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Mapping of the Frozen Fish Supply Chain System at TPI Karangsong, Indramayu

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***Abstract*—** Fish is a highly perishable food. Within eight hours of being caught and landed, it begins to undergo changes that can lead to spoilage. Frozen fish producers face challenges in maintaining product quality and freshness due to the need for refrigerated facilities, such as cold storage and refrigerated trucks, to optimize temperature control during the collection, processing, and distribution phases. This research explores the concept of mapping the frozen fish supply chain at TPI Karangsong, Indramayu, to provide business actors with a comprehensive understanding of the supply chain process from upstream to downstream. Mapping the supply chain is crucial, as it enables all stakeholders to grasp the intricacies of the process involved in their business operations. This is illustrated through the use of influence diagrams and rich pictures. The research findings help identify the various actors involved in the flow of frozen fish products, as well as the key activities within the frozen fish supply chain.

Keywords: *Frozen fish; Mapping the Supply chain; Influence diagrams; Rich picture.*

I. INTRODUCTION

Supply Chain Management (SCM) involves the systematic coordination of activities, spanning from the acquisition of raw materials to the distribution of finished goods to the end consumer, with the aim of enhancing customer satisfaction through the provision of high-quality products and services (Heizer et al., 2020). SCM integrates the movement of products, financial resources, and information in a synchronized manner among suppliers, manufacturers, distributors, retailers, and logistics providers (Haudi et al., 2022, as cited in Yusuf A.M., Soendiantono D., 2022). The core objective of SCM is to optimize the efficiency and effectiveness of the flow of goods, information, and financial assets, thereby aligning with and fulfilling customer expectations (Vistasusiyanti et al., 2017; Moktadir et al., 2018)

In addition, SCM aims to optimize company operations, minimize costs, and maximize customer satisfaction through strong relationships with suppliers and customers and effective communication (Jamaludin M. et al., 2020; Jamaludin M. et al., 2022). The main goal of SCM is to harmonize demand and supply management, reduce costs, and increase the value generated (William J., 2021). The supply chain comprises various entities, each with strengths and weaknesses, influencing the added value and profit margins (Amalia et al., 2020; Dharmawati et al., 2020; Guritno, 2016).

Fisheries management is key to providing livelihoods, bringing it about essential to consistently advance the quality of fishery products. To ensure the quality of the final product during further processing, the quality of fish as a raw material must be maintained (Perdana et al., 2020). Quality improvements start from pre-harvest handling, continue through post-harvest processes, and extend to marketing. Hygienic handling and storage of fish are critical to preventing quality degradation, as these processes significantly impact fish quality.

Since fish contain proteins easily spoiled by bacteria, cooling is the primary method to inhibit bacterial growth and maintain fish quality (Arjadi et al., 2018). Most fisheries companies employ mechanical cooling machines, which are considered the most efficient way to lower product temperature compared to other methods (Prihartanto et al., 2017). The cooling process typically takes place in Cold Storage facilities, which are equipped with buildings and cooling machines to store fishery products.

The fishery product supply chain involves fishermen, agents, processors, distributors, wholesalers, and retailers who collaborate to deliver fish from production points to the market. While fish is an easily accessible and affordable source of nutritious animal protein, the fisheries supply chain is highly complex due to the natural availability of raw materials and the diversity of ownership systems (Batubara et al., 2017). In Indonesia, the structure of the marine and fishery product supply chain is particularly intricate, requiring sophisticated logistics management and incurring high costs (Ministry of Trade, 2010, as cited in Jakaria R.B. & Rini C.S., 2017; Annida et al., 2014, as cited in Febianah W., et al., 2023). Long supply chains can hinder economic growth within communities and result in low fish prices due to conventional management practices (Sengkey C.J., et al., 2020; Katili K., et al., 2020). Additionally, long distances and extended travel times can diminish fish quality (Sulaeman M., et al., 2018).

Implementing a cold chain is a solution for maintaining fish quality through proper cleaning, storage, and the use of ice (Lokollo & Mailona, 2020). Fishery products must be kept at a constant temperature throughout the supply chain to preserve quality and extend shelf life (Li D., Li K., 2023; Ali et al., 2018).

This study explores the mapping of the frozen fish supply chain at PPI Karangsong, Indramayu, to help business actors understand the process from upstream to downstream. This mapping is crucial for all stakeholders—from fishing to delivery to consumers—to effectively manage the supply chain. Additionally, supply chain mapping enables retailers to respond quickly to shortages or lost orders (Biel, 2021).

II. METHODOLOGY

This research employs a qualitative descriptive approach, which is a form of research that aims to describe specific phenomena or events in depth and detail. The study involves creating a traceability map of the frozen fish supply chain system based on interviews and observations. Data collection was conducted through literature reviews and in-depth discussions with various stakeholders and fisheries business experts.

The literature review focused primarily on a perishable product supply chain system, particularly the cold supply chain system for frozen fish. Studi ini berusaha untuk memberikan gambaran yang komprehensif tentang keberlanjutan dalam

industri ikan beku. The research was conducted in Karangsong, Indramayu Regency, West Java, which is the largest fish-producing area in Indramayu and contributes 34.63% of the total fisheries production in West Java as of 2023.

III. RESULTS AND DISCUSSION

1. Mapping the Fisheries Supply Chain System

Supply network mapping is used to understand the factors of the fisheries supply chain, encompassing the entire supply chain process. It helps identify vulnerabilities and risks, enhances transparency regarding commitments and sustainability, and fosters innovation (Norwood & Peel, 2021). This mapping emphasizes environmental issues and supports the integration of product design and delivery throughout the entire supply chain, from producer to consumer (Mubarik et al., 2021). Supply chain mapping offers two main advantages (Sanderson, 2020; Fabbe-Costes & Spring, 2020 in Daniella C., et al., 2022): first, it enhances visualization and monitoring of the entire supply chain process, which is essential for cleaner production; second, it improves supply chain resilience to address challenges posed by the fourth industrial revolution. Beyond increasing visibility and sustainability, mapping also strengthens the supply chain's resilience. Tumanan D. et al. (2017) based their fish supply chain mapping on accessibility, availability, and cost. Perdana T. et al. (2020) developed ideas and concepts from various key actors in the supply chain, including farmers, logistics service providers, market players, industry associations, and central and local governments, which were illustrated in rich pictures.

Mapping the fisheries value chain in Karangsong, Indramayu Regency, provides an overview of the present condition of the cold chain in the fisheries industry. Analyzing the fish value chain is crucial for enhancing the value of frozen fish products at every stage, from production and storage to delivery to consumers (Herdiani L., et al., 2023). The results of this mapping can be used to identify the various actors involved in the stream of fishery wares and the main activities in the frozen fish supply chain. Relationships between actors typically form a pattern where each actor interacts with those one level above or below them. For effective implementation and competitiveness in the global market, supply chain actors must understand the food system and export demand to develop a robust frozen fish supply chain strategy.

Karangsong, Indramayu, is a key fisheries center with numerous large ships and ports, producing over 18,445 tons of catch per year in 2020, valued at IDR 365 billion. The area is notable for having the largest fisheries contribution in West Java, reaching 34.63% in 2023. Karangsong currently hosts a Cold Storage facility with a capacity of 450 tons, aimed at maintaining quality and increasing fish prices. Through the Ministry of Maritime Affairs and Fisheries (KKP), the local government is modernizing various facilities, including fishing gear, ponds, moorings, auction buildings, and river and estuary channels.

The Fish Auction Place (TPI) provided by the government helps fishermen market their catch, increase fish prices, and offer better benefits. This improvement impacts fishermen's income and fish production. However, many frozen fish traders, or Bakul, still use standard refrigerators and simple cooler boxes for storage and distribution, due to limitations in cold storage and cold truck

Data on capture fisheries production at PPI Karangsong from 2019 - 2023 are as follows:

This table is designed to record monthly catch production data for three consecutive years (2021, 2022, and 2023), along with the corresponding price per kilogram in Rupiah.

Table 1. Production data of capture fisheries TPI Karangsong - Indramayu

NO	Month	BLAD BAKUL TOTAL CATCH PRODUCTION					
		2021		2022		2023	
		Prod. (Kg.)	Price (Rp. 000)	Prod. (Kg.)	Price (Rp.000)	Prod. (Kg.)	Price (Rp.000)
1	January			1,710,360	36,126,820	1,317,456	30,917,177
2	February	738,308	15,107,968	1,270,226	28,442,068	1,199,969	28,001,515
3	March	1,266,798	25,065,184	1,643,431	35,468,542	1,900,235	45,216,690
4	April	2,764,565	49,425,636	3,139,791	60,742,379	2,931,668	61,349,971
5	May	2,348,570	39,129,544	1,765,245	35,423,712	2,058,763	43,566,4820
6	June	1,219,943	22,661,464	1,511,821	33,328,487	1,035,278	25,345,2120
7	July	1,238,313	23,631,883	1,252,399	30,963,838	1,841,302	45,166,5880
8	August	1,842,791	35,065,295	1,880,685	41,852,797	1,355,514	32,020,571
9	September	1,207,893	25,525,254	1,424,674	31,589,369	1,396,765	32,280,054
10	October	1,475,398	29,021,324	1,253,597	28,539,833	1,641,226	36,444,903
11	November	1,534,267	31,195,370	2,146,937	47,915,141	927,961	18,505,2520
12	Desember	2,081,730	42,139,996	1,850,634	37,690,846		
T o t a l		17,718,576	74,754,298,098	20,849,800	448,083,832	17,606,137	398,814,4150

Source: KPL Mina Sumitra Karangsong Indramayu Regency

The following is an illustration of the frozen fish supply chain structure in Karangsong, Indramayu.

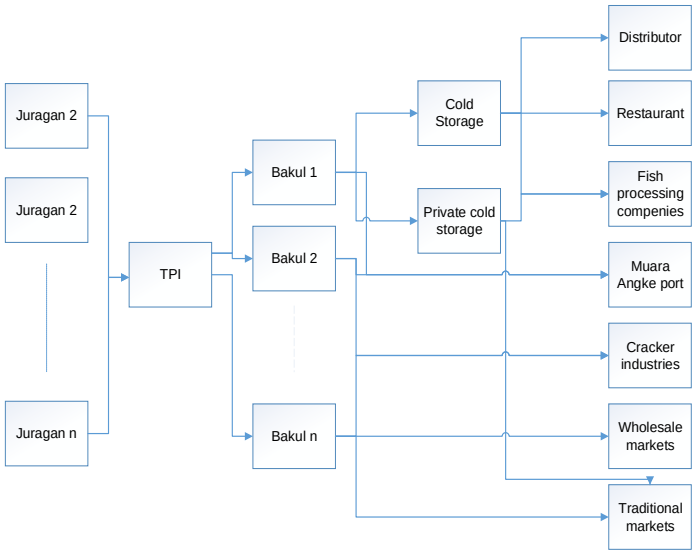

Figure 1. The configuration frozen fish supply chain in Karangsong Indramayu

Distribution Flow of Products from the Juragan to Various Types of Markets or End Consumers

1. Juragan: These are the parties who initially collect the catch or production.
2. TPI (Fish Auction Place/Tempat Pelelangan Ikan): The catch collected by the Juragan is then sent to the TPI to be auctioned.
3. Bakul: After being auctioned, the catch is purchased by bakul (collectors or wholesalers) who then distribute it further.
4. Cold Storage and Private Cold Storage: Some of the catch is stored in cold storage facilities to maintain quality before further distribution.
5. Distribution Channels: The catch that has been handled by the bakul or stored in cold storage is distributed through various channels, including: Distributors, Restaurants, Fish processing companies, Muara Angke Port, Cracker industries, Wholesale markets, Traditional markets

This diagram illustrates the complex distribution chain of fish catches, from collection to reaching the end consumer through various marketing channels.

Influence Diagrams of Frozen Fish Supply Chain System

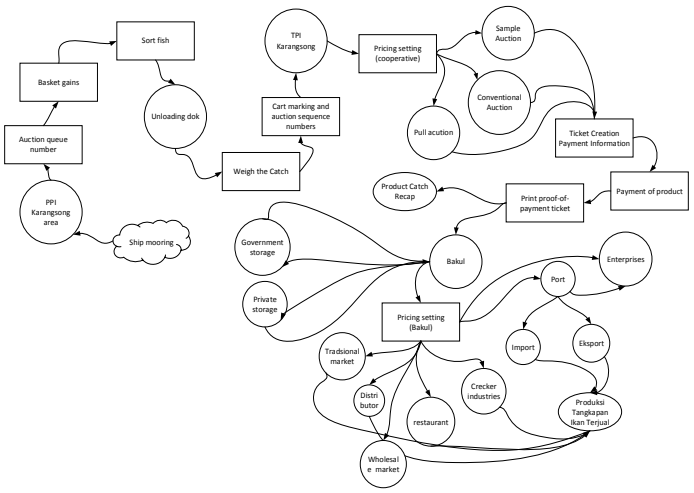

Figure 2. Influence diagram of frozen fish at Karangsong Indramayu

Influence diagrams start with a comprehensive description of the entire situation, encompassing four core components: decision alternatives, risk or influencing factors, given quantities, and calculated quantities or value models. The influence diagram presented in Figure 2 illustrates the flow of the fish product supply chain and the roles of various actors in producing fish capture products within the problem context.

The problem situation, involving the supply chain of frozen fish products and the activities of the actors in producing fish capture products, is depicted using the influence diagram shown in Figure 3. This diagram illustrates the variables involved in tracking the final location in the fish product supply chain, specifically at TPI Karangsong, as influenced by various actors. Influence diagram uses diagrammatic conventions that have meaning, including clouds that represent data, limitations, and uncontrolled inputs, squares that represent controlled inputs, circles that represent components, ovals that represent results, and arrows as relationships between variables.

The influence diagram of fisheries supply chain business activities shows that Juragan is the main actor in the fisheries supply chain. All Juragan here are members of KPL Mirna Sumitra which is located at TPI Karangsong Indramayu because they borrow capital for operational costs and personal costs as well as tax payments from each catch so that all results from the Juragan harvest must be reported and sold to TPI Karangsong.

TPI Karangsong is a player that controls all fishery products in the Indramayu area, especially in determining product prices based on the season. TPI Karangsong cooperates with Juragan and also baskets (buyers of Juragan's harvest) to get fish supplies from various seas such as Java, and Kalimantan to Papua. Before the catch production reaches the customers, several processes must be carried out at TPI Karangsong, the first activity covers the check of catch production and weighing of catch production which will then go through the auction process. The auction process here is divided into three types, the first is the pull auction which is conducted by the Juragan offering directly to the baskets (buyers of the Juragan's harvest) so that the baskets receive the product as ordered, usually in this auction process the selling price is set according to the price set by TPI Karangsong, the second is the conventional auction which is conducted in the same way as the pull auction, but in this auction process the baskets can buy fish outside of what they have ordered, the third is the sample auction which is conducted by providing samples for several fish products which will then be sent to customers who order in large quantities. The whole auction process is done directly with the manager of TPI Karangsong in the administrative process. Fish products that have gone through several administrative processes can be directly managed by both the Juragan and Bakul.

In the distribution process of this system, both the packing process and the shipping process are entirely borne by each (Juragan and Bakul), including packing packaging, and transportation. Suppose the price of the fishery product is high, the marketing process is carried out directly by sending the product to the market in the Indramayu area, distributors who are dominantly located in the Java Island area, especially Indramayu, Bandung, Jakarta, Cirebon, Central Java and East Java, the Cracker Industry in the Indramayu area. To meet national needs (imports) and outside needs (exports), products are usually sent to Muara Angke Port, Jakarta for further distribution using ships. To meet the needs of large companies,

it is usually done by two modes of transportation, namely land transportation modes (trucks) and sea transportation modes (ships) that have cooling facilities. Meanwhile, if the price of the product is low, the fishery products are usually stored in Cold Storage on both government and private property. Therefore, the fishery products that have been sold are the output of this fishery supply chain system.

Rich Picture of Frozen Fish Supply Chain System

One way that can be used to describe certain situations of the frozen fish supply chain is by using rich pictures. The rich picture illustrates the situation of the frozen fish supply chain as shown in Figure 3.

Fishery products that have been obtained from various sea sources with various durations are brought to TPI Karangsong using fishing vessels owned by the Juragan. TPI Karangsong as a government institution has the authority to determine the price of fishery products. Products that have arrived at TPI Karangsong need to be confirmed by going through the first inspection carried out by Officer 1 to check the catch product, which then carries out the process of weighing the catch product based on the type of fish then a product information ticket will be obtained which contains the type of fish and the total weight of the fish. Fish that have gone through the inspection stage, can then carry out the auction process which is carried out directly by the product owner (Juragan).

Products that are successfully sold will be recorded by Officer 2 to make a purchase ticket consisting of three copies: white sheet, yellow sheet, and red sheet. The white sheet will be attached to the board containing the name of the trader, while the red and yellow sheets will be received by the registration and administration officers. The white sheet containing information on the name of the manager, the basket, the fish, and the total weight is taken by the basket from the name board of the manager who then goes to the registration counter. At the registration counter, the registration officer will crosscheck the product order which will then provide a total price. The ticket (white sheet) that has been given a total price is then submitted to the payment counter to make a payment (made in cash) and then will get proof of transaction in the form of a payment receipt. All ticket receipts are submitted to the administration department to crosscheck and recap the daily catch production into a spreadsheet. Products that have gone through the administrative process until payment can be brought by baskets or Juragan. For the next distribution process, there are two actors, namely the Juragan and Bakul.

Juragan has the right to set the price of the product for further buying and selling. The products are taken to cold storage, which is either privately owned or government-owned. If the product is experiencing low prices, the product is usually stored in the warehouse, while if the price is high, the product in the warehouse is usually immediately carried out the packing process which will then be sent (distribution) to large companies that can be passed using two modes of transportation, namely land and sea transportation modes. Meanwhile, to meet national needs (imports) and international needs (exports), products are usually taken to Muara Angke Port, Jakarta.

Bakul also has the right to set the price of the product for further buying and selling. If the price of the product is high, usually the baskets directly distribute the product to markets, restaurants, distributors, and also the cracker industry. Meanwhile, if the price of the product is low, usually the product will be stored in cold storage both government-owned and privately owned. However, it is also possible for the collectors to send their products to Muara Angke Port, Jakarta to fulfill national and international (export) needs.

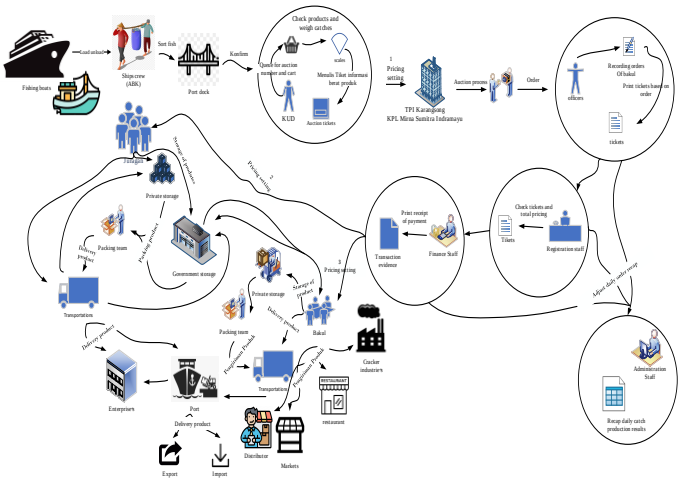

Figure 3. A rich picture of frozen fish in Karangsong Indramayu

CONCLUSION

The frozen fish supply chain system at TPI Karangsong Indramayu was mapped to understand the frozen fish collection, processing, and distribution process from upstream to downstream, involving stakeholders in the frozen fish supply chain system. The problem faced by frozen fish producers is the need for refrigerated facilities including cold storage, and refrigerated trucks to optimize the temperature so that the product maintains the quality and freshness of frozen fish during the process of collecting, processing, and distributing products to consumers. The influence diagram approach is used to conceptualize the real system at TPI Karangsong and describe a certain situation of the frozen fish supply chain using a rich picture. Based on the research results, it is expected that every stakeholder in the frozen fish supply chain system can understand each process. Furthermore, with a complex frozen fisheries system, creating a dynamic system model of the frozen fish supply chain is necessary to obtain policies regarding frozen fish problems at TPI Karangsong.

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