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Optimizing Market Efficiency through Blue Economy: Supply Chain and Risk Analysis of Tuna Fisheries in South Coastal East Java

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ABSTRACT

This study aimed to identify and prioritize risks within the tuna supply chain on the South Coast of East Java, focusing on factors that impact the overall efficiency, sustainability, and economic viability of the industry. The research employs the PROMETHEE method, a multi-criteria decision-making tool, to systematically evaluate and rank risks associated with tuna production, particularly those related to product quality, work safety, and logistical efficiency. The findings reveal that product quality is the most significant risk, primarily driven by the perishability of tuna and inadequacies in cold chain infrastructure. This poses a substantial challenge to maintaining quality from catch to market, threatening the competitiveness of East Java's tuna industry in both local and global markets. The study also emphasized the importance of stakeholder collaboration in managing these risks. By engaging fishermen, middlemen, traders, and other key players in the supply chain, the research provides a comprehensive analysis that captures the diverse challenges faced by different groups. Prioritizing risks enables stakeholders to focus their efforts on the most critical areas, ensuring a more resilient and sustainable supply chain. This research offers valuable insights into risk management within the tuna supply chain in East Java, with practical implications for improving industry practices. By addressing the identified risks—particularly through enhanced cold chain management and stakeholder cooperation—the study provides actionable strategies for strengthening the region's tuna industry. These findings align with broader goals of the blue economy, promoting sustainable practices that support economic development while preserving marine resources.

INTRODUCTION

Optimizing market efficiency within the tuna fisheries sector in South Coastal East Java necessitates a deep understanding of the local supply chain dynamics and the associated risks. Tuna, a vital export commodity from this region, holds a significant

economic value, contributing substantially to both local livelihoods and Indonesia's foreign exchange earnings **(Efani *et al.*, 2022)**. However, the perishable nature of tuna presents challenges in maintaining quality throughout the supply chain, making effective risk management essential. Addressing these risks is crucial for ensuring that tuna products reach consumers in optimal condition, whether in local markets or abroad **(Hu *et al.*, 2022; Khan *et al.*, 2024)**. This research focused on identifying key risks and proposing strategies to enhance supply chain efficiency, aligned with the principles of the blue economy.

The tuna fisheries in Malang Regency, especially around the Sendangbiru Fish Auction Place (TPI), are characterized by high production potential, yet they face multiple challenges in the supply chain. The supply chain involves a complex flow of goods and information, where any disruption can have significant impacts on the final product quality and market competitiveness **(Afifi *et al.*, 2024; Liu *et al.*, 2024)**. Effective supply chain risk management requires a comprehensive understanding of these dynamics to prevent losses and ensure sustainability. By analyzing these risks, this study aimed to develop strategies that not only mitigate the risks but also enhance the overall efficiency of the supply chain **(Pane *et al.*, 2019; Burhanis *et al.*, 2024)**. This approach is essential for maintaining the competitiveness of Indonesian tuna in the global market.

One of the primary concerns in the tuna supply chain is its perishable nature, which demands strict control over various stages of the supply chain, from capture to distribution. If not managed properly, the quality of tuna can degrade, leading to reduced market value and consumer satisfaction **(Mullon *et al.*, 2017; Tangke *et al.*, 2024)**. Risk management in this context involves identifying potential bottlenecks and implementing solutions to minimize disruptions. This includes proper handling, storage, transportation, and timely delivery, all of which are critical to maintaining the integrity of the product **(Tesfaye *et al.*, 2021; Sukardi *et al.*, 2024)**. By focusing on these aspects, the study aimed to enhance the resilience of the tuna supply chain against common risks.

In addition to logistical challenges, the tuna supply chain in South Coastal East Java must also navigate socio-economic factors such as community involvement and local business capabilities. The effectiveness of supply chain management is influenced by the level of engagement from local communities and the capacity of local businesses to adapt to market demands **(Fanzo *et al.*, 2018)**. This study emphasized the importance of integrating these socio-economic factors into the risk management framework. By doing so, it aims to create a more inclusive and sustainable supply chain that benefits all stakeholders, from fishermen to consumers. This integration is vital for fostering long-term growth in the tuna fisheries sector.

Moreover, the principles of the blue economy offer a valuable framework for enhancing the sustainability and efficiency of the tuna supply chain. The blue economy emphasizes the sustainable use of ocean resources for economic growth, improved livelihoods, and the preservation of ocean health **(Martínez-Vázquez *et al.*, 2021)**.

Applying these principles to the tuna supply chain can help balance economic and environmental goals, ensuring that the fisheries sector remains viable in the long term. This study seeked to explore how the blue economy can be effectively integrated into supply chain management practices. Such an approach is expected to yield benefits that extend beyond economic gains, contributing to the overall sustainability of the coastal ecosystem.

Despite the existing body of research on supply chain management, there remains a significant gap in studies that specifically address the integration of the blue economy principles into the tuna supply chain in this region. Previous research has often overlooked the broader implications of sustainable practices in achieving market efficiency **(Reis *et al.*, 2021; Almeida *et al.*, 2023; Bita & Sharifian, 2024)**. This study aimed to bridge that gap by providing a comprehensive analysis of the risks in the tuna supply chain and offering strategies that align with the blue economy. The findings from this research are expected to provide valuable insights that can be applied to other regions with similar challenges. By doing so, it contributes to the broader discourse on sustainable fisheries management.

Thus, optimizing market efficiency in the tuna fisheries sector in South Coastal East Java requires a multifaceted approach that addresses both logistical and socio-economic challenges. By identifying and mitigating risks within the supply chain, and by integrating the principles of the blue economy, this study aimed to enhance the sustainability and competitiveness of the region's tuna fisheries. The research not only fills a critical gap in the literature but also provides practical recommendations for improving supply chain management in the context of sustainable development. As such, it offers a pathway for ensuring that the tuna fisheries sector continues to thrive, benefiting both local communities and the broader economy. The insights gained from this study are expected to inform future efforts in sustainable fisheries management across Indonesia and beyond.

MATERIALS AND METHODS

1. Research sites

This research is located in East Java, specifically in Malang Regency (Fig. 1). The location was selected using purposive sampling due to Malang Regency's status as a significant tuna production center in East Java. This selection is crucial for understanding the dynamics of the tuna supply chain in one of the most critical areas for this commodity. The research was conducted until 2023 to gain a more comprehensive understanding of the developments and challenges faced in the tuna supply chain in this region.

2. Research respondents and data collection

Purposive sampling method was used to determine the research respondents, where subjects were selected based on specific characteristics relevant to the population being studied **(Etikan, 2016)**. The sample in this study consists of 150 respondents, including stakeholders who understand and are directly or indirectly involved in the management of tuna in the southern coastal area of East Java. The respondents for this study included experts, stakeholders, and fishermen/business actors directly involved in tuna fishing activities. These individuals were carefully chosen based on their roles in the tuna supply chain and their knowledge of tuna marketing, ensuring that the data collected reflects the most relevant perspectives on the industry. The data collection process involved two main techniques: first, gathering primary data through in-depth interviews with key informants, such as rice mill processors and distributors, and second, direct field observations to capture real-time activities. Additionally, secondary data were collected from books, research publications, journals, and other resources pertinent to this study.

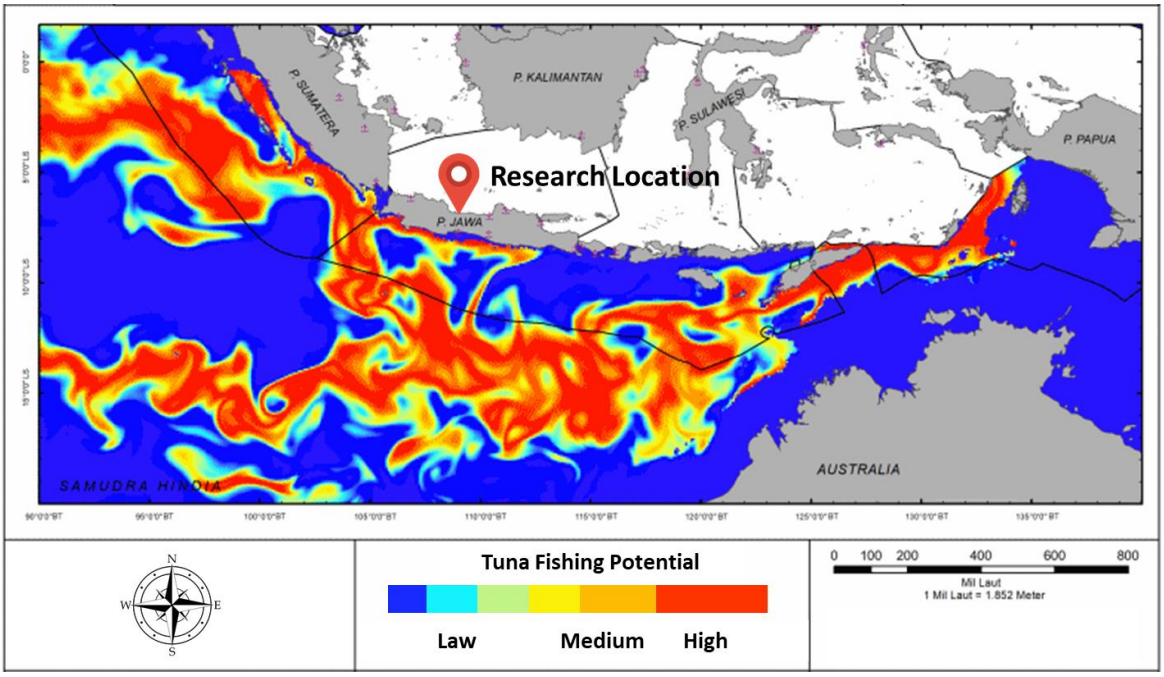

Fig. 1. Research location

3. Data analysis

The data analysis in this research was conducted using both quantitative methods to obtain a comprehensive understanding of the tuna supply chain in the southern coastal area of East Java. The primary focus of the analysis was on identifying and evaluating the risks within the supply chain to optimize market efficiency and sustainability under the blue economy framework. A key component of the data analysis was the application of the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) method. This multi-criteria decision-making tool was used to prioritize and rank the risks identified in the tuna supply chain **(Tiarantika *et al.*, 2024a)**. The

PROMETHEE method allowed for a comparative analysis of each risk based on selected criteria, such as the likelihood of occurrence and the potential impact on market efficiency **(Behzadian *et al.*, 2010; Brans & Mareschal, 2013)**. This method provided a clear ranking of risks, enabling the development of targeted mitigation strategies (Fig. 2).

Following the identification and ranking of risks using the PROMETHEE method, a risk mitigation analysis was conducted. This analysis focused on developing strategies to reduce or eliminate the most critical risks identified. The proposed mitigation strategies were evaluated for their feasibility, cost-effectiveness, and potential to enhance the overall sustainability of the tuna supply chain. The quantitative data ensured that the recommended strategies were both practical and aligned with stakeholder needs.

Finally, the data analysis incorporated an assessment of how the identified risks and mitigation strategies align with the principles of the blue economy. This involved evaluating the risk mitigation of proposed interventions and ensuring that they contribute to long-term sustainability and market efficiency. The analysis also considered how these strategies could be scaled and adapted to other coastal regions facing similar challenges in tuna fisheries management. This comprehensive data analysis approach provided a robust foundation for the study's conclusions and recommendations, ensuring that they are grounded in both empirical evidence and stakeholder input.

Steps	Description	Mathematical	Symbols denoted
1	Problem formulation: Identify alternatives and criteria of the alternatives	$(a, \mathrm{b}), f_j$	(a, b) denoted alternatives, f_j denotes criterion
2	Determination of deviations based on pair-wise comparison	$d_j(a,\mathrm{b}) = f_j(a) - f_j(\mathrm{b})$	$d_j\ (a, \mathrm{b})$ denoted the difference between the evaluation of alternatives a and b on criterion f_j
3	Application of the preference function	$P_j(a, \mathrm{b}) = f_j[d_j(a,\mathrm{b}), \mathrm{j} = 1, \ldots, \mathrm{k}$	$P_j\ (a, \mathrm{b})$ denoted the preference of alternative a with regard to alternative b on each criterion as a function of $d_j\ (a, \mathrm{b})$
4	Calculation of an overall or global performance index	$\forall\ a, b\ \in A$ $\pi(a,b) = \sum_{j}^{k} P_j(a,b)\ w_j$	$\pi\ (a,\mathrm{b})$ of a over b (from 0 to 1) is defined as the weighted sum P_j (a, b) for each criterion, and w_j is the weight associated with jth criteria
5	Calculation of positive and negative outranking flow	$\emptyset^{+}(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a,x)$ $\emptyset^{-}(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a,x)$	$\emptyset^{+}(a)$ denoted the positive outranking flow for each alternative, whereas $\emptyset^{-}\ (a)$ denoted the negative outranking flow for each alternative
6	Calculation of net outranking flow (Complete ranking)	$\emptyset(a) = \emptyset^{+}(a) - \emptyset^{-}(a)$	$\emptyset(a)$ denoted the net outranking flow for each alternative
7	Sensivity analysis of the weighting of the criteria	Using GAIA platform	Final ranking and conclusion

Fig. 2. Step analysis data PROMETHEE adapted from **Talukder and W. Hipel (2018)**

RESULTS

The primary target species for fishermen on the southern coast of East Java include the albacore tuna (*Thunnus alalunga*), the yellowfin tuna (*Thunnus albacares*), and the swoth fish (*Makaira indica*). Bycatch species include the lemadang (*Crophynea hippurus*), the baby tuna, and other varieties. Fishermen using purse seine fishing gear primarily catch schooling fish such as the skipjack tuna (*Katsuwonus pelamis*), with baby tuna often constituting the bycatch (Fig. 3). This diverse range of species highlights the importance of the South Coast of East Java as a significant fishing ground, contributing to the region's economy and livelihood.

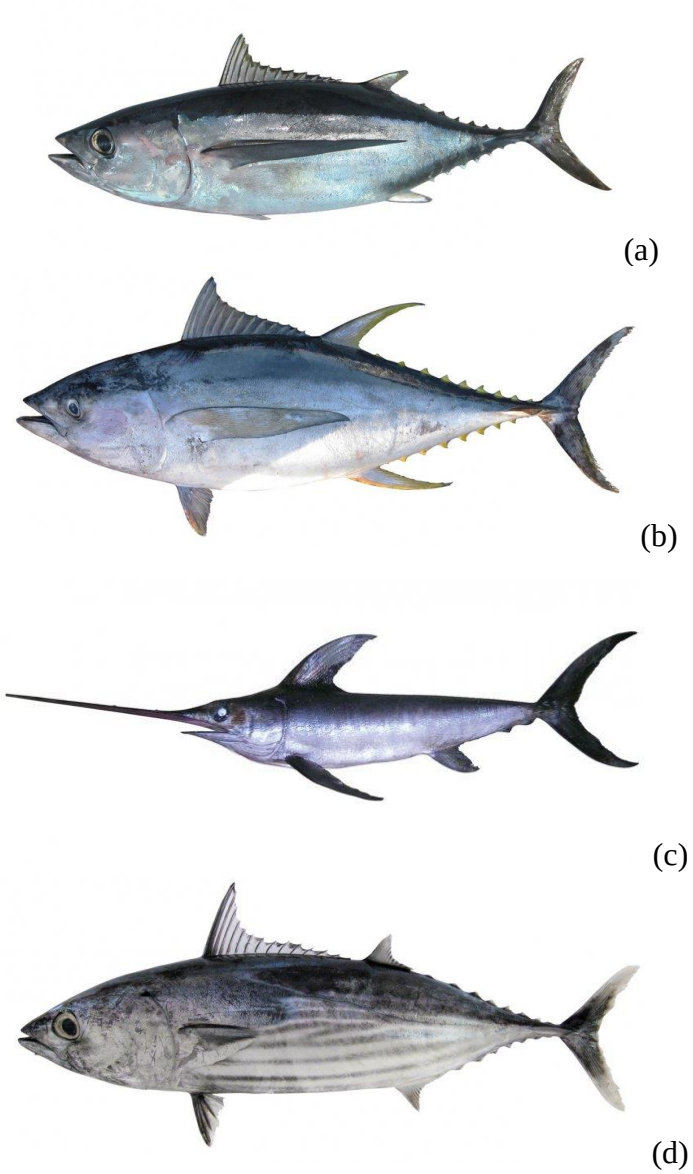

Fig. 3. The dominant type of tuna in South Malang

1. Ranking of dominant marketing risks in tuna resource supply chains

Supply chain risk management plays a crucial role in mitigating potential disruptions within the tuna supply chain **(Macusi *et al.*, 2023; Squires *et al.*, 2023)**. The risks identified in this study can be categorized into reliability, responsiveness, agility, cost management, and asset management. Key risks include product quality, process quality, perfect order fulfillment, and data mismatch. The business impacts of these risks are often more significant than operational risks, as they directly influence the overall efficiency and sustainability of the supply chain. Addressing these risks is vital for maintaining the integrity of the supply chain and ensuring the continuous flow of goods from fishermen to consumers.

The PROMETHEE method was employed to rank the risks associated with the tuna supply chain in the South Coast of East Java. The highest-ranking risks include product quality, work safety security, and the cash-to-cash cycle, all of which received a Phi score of 0.8667. These risks are critical as they directly affect the marketability and profitability of the tuna. In contrast, the lowest-ranking risks, such as order fulfillment cycle time and product delays, scored -0.9333 (Fig. 4 & Table 1), indicating that these factors have a relatively minor impact on the supply chain.

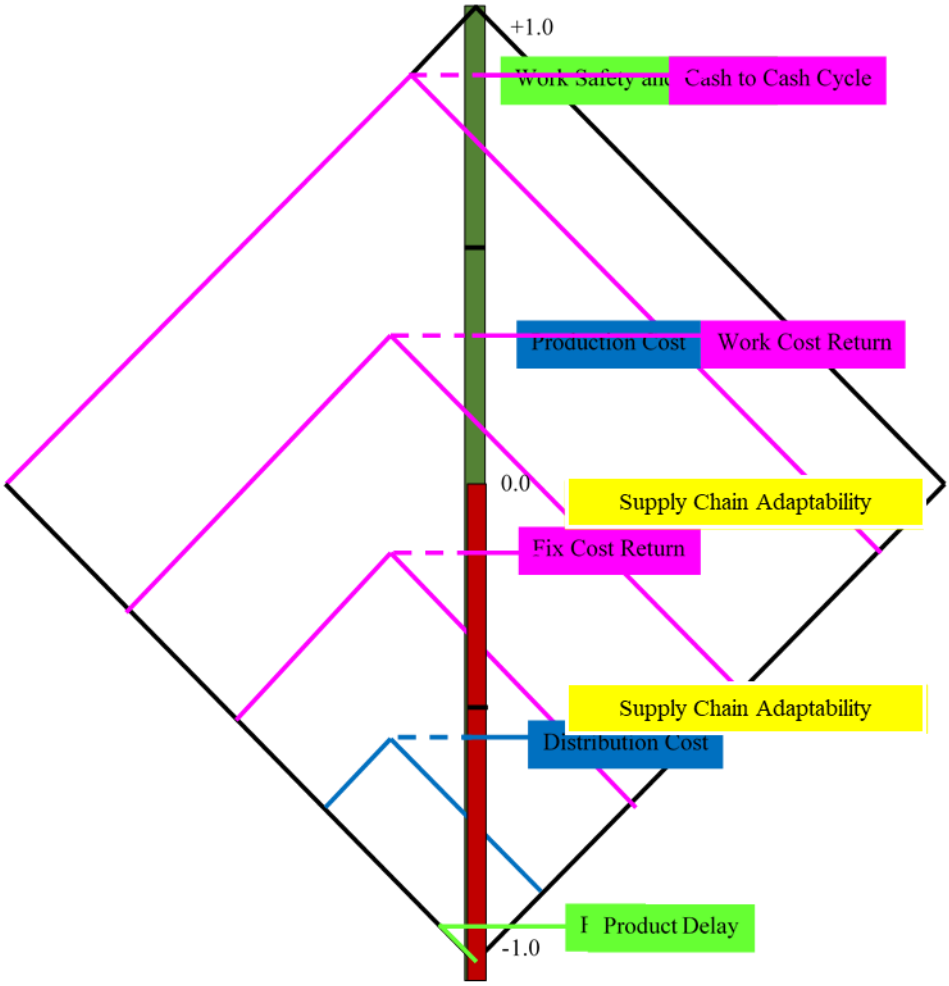

Fig. 4. Highest to lowest risk ranking order

Table 1. Ranking of dominant maketing risk

Rank	Risk on supply chain management	Phi	Phi+	Phi-
1	Product quality	0,8667	0,8667	0,0000
1	Work safety security	0,8667	0,8667	0,0000
1	Cash to cash cycle	0,8667	0,8667	0,0000
4	Data missmatch	0,4000	0,6000	0,2000
4	Production cost	0,4000	0,6000	0,2000
4	Cost of products sold	0,4000	0,6000	0,2000
4	Return on working cost	0,4000	0,6000	0,2000
8	Process quality	-0,0667	0,4000	0,4667
8	Adaptability	-0,0667	0,4000	0,4667
8	Return on fixed assets	-0,0667	0,4000	0,4667
11	Perfect order fulfillment	-0,5333	0,1333	0,6667
11	Upstream supply chain flexibility	-0,5333	0,1333	0,6667
11	Adaptability	-0,5333	0,1333	0,6667
11	Distribution cost	-0,5333	0,1333	0,6667
15	Order fulfillment cycle time	-0,9333	0,0000	0,9333
15	Product delays	-0,9333	0,0000	0,9333

2. Impact of risk ranking on supply chain management

Product quality emerged as the highest risk factor in the tuna supply chain. This is largely due to the perishable nature of fish products, particularly tuna, which require careful handling and storage to maintain freshness **(Fang *et al.*, 2023)**. The lack of adequate cold chain infrastructure can lead to rapid spoilage, resulting in significant financial losses for those involved in the supply chain **(Rahaman *et al.*, 2021)**. Ensuring that product quality is maintained from the point of capture to the end consumer is therefore essential for the sustainability of the tuna fishing industry on the South Coast of East Java. The ranking of risks using the PROMETHEE method provides valuable insights into where the greatest vulnerabilities lie within the supply chain. By focusing on the highest-ranking risks, stakeholders can prioritize their efforts to enhance supply chain resilience. For instance, improving product quality through better storage facilities and handling practices can reduce spoilage and increase profitability. Similarly, addressing work safety and security concerns can help protect the workforce, thereby ensuring continuous operations.

DISCUSSION AND IMPLICATIONS

1. Supply chain flow

The supply chain encompasses a wide range of activities, from upstream to downstream, distributed across various stages of production and sales processes. Upstream activities include people, physical resources, and production processes, while downstream activities involve contracts, sales to customers, distribution, and disposal **(Mehanna *et al.*, 2023)**. The primary goal of the supply chain is to foster collaboration and mutual trust among multiple stakeholders and to eliminate communication barriers, thereby achieving seamless integration of the entire supply network **(Mullon *et al.*, 2017)**. However, stakeholders often struggle to gain a comprehensive view of all transactions and track product origins, especially customers and suppliers, who can only access partial information throughout the supply chain. This lack of visibility can lead to counterfeit products and product quality scandals that negatively impact the entire supply chain **(Fanzo *et al.*, 2018)**. In the tuna fish supply chain depicted in Figs. (5, 6), tuna products flow continuously from producers to consumers.

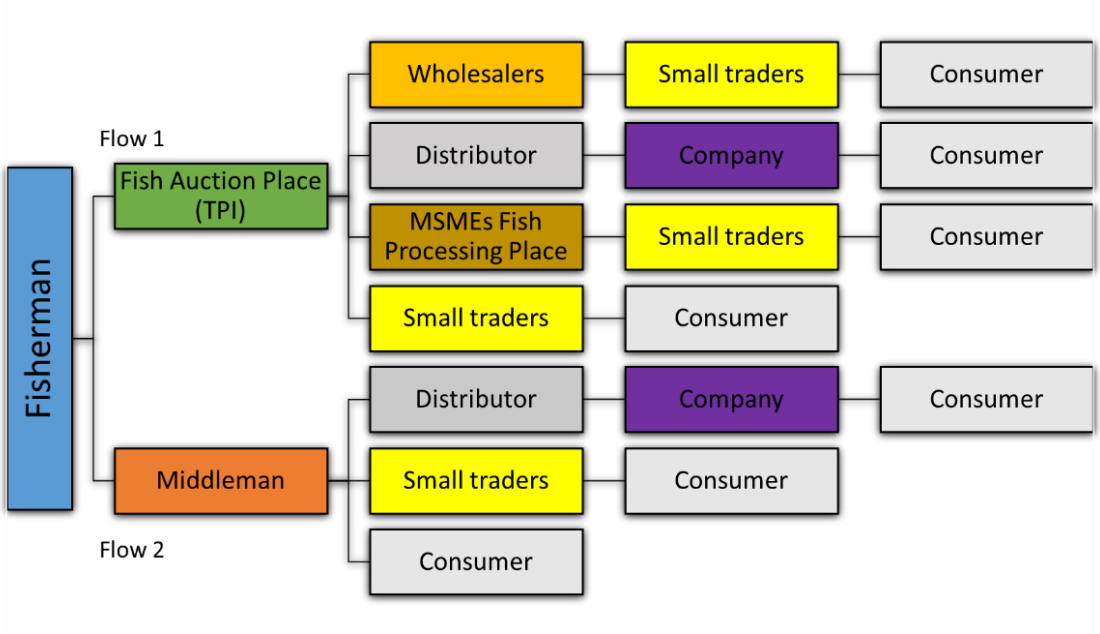

Fig. 5. Supply chain 1

In the fishing industry, the supply chain involves managing the process from the lowest unit to the consumers. However, due to limited supporting infrastructure in fish production centers, the industry incurs high economic costs. This results in low-quality seafood products and significant price disparities **(Fang *et al.*, 2023)**. Therefore, in such an environment, it is necessary to implement good management practices that utilize tools and frameworks to optimize the supply chain. Effective supply chain management can improve overall efficiency and provide greater value and benefits to the business **(Rahaman *et al.*, 2021)**. Specifically, the tuna fish supply chain on the South Coast of East Java begins with fishermen as input units. The flow then divides into two paths: one toward the TPI (fish auction place) and the other toward middlemen.

In the first flow, fishermen, especially large-scale ones with substantial catches, take their fish to the TPI, where the fish are auctioned. Small-scale fishermen typically sell their catch to middlemen. The Fishery Port Unit, responsible for conducting auctions, has established TPIs to improve fishermen's welfare by enabling them to achieve an optimal value for their catches, as current incomes are still considered less effective **(Lee *et al.*, 2024)**. At the TPI, fish are also iced to prevent spoilage, ensuring the quality and safety of fishery products. Fisheries supply chains are long and complex, with components that are difficult to manage and track. Additionally, different fishing industries have varying production and distribution chains depending on the product (for example, tuna requires a maintained cold chain). **Reis *et al.* (2021)**, **Almeida *et al.* (2023)** and **Bita and Sharifian (2024)** argued that relevant stakeholders must consider several aspects to improve this sector. For example, many fishery products are rejected by the target market due to quality and safety issues.

In flow 1, the flow is divided into four levels. The first level involves fish from the TPI being distributed to large traders, then to small traders, and finally to consumers. The second level sees fish from the TPI distributed to distributors, companies, and ultimately consumers. The third level describes fish from the TPI being distributed to MSMEs, small traders, and consumers. At the fourth level, fish from the TPI are distributed to small traders and then to consumers. Therefore, it can be concluded that the fourth level in the first flow is a highly efficient supply chain. In this case, large traders, distributors, fish processing MSMEs, and small traders participate in the fish auction, distributing products from the auction directly to companies and small traders. Distributors and large traders are encouraged to sort the fish based on quality and size before distributing them to small traders and companies. This is crucial to ensure the products meet the required standards. Fish processing MSMEs, generally involved in processing tuna fish products, also play a role in this flow. According **Elegbede *et al.* (2023)**, producers have the responsibility to ensure the safety and quality of their products before releasing them to the market. This is especially important in the fish industry, where optimal management of fish is impossible without careful consideration of consumer safety and security aspects. Therefore, quality control is essential to managing fish as a safe food product.

Small market traders receive fish distribution from large traders and distributors. Fish companies, such as canning and exporting factories, receive fish from the Sendang Biru area. These companies, including ATI from Pasuruan, Cup Indah from Muncar, Bali Maya TT, and Benua Baru, distribute the fish to local and international consumers. Indonesia plays a significant role in the trade and supply of raw materials for seafood for both national and international markets. However, maintaining and improving the quality of its fishery products remains a challenge. In 2012, several European countries rejected Indonesian fishery export products due to non-compliance with certification rules, including the absence of an environmental sustainability certificate (eco-sustainability) **(Efani *et al.*, 2022)**.

In the second flow, the flow is divided into three levels. The first level involves fish coming from middlemen and then going to distributors, companies, and consumers. At the second level, fish from middlemen are distributed to small traders and then to consumers. The third level has the supply chain being very short, with the fish moving directly from middlemen to consumers. Thus, in the third level, it can be concluded that the distribution of tuna fish is very efficient and effective.

The marketing of fish caught by Sendang Biru fishermen involves a complex supply chain flow that includes several actors: fishermen, middlemen, distributors, small traders, companies, and consumers. The core idea of this supply chain is that customer satisfaction depends on the integrated efforts of suppliers, manufacturers, and distributors. The performance of individual components of the supply chain may not suffice to achieve these goals **(Efani *et al.*, 2022)**. In this supply chain, the producers are

the Sendang Biru fishermen, who sell their catch to middlemen. Distributors and small traders then purchase the fish from middlemen. Distributors supply the fish to companies, while small traders sell the fish directly to consumers. It is worth noting that improving the performance of individual components of the supply chain alone may not be enough to meet customer needs.

In the fish industry, companies receive fish from distributors. The distributors sort the fish according to quality and size, based on the recipient company's requirements. The recipient company then cans the fish and distributes them to supermarkets or exports them to foreign consumers. Meeting food safety standards is crucial for exporting fish and fishery products to major consumer markets. These standards are often accompanied by specific requirements for export activities. Additionally, private companies that purchase marine products are also required to adhere to food safety standards and tracking regulations **(Pickerell, 2024)**.

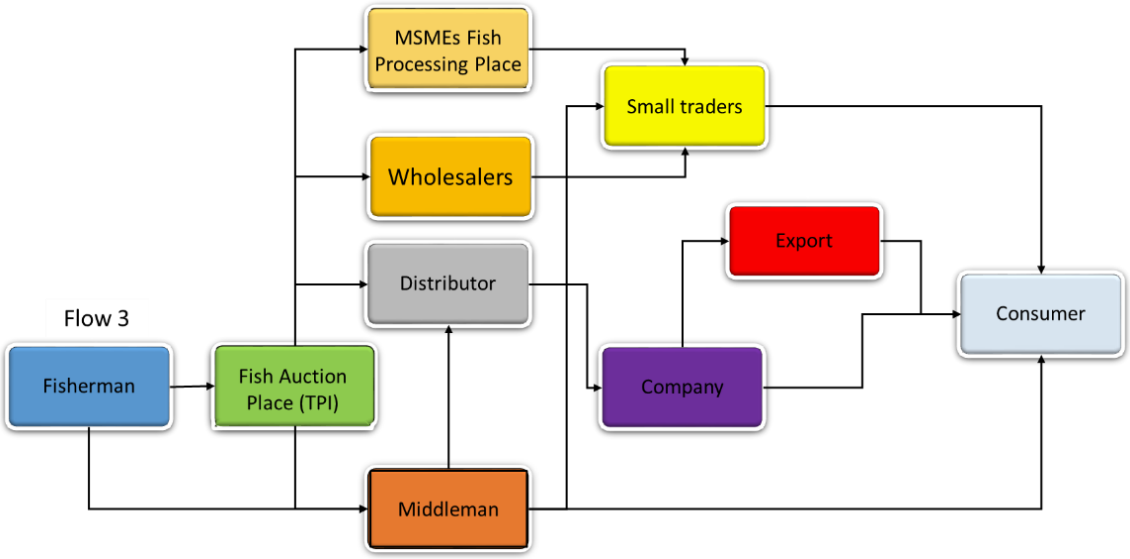

Fig. 6. Supply chain 2

In flow 3, the marketing of tuna fish is divided into two sub-flows. The first sub-flow involves fish being sold from fishermen to TPI, while the second sub-flow involves fish being sold from fishermen to middlemen. Each actor in the marketing flow ensures that the product is transferred safely to the next actor while maintaining its quality. To achieve this, the fisheries supply chain management (SCM) system must strictly monitor environmental parameters and product quality at every step **(Pane *et al.*, 2019)**. Each participant in the marketing flow strives to keep costs as low as possible while distributing the product to its partners. They can track the products and deliveries, measure the performance of each activity in the supply chain, and monitor the product's quality during transportation. This information is readily available to all partners in the

supply chain, helping ensure that the distribution process is smooth and effective **(Liu *et al.*, 2024)**.

Initially, the fish industry operates through fish auction activities conducted by TPI, which can be divided into four levels. At the first level, small fish processing businesses, typically independently owned and managed, purchase auctioned fish from TPI and process them into pindang fish products. These small businesses operate independently and do not exert significant control over the market **(Tesfaye *et al.*, 2021)**. The processed fish products are then distributed to small traders before reaching consumers.

At the second level, large traders buy auctioned fish from TPI and distribute them to small traders, who subsequently sell to consumers. In the third level, fish distributors acquire auctioned fish from TPI and sell them to companies such as ATI from Pasuruan, Piala Indah from Muncar, Bali Maya TT, and Benua Baru. These companies then process or repackage the fishery products for distribution to local and international consumers through exports.

Among the level three mentioned above, the most efficient supply chain is found in flow 3. In this flow, fishermen sell their catch to middlemen, who then sell it directly to consumers. However, other actors can also increase the supply chain's efficiency by effectively managing the chain. Running a fisheries business involves several processes, such as processing the product and distributing it to consumers, companies, or other actors in the supply chain, to generate profits. A well-managed supply chain can lead to profits and efficient output. Efficient supply chain management (SCM) can help reduce costs, increase the number of consumers, and shorten the time to deliver products to the market. The key to an efficient SCM system is close collaboration among stakeholders in the supply chain, as an optimized system can enable all players in the supply chain to collaborate effectively and efficiently **(Pickerell, 2024)**.

The end of the supply chain flow is when consumers receive the fishery products. The current tuna fish supply chain still relies heavily on manual processing and old equipment, particularly in the TPI and fishermen's villages. This situation is exacerbated by insufficient cold chain infrastructure, leading to frequent damage to fish products. Another issue is the inefficient transportation system and the long supply chain, which contribute to the high costs and lengthy delivery times from production to consumption points. To improve the tuna fish supply chain, it is necessary to adopt new approaches to technology and management that emphasize sustainability, efficiency, and reliability. The ongoing challenges in the tuna fish supply chain highlight the need for stakeholders to continue improving the system, ensuring the effective management of the entire supply network, and increasing overall efficiency.

2. Marketing risks in tuna resource supply chains

The results of this study offer critical insights into the supply chain risks associated with tuna production on the South Coast of East Java, particularly within the context of the blue economy. The primary goal of this research was to identify and prioritize the risks within the tuna supply chain that could impact the overall efficiency, sustainability, and alignment with blue economy principles. Through the application of the PROMETHEE method, the research successfully identified the product quality as the most significant risk, affirming the initial hypothesis that the perishability of tuna poses a substantial challenge to the supply chain. This risk is particularly relevant in the blue economy context, where sustainable practices and the efficient use of marine resources are paramount.

The emphasis on product quality as the highest risk factor directly addresses the research objective of understanding the key vulnerabilities in the supply chain **(Mullon *et al.*, 2017; The Economist Group, 2022; Hu *et al.*, 2024)**, especially those that could undermine the sustainable use of marine resources. Tuna, being a highly perishable commodity, requires meticulous handling and storage to maintain its quality from the point of catch to the final market **(Lee *et al.*, 2024)**. The study's findings highlight the inadequate cold chain infrastructure as a critical gap, which not only threatens the quality of the tuna but also the economic viability of the entire supply chain. This issue is central to the blue economy, where the focus is on maximizing the economic benefits of marine resources while ensuring their long-term sustainability **(Mehanna *et al.*, 2023)**. The findings suggest that improving cold chain infrastructure could significantly enhance the sustainability and efficiency of the tuna supply chain, contributing to broader blue economy goals.

The diverse characteristics of the respondents, including fishermen, middlemen, traders, and other stakeholders, provided a comprehensive perspective on the supply chain's complexities. Each stakeholder group faces its own set of challenges and risks, which collectively contribute to the overall risk landscape identified in the study. By incorporating these varied perspectives, the research was able to capture the full scope of risks affecting the tuna industry in this region. This comprehensive approach aligns with the principles of the blue economy, which emphasize the need for inclusive and participatory approaches to resource management, ensuring that all stakeholders are involved in the decision-making process **(Bax *et al.*, 2022; Loring, 2023)**.

The findings regarding lower-ranked risks, such as order fulfillment cycle time and product delays, suggest that while logistical efficiency is relatively well-managed, the focus must remain on the more critical issues of product quality and work safety. This conclusion directly ties back to the research objective of prioritizing risks to guide effective risk management strategies. From a blue economy perspective, addressing these critical risks is essential for maintaining the long-term sustainability of the tuna supply chain **(Mercogliano & Santonicola, 2019; Almeida *et al.*, 2023)**. By prioritizing these

risks, stakeholders can ensure that the supply chain not only operates more efficiently but also adheres to sustainable practices, which are fundamental to the blue economy.

Additionally, the study's findings on the implications of these risks extend to the broader economic context, which was another key aspect of the research. The high risk associated with product quality does not just affect local operations but also has significant ramifications for the competitiveness of East Java's tuna industry in the global market. This underscores the importance of addressing these risks to maintain the region's position as a key player in the international tuna market, a goal that is consistent with the blue economy's emphasis on sustainable economic development **(Elegbede *et al.*, 2023)**. By ensuring that the tuna industry remains competitive while adhering to sustainable practices, East Java can contribute to the global blue economy, which seeks to balance economic growth with the preservation of marine ecosystems.

The role of collaboration among stakeholders in managing these risks was also highlighted, reinforcing the research's objective of identifying strategies for improving the supply chain **(Pickerell, 2024)**. The study found that an effective risk management requires a coordinated approach, where stakeholders share resources and knowledge to mitigate risks more effectively. This finding supports the blue economy principle of fostering collaboration among various sectors to achieve sustainable outcomes **(Tiarantika *et al.*, 2024b)**. By promoting stakeholder collaboration, this research provides a pathway for enhancing the resilience and sustainability of the tuna supply chain, aligning with the broader goals of the blue economy.

Finnaly, the discussion effectively ties the results back to the research objectives, demonstrating how the identification and prioritization of supply chain risks on the South Coast of East Java can lead to actionable strategies for improving the tuna industry's resilience and sustainability. By focusing on the critical risks of product quality and work safety, and fostering stakeholder collaboration, this research provides a clear pathway for enhancing the efficiency and competitiveness of the tuna supply chain. These findings are crucial for contributing to the region's economic development and sustainability goals within the framework of the blue economy, ensuring that marine resources are used efficiently and sustainably for the benefit of present and future generations.

3. Research implication

This research yields several important implications that impact the management of the tuna supply chain on the South Coast of East Java, particularly within the context of the blue economy. First, the study highlighted the urgent need to develop an adequate cold chain infrastructure to maintain the quality of tuna products. Investment in this infrastructure will not only reduce the risk of product spoilage but also enhance the competitiveness of the tuna industry in global markets. This aligns with the principles of the blue economy, which emphasize efficiency and sustainability in the management of marine resources.

Second, the findings that product quality and work safety are the highest risks in the tuna supply chain indicate the necessity of improving operational standards. By adopting best practices in fisheries management, the industry can ensure that product quality is maintained while also improving worker safety. This approach is crucial not only for the well-being of workers but also supports efforts to maximize the economic benefits from marine resources without compromising environmental quality, a key principle of the blue economy. The study underscores the importance of stakeholder collaboration in managing risks within the tuna supply chain. By involving fishermen, traders, entrepreneurs, and other relevant parties, this collaborative approach can help address the challenges faced in the supply chain, ensuring that the industry can operate more efficiently and sustainably. These implications support the strengthening of East Java's tuna industry in global markets while promoting the sustainability of marine resources in accordance with the principles of the blue economy.

CONCLUSION

The tuna supply chain faces high transaction costs, which are passed along, diminishing Malang Regency's competitiveness in local and global markets. Each step in the chain, from fishermen to TPI, middlemen, wholesalers, and small traders, adds a price margin that raises costs. While TPI facilitates auctions, small-scale fishermen often sell to middlemen who distribute to various buyers. To maintain fish quality, standard handling procedures are followed, including ice storage and refrigerated transport.

This study identified key risks in the tuna supply chain, highlighting product quality and work safety as significant challenges. Addressing these risks is essential for improving the industry's efficiency, competitiveness, and sustainability, in line with blue economy principles. Investing in cold chain infrastructure and fostering stakeholder collaboration are crucial for mitigating these risks.

However, the research is limited to the South Coast of East Java, which may not reflect broader complexities in other regions. Future studies should consider expanding the geographic scope and incorporating more diverse data sources for stronger validation.

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