Supply Chain Integration in the Indonesian Aquaculture Industry; Finding Challenges and Opportunities

Rr Rieka Febriyanti Hutami[1,2*], Togar M. Simatupang[1], and Liane Okdinawati[1]

[1] Bandung Institute of Technology, Bandung, Indonesia
[2] Telkom University, Bandung, Indonesia
*rieka_hutami@sbm-itb.ac.id

Abstract. Aquaculture presents an alternative food security solution, and in Indonesia, the industry is rapidly expanding due to abundant natural resources. Indonesia is a significant player in aquaculture production in Southeast Asia, ranking third globally after China and India. In 2019, Indonesia also joined the top five consumers of aquaculture products, alongside China, India, the United States, and Japan. Aquaculture is more diverse than other agricultural sectors and very challenging due to the variety of aquaculture types, ownership structures, and watering channel management methods. and other factors that need to be integrated because one of the reasons is they operate with supply chains that have a limited degree of integration, particularly with retailers and private standards schemes. This integration involves both customers and suppliers along with supply chain risks has received less attention. This complex integration cannot be done by fish farmers or aquaculture companies alone. It requires cooperation between fish farmers, engineers, scientists or academics, software developers, economists and relevant government agencies to integrate everything effectively. This study will focus on describing the potential supply chain integration along with it challenges. This study uses systematic literature review or SLR as a method to review the existing literature on a particular topic so that the results of SLR can be used to see the gaps from previous studies combined with bibliometric analysis. The study aims to provide a brief bibliometric review studies in understanding challenges and opportunities in supply chain integration. The findings show that, while initiatives for integration exist, there are still significant gaps and areas for improvement. This study focuses on literature that discusses supply chain integration in the aquaculture industry. The bibliometric reviews in this study will delve into supply chain integration in the aquaculture industry, providing valuable insights for researchers and practitioners in this field. Additionally, they will aid stakeholders in understanding the challenges and opportunities present in this industry.

Keywords: Aquaculture, Supply Chain Integration, Systematic Literature Review, Bibliometric Analysis

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1 INTRODUCTION

Aquaculture, also known as fish farming, is not the same as capturing fisheries. Aquaculture refers to the cultivation of aquatic organisms. Aquaculture is a method of controlling or keeping aquatic creatures in a human-controlled environment. These aquatic species comprise not just fish (Pisces), but also crustaceans and mollusks, which are included in the legal definition of fish. Aquaculture products are usually essential in fulfilling public consumption needs, providing ornamental fish, and producing industrial items such as medications, cosmetics, and crafts (Debnath et al., 2009).

In supporting the Sustainable Development Goals (SDGs), aquaculture plays a crucial role in several goals of the seventeen SDGs, namely 1st goal: of no poverty, 2nd goal of zero hunger and the 14th goal: life below water. To eradicate poverty, aquaculture can contribute both socially and economically by creating job opportunities. By increasing the number of aquatic productions, it can supply food both for people who live in coastal and rural areas. In addition, aquaculture also provides a source of protein from seafood that can help fulfil nutrition. In the end, aquaculture can also support the achievement of the 14th SDG, which aims to end overfishing and restore fish stocks to sustainable levels.

Fig.1 Sustainable Development Goals (Source: United Nation, 2024)

The world's expanding population may be well-fed and nourished by aquaculture. Aquatic foods are becoming more acknowledged for their crucial significance in food security and nutrition, not just as a source of protein, but also as a unique and incredibly diversified supply of critical fatty acids known as omega-3 along with other micronutrients (Kamaruddin & Baharuddin, 2015). As the largest country in Southeast Asia, Indonesia's archipelago represents one of the most unusual areas in the world because it is located between two continents and two oceans, namely, the Asian & Australian continents, and the Indian & Pacific Oceans (McDivitt et al., 2024) .It is also located between the confluence of two mountains, the Pacific circumspect and the Mediterranean circumspect, which makes Indonesia a rich country in terms of natural resources. Another benefit is Indonesia is also located on the world's trade and shipping routes, including trade routes between East Asian countries with Europe, the Middle East and India as well as trade routes between Asian countries with Australia and New Zealand

(McDivitt et al., 2024). At the same time, Indonesia is a large country, composed of 17,508 islands with a total area is about 3,226,935.94 miles or (5,193,250 km2) both land and sea. Indonesia can be referred to be a maritime country because most of its territory is covered by water (Legge et al., 2024).

Indonesia's aquaculture sector is experiencing rapid growth, presenting excellent expansion opportunities. The country's abundance of natural resources, including coastal areas and lakes, makes it ideal for aquaculture activities. As one of Southeast Asia's top producers of aquaculture products, Indonesia focuses on species like tilapia, catfish, and shrimp. The country's aquaculture industry is among the fastest-growing globally. While marine capture fisheries exist, production has surged by 34% in the past decade, rising from 5.0 million tons in 2010 to over 6.7 million tons in 2018. During the same period, Indonesia's aquaculture output more than quadrupled (>+100%), increasing from 2.4 million to 5.4 million tons and providing employment for nearly 3.3 million individuals. The marine aquaculture industry, valued at over $6 billion annually, contributes approximately 43% of total aquaculture production. Furthermore, Indonesian seaweed farming has grown even more rapidly, expanding from under 4 million tons in 2010 to 9.3 million tons in 2018, a more than 130% increase, accounting for nearly 30% of global production (World Bank, 2021).

The advancement of aquaculture in the last 50 years has been fueled by the implementation of new scientific and technological advancements. New technologies can disrupt business processes and pose a challenge for fish farmers who may not have the necessary skills, funding, and infrastructure to adopt them (Yue & Shen, 2022). The disparity between technology and practical implementation in various stages of aquaculture complicates the aquaculture process in the field. Different aquaculture systems, types of aquacultures, variations in owned equipment, and water treatment processes necessitate suitable integration strategies. According to Schrobback et al. (2021), supply chain integration can help alleviate the adverse effects of technological disruption in the aquaculture supply chain. It's important to note that integration cannot eliminate all negative consequences, and careful consideration of these issues is required when implementing new technology. Integration with consumers on the demand side of the supply chain allows companies to gain a better understanding of customer expectations, the cultural influences on customer purchases, and customer priorities. Meanwhile, effective visibility will facilitate collaboration with other stakeholders for demand planning and information dissemination across the supply chain. In the other hand, The National Fish Logistics System (SLIN) is being improved by the Ministry of Maritime Affairs and Fisheries to streamline the movement of fish from production centres to industrial hubs. An integrated, effective, and efficient supply chain management system for fish and fishery products is necessary to enhance the capacity and stability of the upstream-downstream fishery production system, regulate price variances, and meet domestic consumption demands (Ghivarianto, 2020). Given the intricate nature of the sector, encompassing various types and engaging numerous parties, it is imperative to have supply chain integration. Nonetheless, it would be prudent to first understand the obstacles and prospects within this industry before proceeding with further integration in the supply chain. This study aims to address research inquiries such as the challenges encountered by enterprises in the aquaculture sector and the opportunities, they are likely to encounter.

2 LITERATURE REVIEW

2.1 Supply Chain Management

The procedure of converting raw materials into semi-finished and finished products, and thereafter distributing them to customers, is known as Supply Chain Management (Heizer et al., 2017). Every step required to meet consumer demand, whether direct or indirect, falls under the umbrella of supply chain management. This encompasses not only businesses and suppliers, but also transportation, storage facilities, retailers, and customers. Supply chain management responsibilities are aided by marketing, new product development, distribution, operations, customer service and finance. According to Power (2005), supply chain management involves the coordination and integration of both internal and external flows. Flows move within a company's processes. A supply chain involves the movement of activities and materials from initial suppliers to end customers or through upstream and downstream connections managed by organizations participating in the production of products and services that ultimately deliver value to the consumer (Chopra & Meindl, 2013).

2.2 Supply chain integration

The integration of the supply chain is crucial at both strategic and operational levels, and various performance outcomes, such as financial, informational, and physical integration, as well as supplier, internal, and customer integration, quality integration, information sharing, upward and downward supply chain, operational coordination, strategic partnership, and synchronized planning, have been examined at different levels of Supply Chain Integration, including operational, tactical, and strategic, (Hasan & Shipton, 2021). In a study conducted by Zainol et al. (2016), three factors associated with supply chain integration were identified: external integration with customers, external integration with suppliers, and risk from supply chain, each of which can have a distinct impact on company performance. It is also possible that the effects of technological advancements on these three aspects of supply chain integration differ. The authors subsequently delve into these concepts. This research defines external integration within the supply chain as collaborative approaches between suppliers and customers to achieve mutually beneficial outcomes. The improvement of supply chain integration entails enhancing connections within each part of the chain to facilitate improved decision-making and foster more effective interaction among all participants, leading to increased visibility and the identification of supply chain bottlenecks (Power, 2005).

3 RESEARCH METHODOLOGY

In a study, it is very important to ensure that each stage is carried out clearly and correctly. This research aims to describe the challenges and barriers in the supply chain by using a literature study. Before performing bibliometric analysis, it's crucial to confirm that the selected article or literature study utilizes appropriate methodology and reliable sources. A systematic literature review (SLR) is employed to verify the accuracy of retrieving articles from journal databases. This method is often used to supplement bibliometric analysis by offering a systematic approach to summarizing and synthesizing current and prior studies within the desired research area.

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The systematic literature review yields articles that are deemed pertinent to the upcoming study. These articles will undergo analysis using bibliometric analysis, which has been recognized as an effective method for identifying research trends, patterns, and connections, as well as for visualizing the results. Utilizing bibliometric analysis simplifies and enhances the reliability of analyzing large numbers of papers. It also facilitates in-depth exploration of the relationships between articles, citations, co-citations, and keywords. This serves as a valuable visual tool that enables readers to easily pinpoint areas warranting further study. The VOS viewer software is employed for bibliometric cluster visualization. Consequently, the findings may provide comprehensive insights into our research area (van Eck & Waltman, 2014).

4 RESULT

Figure 4 shows the methodological structure of the literature review conducted for this research using PRISMA which has been adapted from Page et al., (2021). The Systematic Literature Review (SLR) consists of four steps, which are (i) identification, (ii) screening, and (iii) inclusion.

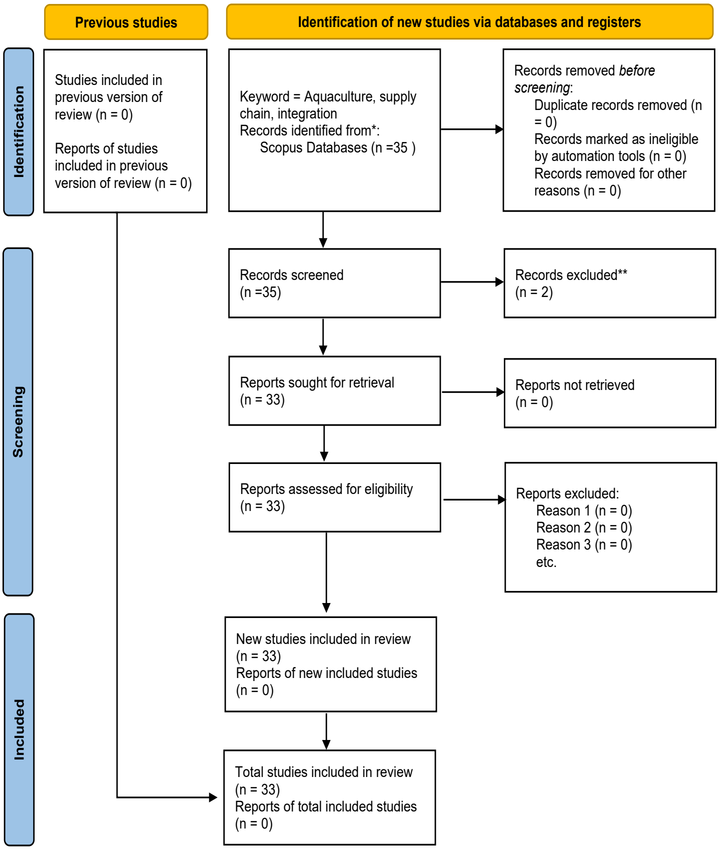

Fig 2. Prisma Analysis

4.1 Define the search words

Identifying the relevant phrases or keywords for data collection concerning supply chain integration is the first step. These keywords should be descriptive and specifically related to word variations and mathematical expressions. Our data is gathered from the Scopus database (www.scopus.com), which is known as the most comprehensive indexer of high-quality scholarly publications. Prior to searching the Scopus.com database, we conducted bibliometric analysis to perform a systematic literature review (SLR), recognize research trends, patterns, and connections, and visually display the findings. To ensure the authenticity of the files, it is essential to construct and document a Word database before commencing the process. The keywords used in this investigation are as follows: TITLE-ABS-KEY (Aqua) OR TITLE-ABS-KEY (Aquaculture) OR TITLE-ABS-KEY (aquamarine) AND TITLE-ABS-KEY (supply AND chain) AND TITLE-ABS-KEY (integration).

4.2 Pre-elimination search results

In this stage, relevant articles obtained from the original search query results are compiled and stored. The search was conducted in 2024, yielding 33 publications published between 2001 and 2024, as depicted in Figure 2. The exported initial search results are now available in CSV format, containing author names, DOIs, publication years, source titles, document titles, citation counts, document sources and types, author citations, volume, publication details, pages, publisher affiliations, abstracts, keywords, and conference information. A selection process was undertaken to ensure the relevance of the results to the study objectives, given the limited number of papers in this research. The articles chosen were selected based on their pertinence to business and management, totaling 33 articles. Further selection involved a meticulous review of the article abstracts, resulting in the identification of 13 articles published between 2001 and 2020.

4.3 Conducting analysis using R packed and VOS viewer

The first step is to choose and save the most relevant articles from the initial keyword query results. The search results are first converted into CSV format, which includes author names, publication years, source titles, document titles, volumes, publications, citations, pages, DOIs, citation counts, article source and document types, and bibliographic information, which will be used for bibliometric analysis. This procedure was conducted using an R programming tool and was based on particular criteria such as publishing, journal, author, principal state institutions, contributing authors, keywords, and the evaluation of collaboration networks among authors, institutions, and nations. Simultaneously, network analysis was carried out utilizing a VOS viewer. The purpose of examining the R findings is to identify and understand trends.

Table 1 Main Information from Bibliometric Analysis

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2001:2024
Documents	33
Average citations per doc	11.73
References	2284
DOCUMENT CONTENTS	
Keywords Plus (ID)	240
Author's Keywords (DE)	130
AUTHORS	
Authors	117
Authors of single-authored docs	5

Description	Results
AUTHORS COLLABORATION	0
Co-Authors per Doc	3.67
DOCUMENT TYPES	
article	23
book	1
book chapter	3
conference paper	3
conference review	1
editorial	1
review	1

The research articles obtained from the systematic literature review (SLR) via the Scopus database cover studies conducted from 2001 to 2024. The average citation rate per year for the 33 articles analyzed was determined to be 11.73. A total of 240 keywords were employed throughout the research. The total number of authors involved in the research is 117, starting from author 1 and proceeding through author 2. Whereas 33 articles had as many as five co-authors, the average co-author count per article is 3.65. Based on Table 1, it is evident that there is no collaboration between the authors. This indicates a lack of communication between the authors. Articles proved to be the most prevalent source of information, with a total of 23, followed by three book chapters and three conference papers.

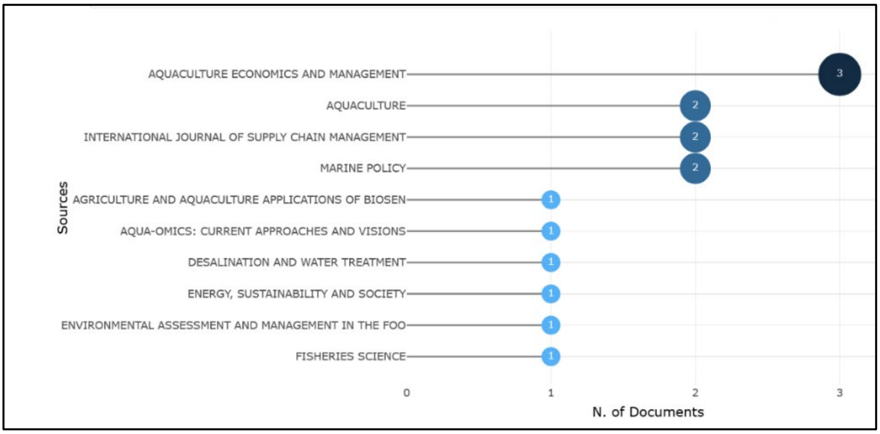

Fig. 3. Most Relevant Resources

The distribution of the most relevant sources related to supply chain integration in the aquaculture industry is shown in Figure 3. There are two articles from the Journal of Aquaculture Economics and Management. The journals

Aquaculture, International Journal of Supply Chain Management and Journal of Marine Policy had two relevant articles each. While the other six journals have one relevant article each.

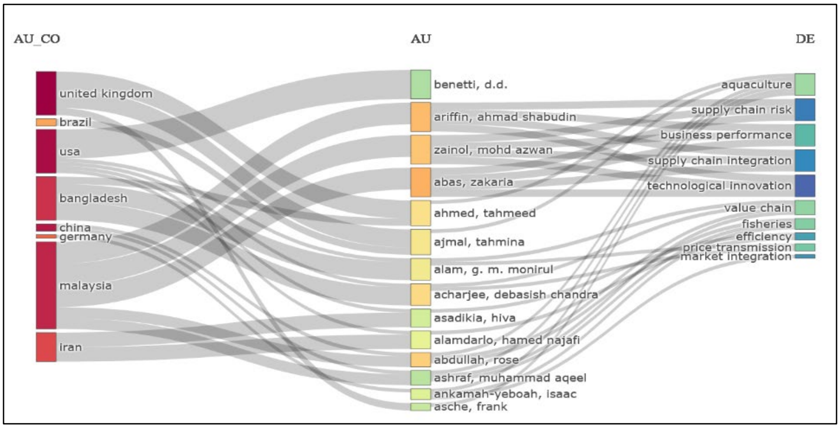

Fig. 4 Three-Field Plot

Three-field plot analysis in Figure 4, contains information about the top 15th list of the most countries, authors and keywords that appear from 33 articles being analyzed. Most of the articles came from Malaysia, with the names of authors Ariffin, Ahmad Shabudin, Zainol, Mohd, Azwan, Abas, and Zakaria and this article focuses on several keywords such as supply chain risk, business performance, supply chain integration technological innovation. The second dominant country was Bangladesh, and the third one was the UK. Based on the cited author, Asche F is the most cited author with 42 citations and a total link strength of 19.80.

4.4 Cluster and Network Analysis

This study utilizes VOS viewer software for clustering and network analysis of halal providers' food supply chains. This sort of analysis involves all keywords and considers co-occurrence as the unit of analysis.

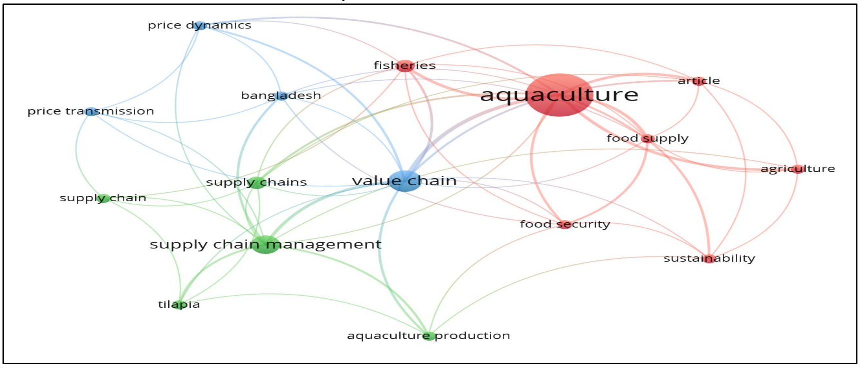

Fig. 5 Co-occurrence with all "Aquaculture" and "Supply Chain Integration" keywords

The VOS viewer tool or software is used in this research to conduct cluster formation and network analysis, providing graphical visualization and grouping analysis of Supply Chain Integration in the Aquaculture industry. This analysis involves co-occurrence and unit of analysis, encompassing all keywords. The clustering results obtained with the VOS viewer reveal three clusters, as depicted in Figure 5. The links (edges) represent the frequency of relationships between nodes. Aquaculture, supply chain management, and value chain are the prominent nodes, indicating their frequent usage. Supply chain integration is considered within the scope of supply chain management in this study. The findings are presented in three color-based clusters, namely red, blue, and green.

5 DISCUSSION

Challenge and Opportunity in the Aquaculture Industry

Aquaculture is more diverse than other agricultural sectors, the industry faces considerable challenges. These challenges faced by the aquaculture industry include issues related to sustainability of production, environmentally friendly concepts, regulations on food safety and the use of better technology. According to Rosenthal et al. (1985) one of the obstacles to aquaculture expansion is environmental concerns. Aquaculture has several negative effects on the environment, such as self-pollution, habitat degradation from aquaculture, resource competition, administrative and regulatory restrictions, and insufficient engagement with industry. Previously, the prospect of aquaculture having an impact on the environment was mainly ignored. Aquaculture, like any other industry, can emit enormous amounts of pollutants that degrade water quality and increase the risk of disease. In terms of habitat destruction, aquaculture can be the cause if not managed properly. In addition, technological innovation to achieve significant business performance also needs to be considered. found that the fast expansion of China's shrimp farming business has drawn investment from other industries. However, the educational background and technical skills possessed by shrimp farmers could not meet the expected requirements. The shrimp farmers lacked the necessary technology, lack of understanding of water quality and feeding methods, and inadequate management, leaving them defenseless in the event of an accident. argues farmers with a relatively high degree of education enhance communication between scientists and farmers, making it simpler to achieve the objective of farming for revenue. In contrast, farmers in underdeveloped tropical nations typically have little to no formal education. They are unfamiliar with soil chemistry or mathematical analysis. Aside from cost, there are numerous other factors to consider while adopting new technology (Zainol et al., 2016). However, among these challenges, there is one crucial aspect that has received less attention, namely external integration with both customers and suppliers along with supply chain risks.

The future opportunity can be seen by projecting the current trend. Several researchers can identify these opportunities in the future. According to Rowan (2023) the Food and Agriculture Organization (FAO) projects that global population growth will reach 10 billion by 2050. This means that to meet the world's food needs, aquaculture must continuously improve, and technological development is one of the supporting factors to meet these needs. Based on some estimations, aquaculture will grow, with salmon farming expected to expand not just into countries like Norway, Canada, France, and the UK, but also into much smaller geographic areas like the northern hemisphere. The cultivation of seaweed has gained popularity in Europe over the last few decades. This is supported by recent trends related to bioeconomy based on natural resources, including seawater. Creating bioenergy from seaweed carbohydrates is the primary objective of research being done in Norway in the areas of seaweed farming and processing technology development this trend might happen in Indonesia. Global integration between supply chain and agriculture, including agriculture is evolving as new technologies and disciplines emerge, with the potential to change the amount and quality of food and agriculture produced and consumed throughout the world. The exchange of commodities, services, and ideas among farmers, suppliers, consumers, entrepreneurs, and researchers has been made possible by the global integration of supply chains and agricultural markets. These fast changes and rising conflicts indicate that developing nations will need to establish more responsive, dynamic, and competitive agricultural sectors in the short to medium term to profit from the changing global system. It will be necessary for emerging nations to have creative policies, initiatives, and investments to stay up with the increasing demands of agricultural innovation.

In Indonesia, the first barrier that aquatic farmers face is the high cost of feed. Most of the food comes from other countries, which results in high feed prices. There are still relatively few business firms in the area producing high-quality raw materials for local feed production. Lack of concern for the quality of the seeds also becomes another challenge. Seeds are a crucial component that affects cultivation. Diseases and parasites can be transmitted via contaminated seeds. Due to a lack of expertise in aquaculture, cultivators believe that they may simply cultivate without consideration for quality seeds (Zainol et al., 2016). Despite the contributions and opportunities of aquaculture in Indonesia, some challenges could negatively impact its productivity. The first barrier that aquatic farmers face is the high cost of feed. Most of the food utilized comes from other countries, which results in high feed prices. There are still relatively few business firms in the area producing high-quality raw materials for local feed production (Zainol et al: 2016). The second barrier is a lack of concern for the quality of the seeds utilized. Seeds are a crucial component that affects cultivation. Diseases and parasites can be transmitted via contaminated seeds (Zainol et al: 2016). Due to a lack of expertise in aquaculture, cultivators believe that they may simply cultivate without consideration for quality seeds. This is the third issue concerning the availability of skilled aquaculture personnel (Yue & Shen, 2022). The fourth barrier is a resource used between stakeholders' studies from Naegel (1994). Both (Lane et al., 2008) and Rosenthal et al. (1985) stated that there is a complex interaction between marine resources, ecosystems, and other resource users that caused potential disputes concerning the use of land and water resources, in which fish farmers must compete with other users.

6 CONCLUSION AND RECOMMENDATION

From the article, we can now that aquaculture is a complex industry. It consists of a lot of stakeholders with different interests and also aquaculture itself has a lot of different types. The development of aquaculture over the past 50 years has been driven by the application of new science and technology (Zainol et al., 2016). Several new technologies have the potential to transform the aquaculture industry and disrupt it at the same time (Rowan, 2023). Recirculating Aquaculture Systems (RAS) is one example of technology that can help mitigate resources and land conflict in aquaculture (Martins et al., 2010). Although the adoption of technologies has been slow, aquaculture businesses agreed that the application of new technologies can support sustainable and profitable aquaculture (Yue & Shen, 2022). Using digital technology, aquatic farmers can promote their products directly to consumers, eliminating the need for a long supply chain and lowering transaction costs (Rowan, 2023). Integrating aquaculture into agricultural production systems can help to maximize productivity and profitability while utilizing limited land. The People's Republic of China is one country that has effectively combined many various technologies, including aquaculture into agriculture technology. As a result, there is an opportunity to optimize production on limited land while also increasing revenue (Naegel, 1994) . Studies undertaken in Egypt reveal that basic agricultural technology results in low earnings. However, various technologies have been developed to boost aquaculture production in Egypt, which may provide a solution to issues such as energy consumption, fish seed quality, and water and land use conflicts (Soliman & Yacout, 2016).

7 LIMITATION AND FUTURE RESEARCH

A study by Xia et al. identified strategies that can be used to overcome obstacles in aquaculture and potentially disrupt aquaculture business models (Rowan, 2023). These strategies include alternative oils and proteins for fish food, recirculation aquaculture systems, vaccinations, genome editing, use of solar energy, technology for disease monitoring and mitigation, new marketing strategies, artificial intelligence, blockchain, and cyber security. According to Rosenthal et al. (1985) high technology will be employed to preserve water quality, which is critical in aquaculture systems. Water quality management is also expected to be low-cost to have no impact on feeding quality. It aims to optimize the health and hygiene of the farming environment. The major impacts of the current potentials are derived from (1) an optimal aquaculture environment, (2) disease mitigation, (3) genome editing for disease resistance, fast-growing crosses, and gender-appropriate output. Furthermore, aquaculture contributes significantly to environmental protection. The government plans to utilize aquaculture as a key approach to safeguard natural populations of endangered species due to the increasing number of threatened species. Aquaculture must prioritize the protection of species that have potential for commercial use. This highlights the significance of breeding aquarium fish within the aquaculture industry. Enhancing the aquaculture business requires collaboration and integration among stakeholders. Research through bibliometric analysis and SLR indicates the presence of substantial areas for improvement, as there is still a wide gap between studies. Areas for potential future research include the integration of supply chains and the development of a maturity model for assessing supply chain integration. In addition, there is a need to study the dynamics of stakeholder relationships and create frameworks for enhancing coordination and collaboration within the supply chain. Another area is to explore the benefits and challenges of diversifying supply chains to enhance resilience, as well as to investigate the potential for developing flexible and adaptive supply chain models. The analysis in this study is limited because we only utilized the SCOPUS database and had access to Emerald Publishing. In the future, we could consider incorporating articles from additional sources. Furthermore, this forms part of an initial study that requires further investigation.

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