frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 05 September 2024
DOI 10.3389/fmars.2024.1420755

OPEN ACCESS

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RECEIVED 21 April 2024
ACCEPTED 12 August 2024
PUBLISHED 05 September 2024

CITATION
Mohsin M, Yin H and Mehak A (2024) Sustainable solutions: exploring risks and strategies in Pakistan's seafood trade for marine conservation.
Front. Mar. Sci. 11:1420755.
doi: 10.3389/fmars.2024.1420755

Sustainable solutions: exploring risks and strategies in Pakistan's seafood trade for marine conservation

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Global literature highlights risks in the seafood trade and suggests mitigation methods, but these issues are often overlooked in developing countries, particularly in Pakistan, due to ineffective policy implementation. This underlines the urgent need for a thorough investigation into Pakistan's seafood trade to address its multifaceted risks and revive this agricultural sector. This study is notable for being the first to explore these uncharted risks in Pakistan's seafood trade, which can help achieve the sustainable development goals (SDGs) of the United Nations, particularly SDG 14 (life underwater) and SDG 2 (zero hunger). Primary data were gathered from 626 respondents using snowball sampling and structured questionnaires from July 13, 2023, to December 27, 2023. The study used multi-criteria decision analysis, including fuzzy Analytic Hierarchy Process (AHP) and Importance Performance Analysis (IPA), and multivariate analysis, comprising Analysis of Moment Structures (AMOS), to analyze the data. The findings revealed that 'environmental risks' were the most significant, followed by 'infrastructure and logistic risks'. The biggest sub-risk identified for managerial focus includes overfishing. Controlling overfishing is critical for ensuring marine conservation and reviving the seafood trade. Several sub-risks, like seafood prices, marketing strategies, consumer preferences, and tastes, are critical but never addressed in the regulations. Furthermore, risk perception mediates the relationship between risk management and risk performance. The survey respondents reported low-risk perception and inadequate management measures. Besides, this study expounds on ramifications, shortcomings, and areas for further research.

KEYWORDS

sustainable solutions, risk analysis, seafood trade, decision making, marine conservation

1 Introduction

The fisheries sector plays a central role in establishing a balance between marine conservation and human economic needs (Eriksson et al., 2019). This sector is intertwined with marine conservation through a complex web of ecological, economic, and social interactions. For example, overfishing, driven by the growing global demand for seafood, poses a significant threat to marine biodiversity and ecosystem health (Sumaila et al., 2016; Farmery et al., 2022). Moreover, unsustainable fishing practices lead to the depletion of fish stocks, the catch of non-targeted fish species as bycatch, and disrupt marine food chains (Kumar et al., 2019; Takyi et al., 2023). Such impacts not only jeopardize the long-term viability of fisheries but also undermine the resilience of marine ecosystems, which are vital for achieving the United Nations' Sustainable Development Goals (SDGs). The fisheries sector is crucial to Pakistan's food security and socio-economic development by providing up to 1.7 million people with job opportunities (Kaczan and Patil, 2020). Despite its enormous potential, fisheries production is low, contributing about 0.5% of the GDP, which is much less when compared to other regional competitors such as India and Bangladesh (Employers Federation of Pakistan, 2019). Pakistan exports a wide range of seafood products, viz., smoked, chilled, fresh, frozen, and salted, to many countries. Major importers of Pakistani seafood products are China, Thailand, and Vietnam. Pakistan exports around 17% of the total fish production and seafood products worth $400 million annually (Shah et al., 2017; The World Bank, 2018; Food and Agriculture Organization, 2023).

However, compared to its potential, the fisheries sector's contribution to the national economy is negligible. Its lesser contribution and underperformance are outcomes of various risks this sector faces (Rehman et al., 2019). For instance, Kalhoro et al. (2014) reported that overexploitation is the most prevalent risk faced by the fisheries sector in Pakistan causing less catch quantities and leading to reduced export earnings. In addition, the size of the caught fish is also small, resulting in higher quantities of trash fisheries (Panhwar et al., 2016). Moreover, water pollution in the coastal areas is causing havoc to marine life, sharply decreasing fish fauna and causing potential health hazards for those who consume fish (Haseeb-ur-Rehman et al., 2023). According to Noman et al. (2022) lack of coordination among multiple regulatory bodies leads to redundant efforts and trade delays. Furthermore, high tariff rates are negatively impacting seafood trade performance in Pakistan (Leroy et al., 2016; Noman et al., 2022). Thus, the fisheries sector in Pakistan is exposed to diverse risks which are hindering this sector's economic performance.

Risk is an intuitive concept characterized by variability. It means the potential for some unwanted outcome (Asche et al., 2020). Risk is referred to as realized risk when bad things happen. Risk management is implemented in two stages to deal with risk. The first stage involves identifying and categorizing risks, while the second stage initiates risk mitigation strategies. Risk management in fisheries has evolved significantly, particularly since the 1990s, with an increasing emphasis in the literature on managing risk (Sethi, 2010). In this context, decision analysis is the most reliable and popular way of treating risks associated with the fisheries (Varkey et al., 2016). This analysis helps to identify potential risks quantitatively and qualitatively. Thus, the decisions based on this analysis address multi-faceted risks and are well-suited for fisheries management. The decision-making process involves the preferences of the stakeholders, managing potential risks, and minimizing the effects of realized risks (Hannouf and Assefa, 2018; Abdullah et al., 2021). Multi-criteria decision analysis (MCDA) is used when the objective is to manage compound and complex objectives. MCDA helps to achieve managerial goals by highlighting potential administrative pitfalls. MCDA quantitatively ranks multiple options, making decision choices easy (Wu et al., 2017; Morgan, 2017). As mentioned, the seafood trade is confronted by numerous risks, so using MCDA is imperative.

Online literature documents various aspects of the seafood trade in Pakistan (Atif et al., 2017; Ali et al., 2020; Noman et al., 2022). However, it has three significant drawbacks. First, it does not examine all the risks associated with the seafood trade. Second, it does not compare various risks based on their importance. Third, it does not study the factors that can mediate the relationship between risk management and risk performance. Besides, it does not use robust statistical routines and employs limited data in most cases. Due to these setbacks, this literature cannot guide managers and policymakers to make effective management plans. This study aims to address this research gap by answering the research question: what are the status, opportunities, and challenges of seafood trade risk management? Depending on this research question this study has the following three objectives representing each part of the research question:

Objective 1: Are there risks associated with the seafood trade, and if so, how can they be ranked for better management? (status)

Objective 2: Is there any room to upsurge seafood trade risk management performance, and if so, what are the potential options? (opportunities)

Objective 3: How do risks and performance relate? Can risk perception mediate the relationship between risk management and risk performance? (challenges)

This study ranks and prioritizes risks using data collected from various stakeholders and reliable statistical techniques. It will facilitate the formulation and implementation of effective seafood trade management policies. It is essential to mention that SDGs are a guideline for making a national development plan in Pakistan (Kaczan and Patil, 2020). Two of these SDGs, i.e., Zero Hunger (Goal 2) and Life Below Water (Goal 14), are particularly relevant to this study. The target of achieving SDG 2 cannot be accomplished until 2030 without ensuring food security in Pakistan. This goal is fundamental in the context of Pakistan, the 6th most populous country in the world (Zahir, 2023). Moreover, the sustainable development of marine resources is essential to achieving SDG 14 and contributing to marine conservation. Hence, both of these goals are interrelated. This study paves the way to attaining these goals by identifying, categorizing, and prioritizing risks and helping to increase the performance of the seafood trade in Pakistan.

2 Literature review and conceptual framework

2.1 MCDA

In risk management, MCDA can be employed to perform two distinct tasks, i.e., ranking of risks and identification of potential areas for performance management. These tasks are accomplished through multiple-objective optimization (MOO) and goal programming (GP) (Trigui et al., 2018; Al-Husain and Khorramshahgol, 2020). MOO deals with multiple objectives and sorts out those worth considering. The redundant objectives are omitted. This strategy is crucial for conducting effective management (Pascoe et al., 2017). On the other hand, GP specifically targets performance aspects of the management (Vaidya and Kumar, 2006). The Analytic Hierarchy Process (AHP) and the Importance Performance Analysis (IPA) render the MCDA method and are used to achieve MOO and GP, respectively (Vaidya and Kumar, 2006; Sethi, 2010). Thus, their synergetic use is very suitable to achieve comprehensive management targets. That's why multiple studies have used these statistical routines together in the same study (Diaz et al., 2017; Ma et al., 2022).

Statistically, AHP quantitatively ranks decision options by considering tangible and intangible aspects of the assessment process (Subramanian and Ramanathan, 2012). It breaks down compound and ambiguous problems into smaller, simpler elements, making choices easy. The assessment process by AHP involves using sensitivity analysis, which ensures that results are dependable. Thus, AHP can help make reliable decisions even under complex and vague conditions (Chang, 1996; Chan and Kumar, 2007). Conversely, IPA establishes a relationship between management and performance aspects of various attributes. This results in the formation of a quadrant on which each management value estimated is plotted along with its performance values, thus constructing a grid known as quadrant analysis (Sawitri et al., 2020; Das et al., 2022). This analysis serves as a lighthouse for the decision-makers to identify areas where management should focus. In addition to MCDA, multivariate analysis serves as a dependable statistical technique utilized in management studies to assess whether a specific factor mediates between management and performance (Rust et al., 2014; Wu et al., 2014). Analysis of Moment Structures (AMOS) is frequently employed in scientific studies to conduct multivariate analysis. This statistical tool is particularly useful in studies where a single factor mediates the relationship between independent and dependent variables (Amadu et al., 2021). Thus, given the features and relevance of the fuzzy AHP, IPA, and AMOS, we employed them in this study.

2.2 Economic risks

Seafood trade is subject to price fluctuations and cross-price risks due to price sensitivity (Dahl and Oglend, 2014). The heterogeneity of market information and fluctuating exchange rates complicate marketing strategies, reducing trade efficiency (Sethi, 2010; Dong and Truong, 2023). Fluctuations in fishing production and disordered market data often lead to losses for producers (Gephart et al., 2017). Several factors impede seafood trade development, including circulating capital and finance (Kaczan and Patil, 2020). There is a lack of financial aid for high-risk industries, such as fishing, in Pakistan's financial system (Noman et al., 2022). A study conducted by Lebiedzinska et al. (2006) has shown that high prices of fish result in lower consumption quantities. Qasim et al. (2020) argued that seasonal consumption of fish is the main driver of fish demand in Pakistan. The quality and safety of fish are a major concern for Pakistani consumers, as many commercial fish, such as Catla catla, are high in toxins (Saleem et al., 2022). Seafood marketing strategies in Pakistan have many deficiencies, such as poor packing, substandard labels, and no marketing campaign (Mohsin et al., 2017).

2.3 Environmental risks

A study conducted by Allison et al. (2009) declared Pakistan among the most vulnerable countries in the world in which seafood trade patterns are heavily affected by climate change. Overexploitation has led to a significant decrease in fish catch quantities, thereby negatively impacting the available fish biomass for trade (Noman et al., 2022). Fisheries in Pakistan are severely threatened by pollution, overfishing, and habitat destruction (Iqbal et al., 2013). The effects of climate change on fisheries biodiversity and their abundance are very intense causing economic losses to the coastal communities (Salik et al., 2015). Fishery stocks of many commercial fish in Pakistan have considerably decreased due to intensive and illegal fishing operations (Khan and Khan, 2011; Ali et al., 2020). Mehak et al. (2018) have reported that despite overexploitation and overcapacity issues the number of fishing vessels has increased uncontrolled in Pakistan. A study conducted by Jilani (2018) found that the coastal waters of Pakistan have extremely low levels of dissolved oxygen and high pH making marine life very difficult to thrive.

2.4 Policies and regulations risks

Several legislative deficiencies exist in Pakistan related to fisheries management, including a reliable licensing system and overcapacity management (The World Bank, 2018). The ineffective existing regulatory structure makes matters worse by ignoring livelihood issues (Khan and Khan, 2011). According to Kaczan and Patil (2020) sustainable and productive fisheries require investment and policy changes in Pakistan. The lack of trade-promoting policies in Pakistan hinders seafood trade, according to a study conducted by Mehak et al. (2020). Yeo and Deng (2019) employed the gravity model to determine changes in trade between Pakistan and its neighboring countries. Their finding indicates that suitable trade agreements and trade-promoting policies can significantly enhance seafood trade performance. Seafood trade is not adequately facilitated, and no policies are in place to promote it (Sharif et al., 2014). The Global Enabling Trade Index ranks Pakistan 116 out of 132 countries in trade efficiency. The export process involves seven documents, with a processing time of 21 days, reducing export efficiency. Market diversity is direly needed to upsurge seafood trade in Pakistan (Government of Pakistan, 2015).

2.5 Socio-cultural risks

Seafood trade in Pakistan is hindered by quality concerns (Sharif et al., 2014). According to Mehak et al. (2023), fishery exports cannot be increased without adherence to mandatory sanitary and phytosanitary (SPS) standards. Several countries, including Saudi Arabia, the USA, and the EU, have banned seafood imports from Pakistan due to poor quality issues causing huge economic losses (Shabir and Kazmi, 2007; The Fish Site, 2007, The Fish Site, 2016). The consumption of fish is directly influenced by income, domestic seafood supply, and education, according to a study conducted by Feng et al. (2000).

2.6 Infrastructure and logistics risks

In Pakistan, there is no swift transport system, causing shipment delays and adversely affecting the quality of seafood (Mehak et al., 2020). Pakistan is ranked 60 out of 130 countries in terms of road quality (Government of Pakistan, 2015). According to Shafi et al., 2020 fish markets in Pakistan mostly do not have appropriate cold storage facilities which results in enzymatic as well as microbial spoilage of the seafood resulting in compromised quality. In total, there are 27 seafood processing plants in Pakistan out of which only 8 are functional. There is only one plant associated with canning (Marine Fisheries Department, 2012; MFF Pakistan, 2016). Unfortunately, due to the lack of adequate processing facilities most of the fish catch, about 90%, is exported frozen and unprocessed to other countries resulting in huge economic losses (Sharif et al., 2014).

3 Materials and methods

3.1 Technical route and study framework

This study was carried out using a systematic scientific approach. First, a thorough review of the literature related to seafood trade risk management in Pakistan was conducted to develop a solid foundation for the study. Second, research gaps were identified and research questions were formulated. Third, a survey questionnaire was developed to collect relevant data. Fourth, in order to evaluate the collected data and produce reliable results, reliable statistical methods were selected. Fifth, the obtained results were discussed and suggestions were made. The study framework and technical route, including these steps, are graphically represented in Figure 1. The goal of this study is to enhance the efficiency and long-term viability of Pakistan's seafood trade.

3.2 Risk classification

Risk classification is the central aspect of this study. Therefore, a robust and reliable system was adopted to classify them. First, risks were listed and classified according to the descriptions of Tingley et al. (2010) and Gray et al. (2010). Second, this list was discussed later with stakeholders to check the existence of these risks in Pakistan. Third, some risks not reported in Pakistan were removed from the list. Fourth, this list was verified through a literature review. Thus, this study uses a reliable risk classification that represents Pakistani risks. Finally, a two-tiered risk hierarchy or construct was formulated to better understand the complexities of risks associated with the seafood trade in Pakistan. The first tier of this hierarchy is comprised of five main risks critical to the seafood trade in Pakistan. Whereas, the second tier is composed of 24 sub-risks classified under these main risks (Figure 2).

3.3 Formulation of questionnaire survey

This study adopted a systematic approach to collect data. A detailed literature review led to the development of a precise questionnaire utilizing Saaty's nine-point scale (Saaty, 2008) and incorporating fuzzy AHP, IPA, and AMOS. This nine-point scale was chosen over the conventional five-point scale to enhance sensitivity and granularity in capturing respondent's perceptions of preferences, aligning with the study's objectives. This scale allows for a more nuanced exploration of attitudes, offering additional levels of differentiations crucial for comprehensive data analysis. Its adoption aims to better capture subtle variations in opinions, ensuring a more robust and detailed examination of survey data in the context of this research. The questionnaire was reviewed by a panel of three professors to improve its relevance and smoothness of writing. This questionnaire consisted of three parts, viz., personal information, risk ratings, and option-based questions. Later on, the questionnaire was pretested in Sindh by 30 respondents to validate its effectiveness by removing irrelevant questions. To expand our respondent base, we employed the snowball sampling technique. This approach started with a small group of initial respondents who, after completing their surveys, referred other participants within their networks. This method was particularly effective in enhancing the diversity and comprehensiveness of our data.

3.4 Data collection

The data collection period extended from July 13, 2023, to December 27, 2023. The survey respondents were approached through in-person discussions and telephone calls during this period. Snowball sampling technique was employed to find potential survey participants. Before data collection, a brief explanation about the purpose of this planned study was given to the respondents. The target group for the survey included various stakeholders such as anglers, seafood processors, official private entities, academics, and knowledgeable buyers. In the survey, 352 respondents (56.2%) were from Sindh, while 274 (43.8%) were

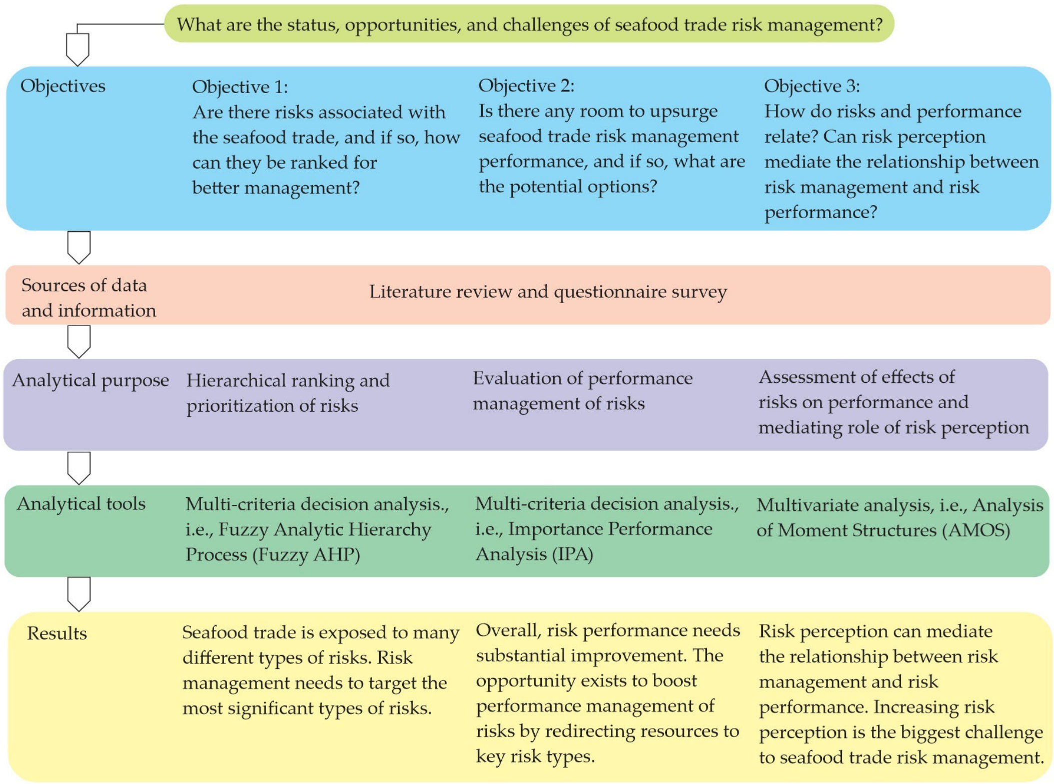

FIGURE 1
Graphical representation of study framework and technical route.

from Balochistan, aiming to capture their valuable insights and perspectives on seafood trade risks in Pakistan. Only 626 questionnaires were deemed valid for fuzzy AHP and IPA analysis, as their consistency ratio was below 0.1. For AMOS, these questionnaires were also validated. Table 1 illustrates the socio-demographic profile of the survey respondents, including pertinent information about their backgrounds, experiences, and contexts.

3.5 Data analysis

This study utilized the fuzzy AHP and the IPA methods, implemented via Expert Choice 2000 software. Moreover, multivariate analysis was conducted by employing AMOS 18.0. To determine the survey response rate, the number of completed surveys was divided by the total sent out and then multiplied by 100. Response rates varied across regions. Sindh achieved a 73% response rate, while Balochistan recorded a 61% response rate.

3.6 Fuzzy analytic hierarchy process

AHP, developed in 1977 by Saaty, is a popular and reliable approach to risk management. It is widely used in many fields today, with some modifications to the original methodology (Teniwut et al., 2019; Vyas et al., 2019; Giamalaki and Tsoutsos, 2019; Havle and Kilic, 2019). Fuzzy logic, crucial to decision-making, enhances outcomes and serves as a vital component alongside AHP. This logic is used to solve the complexity of issues where vague information is available but no precise scenario exists. The fuzzy AHP approach works well when items serve as models for judgments because they are linguistically related (Dursun and Karsak, 2010). This approach is employed in this study to quantify the advantages of one option over another by comparing stakeholder preferences. This approach breaks the overall seafood risk scenario into tiers, with various risks within each tier. Fuzzy numbers are used to present options more comprehensively, enhancing the decision-making process. To compute risk weights, a geometric average is calculated based on survey respondents' choices (Wind and Saaty, 1980; Buckley, 1985). This facilitates the creation of fuzzy matrix representations of values, incorporating both the high and low values in the dataset. The average is determined by averaging the maximum values reported by respondents. Subsequently, this matrix is employed to assign weights to risks based on their relative importance. Stakeholders prioritize risks in fuzzy AHP, leading to rational assumptions and decisions. If the target is optimization, fuzzy AHP enables a seamless alignment between stakeholders' objectives and goals (Mardle and Pascoe, 1999; Sethi, 2010).

3.6.1 Fuzzy matrix

Fuzzy matrix (Equation 1)

$$\tilde{A} = [\tilde{a}_{ij}]_{n\times n} \quad \text{(Eq. 1)}$$

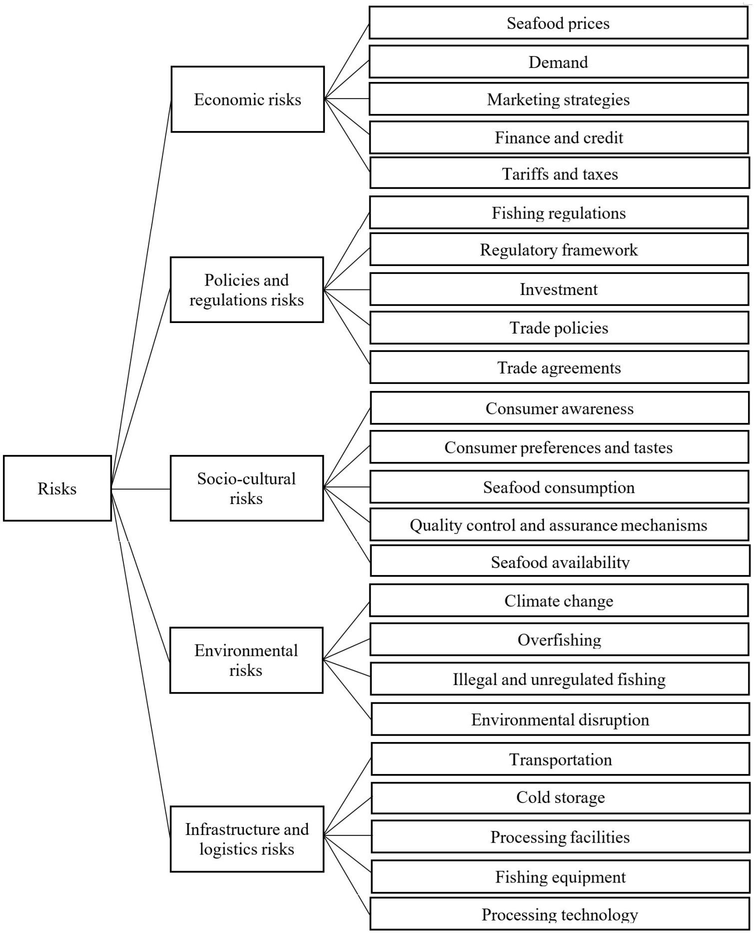

FIGURE 2
Two-tiered hierarchy of seafood trade main risks and sub-risks.

having positive as well as reciprocal features was created. In this matrix, a_{ij} represented the fuzzy triangular number and was expressed as follows (Equation 2):

$$\tilde{a}_{ij} = [l_{ij}, m_{ij}, u_{ij}] \quad \text{(Eq. 2)}$$

Other parameters were denoted as follows (Equation 3):

$$[l_{ij}, m_{ij}, u_{ij}] = \begin{cases} [1, 1, 1,], & if \quad i = j; \\ \left[\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}}\right], & if \quad i \neq j \end{cases} \quad \text{(Eq. 3)}$$

In the next step, generalization of fuzzy triangular number was obtained by employing the following formula (Dursun and Karsak, 2010) (Equation 4):

$$\left[\min_{1 \ll k \ll 24}\left\{a_{ij}^{(k)}\right\}, \left(\prod_{k=1}^{24} a_{ij}^{(k)}\right)^{1/24}, \max_{1 \ll k \ll 24}\left\{a_{ij}^{(k)}\right\}\right] \quad \text{(Eq. 4)}$$

Pair-wise comparison of risks was represented as $a^{(k)}$. Where, k values varied between 1 and 24. A fuzzy set of inverse functions was combined with these comparison pairs. Here, a_{ij} was represented as follows (Equation 5):

$$\tilde{a}_{ij} = \begin{cases} [1, 1, 1,], & if \quad i = j; \\ (\tilde{a}_{ij})^{-1}, & if \quad i \neq j \end{cases} \quad \text{(Eq. 5)}$$

Both i and j in this equation varied between 1 and 24.

3.6.2 Estimation of fuzzy weights

The geometric mean and weights method proposed by Saaty (1977) were employed to estimate the local weights of risk variables. Geometric mean for risk variables was computed using mathematical calculations related to fuzzy triangular numbers. Weights, $\tilde{W}_i$, were estimated using the following formula (Equation 6):

$$\tilde{w}_i = \left(\prod_{j=1}^{n} \tilde{a}_{ij}\right)^{1/n} = \left[\left(\prod_{j=1}^{n} l_{ij}\right)^{1/n}, \left(\prod_{j=1}^{n} m_{ij}\right)^{1/n}, \left(\prod_{j=1}^{n} u_{ij}\right)^{1/n}\right], i = 1, 2, \ldots, n \quad \text{(Eq. 6)}$$

Here, each risk variable (i^{th}) had a value between 1 and 24. $\tilde{W}_i$ was then summed based on earlier estimates. This summation was expressed as follows (Equation 7):

TABLE 1 Socio-demographic profile of survey respondents.

Attributes		Number	%
Spousal standing	Unwed	136	21.7
	Wedded	490	78.3
Sex	Masculine	574	91.6
	Feminine	52	8.4
Age	21~30 years	56	8.9
	31~40 years	542	86.6
	51~60 years	28	4.5
Work-related Experience	6~10 years	88	14.1
	11~15 years	382	61.1
	16 years and above	156	24.8
Certification	Primary education	68	10.8
	Secondary education	222	35.4
	Tertiary education	250	39.9
	Ph.D.	86	13.9
Region	Sindh	352	56.2
	Balochistan	274	43.8
Stakeholders	Anglers	132	21.1
	Seafood processors	204	32.6
	Official or private entities	72	11.5
	Academics	102	16.3
	Buyers (knowledgeable)	116	18.5
	Total	626	100.0

$$\sum_{i=1}^{n}\tilde{w}_i = \left[\sum_{i=1}^{n}\left(\prod_{j=1}^{n} l_{ij}\right)^{1/n}, \sum_{i=1}^{n}\left(\prod_{j=1}^{n} m_{ij}\right)^{1/n}, \sum_{i=1}^{n}\left(\prod_{j=1}^{n} u_{ij}\right)^{1/n}\right] \quad \text{(Eq. 7)}$$

Finally, the fuzzy weights were estimated by employing the following equation (Equation 8):

$$\tilde{W}_i = \frac{\tilde{w}_i}{\sum_{i=1}^{n}\tilde{w}_i} = \left[\frac{\left(\prod_{j=1}^{n} l_{ij}\right)^{\frac{1}{n}}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} u_{ij}\right)^{\frac{1}{n}}}, \frac{\left(\prod_{j=1}^{n} m_{ij}\right)^{\frac{1}{n}}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} m_{ij}\right)^{\frac{1}{n}}}, \frac{\left(\prod_{j=1}^{n} u_{ij}\right)^{\frac{1}{n}}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} l_{ij}\right)^{\frac{1}{n}}}\right], \quad i = 1, 2, \ldots, n \quad \text{(Eq. 8)}$$

3.6.3 Calculation of crisp number

In order to obtain a crisp number, it was necessary to perform a defuzzification process expressed as follows: $W_i = (l_i^W + 2m_i^W + u_i^W)/4, i = 1, 2, \ldots, n$. Here, i ranged between 1 and 24. Moreover, all risk variables were standardized to find the corresponding local weights along with a crisp number for each risk variable. This process was described as follows (Equation 9):

$$W_i = W_i / \sum_{i=1}^{n} W_i, i = 1, 2, \ldots, n \,. \quad \text{(Eq. 9)}$$

3.7 Importance performance analysis

In 1977, Martilla and James proposed a methodology for assessing sector performance. This technique has proven to be an effective and convenient tool for both researchers and managers alike. It facilitates data interpretation and simplifies the process of making strategic decisions, allowing for the development of a more effective management program (Azzopardi and Nash, 2013). This method employs a matrix to determine the average value between performance data and importance data, indicating a potential relationship between them. In this matrix, known as quadrant

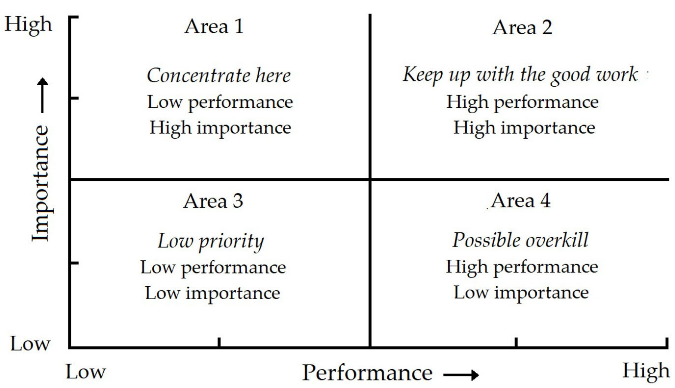

FIGURE 3
Visual depiction of quadrant analysis in Importance-performance analysis.

analysis, the x-axis measures the performance of each risk element, while the y-axis assesses its importance (Figure 3). The four quadrants of the IPA reflect the importance and performance attributes that respondents attribute to specific risk elements. Each quadrant represents distinct opinions, resulting in different management measures. The four quadrants of the IPA are as follows:

1. Concentrate here - low performance and high importance: This quadrant indicates an immediate need to address problems and improve the situation.
2. Keep up with the good work - high performance, high importance: This quadrant represents that current management is working well.
3. Low priority - low performance, low importance: This quadrant indicates that no additional effort is required and there are no major weaknesses associated with it.
4. Possible overkill - high performance, low importance: This quadrant signifies that instead of allocating resources to these attributes, it might be more beneficial to redirect them elsewhere (Azzopardi and Nash, 2013).

3.8 Analysis of moment structures

AMOS 18.0 was utilized to analyze the relationship between seafood trade risks and performance, and the role of risk perception in mediating this relationship. Three matrix were used to implement structure equation modeling (SEM). The first matrix was represented as follows (Equation 10):

$$\eta = B\eta + \Gamma\xi + \varsigma \quad \text{(Eq. 10)}$$

Here, B denoted the coefficient of endogenous variables, i.e., η. Whereas, ξ represented the coefficient of exogenous variables, i.e., Γ. The second matrix was annotated as follows (Equation 11):

$$Y = \Lambda y\eta + \varepsilon \quad \text{(Eq. 11)}$$

Here, Y and Λy expressed endogenous variables and their coefficients, in that order. On the other hand, ε symbolized all error estimates. The third matrix was expressed as follows (Equation 12):

$$X = \Lambda x\xi + \delta \quad \text{(Eq. 12)}$$

Here, X and Λx represented exogenous variables and their coefficients, correspondingly. Whereas, δ denoted all of the error estimates (Narayanan, 2012; Shek and Yu, 2014).

4 Results

4.1 Demographic characteristics of survey participants

The survey included 136 (21.7%) unmarried and 490 (78.3%) married respondents. The majority were male (91.6%) compared to female respondents (8.4%). Respondents predominately fell into the age groups of 31~40 years (86.6%) and 11~15 years of work experience (61.1%). Education-wise, most held tertiary degrees (39.9%). Geographically, the survey drew primarily from Sindh (56.2%) and Balochistan (43.8%). Occupationally, respondents were mainly food processors (32.6%), followed by academicians (16.3%) and buyers (18.5%).

4.2 Fuzzy AHP rankings of main risks by using local weights

According to the local weights assigned to the main risks, Table 2 shows the fuzzy AHP rankings of these risks. 'Environmental risks' (0.367) achieved the highest ranking, following 'infrastructure and logistics risks' (0.244) in the order of prioritization. Moreover, it should be noted that 'economic risks' (0.209) came in third place, 'socio-cultural risks' (0.098) ranked in fourth place, and 'policies and regulations risks' (0.081) came in fifth place.

4.3 Fuzzy AHP rankings of all sub-risks by using global weights

The overall ordering of sub-risks using global weights is presented in Table 3. The top three ranking sub-risks in terms of their importance are overfishing, climate change, and transportation.

4.4 IPA rankings of main risks

Table 4 shows the IPA rankings of the main risks. Regarding ranking risks, 'infrastructure and logistics risks' was ranked as the top risk (4.421), and then came 'economic risks' (4.123). Moreover, the 'environmental risks' (3.661), the 'socio-cultural risks' (3.449), and the' policies and regulations risks' (3.011) ranked third, fourth, and fifth, respectively.

4.5 Improvement assessment analysis

In Figure 4, the quadrant classification of the sub-risks in IPA is presented. Area 1 is meant to represent sub-risks having high

TABLE 2 Fuzzy analytic hierarchy process rankings of main risks by using local weights.

Risk Factors	Importance	Rank
Environmental	0.367	1
Infrastructure and logistics	0.244	2
Economic	0.209	3
Socio-cultural	0.098	4
Policies and regulations	0.081	5

TABLE 3 Fuzzy analytic hierarchy process rankings of all sub-risks by using global weights.

Risks	Sub-risks	Importance	Rank
Environmental	Overfishing	0.122	1
Environmental	Climate change	0.091	2
Infrastructure and logistics	Transportation	0.075	3
Socio-cultural	Quality control and assurance mechanisms	0.061	4
Policies and regulations	Regulatory framework	0.051	5
Environmental	Illegal and unregulated fishing	0.033	6
Environmental	Environmental disruption	0.046	7
Economic	Demand	0.043	8
Economic	Seafood prices	0.042	9
Policies and regulations	Investment	0.041	10
Infrastructure and logistics	Cold storage	0.038	11
Infrastructure and logistics	Processing technology	0.037	12
Socio-cultural	Consumer awareness	0.021	13
Economic	Marketing strategies	0.021	14
Economic	Tariffs and taxis	0.034	15
Policies and regulations	Fishing regulations	0.032	16
Socio-cultural	Seafood consumption	0.023	17
Infrastructure and logistics	Processing facilities	0.036	18
Socio-cultural	Seafood availability	0.033	19
Policies and regulations	Trade policies	0.031	20
Policies and regulations	Trade agreements	0.028	21
Economic	Finance and credit	0.026	22
Socio-cultural	Consumer preferences and tastes	0.019	23
Infrastructure and logistics	Fishing equipment	0.016	24

importance but low performance when it comes to the overall performance. These risks, therefore, indicate that improvements are needed and include 'transportation', 'cold storage', 'demand', 'marketing strategies', 'overfishing', 'regulatory framework', and 'seafood availability'. Area 2 represents the sub-risks within the model that have high importance and performance. The management of these risks, therefore, continued to be carried out. Among these are 'processing facilities', 'seafood prices', 'finance and credit', 'environmental disruption', 'fishing regulations', 'consumer preferences and tastes', and 'quality control and assurance mechanisms'. In Area 3, sub-risks with low importance and low performance were grouped together, which means they have low priority. Among these risks are 'fishing equipment', 'tariffs and taxes', 'illegal and unregulated fishing', 'investment', 'trade policies', and 'consumer awareness'. Those sub-risks with low importance but high performance have been grouped into Area 4. There is a need to reallocate the resources spent on managing these sub-risks to those belonging to Area 1 so that they can be managed more effectively. Among them are 'processing technology', 'climate change', 'trade agreements', and 'seafood consumption'. Sub-risks were given codes. Table 5 summarizes sub-risks and their corresponding codes.

TABLE 4 Importance-performance analysis rankings of main risks.

Risks	Importance	Rank
Infrastructure and logistics	4.421	1
Economic	4.123	2
Environmental	3.661	3
Socio-cultural	3.449	4
Policies and regulations	3.011	5

4.6 Validation of reliability

A reliability test was conducted to validate data accuracy. The results of this test are listed in Table 6. Economics risks were evaluated through five questions, yielding an estimated Cronbach's alpha (CA) coefficient of reliability of 0.938. The environmental risks assessment consisted of four questions, resulting in a CA of 0.936. In addition, infrastructure and logistics risks were investigated with five questions, with a CA of 0.952. Furthermore, the performance evaluation comprised four questions, resulting in a CA of 0.887. The CA estimate for each construct exceeded 0.6, indicating data reliability.

4.7 Correlation between constructs

Table 7 presents the correlation findings among all constructs employed in this study. AVE values are listed at the top of every column, and correlation estimates are shown below. Correlation strength is determined by their values, whereas negative signs indicate negative relationships between constructs. As the AVE estimates exceed the squared correlations, it can be inferred that all variables are discriminately accurate.

4.8 Validation of structure equation modelling

Modeling indicators like CMIN/DF, RMR, and CFI represent equation fitting. The NFI method can sometimes give higher

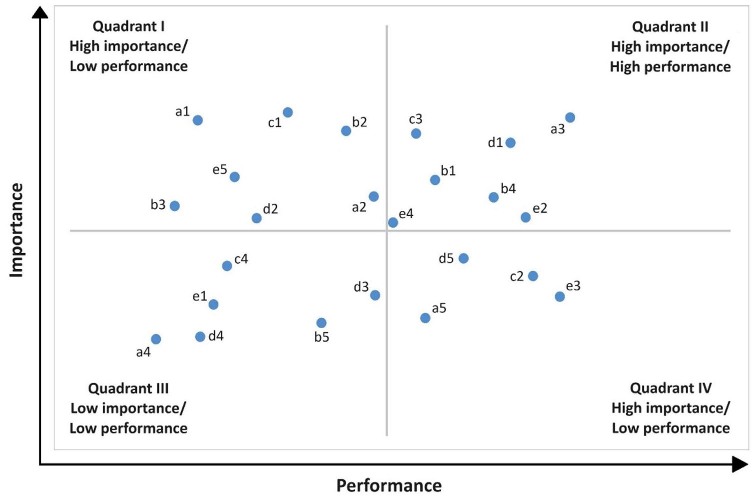

FIGURE 4
Quadrant classification of sub-risks in Importance-performance analysis.

estimates when complex equation structures are used in the equation. It is more appropriate to consider the CFI index in these situations (McDonald and Ho, 2022). It is imperative to note that all of the indices values meet standard criteria, demonstrating the reliability of the model (Table 8).

4.9 Mediating effect of risk perception

Statistics outlined in Table 9 illustrate the mediating role of risk perception between risk management and risk performance. Differences in results between Sindh and Balochistan indicate the mediating effect of risk perception. For Sindh, economic risks (estimate = 0.376 and CR = 2.936***), environmental risks (estimate = 0.367 and CR = 3.251***), and infrastructure and logistics risks (estimate = 0.391 and CR = 2.834***) mediate performance significantly. Furthermore, for Balochistan, economic risks (estimate = 0.464 and CR = 3.122***), environmental risks (estimate = – 0.343 and CR = – 3.495***), policies and regulations risks (estimate = 0.381 and CR = 3.226***), and occupational risk (estimate = – 0.324 and CR = –4.639), and infrastructure and logistics risks (estimate = 0.287 and CR = 2.845**) were estimated to have a significant mediating effect on performance.

5 Discussion

The findings of this study reveal that the main risks faced by Pakistan's seafood industry include infrastructure and logistics risks, environmental risks, and economic risks. Additionally, risk management should focus on the sub-risks of overfishing, climate change, and transportation. The significance of these sub-risks cannot be overstated, as they are not only ranked as top concerns by the fuzzy AHP, but also placed in quadrant 1 by the IPA, highlighting problems related to performance management. Published literature supports these findings (Panhwar et al., 2016; Shah et al., 2017). The tragedy of the commons is often associated with global fisheries (Manning et al., 2018). Technology makes the matter even worse, as small boats can harvest fish biomass beyond a sustainable threshold levels (Scherrer and Galbraith, 2020). This situation is reported to have impacted Pakistani fisheries leading to overfishing (Noman et al., 2022). On the other hand, to attain SDG 14 it is crucial to control overfishing. Hence, overfishing is the top concerning sub-risk in Pakistan. A number of studies indicate that Pakistan's marine resources are under constant pressure from overfishing (Kalhoro et al., 2014; Noman et al., 2022).

The fisheries sector in Pakistan, especially in Sindh, faces severe overfishing, leading to a 2% annual decline in capture production over the last 20 years (DAWN, 2017). The National Fisheries and Aquaculture Policy Agenda (USAID, 2014) and The Sindh Fisheries Ordinance of 1980 aim to promote sustainable fishing and control overfishing. Particularly, section 2 of the National Policy put emphasis on controlling various aspects of overfishing (Government of Pakistan, 2007). Moreover, Pakistan is a signatory to the FAO, therefore, it should follow responsible fishing practices (Food and Agriculture Organization, 1995) and strive to achieve SDG 14. However, the desired output is not witnessed until now. It is reported that the number of operational trawlers is double the recommended ones contributing in overfishing heavily (USAID, 2014). A majority of the survey participants, 69%, expressed concerns about the implementation of regulations. According to them, some fishermen, even those caught doing overfishing, cannot be punished properly. Moreover, penalty procedures have significant flaws and cannot improve the situation.

There are multiple concerns pertaining to the sustainable use of fishing resources and the management of overexploitation. Inadequate data is an impediment to the conservation of commercially important species, as species are frequently clustered together, hence complicating the decision-making process. The successful mitigation of overfishing necessitates a robust political determination to enforce regulations (Government of Pakistan, 2007). To address overfishing, it is necessary to strengthen and enforce fisheries rules, as well as establish

TABLE 5 Distribution of sub-risks in quadrant analysis.

Code	Sub-Risks	Importance Weights (%)	Performance Weights (%)	Quadrant
a1	Transportation	4.432	3.524	1
a2	Cold storage	4.137	3.943	1
a3	Processing facilities	4.486	4.472	2
a4	Fishing equipment	3.511	3.374	3
a5	Processing technology	3.654	4.112	4
b1	Seafood prices	4.171	4.124	2
b2	Demand	4.408	3.892	1
b3	Marketing strategies	4.111	3.452	1
b4	Finance and credit	4.103	4.256	2
b5	Tariffs and taxes	3.621	3.836	3
c1	Overfishing	4.494	3.729	1
c2	Climate change	3.821	3.340	4
c3	Environmental disruption	4.386	4.079	2
c4	Illegal and unregulated fishing	3.886	3.616	3
d1	Fishing regulations	3.296	4.301	2
d2	Regulatory framework	4.018	3.689	1
d3	Investment	3.724	3.991	3
d4	Trade policies	3.555	3.384	3
e1	Consumer awareness	3.714	3.571	3
e2	Consumer preferences and tastes	4.021	4.322	2
e3	Seafood consumption	3.734	4.443	4
e4	Quality control and assurance mechanisms	4.181	4.125	2
e5	Seafood availability	4.214	3.627	1

comprehensive monitoring and surveillance systems. Fache and Pauwels (2020) assert that there is a coordinated effort to promote sustainable fishing methods and formulate fishery management plans that are grounded in scientific data and adaptive techniques. According to Noman et al. (2022), the establishment of closure seasons and the regulation of mesh size can be effective strategies in mitigating the issue of overfishing. Research indicates that the precautionary principle should be applied in this context (Pan and Huntington, 2016). In addition, it is crucial to enhance the public awareness on the importance of adopting responsible fishing practices and safeguarding the well-being of fish populations. Risk perception plays a crucial role in the implementation of risk management strategies in Pakistan. However, a significant proportion of survey respondents (73%) reported a low levels of risk perception. They frequently mentioned that these risks are either overlooked or tolerated rather than being promptly reported and effectively addressed, which presents a major obstacle in the overall risk management process.

TABLE 6 Validation of reliability.

Construct	No. of questions	Cronbach's Alpha
Economic	5	0.938
Environmental	4	0.957
Policies and regulations	5	0.924
Socio-cultural	5	0.936
Infrastructure and logistics	5	0.952
Performance	4	0.887

This study also finds that existing regulations mostly address general types of risks. There are several types of sub-risks reported in this study such as seafood prices, marketing strategies, consumer preferences, and tastes etc. that are very important but never addressed in the regulations. Furthermore, some sub-risks, such as overfishing, are frequently addressed in regulations, but the apparent situation has not improved, raising major concerns about the performance management of these sub-risks. About half of the survey participants, 51%, reported poor management practices in Pakistan. In contrast, 66% of respondents suggested extension

TABLE 7 The matrix representing the correlation between constructs.

Construct	1	2	3	4	5	6
Economic	**0.821**					
Environmental	0.711***	**0.832**				
Policies and regulations	0.405***	0.525***	**0.809**			
Socio-cultural	0.373***	0.481***	0.582***	**0.838**		
Infrastructure and logistics	0.476***	0.334***	0.471***	0.661***	**0.817**	
Performance	− 0.503***	− 0.451***	− 0.374***	− 0.457***	− 0.414***	**0.726**

Bold values indicate average variance extracted.
Asterisk signs means significance.

TABLE 8 The matrix representing the correlation between constructs.

	CMIN	P	AGFI	GFI	NFI	TLI	RMR	CFI	IFI	CMIN/ DF
Fit of Model	984.741	0.000	0.956	0.913	0.985	0.917	0.041	0.959	0.977	1.843
Standard			≥0.9	≥0.9	≥0.9	≥0.9	<0.05	≥0.9	≥0.9	>1, <3

services to address the current situation. Therefore, more emphasis should be placed on the performance evaluation of the existing management regime.

There is a negative correlation between risks and performance. Clearly, increasing risks will reduce the performance of the seafood trade sector and jeopardize the attainment of SDG 2. Thus, comprehensive management measures are needed to revive this sector. Moreover, in Sindh, economic, environmental and infrastructure and logistics risks affect performance. Whereas in Balochistan economic, environmental, policies and regulations and infrastructure and logistics affect performance. This difference in the effect of risks on performance between provinces is regarded as the mediating effect of risk perception. Thus, there is a need to increase risk awareness levels through risk communication. This process will automatically impact the relationship between risk management and risk performance thus helping in the effective risk management process. Moreover, there is also a need to address cultural traditions. For instance, there is a seasonal consumption of seafood in Pakistan during the winter season, particularly in the inland areas. Fish is considered a "hot" food based on its perceived effects on the body and is generally avoided in the summer season. There is a need to change this cultural tradition by explaining the benefits of consuming fish through education. Implementing effective supply chain management practices ensures consistent delivery and high customer satisfaction, which reduces demand volatility (Ferrer-Perez and Gracia-de-Renteria, 2020).

Around 80% of the survey participants blamed poor seafood quality issues for decreased trade volume. To build consumer confidence in food safety a robust traceability system is still direly needed. Unfortunately, due to persistent seafood quality issues, there has been a cancellation of seafood trade orders from various countries including the EU, Saudi Arabia, etc (The Fish Site, 2016; Business Recorder, 2022). Another reported issue in the literature that is significantly contributing to the risks of seafood consumption and consumer preferences and tastes is pollution (Jilani, 2018). Pakistani coastal waters are heavily affected by this problem. The general seafood consumers therefore show less tendency to consume seafood frequently. Thus, addressing pollution effectively and reinforcing

TABLE 9 Mediating role of risk perception.

Risk effect on performance	Sindh			Balochistan		
	Estimate	CR	Result	Estimate	CR	Result
Economic → Performance	0.376	2.936***	Accept	0.464	3.122***	Accept
Environmental → Performance	0.367	3.251***	Accept	− 0.343	− 3.495***	Accept
Policies and regulations → Performance	− 0.073	0.383	Reject	0.381	3.226***	Accept
Socio-cultural → Performance	0.022	0.179	Reject	− 0.051	− 0.331	Reject
Infrastructure and logistics → Performance	0.391	2.834***	Accept	0.287	2.845**	Accept

Asterisk signs means significance.

quality control mechanisms is the key to boosting seafood consumption in Pakistan (Saher and Kanwal, 2019; Hori et al., 2020).

5.1 Implications, limitations, and future research directions

This study provides valuable insights that can help mitigate seafood trade risks in Pakistan. By comparing and prioritizing risks, this study suggests a practical roadmap for mitigating risks according to their hierarchy. Thus, it will help to develop more effective directional management plans rather than blind ineffective management practices. It also optimizes resource allocation which is very important in the context of Pakistan where resources are extremely limited. The core finding of this study is to increase risk awareness. Increasing risk awareness can significantly improve management performance. Thus, this study can help to make effective and feasible management policies that are deemed necessary to revive the seafood trade in Pakistan and achieve SDG 14 and 2. However, this study has some limitations. Such as data collected for this study belongs to some specific geographic region that may be unable to reflect a complete and real picture of the country's entire seafood trade landscape. Moreover, data collection time does not span over the whole year which may result in missing temporal variation of risk perception. In addition, the statistical method employed in this study also confers their own inherent disadvantages that must also be considered. Collected data entirely reflects stakeholders' perception of risks thus there are chances of biases. Furthermore, risks associated with trade are dynamic in nature thus current evaluation of risks can be different from the future situation.

Several opportunities for further research emerge based on the findings of this study. For instance, a more detailed analysis of the sub-risks within each primary risk category is necessary. Moreover, expanding the geographic scope of the study within Pakistan can provide insights into how risks differ across different regions. Studies based on the data collected through a single stakeholder group can yield group-specific results that can be helpful to efficient resource allocation and targeted solutions. In addition, studies related to the evolution of risks and their temporal dynamics can be a good opportunity for future research. Furthermore, conducting comparative analyses with other developing countries with substantial seafood trade can yield insights into the context-specificity of risk management strategies. Additionally, research focusing on the enhancement of extension services can offer practical insights for policy and practice.

6 Conclusion

The findings of this pioneering study shed light on the complex and multifaceted risks plaguing the seafood trade in Pakistan. The research revealed that environmental risks, infrastructure, and logistics risks are the two dominant risk categories influencing the seafood trade. Economic risks, socio-cultural risks, and policies and regulations risks also play significant roles, but they are comparatively less influential. Applying multi-criteria decision-making techniques, including fuzzy AHP and IPA, and multivariate analysis, including AMOS, allowed for a comprehensive statistical understanding of the data. This analysis identified specific sub-risks that demand immediate managerial attention due to their high importance but low performance, including transportation, cold storage, demand, marketing strategies, overfishing, regulatory framework, and seafood availability. It was evident from the survey respondents' perspectives that there is a low level of risk perception among stakeholders in the seafood trade, and there needs to be more adequate management regulations to address these risks effectively. The significance of this research lies in its contribution to the literature by highlighting an uncharted area of concern in the seafood trade of Pakistan and guiding the formulation of targeted policy interventions to achieve SDGs 14 and 2. The study's limitations include a restricted geographical focus and incomplete temporal coverage of data, potentially limiting the generalizability of findings. Methodological constraints and biases inherent in stakeholder perception data further underscore the need for cautious interpretation. Future research opportunities include detailed sub-risk analysis, expanded regional studies within Pakistan, and targeted investigations into temporal variations and stakeholder-specific perspectives. Comparative studies with other developing nations and efforts to enhance extension services present avenues for advancing policy and practice in seafood trade risk management.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

MM: Formal analysis, Writing – original draft. AM: Data curation, Methodology, Writing – review & editing, Investigation. HY: Writing – review & editing, Investigation, Funding acquisition, Visualization.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was funded by International Business Management (grant number 2023gjkc02) and Achievements of the Oujiang Youth Special Project for Philosophy and Social Sciences Planning in Wenzhou City (Number: 16).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2024.1420755/full#supplementary-material

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