), wholesaler (*paiker*) is another intra-district intermediary actor who purchase fishfrom farmers/fishers, local agents (*faria*), or commission agents and sells fishes to other wholesalers or retailers within the same district. Wholesaler (*paikar*) mainly deals with the commission agents, and this leaves them with the highest cost per MT (BDT 2873.16), which comprise 31.88% of the total marketing cost (BDT 9013.44 per ton). Following the commission payment, *paikars* have to pay an average transportation cost of BDT1879.95 per ton (20.86%). For effective buying and selling, some permanent labor get involved by them. Labor salary covered 11.45% (BDT 1032.07 per ton) of the total marketing cost. Cost of ice (8.42%), loading and unloading cost (4.26%), grading cost (5.62%), temporary labor use cost (5.43%), personal expenses (2.24%) were other expenditures of wholesalers (*paikar*).

Table 24. Structure of marketing cost of different traders (BDT/MT) in fish marketing

Cost components	Local Agent (*Faria*)		Wholesaler (*Bepari*)		Wholesaler (*Paikar*)		Wholesaler (*Aratdar*)		*Aratdar* (Commission Agent)		Retailer		Exporter	
	Tk./ton	%	Tk./ton	%	Tk./ton	%	Tk./ton	%	Tk./ton	%	Tk./ton	%	Tk./ton	%
Labor														
Permanent	0.00	0.00	1671.61	9.97	1032.07	11.45	2207.06	22.52	792.30	12.99	1322.27	22.56	1606.06	8.36
Loading and unloading	0.00	0.00	875.56	5.22	384.20	4.26	870.18	8.88	712.98	11.69	242.60	4.14	9.50	0.05
Grading	0.00	0.00	178.83	1.07	506.37	5.62	0.00	0.00	442.31	7.25	0.00	0.00	0.00	0.00
Others labor cost	901.15	36.25	849.97	5.07	489.34	5.43	1692.02	17.27	474.35	7.78	241.75	4.12	915.16	4.76
Rent of office and storehouse	99.63	4.01	234.89	1.40	149.59	1.66	326.49	3.33	161.14	2.64	276.53	4.72	221.72	1.15
Electricity bill	35.70	1.44	53.12	0.32	53.85	0.60	115.09	1.17	30.98	0.51	73.21	1.25	1486.90	7.74
Mobile bill	30.25	1.22	76.69	0.46	57.43	0.64	114.29	1.17	42.80	0.70	44.86	0.77	773.24	4.02
Market tool/rent	49.58	1.99	332.20	1.98	160.87	1.78	533.19	5.44	353.27	5.79	150.03	2.56	51.47	0.27
Transportation cost	504.41	20.29	1272.40	7.59	1879.95	20.86	717.80	7.32	2116.77	34.71	634.28	10.82	5104.37	26.56
Commission of Aratdar	31.57	1.27	5479.89	**32.67**	2873.36	31.88	0.00	0.00	0.00	0.00	1672.25	28.53	1216.28	6.33
Commission of Local agent/faria/dalal	0.00	0.00	2661.77	**15.87**	0.00	0.00	0.00	0.00	22.60	0.37	235.79	4.02	3639.47	18.94
Personal expenses	115.76	4.66	324.01	1.93	202.29	2.24	587.46	5.99	177.69	2.91	251.35	4.29	1397.92	7.27
License cost	5.63	0.23	15.34	0.09	7.63	0.08	7.91	0.08	6.57	0.11	15.44	0.26	50.67	0.26
House preparing/repairing	28.08	1.13	118.91	0.71	27.67	0.31	171.37	1.75	18.93	0.31	21.45	0.37	277.48	1.44
Ice cost	364.08	14.64	1517.59	9.05	759.12	8.42	1559.36	15.91	548.56	8.99	350.33	5.98	285.07	1.48
Plastic bamboo/ basket	70.27	2.83	128.01	0.76	52.54	0.58	59.25	0.60	36.48	0.60	28.82	0.49	1730.05	9.00
Water	86.67	3.49	205.88	1.23	57.25	0.64	90.16	0.92	34.97	0.57	64.46	1.10	0.00	0.00
Security	12.33	0.50	41.41	0.25	12.29	0.14	17.99	0.18	9.36	0.15	25.75	0.44	7.13	0.04
Disinfectant cost	8.99	0.36	99.88	0.60	20.01	0.22	29.34	0.30	9.10	0.15	18.83	0.32	0.00	0.00
Other machine (Weighting scale)	90.74	3.65	249.59	1.49	172.02	1.91	556.49	5.68	45.82	0.75	44.10	0.75	7.92	0.04
Others cost	51.42	2.07	387.04	2.31	115.58	1.28	144.78	1.48	62.28	1.02	147.27	2.51	436.26	2.27
Total	**2486.25**	**100**	**16774.6**	**100**	**9013.44**	**100**	**9800.23**	**100**	**6099.26**	**100.00**	**5861.37**	**100**	**19216.67**	**100**

Wholesaler (Aratdar)

Wholesaler (*Aratdar*) buys fish directly from farmers/fishers, *beparies*, or *paikers* and sells to retailers. *Aratdars* primarily provide storage facilities to other actors, but they sometimes buy and sell through commission agents and local agents. Besides, they often act as commission agents. Since their primary function is to store fishes, they involve a substantial number of laborers (permanent and temporary) in different activities. A total of BDT 9800.23 per MT was estimated as their total marketing cost, and the permanent and temporary labor use cost cover 22.52% and 17.27% of the total cost. In addition, *Aratdars* incurred BDT 1559.36 per MT in buying ice for the fish, which was 15.91% of the total marketing cost. Other major cost items for *aratdars*were loading and unloading cost (8.88%), transportation cost (7.32%), personal expenses (5.99%), and weighting scale cost (5.68%).

Aratdar (Commission Agent)

Commission agent rarely buy and sell fish; instead, they get a fixed commission on selling the fish for other market actors. Therefore, the highest cost of aratdar was associated with fish transportation, BDT 2116.77 per MT, representing 34.71% of their total marketing cost. Following this, permanent and temporary labor used for loading and unloading comprises of 12.99% and 11.69%. Besides, some other significant charges were incurred in ice purchasing (8.99%), grading (7.25%), labor use for other purposes (7.78%), market tool/rent (5.79%). Therefore, the total marketing cost of *aratdar* (commission agent) was estimated at BDT 6099.26 per ton.

Retailer

Retailers usually are the end seller, purchase fish from various traders and sell directly to the customers. Their total marketing cost was estimated at BDT 5861.37 per MT. Retailers often buy fishes from commission agents (*aratdars*) or local agents, and they paid an estimated commission of BDT 1672.25 perMT, which was 28.53% of their total marketing cost. They also spend BDT 1322.27/MT (22.56%) for permanent labor, the second-highest marketing cost segment of retailers. Besides, the cost of transporting fish and ice shared 10.82% and 5.98% of the total marketing cost.

Exporter

Exporters are wholesalers who buy fish from fish farmers, fishers, or market traders in the domestic market and sell to merchants or in foreign country markets. Among all the traders, exporters exhibit the highest marketing cost, (BDT 19216.67/MT). As the fish was transported from one country to another, transportion costwas the highest cost segment (BDT 5104.37/MT), sharing more than a quarter (26.56%) of total marketing cost. In addition, exporters pay commission for purchasing fish which was BDT 3639.47/MT (18.94% of total marketing cost). Due to international trade policy and for ensuring product quality, exporters emphasize more on fish packaging. It was estimated that for packaging, exporters incurred BDT 1730.05/MT, which in 9% of their total cost. Their other high costs segment was permanent labor use (8.36%), electricity bill (7.74%), personal expenses (7.27%), and commission of *aratdar* (6.33%).

11.3.3.4 Value addition by different actors in capture and culture fisheries

Value addition of inland fish (capture and culture) and associated cost is illustrated for different actors in Table 25.The estimated total value addition in the capture fisheries was BDT 140395.08/MT, lower than culturefisheries (BDT 210937.6/MT). In the capture fisheries sector, wholesaler (*aratdar*) added the most value among the value chain actors (BDT 26500/MT), where aratdar (commission agent) added the least value (BDT 19285.57/MT). On the other hand, wholesalers (*bepari*)added the maximum value among the value chain actors in the culture fisheries sector (BDT 82018.26/MT), and wholesalers (*aratdar*) added the least (BDT 11944.44/MT).

Table 25. Actor-wise value addition in capture and culture fisheries in Bangladesh (BDT/MT)

Traders type	Capture fisheries			Culture fisheries		
	Value addition	Marketing Cost	Net margin	Value addition	Marketing Cost	Net margin
Local Agent (Faria)	26000	2486.25	23513.8	19646.67	2486.25	17160.4
Wholesaler (Bepari)	23401.14	16774.6	6626.54	82018.26	16774.6	65243.7
Wholesaler (Paikar)	20893.7	9013.44	11880.3	45611.84	9013.44	36598.4
Wholesaler (Aratdar)	26500	9800.23	16699.8	11944.44	9800.23	2144.21
Aratdar (Commission Agent)	19285.57	6099.26	13186.3	21106.67	6099.26	15007.4
Retailer	24315.4	5861.37	18454	30609.75	5861.37	24748.4
Total Value Added	140395.08			210937.6		

11.3.3.5 Losses, processing cost, and value addition in shrimp processing industry

Shrimp plays an essential role in the economy of Bangladesh, mainly because of its export importance. It is the second-largest export industry and earned BDT 3527.07 crore in 2017-2018 (DoF, 2018-19). Among Shrimp-producing countries, Bangladesh ranks fourth in terms of Shrimp culture areas and sixth in terms of production volume. The fisheries sector, including Shrimp, contributes about 3.52% to the national GDP and 1.8% to the national export earnings (BBS, 2020). Four different Shrimp types
are being exported from Bangladesh (i.e., galda, bagda, harina, and chaka). In Bangladesh, about 100 Shrimp processing plants existof which 75 are EU-approved (DoF, 2018-19), and the major processing plants are situated in Chittagong, Khulna, and Cox's Bazar district.

Packaging of capture fish

Frozen shrimp for exporting

Regardless of the Shrimp species, the processing losses were between 2-3.6% for the whole (head and shell on) processed Shrimp. Among the Shrimp

species, 'bagda' and 'golda' are biologically larger than 'harina' and 'chaka' shrimp. Therefore, smaller shrimp species are more susceptible to processing loss than larger ones. However, headless Shrimp (any species) shared higher processing losses (between 28-35%) (Table 26).

Frozen shimp exporting packaging

Biologically, the Shrimp body is divided into two large parts: the cephalothorax consisting of the head and chest and the abdomen consisting of the stomach and tail. The cephalothorax is protected by thick chitin skin or also by the carapace. The cephalothorax consists of five heads and eight chest segments. In contrast, the abdomen consists of six components and one tail (telson), where the cephalothorax is almost 30% of the total body part. In addition, all shrimp species contain long antenna, walking legs, and swimming legs. For headless Shrimp, this carapace is removed; thus, an immense processing loss occurred. Furthermore, the golda contains a pair of sizeable chelate leg which are absent in bagda. Therefore, golda loses the chelate leg during the beheading process, making higher losses for golda over bagda.

Table 26. Level of processing losses of shrimps at the factory level

Sl.no	Particulars	Share of loss (%)			
		Bagda	Golda	Harina	Chaka
1.	Head and shell on (whole)	2	2.5	3	3.6
2.	Headless	32	35	28	28
3.	Peeled and deveined (P&D)	46	50	-	-
4.	Headless, shell on, deveined (Easy Peel)	32	36	-	-
5.	Fantail	32	35	-	-
6.	Others	16	17	18	19

Furthermore, peeled and deveined (P&D) shrimp exhibits the highest processing loss (46-50%) where harina and chaka are not used for P&D. In P&D products, together with head, tail, and vein are also removed, causing the highest processing loss for P&D. Easy peel and fantail Shrimp had the similar loss (32-36%). In easy peel and fantail processed products, head/carapace and vein are removed, resulting in an enormous processing loss (more than 32%-36%). Along with the mentioned processed Shrimp, another 16%-19% processing loss occurs from different reasons.

At shrimp processing industry level, major cost was divided into 2 categoriesi.e., fixed cost and variable cost. In fixed cost, manpower cost (37%) was the major cost accounting monetary value of BDT 47250/MT and, land and licensing costs are minor (<1%) (Table 27). Total variable cost was more than 61% where major costing for utilities, packaging and labeling, interest on operating capitals and freight were 18.72%, 11.83%, 10.12% and 13.54%, respectively. Cost for raw materials, labor, and transport was 1-3%. Other variable costs including machinery

equipments, buildings and office equipments were less than 1% in the shrimp processing industry.

Table 27. Level of Shrimp processing cost at the factory level

Cost items	**Total cost** (BDT/MT)**)**	**% share**
Fixed cost		
Manpower cost (Permanent)	47250	37.24
Land rent	527	0.42
License fee	53	0.04
Sub total	**47830**	37.70
Variable cost		0.00
Raw materials	2939	2.32
Transportation cost	1324	1.04
Preservation cost	1205	0.95
Pre-processing cost	103	0.08
Certificate cost	673	0.53
Packaging and labeling	15007	11.83
Frozen storage	601	0.47
Utilities	23752	18.72
Labor cost	1609	1.27
Interest on operating capital	12837	10.12
Stationary	92	0.07
Freight	17181	13.54
Miscellaneous	502	0.40
Sub total	77825	61.35
Depreciation of Machinery equipment's & building	1106	0.87
Depreciation of office equipment	102	0.08
Sub total	**1208**	0.95
Total	**126863**	**100**

Farmers or processors can gain extra income not only by further processing Shrimp but also by supplying specific markets with targeted product forms as well. Table 28 presents the value addition of Shrimp processing for exports in Bangladesh. Value addition of Shrimp is done in various forms such as head and shell on (whole), headless, peeled and deveined (P&D), headless, shell-on, deveined (easy peel), fantail, etc. Results revealed that the highest value addition was observed for a total BDT 460692/MT for fantail Shrimp, followed by headless (BDT 433512/MT). Coated fantail round Shrimp is a delicious, high-value snack popular in fast food joints and restaurants. The lowest value addition was found for the head and shell-on Shrimps, BDT 227538/MT. The whole Shrimp (head and shell on) goes through very little processing in the plant, but the product needs to be treated carefully to avoid physical damage, especially to the head.

Table 28. Scenario of Value addition of Shrimp processing for exports

Particulars	**Marketing margin (BDT/MT)**	**Processing cost (BDT/MT)**	**Value addition (BDT/MT)**
Head and shell on (whole)	354401	126863	227538
Headless	573061	139549	433512
Peeled and deveined (P&D)	455811	142086	313725
Headless, shell on, deveined (Easy peel)	526161	140071	386090

Fantail	607501	146809	460692
Others	336261	121203	215058

11.3.3.6 Total cost (harvesting cost) for marine fish by the artisanal fishing boat owner

When marine fishers harvested different types of fish, a large amount of expense is incurred. Some costs are fixed for marine artisanal fishers, and it appears that fixed cost was 14.23% of the total cost (Table 29). Interest in operating capital was the highest (6.02%), and depreciation on chara cost (0.10%) was the lowest. Fishermens' food, license renewal, ice, fuel, Mobil, maintenance, and maintenance cost of boat/trawler, engine, *aratdar* commission, and labor charge for unloading cost were included in variable cost. The total variable cost of fishers was BDT 40,731/MT, 85.77% of the total cost (BDT47489/MT).

Table 29. Annual total cost (harvesting cost) of artisanal fishing boat owner (BDT/MT)

Cost items	Total cost (BDT/MT)	% share
Fixed cost		
First license cost	271	0.57
Depreciation on boat cost	1773	3.73
Depreciation on engine cost	375	0.79
Depreciation on the net cost	1098	2.31
Depreciation on rope cost	272	0.57
Depreciation on boya cost	62	0.13
Depreciation on chara cost	50	0.11
Interest on operating capital	2857	6.02
Subtotal	**6758**	**14.23**
Variable cost		
License renew cost	57	0.12
Fishermen food cost	5600	11.79
Ice cost	4618	9.72
Fuel cost	11732	24.70
Mobil cost	751	1.58
Maintenance cost of boat/ Trawler	796	1.68
Maintenance cost of the engine	628	1.32
Miscellaneous cost	522	1.10
Aratdar Commission	15904	33.49
Labor charge for unloading	123	0.27
Subtotal	**40731**	**85.77**
Total	**47489**	**100.00**

11.3.3.7 Profitability for marine fish by the artisanal fishing boat owner

Boat owner gets a profit share of 56.25% while the associated staff of the boat gets 43.75%. In the winter, the owner and boat staff get equal profit share. Calculated for the year-round, the boat owner gets 56.25% profit margin, and on average, it was BDT 155005 per MT (Table 30).

Table 30. Profitability of artisanal fishing boat owner (BDT/MT)

Items	Amount (BDT/MT)
Total return	323054
Total cost (-)	47489

Profit of a boat	275565
Profit of the boat owner (56.25%)	**155005**

11.3.3.8 Marketing cost for marine fish by traders

Wholesaler (*bepari*) is found to have incurred the highest marketing cost by paying commission to *aratdar* (BDT 10985/MT). Transportation cost accumulates a good portion for *bepari* (BDT 1639/MT)and *paikar* (BDT 5039/MT), although transportation cost varies from area to area depending on distance coverage. The per metric ton average marketing cost of marine fish in different actors like *bepari*, *paiker*, *aratdar*, retailer, processor (freezing), processor (drying), and processor (salting) were BDT 26436/MT, BDT9244/MT, BDT3541/MT, BDT4412/MT, BDT3400,7 BDT448/MT, and BDT17300/MT, respectively. The highest marketing cost was incurred by *bepari*. The following highest marketing cost was found for salting fish processors due to higher labor costs in the process (Table 31). Freezing fish processors' marketing cost was the lowest because they purchase fish from local wholesalers or *aratdar*.

Table 31. Marketing cost of marine fish of the involved traders (BDT/MT)

Cost items	**Traders**						
	Bepari	***Paiker***	***Aratdar***	**Retailer**	**Processor (Freezing)**	**Processor (Dry fish)**	**Processor (Salting)**
Permanent labor	574	255	285	798	1373	981	2341
Loading and unloading	388	175	266	252	0	775	618
Grading	1119	0	416	0	0	0	0
Others labor cost	468	119	331	125	70	0	2830
Rent of office and storehouse	107	47	75	345	466	303	680
Electricity bill	35	7	16	74	367	29	244
Mobile bill	26	15	16	31	51	18	49
Market tool/rent	274	174	116	316	146	63	193
Transportation cost	1639	5031	919	347	149	404	1206
Commission of aratdar	10985	1586	0	1117	0	67	646
Commission of local agent	8862	39	678	146	0	10	1945
Personal expenses	149	55	74	190	95	83	223
License cost	44	6	7	89	20	8	138
Maintenance cost	81	28	0	75	25	35	43
Ice cost	691	679	229	300	528	39	167
Plastic/Bamboo basket	344	476	46	38	46	2990	260
Water	509	520	44	32	0	1270	5600
Security	109	7	3	34	53	98	57
Antiseptic & cleaning items	7	11	8	66	0	164	0
Other materials	25	14	12	37	11	111	60
Total	**26436**	**9244**	**3541**	**4412**	**3400**	**7448**	**17300**

11.3.3.9 Value addition of traders of marine fish

The average value addition by the traders of marine fish, i.e., wholesaler (*bepari*), wholesaler (*paikar*), *aratdar*, retailer, freezing fish processor, dried fish processor, and salting fish processor, were estimatedas BDT 32425/MT, BDT 48508/MT, BDT 16489/MT, BDT 25178/MT, BDT 81357/MT, BDT 44210/MT, and BDT 106597/MT, respectively. Among all the intermediaries, salting fish processors add up the highest value by processing the Hilsha fish,

followed by the freezing fish processor, wholesaler (*paikar*), dried fish processor, retailer, *aratdar*, and wholesaler (*bepari*) (Table 32).

Table 32. Value Addition of different intermediaries of marine fish (BDT/MT)

Traders	Value addition	Marketing Cost	Net margin
Wholesaler (*Bepari*)	32425	26436	5989
Wholesaler (*Paikar*)	48508	9244	39264
Aratdar	16489	3541	12948
Retailer	25178	4412	20766
Processor (Freezing)	81357	3400	77957
Processor (Dry fish)	44210	7448	36762
Processor (Salting)	106597	17300	89297

11.3.3.10 Total cost (harvesting cost) for marine fish by industrial fishing vessel

With large-scale operations, the marketing costs rose significantly. Nearly a quarter (24.57%) of the total marketing cost occurred due to the fixed cost of the harvesting (Table 33). Interest on operating capital accumulated the highest portion of the fixed cost (16.47%). Therefore, the total variable cost of fishers for harvesting marine fish using industrial fishing vessels was estimated at BDT 51826/MT, sharing 75.43 % of the total cost.

Table 33. Annual total cost (harvesting cost) of marine fish of an industrial fishing vessel (BDT/MT)

Cost items	Total cost (BDT/MT)	% Share
Fixed cost		
First license cost	86	0.13
Depreciation on vessel cost	2084	3.03
Depreciation on the net cost	2101	3.06
Depreciation on echo sounder	34	0.05
Depreciation on sonar cost	1270	1.85
Interest on operating capital	11305	16.45
Subtotal	**16880**	**24.57**
Variable cost		0.00
License renew cost	72	0.10
Staff salary cost	5683	8.27
Staff bonus	2691	3.92
Staff food cost	1396	2.03
Diesel cost	37293	54.28
Mobil cost	963	1.40
Drinking water cost	193	0.28
Gas cost	57	0.08
Jetty/boya fair cost	425	0.62
Electricity cost	120	0.17
Engine maintenance cost	526	0.77
Net maintenance cost	1115	1.62
Navigation equipment maintenance cost	114	0.17
Polybag cost	71	0.10
Grocery items	38	0.06
Sampan fair cost	100	0.15
Docking cost	853	1.24
Medical bill	38	0.06
Port and river duties	78	0.11

Subtotal	**51826**	**75.43**
Total	**68706**	**100.00**

11.3.3.11 Profitability of industrial fishing vessel

Industrial fishing vessels were profitable as they have a total return of BDT 106400/MT from marine fish, where total costwas BDT 68706/MT. Consequently, it indicated the profitof marine fish of an industrial fishing vessel stood at BDT 37694/MT (Table 34).

Table 34. Profitability of marine fish of an industrial fishing vessel (BDT/MT)

Items	**Amount (BDT/MT)**
Total return	106400
Total cost (-)	68706
Profit	**37694**

11.3.4 Marine dried fish industry in Bangladesh

Dried fish (*shutki*) is one of the most popular food items and is widely consumed in Bangladesh. It usually comes from two sources (i.e., marine dried fish and freshwater dried fish). In the coastal region and all over the country, drying is an enormous fish processing activity in the aspect of value and volume. Bangladesh has exported 3144 MT (worthing BDT 425.9 million) of dried fish during the 2018-19 fiscal year(DoF, 2019). Fish drying is considered to be the least expensive method of fish preservation (Hassan *et al.*, 2013; Balachandran,2001). The dried fish product is easily transportable, marketable, and storable (Nowsad,2007). A significant portion of the dried fish is exported that earns a good amount of foreign currency which is being produced in coastal areas (Cox's Bazar, Chattogram, Khulna, Patuakhali and Barguna districts) of Bangladesh.

11.3.4.1 Estimation of processing loss of dried fish species

In marine dried fish, the processing losses include both the body-water and body parts losses (Table 35). Regardless of the marine fish species, average body water losses were 59.40%, and body parts losses were 6.57%, with an average total of 65.97%. Among the dried fish, the highest body water loss was in Sardine and Bombay duck fish (64.29%), and the lowest was in Mackerel fish (52.77%). Biologically the body constituents of Bombay duck contain more than 90% water, and Mackerel is a flat/thin small-sized finfish. Therefore, high body-water content and smaller body size might favor (easy) and higher water losses for the respective species during the drying activities. Body parts loss was the highest for Mackerel (8.19%) and the lowest for Shrimp (3.14%). Mackerel is a highly fleshed fin fish containing fin, gill, and intestine; removed before the drying process that caused higher physical/body parts losses. On the other hand, shellfish like Shrimp are dried without removing the shell as a whole. Thus, the lowest physical loss occurred in case of Shrimp. The total losses were the highest (71.25 %) and the lowest (60.952%) for Bombay duck and Mackerel respectively. Again, removal of the higher body-water content of Bombay duck resultedthe maximum total loss. Although higher body parts loss was in Mackerel, its higher flesh/meat content may cause lower water loss and lower total loss.

Table 35. Species wise processing losses of marine dried fish in Bangladesh

Identity		Type of loss		
Local name	**English Name**	**Body water loss (%)**	**Body parts loss (%)**	**Total loss (%)**
Kowa/Surma	Mackerel	52.77	8.19	60.95
Sada Datina	Snapper	54.97	7.17	62.14
Kamila/(Sea) Bain	Eel	57.99	5.60	63.59
Vetki/Koral	Sea Bass	55.71	7.93	63.64
Lakkha	Lakkha	59.39	5.17	64.56
Maitya/Bom maitya/Bottle	Tuna	57.09	7.85	64.95
Churi	Ribbon	60.19	5.76	65.95
Rupchanda/Chanda	Pomfret	59.09	6.95	66.04
Chingri	Shrimp	63.24	3.14	66.39
Poa/Poma/pama	Jew fish	59.99	7.56	67.56
Boiragi & Mola		60.29	7.27	67.58
Dhela		62.29	6.19	68.48
Chapila	Sardine	64.29	6.23	70.52
Loittya	Bombay duck	64.29	6.96	71.25
Average		**59.400**	**6.57**	**65.97**

11.3.4.2 Processing and marketing cost of marine dried fish

The processing and marketing cost for dried marine fish is associated with dry fish processors, *aratdar*, wholesalers, and retailers.During the drying process, dried fish processors pay the major relevant costs, which was on average, BDT 46780/MT. The permanent and other labor costs were significant (BDT 7000- BDT 14000/MT) for the processors. In addition, the processors also carry commission agents' payment, *aratdars'* commission, transport, grading, salt, and ice costs, ranging from BDT 2000 to 5000/MT (Table 36). *Aratdar* had minimum cost involvement for permanent labor and office/storeroom rent, an average of BDT 436/MT. Wholesalers' high cost came from paying the commission (BDT 3000/MT) to *aratdar* and loading and unloading (BDT 1500/MT). Finally, retailers' cost mainly involved the room rent, transport, market toll, electricity, mobile bill, and others on average BDT 1600/MT.

Table 36. Processing and marketing cost of marine dried fish (BDT/MT)

Items	Stakeholders			
	Dry fish Processor cost (BDT/MT**)**	***Aratdar* (**BDT/MT**)**	**Wholesaler (**BDT/MT**)**	**Retailer (**BDT/MT)
Permanent labor	14000	210.23	0	0
Loading and unloading	540	0.00	1500	0
Grading	3500	0.00	0	0
Other labor cost	7000	0.00	0	0
Rent of office / store house	3000	100.62	110	770
Electricity bill	1180	10.59	0	140
Mobile bill	770	30.18	40	60
Market toll/rent	0	0.00	0	220
Transportation cost	3750	0.00	610	210
Commission of aratdar	5000	0.00	3000	0
Commission of local agent/faria/dalal	1900	0.00	0	0
Personal expenses	270	60.37	80	80
License cost	0	0.21	0	0
Ice cost	2000	0.00	0	0
Plastic/bamboo basket	150	4.2	70	10
Water	0	0.00	0	70
Salt	1990	0.00	0	0
Security	340	0.00	0	20
Weighting scale	120	0.00	0	20
Preparing bamboo/wooden Chang	1270	0.00	0	0
Total	**46780**	**436.3**	**5410**	**1600**

11.3.4.3 Value addition in marine dried fish

Scenario of value-addition of dried marine fish by different actors is presented in Table 37. Processors obtained higher gross margin (BDT 78693/MT) than other traders but had higher marketing costs (BDT 46780/MT). Retailers received a lower gross margin (BDT 49720/MT) than processors.Usually, retailers store for a more extended period and sell small quantities to the consumers, which enable retailers to receive higher value addition (BDT 48120/MT). The *aratdar*did not have any ownership to the product, and they get a commission from sales, thus less value-addition obtained by them. The wholesaler had less value-addition than retailers and processors because they invest money for a limited time, which enable them to receive lower value-addition (BDT 29630/MT) than the other actors in the system.

Table 37. Value addition of different actors of marine dried fish (BDT/MT)

Traders	Gross Margin (BDT/MT)	Marketing Cost (BDT/MT)	Value addition (BDT/MT)
Processor	78693.00	46780.00	31913.00
Aratdar	12910.00	436.30	12473.70
Wholesaler	35040.00	5410.00	29630.00
Retailer	49720.00	1600.00	48120.00

11.3.4.4 Species-wise value addition in marine dried fish

Marine waterbodies are rich in diversified fishes. Among the captured fish species, not all have equal demand to the consumer and value-added by the actors. Data in Table 38 demonstrates the value addition of marine dried fish according to species, where the average marketing margin for marine dried fish was BDT 78693/MT. Shrimp obtained the highest market margin (BDT 84882/MT) followed by Lakhua (BDT 84677/MT), Dala (BDT 69384/MT), and Loitya (BDT 69384/MT). Species-wise, the average value addition was BDT 31913/MT and maximum for Rupchanda BDT 63494/MT followed by Vetki (BDT 53147/MT), Shrimp (BDT 38102/MT), and Lakhua (BDT 37897/MT), where the minimum was BDT 16390/MT for Chapila. Marine species such as Shrimp and Loitya require low-priced raw materials and low production/processing costs. The commercially important species such as Rupchada, Vetki, and Lakhua are highly valued fish preferred by elite class people who can pay higher prices; thus, higher value-addition occurred for these species. The lowest value-addition was for Chapila. Due to high-fat content, rapid oxidation occurred during drying and storage time, and higher storage loss was marked this species as lower value-adding species.

Table 38. Species wise value addition of marine dried fish (BDT/MT)

Species	Marketing margin(BDT/MT)	Value addition(BDT/MT)
Loitya	69384	22604
Dala	69724	22944
Boiragi&Mola	75899	29119
Maitya/Tuna	72797	26017
Poa	68442	21662
Chhuri	75345	28565
Chapila	63169	16,390
Lakhua	84677	37897
Rupchanda	110274	63494
Kamila	73330	26550
SadaDatina	78620	31840
Kowa	75240	28460
Shrimp	84882	38102
Vetki	99927	53147
Average	**78693**	**31913**

Fig 41 showed the flow diagram of processing activities of (dried) marine fishes. Dried marine fish processing steps needed raw materials from fishers/aratdar and washing with the plastic and aluminum containers in the river/canal water. After washing, the sorting and grading were done in hand, cutting body parts/gutted, rewashing in normal water, dipping into salt solution in a big dram, sun drying for 1-5 days in bamboo made chala, packaging in plastic/jute bag and storage, and finally marketed the produce.

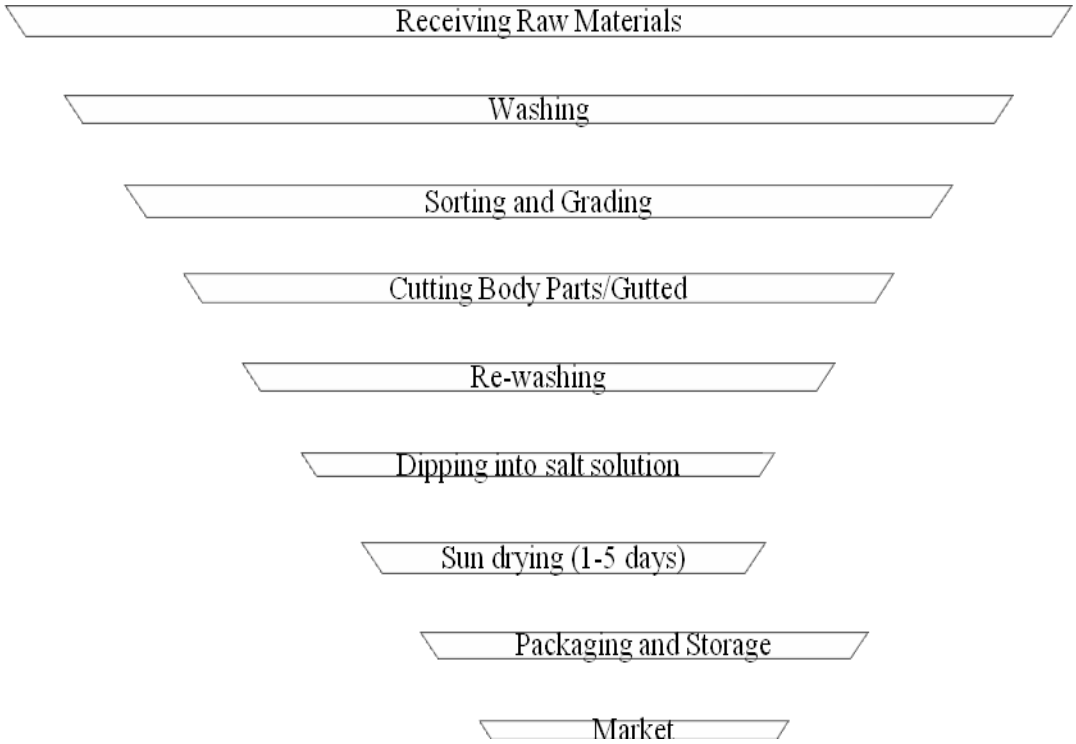


Fig 41. Flow chart of dried marine fish processing.

11.3.5 Marketing efficiency measurement

The concept of marketing efficiency is broad and dynamic. In simple words, marketing efficiency is the maximization of the input-output ratio. Specifically, it is the ratio of the net price received by the farmers and all the costs in marketing the commodity and loss incurred in the process.However, marketing efficiency can be measured in different ways such as Shephard method, Acharya and Agarwal's method, Marketing efficiency index method and Composite index method. Though different efficiency measurement methods show different results of channel efficiency, but this study considered the efficient channel which has the highest rank at least in two efficiency measurement method.

11.3.5.1 Marketing efficiency measurement of Rui

More than ten Rui marketing channels were found in the study areas but for the simplicity we only considered 3 major channels by which more than 60% transaction were performed. These three channels are as follows:
Channel I: Fish farmer →*Bepari*→ Commission Agent →*Paiker*→ Retailer → Consumer
Channel II: Fish farmer →*Bepari*→ Commission Agent → Retailer → Consumer
Channel III: Fish farmer → Commission agent →Retailer → Consumer

The indicators measuring efficiency in different channels of Rui are shown in Table 39. The results revealed that the producer selling price was the same in the channel I and channel II, which was the highest. Besides, the consumers purchased price, which was BDT 275.83 per kg in all channels. The price spread was BDT 115.15 per kg in channel III, which was the highest, followed by channels I and II. Marketing cost was the lowest for channel III, which was BDT 27.72/kg. In addition, the marketing margin was lowest in channel I and the highest in channel III. Producers share in channel I and channel II were 64.04% which was the highest, followed by channel III.

Table 39. Efficiency measurement of the value chain of Rui

Indicators	**Channel I**	**Channel II**	**Channel III**
Producer selling price (BDT/kg)	176.65	176.65	160.68
Consumers purchased price (BDT/kg)	275.83	275.83	275.83
Price spread/ Total Marketing Margin (BDT/kg)	99.18	99.18	115.15
Total marketing cost (BDT/kg)	53.5	44.49	27.72
Net marketing margin (BDT/kg)	45.68	54.69	87.43
Producer share (%)	64.04	64.04	58.25
Rate of return	1.85	2.23	4.15
Shephard method			
Consumer purchase price (BDT/kg)	275.83	275.83	275.83
Total marketing cost (BDT/kg)	53.5	44.49	27.72
Efficiency	5.16	6.20	9.95
Rank	III	II	I
Acharya and Agarwal method			
Consumers purchased price (BDT/kg)	275.83	275.83	275.83
Producer selling price (BDT/kg)	176.65	176.65	160.68
Total marketing cost (BDT/kg)	53.5	44.49	27.72
Net marketing margin (BDT/kg)	45.68	54.69	87.43
Efficiency	1.78	1.78	1.40
Rank	I	I	II
Marketing Efficiency Index Method			
Total marketing cost (BDT/kg)	53.5	44.49	27.72
Total net marketing margin (BDT/kg)	45.68	54.69	87.43
Efficiency	1.85	2.23	4.15
Rank	III	II	I
Composite Index Method			
Producer share (Rank)	1	1	2
Total marketing cost (Rank)	3	2	1
Net marketing margin (Rank)	3	2	1

Indicators	Channel I	Channel II	Channel III
Rate of return	3	2	1
Mean score	2.5	1.75	1.25
Rank	III	II	I

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of channel

There are several methods for measuring the efficiency of the supply chain. As per the Shephard method, it was observed that the higher ratio means the higher efficiency and vice-versa. Table 39 show that the marketing efficiency of channel III was the highest as marketing cost was the lowest in this channel. On the other hand, the least efficient channel was the channel I due to its higher marketing cost.As per Acharya and Agarwal method, the greater the score indicates, the higher is the efficiency and vice-versa. The estimated efficiency score was identical for channel I and channel II. The result suggested that both channels I and II were most efficient since having a higher score compared to channel III. According to the marketing efficiency index method, the channel having the highest score is considered the most efficient one and vice-versa. Results revealed that channel III got the first rank by getting a higher efficiency score (4.15) than channel I and channel II. The least efficient channel was the channel I since having a higher marketing cost.

The composite index method is another effective method of measuring the marketing efficiency of fish species. Producer share, marketing cost, marketing margin, and rate of return are considered in the composite index method. As per this method, the channel obtaining the least mean score is regarded as the most efficient channel. It was evident from findings that channel III was the most efficient (Mean score 1.25), while channel I was the least efficient one.

11.3.5.2 Efficiency measurement of the value chain of Pangas

Likewise Rui marketing channel, the study was also selected three major channels for pangas fish marketing which are as follows:

Channel I: Fish farmer → Commission agent → Retailer → Consumer
Channel II: Fish farmer →*Faria*→ Commission agent → Retailer →Consumer
Channel III: Fish farmer → Commission agent →*Paiker*→ Retailer →Consumer

Like Rui fish, the indicators measuring efficiency in different channels of Pangas fish are shown in Table 40. It appeared that channel II has the lowest producer selling price (BDT 85.93/kg) of all three channels. The maximum price spread was (BDT 47.71/kg) in channel II, followed by channels I and III. Channel II had both the highest market margin. Producers share in the channel I and channel III were 70.25% which was the highest, followed by channel II.

In the Shephard method, it is considered that the higher ratio means the higher efficiency and vice-versa. According to Acharya and Agarwal method and the Marketing Efficiency Index method, a higher score indicates higher efficiency and vice-versa. For all the three ways specified, channel I obtained the highest efficiency score and ranked first among the three channels, followed by channel II.

Table 40. **Efficiency measurement of the value chain of Pangas**

Indicators	**Channel I**	**Channel II**	**Channel III**
Producer selling price (BDT/kg)	93.88	85.93	93.88
Consumer purchasing price (BDT/kg)	133.64	133.64	133.64
Price spread (BDT/kg)	39.76	47.71	39.76
Total marketing cost (BDT/kg)	27.72	32.09	36.72
Net marketing margin (BDT/kg)	12.04	15.62	3.04
Producer share (%)	70.25	64.30	70.25
Rate of return	1.43	1.49	1.08
Shephard Method			
Consumer purchase price (BDT/kg)	133.64	133.64	133.64
Total marketing cost (BDT/kg)	27.72	32.09	36.72
Efficiency	4.82	4.16	3.64
Rank	I	II	III
Acharya and Agarwal Method			
Consumer purchasing price (BDT/kg)	133.64	133.64	133.64
Producer selling price (BDT/kg)	93.88	85.93	93.88
Total marketing cost (BDT/kg)	27.72	32.09	36.72
Net marketing margin (BDT/kg)	12.04	15.62	3.04
Efficiency	2.36	1.80	2.36
Rank	I	II	I
Marketing Efficiency Index Method			
Total marketing cost (BDT/kg)	27.72	32.09	36.72
Net marketing margin (BDT/kg)	12.04	15.62	3.04
Efficiency	1.43	1.49	1.08
Rank	II	I	III
Composite Index Method			
Producer share (Rank)	1	2	1
Total marketing cost (Rank)	1	2	3
Net marketing margin (Rank)	2	1	3
Rate of return	2	1	3
Mean score	1.5	1.5	2.5
Rank	I	I	II

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of channel

11.3.5.3 Efficiency measurement of value chain of Shrimp (domestic)

In the case of inland shrimp marketing channel, out of available six marketing channels, following three channel were the most traded channel in the study areas which are as follows:

Channel I: Fish farmers → Faria → Commission agent → Retailers → Consumers
Channel II: Fish farmers → Commission agent → Retailers → Consumers
Channel III: Fish farmers → Commission agent → Bepari → Retailers → Consumers

The efficiency of Shrimp (inland) channels is shown in Table 41. Channel I got the lowest producer selling price (BDT 460/kg) and the highest price spread (BDT 90/kg) over other

channels. In all three channels, the average consumer purchase price was equal (BDT 550/kg). In terms of total marketing cost, channel II was the most efficient one with the lowest cost (BDT 27.71/MT), and channel III was the least efficient (BDT 44.48/kg). Therefore, Channel II ranked first, having the lowest marketing cost, and highest producer share (88.09%).

Table 41. Channel wise efficiency measurement of the value chain of Shrimp (domestic)

Indicators	**Channel I**	**Channel II**	**Channel III**
Producer selling price (BDT/kg)	460	484.51	484.51
Consumer purchasing price (BDT/kg)	550	550	550
Price spread (BDT/kg)	90	65.49	65.49
Total marketing cost (BDT/kg)	32.09	27.71	44.48
Net marketing margin (BDT/kg)	57.91	37.78	21.01
Producer share (%)	83.64	88.09	88.09
Rate of return	2.80	2.36	1.47
Shephard Method			
Consumer purchase price (BDT/kg)	550	550	550
Total marketing cost (BDT/kg)	32.09	27.71	44.48
Efficiency	17.14	19.85	12.37
Rank	II	I	III
Acharya and Agarwal Method			
Consumer purchasing price (BDT/kg)	550	550	550
Producer selling price (BDT/kg)	460	484.51	484.51
Total marketing cost (BDT/kg)	32.09	27.71	44.48
Net marketing margin (BDT/kg)	57.91	37.78	21.01
Efficiency	5.11	7.40	7.40
Rank	II	I	I
Marketing Efficiency Index Method			
Total marketing cost (BDT/kg)	32.09	27.71	44.48
Net marketing margin (BDT/kg)	57.91	37.78	21.01
Efficiency	2.80	2.36	1.47
Rank	I	II	III
Composite Index Method			
Producer share (Rank)	2	1	1
Total marketing cost (Rank)	2	1	3
Net marketing margin (Rank)	1	2	3
Rate of return	1	2	3
Mean score	1.5	1.5	2.5
Rank	I	I	II

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of channel

According to the Shephard, Acharya and Agarwal method, channel II was considered as the most efficient one. Composite index method also referred the channel II was the most efficient chain.

11.3.5.4 Efficiency measurement of value chain of Hilsha (inland)

Different indicators measuring the efficiency of the major three channels of Hilsha (inland) are shown in Table 42. The producer selling price was found maximum for channel III (BDT 567.81/kg), followed by channel II (BDT 553.04/kg) and channel I (BDT 550/kg). Besides, the consumers purchased prices in all channels were equal (BDT 648/kg) while the price spread was the highest (BDT 98/kg) for channel I. Further, channel I and III had the lowest marketing cost (BDT 74.90/kg) and channel I showed the highest market margin (BDT 23.1/kg). Although channel III showed the highest producer share (87.63) but channel I shows the highest rate of return (1.31). Thus, channel III was considered as the most efficient one. In two different market efficiency measurement techniques (Shephard and Acharya and Agarwal), channel III was the most efficient channel for hilsha (inland), followed by channel II.

Table 42. Channel wise efficiency measurement of Hilsha (inland)

Indicators	**Channel I**	**Channel II**	**Channel III**
Producer selling price (BDT/kg)	550	553.04	567.81
Consumer purchasing price (BDT/kg)	648	648	648
Price spread (BDT/kg)	98	94.96	70.19
Total marketing cost (BDT/kg)	74.9	84.7	74.9
Net marketing margin (BDT/kg)	23.1	10.26	5.29
Producer share (%)	84.88	85.35	87.63
Rate of return	1.31	1.12	0.94
Shephard method			
Consumer purchase price (BDT/kg)	648	648	648
Total marketing cost (BDT/kg)	74.9	84.7	74.9
Efficiency	8.65	7.65	8.65
Rank	I	II	I
Acharya and Agarwal method			
Consumer purchasing price (BDT/kg)	648	648	648
Producer selling price (BDT/kg)	550	553.04	567.81
Total marketing cost (BDT/kg)	74.9	84.7	74.9
Net marketing margin (BDT/kg)	23.1	10.26	5.29
Efficiency	5.61	5.82	7.08
Rank	III	II	I
Marketing efficiency index method			
Total marketing cost (BDT/kg)	74.9	84.7	74.9
Net marketing margin (BDT/kg)	23.1	10.26	5.29
Efficiency	1.31	1.12	1.07
Rank	I	II	III
Composite index method			
Producer share (Rank)	3	2	1
Total marketing cost (Rank)	1	2	1
Net marketing margin (Rank)	1	2	3
Rate of return	1	2	3
Mean score	1.50	2.00	2.00
Rank	I	II	II

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of channel

11.3.5.5 Efficiency measurement for marine Hilsha

Marine Hilsha has adequate demand in domestic and international markets. Out of all the existing channels with respect to supply of marine Hilsha, the widely practiced channels are:

Channel I: Fisherman →*Aratdar*→ Retailer → Final consumer
Channel II: Fisherman → Supplier/*Dalal*→ Exporter
Channel III: Fisherman → Salting fish Processor → Consumer

Table 43. Channel wise efficiency measurement of marine Hilsha

Indicators	**Channel I**	**Channel II**	**Channel III**
Producer selling price (BDT/kg)	640	679	286
Consumer purchasing price (BDT/kg)	670	706	406
Price spread (BDT/kg)	30	27	120
Total marketing cost (BDT/kg)	3.64	5.22	13.78
Net marketing margin (BDT/kg)	26.36	21.78	106.22
Producer share (%)	95.52	96.18	70.44
Rate of return	8.24	5.17	8.71
Shephard method			
Consumer purchase price (BDT/kg)	670	706	406
Total marketing cost (BDT/kg)	3.64	5.22	13.78
Efficiency	184.07	135.25	29.46
Rank	I	II	III
Acharya and Agarwal method			
Consumer purchasing price (BDT/kg)	670	706	406
Producer selling price (BDT/kg)	640	679	286
Total marketing cost (BDT/kg)	3.64	5.22	13.78
Net marketing margin (BDT/kg)	26.36	21.78	106.22
Efficiency	21.33	25.15	2.38
Rank	II	I	III
Marketing efficiency index method			
Total marketing cost (BDT/kg)	3.64	5.22	13.78
Net marketing margin (BDT/kg)	26.36	21.78	106.22
Efficiency	8.24	5.17	8.71
Rank	II	III	I
Composite index method			
Producer share (Rank)	2	1	3
Total marketing cost (Rank)	1	2	3
Net marketing margin (Rank)	2	3	1
Rate of return	2	3	1
Mean score	1.75	2.25	2.00
Rank	I	III	II

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of the channel

The indicators measuring efficiency for the above mentioned three channels are shown in Table 43. Channel II received higher price (BDT 679/kg), and consumers can purchase with the lowest price spread (BDT 27/kg). In channel III, the price spread was maximum (BDT 120/kg) while producers received the lowest price (BDT 286/kg). Channel I was the most efficient as per Shephard method while channel II was the most efficient as per Acharya and Agarwal method and followed by channel I. It was difficult to make a conclusion based on three efficiency measurement methods, therefore, with the help of composite index method we may conclude that channel I was the most efficient channel while it was the second most efficient one in Acharya and Agarwal method and Marketing efficiency index method.

11.3.5.6 Marketing efficiency of marine Shrimp

Shrimp as an exportable item seems to have brought some improvement in the value chain. However, the marketing efficiency of marine shrimp is directly related to the cost involved in trading shrimp from the fishers to the overseas market. The improvement in the marketing efficiency of marine shrimp is essential since an efficient marketing channel indicates higher benefits for exporters. In most cases, the Shrimp is supplied through the following channels:

Channel I: Fisherman /Fishing Vessel (Artisanal/Industrial) →*Aratdar*/Depot owner/Fish Company → Wholesaler → Retailer → Final consumer

Channel II: Fisherman /Fishing Vessel (Artisanal/Industrial) →*Aratdar* /Depot owner/Fish Company → Processing plant → Exporter

Channel III: Fisherman /Fishing Vessel (Artisanal/Industrial) → Local agent/Account holder/Commission→ Processing plant → Exporter

Different indicators are used to measure the efficiency of different channels (Table 44). Results show that channel II obtained the highest price spread (BDT 391 per kg). At the same time, the consumer purchase price was the lowest in channel I. The lowest marketing cost was incurred in channel I (BDT 10.05/kg) and in contrast, channel III incurred the highest (BDT 40.66/kg). Besides, channel II had the maximum net market margin (BDT 350.39/kg) while channel I had the lowest (BDT 79.95/kg). The producer share was the highest in channel I. Considering this case, the channel I was the most efficient channel among all. Using all the methods of calculating marketing efficiency (i.e., Shephard method, Acharya and Agarwal method, Marketing efficiency index method, Composite index method), the channel I was found the most efficient one.

Table 44. Efficiency measurement of marine Shrimp supply channel

Indicators	Channel I	Channel II	Channel III
Producer selling price (BDT/kg)	389	389	398
Consumer purchasing price (BDT/kg)	479	780	780
Price spread (BDT/kg)	90	391	382
Total marketing cost (BDT/kg)	10.05	40.61	40.66
Net marketing margin (BDT/kg)	79.95	350.39	341.34
Producer share (%)	81.21	49.87	51.03
Rate of return	8.96	9.63	9.39
Shephard method			
Consumer purchase price (BDT/kg)	479	780	780
Total marketing cost (BDT/kg)	10.05	40.61	40.66
Efficiency	47.66	19.21	19.18
Rank	I	II	III
Acharya and Agarwal method			
Consumer purchasing price (BDT/kg)	479	780	780
Producer selling price (BDT/kg)	389	389	398
Total marketing cost (BDT/kg)	10.05	40.61	40.66
Net marketing margin (BDT/kg)	79.95	350.39	341.34
Efficiency	4.32	0.99	1.04
Rank	I	III	II
Marketing efficiency index method			
Total marketing cost (BDT/kg)	10.05	40.61	40.66
Net marketing margin (BDT/kg)	79.95	350.39	341.34
Efficiency	8.96	9.63	9.39
Rank	III	I	II
Composite index method			
Producer share (Rank)	1	3	2
Total marketing cost (Rank)	1	2	3
Net marketing margin (Rank)	3	1	2
Rate of return	3	1	2
Mean score	2.00	1.75	2.25
Rank	II	I	III

Note: 1 indicates higher efficiency, and 3 indicates the less efficiency of channel

11. Research highlight

Title: Post-harvest Losses, Supply and Value Chain Analysis of Fisheries Sub-sector in Bangladesh

Background

Post-harvest loss (PHL) is one of the inevitable parts of food loss. However, the fisheries sub-sector of Bangladesh undergoes serious PHL every year due to ignorance and oversight in the processing and handling throughout the supply chain from the harvest to retail distribution. It also brings out severe economic loss for the fishers, fish farmers, and actors of the supply chain. Therefore, it is imperative to generate policy recommendations for taking legitimate interventions to reduce fisheries' PHL. To this end, this study aims to generate in-depth information on PHL, supply, and value chain in the fisheries sub-sector of Bangladesh.

Objectives

a) Assessing PHL (quantitative) and causes of losses of capture, culture and marine fisheries of Bangladesh.
b) Analyzing existing supply chain structure of capture, culture and marine fisheries of Bangladesh.
c) Analyzing value chain structure, and extent of value addition of specific fish species.

Methodology

This study covered 64 districts, 173 upazilas, and 1463 markets of Bangladesh. However, this is the first empirical study of fisheries sector in Bangladesh considering a massive primary data of 24672 stakeholders of which 21575 from inland and 3097 from marine fisheries. Among the sample of inland fisheries, 3850 fishers, 4656 fish farmers, and 13069 traders were interviewed. Among the sample of marine fisheries, data were collected from 889 marine fishers and 2208 marine fish traders throughout the country. In total four interview schedules were developed for fisher/fish farmers and traders in the case of inland and marine fisheries. Alongside the primary data collection, 87 Focus Group Discussions (FGDs) were arranged to validate the collected data. However, this study considered 202 inland species and 86 marine species to estimate the post-harvest loss. Questionnaire Loss Assessment Method (QLAM) and descriptive approach based on field-level data was employed to summarize the findings of PHL of fisheries. To evaluate the supply chain performance at different stakeholders and markets (spot, contract, relational and cooperative), data were collected based on six indicators, namely, efficiency, effectiveness, quality, reliability, flexibility, and capability, using a five-point Likert scale. Shephard method, Acharya and Agarwal method, Marketing Efficiency Index Method, and Composite Index Method were employed to investigate the efficient value chain of different fish species.

Key findings

- The estimated aggregate post-harvest losses were 59.70 kg/MT whereas physical loss was 3.37 kg/MT and market loss was 56.33 kg/MT.
- In terms of aggregate monetary value, the country faces fishery post-harvest loss accounting BDT 1968.69, BDT 318.22, and BDT 651.11 crore for capture, culture, and marine fishery.
- According to the intensity of losses, capture sub-sector accounts for the highest PHL (59.70 kg/MT), followed by marine (36.53 kg/MT) and culture (6.74 kg/MT) fisheries.
- At the nationwide comparison, severe PHL was observed in Dhaka, Tangail, Mymensingh, Gazipur, Kishorganj, Netrokona, Habiganj, Sylhet, Pabna, Rajshahi, Natore, Bogura, Chapainawabganj, Noakhali, and Chattogram districts.
- Species-wise the most physical loss was found for Hilsha (capture), Rui (culture), Punti (low-value species), Mola, Kachki, and Chanda (small indigenous species) and lottiya (marine). on the other hand, market losses were observed for Chanda, Kachki, Bighead carp, and Mola.
- The highest physical loss of fish occurred in *Boishakh (Apr-May), Joishtho (May-Jun),* and *Chaitra (Mar-Apr)* months in capture fisheries while *Chaitra (Mar-Apr), Boishakh (Apr-May),* and *Sravon (Jul-Aug)*for culture fisheries at both farm and trader levels.
- The predominant causes for the physical loss of capture and culture fisheries were ‘delayed in marketing the fish and higher temperature’, followed by the causes of ‘inappropriate harvesting method’ and ‘longer harvesting duration’. In case of marine fisheries, the most significant issue of physical loss was ‘more time attached with the net’ since fish are trying to escape from the trap and put pressure on the net; thus, the physical damage occurred on the fish body surface.
- The unexpected supply (excess supply) ranked first, followed by ‘delaying in marketing the fish and temperature’ in both capture and culture fisheries were the main reasons for the market loss.
- In backward and forward linkage, all actors maintained a contractual/ managed/ not managed relationship with the fellow actors in capture, culture and marine fisheries sub-sector.
- The supply chain performance in terms of efficiency and capability is not satisfactory among the entire stakeholders because of poor market environment, poor infrastructure and insufficient storage facilities leading to delayin selling fish at a lower price.
- In case of capture, culture and marine fisheries, local agent (*faria*), wholesaler (bepari) and processor (salting) added the most value among the value chain actors, respectively.

Keywords: Post-harvest loss, Supply chain, Value chain, Capture fisheries, Culture fisheries, Marine fisheries.

B. Implementation Status

1.1 Cordination Component (BARC): Not applicable

1.2 Component 1 (BAU)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk)	Physical (No.)	Financial (Tk)	
(a) Office equipment					Target achieved 100% as per plan
1. Steel Almirah	1	23800	1	23800	
2. Executive Table	2	20000	2	20000	
3. Executive Chair	2	10000	2	10000	
4. Visitor Chair	4	4000	4	4000	
5. Computer Table	2	5000	2	5000	
6. Computer Chair	2	3500	2	3500	
(b) Lab &field equipment					Target achieved 100% as per plan
1. Desktop Computer	2	60000	2	60000	
2. Printer	1	19799	1	19799	
3. Scanner	1	10000	1	10000	
4. Laptop	1	60000	1	60000	
5. UPS	2	10000	2	10000	
6. Digital Camera	1	25000	1	25000	
(c) Other capital items					

1.3 Component 2 (PSTU)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk)	Physical (No.)	Financial (Tk)	
(a) Office equipment					Target achieved 100% as per plan
7. Steel Almirah	1	24000.00	1	24000.00	
8. Executive Table	2	40000.00	2	40000.00	
9. Executive Chair	2	20000.00	2	20000.00	
10. Visitor Chair	4	16000.00	4	16000.00	
11. Computer Table	2	10000.00	2	10000.00	
12. Computer Chair	2	7000.00	2	7000.00	
(b) Lab &field equipment					Target achieved 100% as per plan
7. Desktop Computer	2	120000.00	2	120000.00	
8. Printer	1	20000.00	1	20000.00	
9. Scanner	1	10000.00	1	10000.00	
10. Laptop	1	60000.00	1	60000.00	
11. UPS	2	20000.00	2	20000.00	
12. Digital Camera	1	25000.00	1	25000.00	
(c) Other capital items					

12. Establishment/renovation facilities

Coordination component: 1

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Work Partition of Ground Floor Room No:122,124 and Renovation in Main Building, BARC	297210/-	297210/-			Achievement 100%

13. Training/study tour/ seminar/workshop/conference organized by the sub-project

Description	Number of participants			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
Inception Workshop (1)	56	7	63	1 day	All workshops held at the Conference room of BARC as per schedule of activity of the
Half yearly Research Prog. Review Workshop (2 no.)	65+ 62	9+8	144	1+1 = 2 days	
Annual Research Prog. Review Workshop (2 no.)	60+63	7+8	138	1+2 =3 days	
Project Completion Report Review Workshop (1 no)	45	6	52	1 day	
(a) Training					
Enumerator Training of BAU component	15		15	5	Training organized on survey and data recording
Enumerator Training of PSTU component	15		15	5	
Enumerator Training of both component at BARC	30		30	2	

C. Financial and physical progress (Combined and component wise)

1. Financial and physical progress (combined)

Fig in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	6521337	6529693	6517068	12625	99.93	Not applicable
b. Field research/lab expenses and supplies	21475776	21419887	21419587	300	99.74	
c. Operating expenses	2880733	2824855	2824200	655	98.04	
d. Vehicle hire and fuel, oil & maintenance	3399823	3360650	3360650	0	98.85	
e. Training/workshop/seminar etc.	286800	286710	286710	0	99.97	
f. Publications and printing	440000	390000	390000	0	88.64	
g. Miscellaneous	312462	312682	312682	0	100.07	
h. Capital expenses	1028209	1029442	1029442	0	100.12	
Total	**36345140**	**36153919**	**36140339**	**13580**	**99.44**	

2. Coordination component (BARC)

Fig in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	1350000	1350000	1350000	0	100.00	Not applicable
b. Field research/lab expenses and supplies	0	0	0	0	0	
c. Operating expenses	226136	225841	225841	0	99.87	
d. Vehicle hire and fuel, oil & maintenance	472518	472518	472518	0	100.00	
e. Training/workshop /seminaretc.	150000	150000	150000	0	100.00	
f. Publications and printing	400000	390000	390000	0	97.50	
g. Miscellaneous	104136	101052	101052	0	97.04	
h. Capital expenses	297210	297210	297210	0	100.00	
Total	**3000000**	**2986621**	**2986621**	0	99.55	

3. Component 1 (BAU)

Fig in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	2224047	2213492	2200867	12625	98.96	Not applicable
b. Field research/lab expenses and supplies	8301776	8244440	8244140	300	99.31	
c. Operating expenses	965985	927756	927101	655	95.97	
d. Vehicle hire and fuel, oil & maintenance	1800000	1760000	1760000	0	97.78	
e. Training/workshop/seminar etc.	0	0	0	0	0.00	
f. Publications and printing	0	0	0	0	0.00	
g. Miscellaneous	148613	150600	150600	0	101.34	
h. Capital expenses	371599	371599	371599	0	100.00	
Total	**13812020**	**13667887**	**13654307**	**13580**	**98.86**	

4. Component 2 (PSTU)

Fig in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance / unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	2947290	2966201	2966201	0	100.64	Not applicable
b. Field research/lab expenses and supplies	13174000	13175447	13175447	0	100.01	
c. Operating expenses	1688612	1671258	1671258	0	98.97	
d. Vehicle hire and fuel, oil & maintenance	1127305	1128132	1128132	0	100.07	
e. Training/workshop/ seminar etc.	136800	136710	136710	0	0.00	
f. Publications and printing	40000			0	0.00	
g. Miscellaneous	59713	61030	61030	0	102.21	
h. Capital expenses	359400	360633	360633	0	100.34	
Total	**19533120**	**19499411**	**19499411**	**0**	**99.83**	

D. Achievement of Sub-project by objectives: Technology generated/ developed

Not Applicable for this sub-project

E. Information/knowledge generated/policy generated

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
Assessing Post-harvest losses & their causes	Calculated nationwide fish (species wise) losses from harvest to consumption of all stakeholders' level	Generate valuable data and information related to post-harvest loss of capture, culture and marine fisheries of Bangladesh.	• Increased market competitiveness in the local, regional, national, and international level; • Enhanced supply chain performance and used for further relevant research works; • Increased managerial capacity of the supply and value chain actors; • Government, NGOs and other private research organizations will get an excellent basis for designing their fisheries research priorities in the field of supply and value chain as well as post-harvest losses of different fish species all over the country. • Developed a supply and value chain, and post-harvest database
Analysis of existing supply chain structure	Supply chain performance and supply chain networking analysis of fish stakeholders were applied	Efficient supply chain of capture, culture and marine fisheries were identified	
Analysis of value chain structure & extend of value addition	Value chain mapping of fish species (capture, culture and marine) in Bangladesh were done	Value chain mapping of fish species was developed	

F. Materials development/publication made under the sub-project

Publication	Number of publications		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/ leaflet/ flyer etc.			
Journal publication	**-03** • Nature, Extent of and Reasons for Post-harvest Losses of Fisheries at Farm level in the Developing Countries • The Effect of Smartphone Usages on Supply Chain and Post-harvest Loss of Capture Fisheries in Bangladesh • Measuring Post-harvest Losses of Different Proprietorship at Farm Level in Capture Fisheries	**-1** Post-harvest losses of capture, culture and marine fisheries of Bangladesh	• International Journal of Business and Economy • Submitted to Aquaculture Journal • Submitted to Aquaculture International • Submitted to Bangladesh Journal of Agricultural Economics
Video clip/TV program		Facebook-Page, 3 video clips	Post-harvest loss, market structure and facilities, and fish selling activities

G. Description of the generated Technology/knowledge/policy

i. Technology fact sheet

Not Applicable for this sub-project

ii. Effectiveness in policy support (if applicable)

Context

Fish is an important source of protein in the dietary requirement, and it offers valuable income source for leading the livelihood of millions. The demand for fish is growing at the consumer level to maximize the food and nutrition security. Therefore, the reduction in PHL of fishes can make a major contribution to meet this upsurge demand, which in turn, enhance the income of producers as well as the food security status of consumers. Post-harvest quality loss (quantitative and qualitative loss) estimation and its remedial measures of culture, capture and marine fisheries are crucially important for the country. Supply chain analysis and value-chain mapping knowledge is highly important to reduce post-harvest losses of fish.

The main scenario of post-harvest loss (PHL) of fisheries included the main three sub-sector i.e culture, capture and marine fisheries sources of Bangladesh. Physical loss and market loss including quality loss and market force loss were estimated source-wise, species wise-loss (high-valued and low-valued fish), stages-wise (fishing, harvesting, processing, transport, storage and marketing) for culture, capture and marine fisheries in Bangladesh. Monetary value loss due to physical loss in culture, capture and marine fisheries were identified in respect to the specific reasons for physical losses. The actors considered for culture and capture fisheries are fishers/fish farmer, faria, bepari, paikar, aratdar, commission agents, and retailer; and for artisanal and industrial fisheries are fishermen, bepari, paikar, aratder, retailer, processor (freezing, drying and salting). In addition, supply chain analysis (with % share) and value-chain mapping were also conducted for culture, capture and marine fisheries.

Generated knowledge

The findings of this study revealed that the estimated overall PHL was 59.70 kg/MT, which was comprised of physical loss (3.31 kg/MT) and market loss (56.33 kg/MT) in case of capture fisheries. On the other hand, the estimated overall PHL in culture fisheries was 6.74 kg/MT, including physical loss of 0.99 kg/MT and market loss of 5.75 kg/MT. The medium quality fish loss was a major concern in inland fisheries, and it was 40.30 kg/MT and 3.91 kg/MT for both capture and culture fisheries, respectively. There is a substantial amount of PHL in the marine fisheries, which was around 36.53 kg/MT, including total market and physical loss were 26.00 and 10.53 kg/MT, respectively. However, the fisheries sub-sector of Bangladesh lost almost BDT 2940 crore every year in terms of PHL. Regarding the different inland waterbodies, the highest amount of PHL emanated from the river (10.69 kg/MT), while it was 6.66 kg/MT for pond culture. The PHL varied according to the fish species, and the higher PHL occurred for Hilsha, which was 2.93 kg/MT among high-value species in capture fisheries. In contrast, among low-value species in capture fisheries, the higher PHL occurred for Punti, which was 1.52 kg/MT. In culture fisheries, the estimated PHL was higher for Rui (high-value species) and Mrigal (low-value species), which were 1.14 kg/MT and 0.86 kg/MT, respectively. Specie-wise,

higher physical losses were observed for Mola, Kachki, and Chanda (10.98-14.98 kg/MT) due to small indigenous species (SIS). Similarly, species specifically Chanda, Kaski, Bighead carp, and Mola had higher market loss. The PHL appeared at a different stage of the supply chain; the highest PHL was observed at the selling stage for both inland and marine fisheries. The predominant causes for the physical loss of capture and culture fisheries were delay in marketing fish and higher temperature, followed by the causes of inappropriate harvesting method and longer harvesting duration. The unexpected supply and delay in marketing of the fish were the main reasons for the market loss in both capture and culture fisheries. However, the most significant issue of marine fishes' physical loss at the fishers' stage was due to more time attached with the net, while the imbalance of demand and supply was the main reason for market loss at the traders' stage.

This study also assessed the supply chain network and mapping of inland and marine fisheries along with the post-harvest loss. Besides, this study also measured the performance of supply chains. We identified twelve channels for culture fisheries, fifteen channels for capture fisheries, and ten channels for marine fisheries through which fishes flowed from producers to consumers. Various stakeholders are involved in the fish supply chain; among them, fishers sold most of the total catch fish (48.63%) to the *aratdar* (commission agents). Similarly, fish farmers mostly sell their fishes to commission agents (56.23%), followed by wholesalers (*bepari*) (27.43%). However, the artisanal fishers mostly sold their fish to wholesalers (*aratdars*) (78%) and suppliers/*dalal* (10%) based on their achieved financial support. In backward linkage, fishers got financial, training, extension, or input supports from different NGOs, Department of Fisheries (DoF) of Ministry of Fisheries and Livestock (MoFL), money lenders, and cooperatives. Fishers had contractual arrangements with *aratdars* (commission agent), and relational arrangements with the retailers and consumers in the forward linkage. Fish farmers had contractual or relational arrangements with the feed mills or shops. They procured inputs such as fingerlings, medicines, fertilizers, fishnet, and other equipment based on price as well as business liaison. In forward linkage, farmers often sold fish on arranged contractual agreement with *aratdar* (commission agent) and wholesaler (*bepari*). The supply chain networking of the Shrimp processing plant is quite different; Shrimp processing plant had contractual arrangements in their backward linkage with account holders, commission agents, local agents, depot owner, *aratdars*, banks, DoF, and ice suppliers. But shrimp processing plants are connected only to the exporter in forwarding linkage. To evaluate the supply chain performance at different stakeholders and markets, we analyzed six supply chain performance indicators: efficiency, effectiveness, quality, reliability, flexibility, and capability. The performance score of quality is dissatisfactory for fishers and fish farmers. The overall performance of efficiency and capability is not satisfactory among the entire stakeholders. This study also unveiled that the comprehensive performance of effectiveness, quality, reliability, and flexibility are good in the entire market arrangement. The overall efficiency and capability score indicate the poor performance of all market arrangements. The study also provides a brief outlook of value chain analysis frameworks for different species of capture, culture, and marine fishes underlying to identify the most efficient chain. The value chain of carp fishes indicates that around 1.63 times value addition took place in the process of retail distribution (from fish farmers to consumers), while it was 1.49 times for Pangas in terms of monetary value. Local agents (*faria*) added the most value among the value chain actors in the capture fisheries sector, while wholesalers (*bepari*) added the maximum value in the culture fisheries. Besides, processing (salting) adds up the highest value for marine fisheries. However,

the highest value addition is observed for fantail shrimp, followed by headless among the marine shrimp species. Shrimp has the highest market margin (BDT 84882.5/MT), followed by Lakhua (BDT 84677.5/MT). Species-wise, the average value addition is BDT 31913.73/MT and maximum for Rupchanda BDT 63494/MT followed by Vetki (BDT 53147/MT) and Shrimp (BDT 38102.5/MT). However, the lowest value-addition was for Chapila. According to the overall efficiency of Rui, we found that channel III (Fish farmer → Commission agent → Retailer → Consumer) was the most efficient channel. Regarding Pangas and inland Shrimp, channel I and channel II (Fish farmer → Commission agent → Retailer → Consumer) was the most efficient value chain (channel), respectively. However, the efficient value chain of marine Shrimp was dissimilar to inland Shrimp, and we found that Channel I (Fisherman /Fishing Vessel (Artisanal/Industrial) →*Aratdar* /Depot owner/Fish Company → Wholesaler → Retailer → Final consumer) was the efficient value chain. Moreover, this study found channel I (Fisherman → Salting fish Processor → Consumer) was the most efficient value chain for marine Hilsha.

H. Technology/knowledge generation/Policy Support (as applied)

i. Immediate impact on generated technology: *Not Applicable*

ii. Generation of new knowledge that help in developing more technology in future

- An updated quantitative and comprehensive knowledge of post-harvest losses of different stakeholders at local level was documented. Source-, species- and region-wise information of post-harvest losses will help to shape and think on developing the technology of reducing the post-harvest losses of capture, culture and marine fisheries across the country.

iii. Technology transferred that help increased agricultural productivity and farmers' income: *Not Applicable*

iv. Policy Support

- **Improving infrastructure facilities in landing center**. Capture and marine fisheries need more emphasis to reduce PHL and maintain quality through improving infrastructure facilities in landing center, use of adequate quality ice and maintain the Standard Operating Procedures (SOP) along the e supply chain.
- **Using modern post-harvest technology.** Along the supply chain, actors should use insulated containertank, quality ice, cold chain management (use of refrigerated vehicle), and improved packaging which can reduce the post-harvest market loss.
- **Improving post-harvest handling process.**Special attention needs to be given in respect of fish species, size and body compositions with a view to conduct post-harvest cleaning/washing, sorting, grading and icing appropriately.
- **Developing storage capacity.** During pick/harvest period, storage capacity needs to be enhanced specially for capture fishes. Entrepreneurs should come forward for developing fish storage capacity and diversified ice packaging system.
- **Enhancing supply chain performance.**Supply chain performance need to be enhanced to reduce the PHL in terms of capacity and efficiency of the stakeholders. Stakeholders'

capacity of storing the unsold fish and higher transport capacity are to be arranged. Labor and transportation cost need to be minimized for improving the supply chain efficiency.

- **Introducing mechanization in fisheries and aquaculture.** Adoption of aquaculture mechanization and development of cooperative system for transportation are suggested for the small-scale fisher/fish farmers and other stakeholders.
- **Providing training and institutional support.**Training on awareness and skill development reducing PHL should be conducted for all supply and value chain actors. Stakeholders need to be motivated to use sufficient quality ice, insulated icebox, tank and van, improved packaging and transportation. In addition, motivation, training and institutional support (financial and technical) need to be ensured from different relevant department of Bangladesh.
- **Developing legal regulatory frameworks.**Effective enforcement of legal regulatory frameworks like DoF/FIQC, GAP, GHP, SOP, and SSOP should be ensured. Low-cost best practice demonstration and best practitioners award can be introduced.

I. Information regarding desk and field monitoring of the sub-project

i) Desk Monitoring

Date of the programs	Program descriptions	Implementation Unit	Output
05 June, 2018	Training on implementation procedure related to technical, financial and procurement aspects	PIU, NATP-2, BARC	Sub-project management skill improved
06 November, 2018	Inception workshop	Fisheries Division, BARC	Improvement of sub-project document
03 July, 2019	Annual progress review workshop	Fisheries Division, BARC	Reviewed research progress at various stages implementation, identified lacking & shortfalls, suggestions improved sub-project activities
19 November,2019	Annual review workshop	PIU, NATP-2, BARC	
14 October, 2019	Coordination meeting	Fisheries Division, BARC	
29 January, 2020	Half yearly review workshop	Fisheries Division, BARC	
30 September, 2020	Annual progress review workshop	PIU, NATP-2, BARC	
14, October, 2019 29, June, 2020	Sub-project Coordination meeting	BARC Coordination Unit	Strengthen activities of the sub-project components
29 December, 2020	Special meeting for preparation process of PCR	Fisheries Division, BARC	Oriented with PCR drafting process
27 April, 2021	Submit the sub-project completion report PCR (zoom meeting)	PIU, NATP-2, BARC	Draft PCR developed

ii) Field Monitoring

Monitoring team	Date(s) of visit	Total visit till date	Output
Sub-project Coordinatos unit	PSTU: Aug'2019	2	Increased importance of the field work along with high level participation of the stakeholders
	BAU: Oct' 2020	2	
Technical Division/Unit, BARC	PSTU: Sept'2019	1	Advised new possible areas of to be bring under data collection
PIU-BARC, NATP-2	BAU: Mar'2019	1	Increased interest of the respondents that helped smooth survey works
	PSTU: Oct'2020	1	

iii. Weather data, flood/salinity/drought level and natural calamities: *Not Applicable*

J. Sub-project auditing (covers all types of audit performed)

1. Coordination component

Types of Audits	Major observation/ issues/objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial & Performance Audit by FAPAD on 31.10.19 for the year 2018-2019	No objection raised, found all relevant documents updated as per guideline	353624.00	Financial management of the component found running smoothly till the end of the project. No query or objection raised at any stage of operation by the audit teams.	Financial management & project performance found satisfactory
Financial & Performance Audit by FAPAD on 09.12.20 for the year 2019-2020.	No objection raised, found all relevant documents updated as per guideline	503098.00		Financial management & project performance found satisfactory
Financial & Performance Audit by FAPAD on 11.10.21 for the year 2020-2021.	No objection raised, found all relevant documents updated as per guideline	1086994.00		Financial management & project performance found satisfactory

1. Component 1 (BAU)

Types of audits	Major observation/ issues /objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial & Performance Audit for the year 2018-19	Financial management satisfactory. No objection raised	4100872.00	Financial management of the component found running smoothly till the end of the sub-project.	Submitted satisfactory audit repot in all cases
Financial & Performance Audit for the year 2019-20 & CA farm audit for	Financial management satisfactory. No objection raised	5165618.00		

the year 2019-20				
Financial & Performance Audit for the year 2020-21	Financial management satisfactory. No objection raised	35066 68.00		

2. Component 2 (PSTU)

Types of audits	Major observation/ issues /objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial & Performance Audit for the year 2018-19	Financial management satisfactory. No objection raised	5600019.00	Financial management of the component found running smoothly till the end of the sub-project.	Submitted satisfactory audit repot in all cases
Financial & Performance Audit for the year 2019-20 & CA farm audit for the year 2019-20	Financial management satisfactory. No objection raised	6643662.00		
Financial & Performance Audit for the year 2020-21	Financial management satisfactory. No objection raised	6250283.00		

K. Lessons Learned

- The sub-project enhanced the capacity of research team to deal with filed level producers and actors as well as increased the capacity of collecting necessary from the respondents
- We were not only learned from the results of the research, but also learned the methods of conducting research and the teamwork that is involved with other researchers.
- Bureaucracy problem always hampers the successful implementation of the sub-project activities.

L. Challenges

- One primary challenge for our research team during the pandemic is the delay of data collection from the nationwide stakeholders.
- It was a treble experience of handling the huge data set to obtain the findings of the study.

M. Suggestions for future planning

This sub-project was involved in finding the post-harvest losses of capture, culture and marine fisheries of Bangladesh. From the findings, research team identified that capture and marine fisheries sectors are facing more losses compared to the culture fisheries, which is more commercialized sector in Bangladesh. In addition, the completed sub-project did not consider the biological losses of fishes, which was beyond the Terms of Reference (ToR) of the sub-project, but an important unexplored side of post-harvest losses estimation. Therefore, following areas are to be considered for the future project funding:

- Mitigating the losses of capture and marine fisheries in Bangladesh to increase the amount of fish availability.
- Estimating the biological quality losses of capture, culture and marine fisheries.

- Developing the techniques and tools of reducing post-harvest losses of capture, culture and marine fisheries.
- Enhancing the capacity of the stakeholders to preserve/ storage the captured/ harvested fish at their premises/ marketplaces.

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Signature of the Coordinator	Counter signature of the Head of the organization/authorized representative
	
(Dr. Md. Monirul Islam) Date: 15.11.2021 ***Member Director (Fisheries)*** ***Bangladesh Agricultural Research Council***	**(Dr. Shaikh Mohammad Bokhtiar)** Date: 15.11.2021 ***Executive Chairman*** ***Bangladesh Agricultural Research Council***

Appendices

A. <u>Coordination component</u>

Appendix – BARC: A

Recommendation of the inception workshop and status of action taken

Recommendations	Action Taken
General recommendation • Process of documentation of the study result and its role in the development of the sector need to be specified in the text of both the components	Already mentioned under methodology and output and out comes sections
Component 1 (BAU)	
• Remove the word "fairness" from the second expected outcomes of the component sub-project;	Necessary correction done
• Publish of articles shown in Sl. 6 under expected outcome is not justified. Correct this part;	Correction done
Component 2 (PSTU)	
• Remove the word "fairness" from the second expected outcomes of the component sub-project	Necessary correction done

Appendix – BARC: B

Recommendation of the half yearly workshops

Recommendations of the First Half Yearly Workshop	Action taken
Component 1 (BAU)	
• Suggested to summarize and present the post-harvest fish loss according to group or category that fish species belongs to;	This has been done accordingly
• Period so far covered by the sub-project is about 70% with the actual progress of about 50% research. Completion of the remaining 50% research works (data collection; computing and analysis and report preparation) within a limited period of 30% time is almost impossible or very hard to do. So immediate way out for better performance and/or speed up of the research to achieve the target is emphasized;	Works carried out and completed as per revised plan satisfactorily
Component 2 (PSTU)	
• Above comments (1 & 2 of BAU) are equally applicable for this component also; • In addition to that, activity plan for the next twelve months of PSTU component found not viable technically, that need total revision keeping in mind the deadline of sub-project period;	Revision of research plan done in consultation with the coordinator of the sub-project

Appendix – BARC: C

Recommendation of the Annual workshop

Recommendations of the First Annual Workshop	Action taken
Component 1 (BAU)	
• A considerable fish loss due to improper fish handling and packing in Bangladesh is very much common (both for fresh and marine sectors). But information on handling and packaging loss of fish is missing in the presentation. Further verification of data in his regard suggested;	Information/data on handling and packaging loss of fish gathered and reported in the report
Component 2 (PSTU)	
• Information on discard/loss of fish at farm level during harvesting and handling should be re-examined with proper references	Necessary verification done
Recommendations of the Second Annual Workshop	**Action taken**
Component 1 (BAU)	
• The term "Loss" should be defined properly in the report;	It is done
• As the research is not carrying out any qualitative study of fish at various stages, so it is suggested to replace the term "Quality loss" by the term "Degradation	Proposed change of terminology done
• Under quality use of water and its source for ice preparing may be one of the vital causes of qualitative deterioration of fish in case of ice preservation which has been ignored in the research. Similarly, distant carrying may also an affecting factor for quality degradation which may be taken into account;	All the proposed areas were included under the research activities
Component 2 (PSTU)	
• Profitability and its distribution study is not related with the present study;	These are all considered as the additional information generated under the study
• Identification of value chain affecting factors not done yet;	As per activity plan, these activities were covered later
• Suggested to count degraded raw fish when convert those as raw material for product development (such as dry fish, smoked fish etc) and in such cases duplicate counting should be avoided;	Necessary attempts were made
• Value of physical and monitory loss as shown Hilsa post-harvest loss during drying seems too large. Further verification of the data needed;	Further verification done. No deviation observed

Appendix – BARC: D

Recommendation of the coordination meetings

Central Coordination meeting at BARC	
Recommendations	**Action taken**
• Increase in length of presently use questionnaire size for field survey data collection compelled to reduce the sample size as the sub-project time period is limited and fixed. Therefore, the meeting urged that, it is very important to re-plan data collection sample spots so that it should represent all aspects of post-harvest loss in-spite of decrease in sample size (as was in original PP). PI	A joined discussion of the PIs with the sub-project coordinator held. Accordingly involvement of data collectors and enumerators increase and timely completion of sampling size data

of the two components is suggested to sit together immediately and take necessary action to resolve the matter.	done in spite of having Pandemic disruption.
Two Other virtual Coordination meetings	
Component 1 (BAU)	
• Uniformity in area coverage for data collection within both the components is essential for maintaining uniformity in data tabulation analysis under a joined effort.	Based on activity timeframe of the sub-project document, coordination unit took necessary step for maintaining uniformity in activities of the components
Component 2 (PSTU)	
• Above comment is applicable for PSTU component also	

B. Research components

Appendix- E: *Value chain of Rui fish (Ten channel)*

Channel I: Fish farmer → Local agent (Faria) → Wholesaler (Bepari) → Wholesaler (Paikar) → Aratdar (Commission agent) → Retailer → Consumer

Channel II: Fish farmers → Local agent (Faria) → Wholesaler (Bepari) → Aratdar (Commission agent) → Retailer → Consumer

Channel III: Fish farmers → Local agent (Faria) → Wholesaler (Paikar) → Aratdar (Commission agent)→ Wholesaler (Paikar) →Retailer →Consumer

Channel IV: Fish farmers → Wholesaler (Bepari) → Aratdar (Commission agent) →Retailer→ Consumer

Channel V: Fish farmers → Wholesaler (Bepari) → Aratdar (Commission agent) →Retailer→ Restaurant

Channel VI: Fish farmers → Wholesaler (Aratdar) → Wholesaler (Paikar) →Retailer → Consumer

Channel VII: Fish farmer → Aratdar (Commission agent) → Retailer → Consumer

Channel VIII: Fish farmer → Wholesaler (Bepari)→ Aratdar (Commission agent)→ Wholesaler (Paikar) → Retailer → Consumer

Channel IX: Fish farmer → Wholesaler (Paikar) → Aratdar (Commission agent)→ Retailer → Consumer

Channel X: Fish farmer → Aratdar (Commission agent)→ Wholesaler (Paikar) →Retailer → Consumer

Appendix- F: *Value chain of Pangas fish (Eight channel)*

Channel I: Fish farmers → Local agent (Faria) → Wholesaler (Bepari) → Aratdar (Commission agent) → Retailer → Consumer

Channel II: Fish farmer → Aratdar (Commission agent) → Retailer → Consumer

Channel III: Fish farmers → Local agent (Faria) → Wholesaler (Paikar) → Aratdar (Commission agent)→ Wholesaler (Paikar) →Retailer →Consumer

Channel IV: Fish farmers → Wholesaler (Bepari) → Aratdar (Commission agent) →Retailer→ Consumer

Channel V: Fish farmers → Wholesaler (Aratdar) → Wholesaler (Paikar) →Retailer → Consumer

Channel VI: Fish farmer → Wholesaler (Bepari)→ Aratdar (Commission agent) → Wholesaler (Paiker) → Retailer → Consumer

Channel VII: Fish farmer → Aratdar (Commission agent) → Wholesaler (Paiker) →Retailer → Consumer

Channel VIII: Channel I: Fish farmers → Local agent (Faria) → Aratdar (Commission agent) → Retailer → Consumer

Appendix- G: *Value chain of Shrimp (Six channel)*

Channel I: Fish farmers → Local agents (Faria) → Aratdar (Commission agent) → Retailers → Consumers
Channel II: Fish farmers → Wholesaler (Bepari) → Aratdar (Commission agent) → Retailers → Consumers
Channel III: Fish farmers → Wholesaler (Paikar) → Retailers → Consumers
Channel IV: Fish farmers → Aratdar (Commission agent) → Wholesaler (Paikar) → Retailers → Consumers
Channel V: Fish farmers → Aratdar (Commission agent) → Retailers → Consumers
Channel VI: Fish farmers → Aratdar (Commission agent) → Wholesaler (Bepari) → Retailers → Consumers

Appendix- H: *Value chain of Hilsha (Six channel)*

Channel I: Fishers → Local agent (Faria) → Wholesaler (Bepari) → Aratdar (Commission agent) → Retailer → Consumer
Channel II: Fishers → Wholesaler (Bepari) → Aratdar (Commission agents) → Retailers → Consumers
Channel III: Fishers → Wholesaler (Aratdar) → Wholesaler (Bepari) → Aratdar (Commission agents) → Retailers → Consumers
Channel IV: Fish farmers → Wholesaler (Paikar) → Aratdar (Commission agent) → Retailers → Consumers
Channel V: Fishers → Aratdar (Commission agents) → Wholesaler (Bepari) → Retailers → Consumers
Channel VI: Fishers → Aratdar (Commission agents) → Wholesaler (Paikar) → Aratdar (Commission agents) → Retailers → Consumers