# Blockchain Technology in Fisheries Industry: A Systematic Literature Review

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**Abstract.** This paper explores the potential of blockchain technology in enhancing the fisheries industry, focusing on traceability, sustainability, and economic efficiency. The fisheries sector plays a vital role in global food security but faces significant challenges, including illegal, unreported, and unregulated (IUU) fishing, overfishing, and inefficiencies in supply chain management. This systematic literature review synthesizes existing research on blockchain applications in fisheries, highlighting its capacity to improve transparency and accountability throughout the supply chain. Blockchain's immutable ledger and real-time data sharing can enhance traceability, allowing stakeholders to verify the origins of seafood products and ensure compliance with sustainability standards. Additionally, the technology can reduce transaction costs by eliminating intermediaries, thereby increasing profit margins for fishermen. Despite the numerous benefits, challenges such as integration with existing systems and the need for stakeholder collaboration must be addressed for successful implementation. This study contributes to the growing body of knowledge on blockchain in the fisheries sector and offers insights for policymakers and industry stakeholders seeking to leverage technology for sustainable practices.

## 1 Introduction

The global economy greatly relies on the fisheries industry, making significant contributions to food security, employment, and economic growth [1,2]. It plays a vital role in providing essential nutrients and addressing malnutrition and starvation challenges worldwide [3]. Particularly for developing countries and small island states, the sector supports livelihoods and serves as a social safety net . Nevertheless, inadequate management of many fisheries has led to overfishing and decreased yields [4]. Small-scale fisheries, which play a substantial part in global seafood production, are susceptible to market shocks and require strategies for diversification [5]. While aquaculture has expanded to meet growing demand, it faces sustainability challenges [6]. The COVID-19 pandemic has highlighted vulnerabilities and resilience patterns in the aquaculture supply chain [5].

The fisheries industry in Riau Islands Province has significant potential but faces challenges in optimizing its resources. The sector contributes to the region's economic growth and gross regional domestic product [6]. The challenges faced by the fisheries industry in Riau Islands Province are diverse, including coastal pollution, which poses a threat to the

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sustainability of capture fisheries resources [7]. The influx of foreign fishing vessels and disputes over territories in the South Natuna Sea present further complications [6]. The limited availability of internet and safety concerns impede traditional fishermen's adoption of modern technologies [8]. The province also grapples with geographical limitations, inadequate general allocation funds, and subpar education and health services [9]. Fisheries activities and production are significantly affected by climate change and extreme weather events [9]. Additionally, local fishermen face intense competition and resource conflicts due to their disadvantaged position compared to outsiders [9]. The deterioration of coastal and marine ecosystems, especially coral reefs and fish populations, worsens these challenges [9]. To enhance competitiveness, key focus areas include production, infrastructure, and science and technology [10].

The use of blockchain technology has the potential to effectively tackle issues within fisheries supply chains, particularly by improving transparency, traceability, and reducing fraudulent activities. Numerous research studies have emphasized its capacity to improve visibility from start to finish, combat illegal fishing, and ensure the authenticity of products [11–13]. Blockchain has the capability to offer real-time data at key stages throughout the supply chain, facilitating efficient traceability management [14]. Several solutions based on blockchain have been suggested and put into practice, such as Pacifical Atato, Project Provenance Limited, and IBM's Food Trust [15]. Nonetheless, there are still challenges in widespread implementation, including integration difficulties, limited resources, and the need for organizational preparedness [16]. Despite these obstacles, blockchain technology exhibits potential in establishing more sustainable, transparent, and responsible fisheries supply chains [17].

## 1.1 Problem Statement

### *1.1.1 Inability to verify the origin of seafood products*

Blockchain technology holds potential for verifying the source of seafood products and improving traceability in the supply chain. Numerous research studies have emphasized its ability to boost transparency, reduce fraud, and guarantee the safety of seafood in the industry [12,18,19]. By incorporating secure digital tags, IoT devices, and location data, blockchain can offer unchangeable, comprehensive visibility of seafood products from the moment they are caught until they reach the consumer [18,20]. This technology has the capability to address issues such as mislabeling, illegal fishing, and human rights violations in the seafood supply chain [19,20]. Nevertheless, there are obstacles to overcome, including the necessity for support from stakeholders, operational intricacies, and ensuring fair advantages for coastal communities and small-scale fishers [20,21]. Despite these challenges, blockchain is viewed as a promising tool for improving traceability, transparency, and confidence in the seafood industry [17,22] .

### *1.1.2 Illegal, unreported, and unregulated (IUU) fishing*

Blockchain technology has the potential to address illegal, unreported, and unregulated (IUU) fishing by improving transparency and traceability in fishery supply chains [23,24]. It can create an unchangeable record of transactions, reducing the risk of data manipulation and building trust among stakeholders [20]. By integrating with IoT and machine learning, blockchain allows for real-time monitoring of fish products from harvest to delivery [13,23]. Despite the potential benefits, challenges such as integration issues and limited resources hinder the widespread adoption of blockchain [16]. To fully harness its potential, blockchain initiatives should incorporate decentralized finance solutions, offer tangible incentives, and ensure fair benefits for coastal communities and artisanal fishers [13,20]. Governments and international cooperation are essential for supporting the adoption of blockchain to combat IUU fishing [25].

#### *1.1.3 Inefficient supply chain processes and limited access to real-time data*

Blockchain technology has the potential to address issues in supply chain management, such as inadequate processes and limited access to real-time data. It provides improved traceability, transparency, and security across the supply chain [26,27]. Through its distributed ledger technology, blockchain enables secure and tamper-proof record-keeping, facilitating real-time visibility and enhanced collaboration among stakeholders [28]. It can help in mitigating problems like information asymmetry, double marginalization, and product counterfeiting [29]. The technology also supports sustainable supply chain management practices and can be integrated with other emerging technologies such as AI and IoT [30,31]. However, there are challenges that need to be addressed, including scalability, regulatory uncertainties, and barriers to adoption [32]. Despite these challenges, blockchain offers a promising solution for creating more efficient, transparent, and secure supply chain ecosystems.

#### *1.1.4 Trust issues between suppliers, buyers, and regulators*

The potential of blockchain technology lies in its ability to improve trust in supply chain management through a secure and transparent system for recording and tracking transactions [33]. This technology can foster transparency, flexibility, and trust among supply chain participants, shifting the basis of trust from relationships to the system and understanding [34]. Blockchain enables quick trust-building between unfamiliar partners and can establish a foundation for mutually beneficial relationships [35]. Nonetheless, it does not eliminate the need for trust-building processes entirely [36]. The impact of this technology on trust is intricate, with some studies suggesting that it allows for a trustless system, while others anticipate the strengthening of trust between organizations [35]. Blockchain has the potential to significantly influence purchasing decisions and enhance trust in suppliers, but its implementation necessitates a willingness to share information openly [37].

### 2.1 Objectives

There are two objectives of this study. Our primary objectives is to analyze the potential of blockchain technology in improving fisheries activities, with a focus on traceability, sustainability, and economic efficiency. The secondary objectives are to explore blockchain's role in reducing illegal fishing, to assess how blockchain can enhance supply chain efficiency, to evaluate the impact of blockchain on building trust among stakeholders (producers, distributors, consumers, and regulators).

## 2 Literature Review

The concept of blockchain technology challenges traditional centralized systems by offering a decentralized approach to trust and governance [38,39]. This decentralized structure offers benefits such as improved traceability, transparency, and tamper-resistance in supply chains [40]. However, true decentralization faces challenges, including skewed mining power and scalability limitations [41]. The state remains necessary as a central coordination point in society [38]. Recent research has been focused on developing metrics such as censorship resistance, geographical diversity, and fairness to measure decentralization in blockchain systems [42,43]. Studies have found varying degrees of decentralization in both the infrastructure and organization of blockchain ventures [44]. In addition to cryptocurrencies, the potential applications of this technology extend to areas such as smart grids and internet infrastructure [45,46]. The technology's development prospects include integration with 5G, IoT, and future wireless networks, positioning blockchain as a disruptive and foundational technology with wide-ranging applications [47].

Current traceability systems in fisheries are evolving to address sustainability, food safety, and labor concerns. However, these systems face several limitations. Paper-based systems, common in developing countries, are associated with poor performance and limited computer applications. The existing methods have various drawbacks, including the inability to offer trustworthy information about the source of farmed specimens, the instability of the techniques, and the absence of historical records for the food. [48]. To address these issues, researchers suggest implementing digital traceability systems using technologies such as blockchain [49], RFID [50], Biotechnological tools [51], and PCR-DGGE [48]. However, implementing traceability systems faces technological, social, and economic barriers, particularly in small-scale fisheries [52]. Interoperability among traceability systems remains a significant challenge [53]. Consumer awareness and understanding of traceability are generally low, highlighting the need for improved communication [54]. Additionally, there are economic incentives for misreporting in tuna fisheries, emphasizing the importance of robust traceability systems [55].

Blockchain technology is increasingly being explored in fisheries supply chains to enhance traceability, transparency, and sustainability [13,16]. It offers potential solutions to combat illegal fishing, mislabeling, and lack of transparency [11,14]. Current applications focus primarily on traceability and storytelling, with limited use in payments or decentralized finance [13]. Several blockchain platforms, such as Pacifical Atato, Project Provenance Limited, and IBM's Food Trust, are being implemented in the fisheries sector [15]. However, challenges remain, including scalability issues and the need for interoperability between multiple blockchains [56]. To maximize blockchain's potential in fisheries, future projects should incorporate financing solutions, provide tangible incentives, and integrate IoT for improved data collection [13]. Ensuring equitable benefits for coastal communities and artisanal fishers is crucial for successful implementation [20].

## 3 Conceptual Framework

The conceptual framework can be explained in more detail through three key components: Inputs, the blockchain system, and outputs.

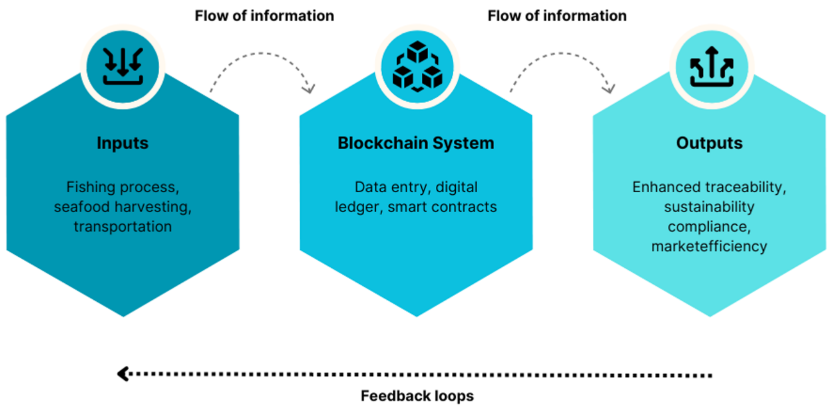


**Fig. 1.** Conceptual framework of blockchain in fisheries industry.

Inputs refers to the various processes involved in the fishing industry, such as the actual act of catching fish, managing and collecting seafood products, and the movement of the seafood from the point of harvest to various points along the supply chain. These activities often face challenges like illegal, unreported, and unregulated (IUU) fishing, a lack of transparency in product origin, and inefficiencies in transportation and record-keeping. These challenges create opportunities for blockchain to improve the process.

Blockchain serves as the core technological intervention in the framework, offering solutions through its unique properties such as tracking information of seafood caught, recording every transaction or change in the supply chain on a digital, decentralized ledger, which is secure and tamper-proof, and smart contracts that is self-executing where terms are enforced automatically once predefined conditions are met

Outputs referes to the expected outcomes of implementing blockchain in fisheries such as provides end-to-end traceability, enforce compliance with fishing quotas, sustainability standards, and environmental regulations by using smart contracts and tamper-proof records, and increases operational efficiency, builds trust between producers, distributors, and consumers by reducing intermediaries and streamlines the supply chain

Flow of Information refers to data flows from the fisheries activities (inputs) into the blockchain system, where it is securely recorded and processed. This data is then used to produce outputs such as traceable seafood products and compliance with sustainability standards.

Feedback Loops refers to the outputs that influence the inputs by creating more transparent and sustainable fishing practices. For instance, enhanced traceability can encourage more responsible harvesting methods.

## 4 Reseach Methodology

This paper only considered the challenges of blockchain in maritime industry, especially in fisheries industry. A Systematic Literature Review (SLR) is used to search, appraise, and synthesize evidence on a specific topic systematically. The process involves defining a

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research question, implementing a search strategy, collecting data, assessing quality, and synthesizing findings.

### 4.1 Systematic Literature Review Protocol

For a stadardized guidelines, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) protocol was used to choose the papers reviewed for this investigation. The PRISMA selection procedure is depicted in Figure 2.

#### *4.1.1 Eligibility Criteria*

- Papers published between January 2020 and October 2024
- The search source are from reputable database
- English language
- Only considered research article and open source
- Subject area covers (1) Business, Management, and Accounting, (2) Economics, Econometrics, and Finance, (3) Engineering
- Keywords used : (1) Blockchain in fisheries industry, (2) Blockchain AND IUU Fishing, (3) Blockchain in Maritime Industry
- Papers were assessed for inclusion or exclusion based on the content of the abstract, introduction, and conclusion. The selection of papers aimed to ensure that each taxonomy category included at least one, and ideally multiple, representative papers.

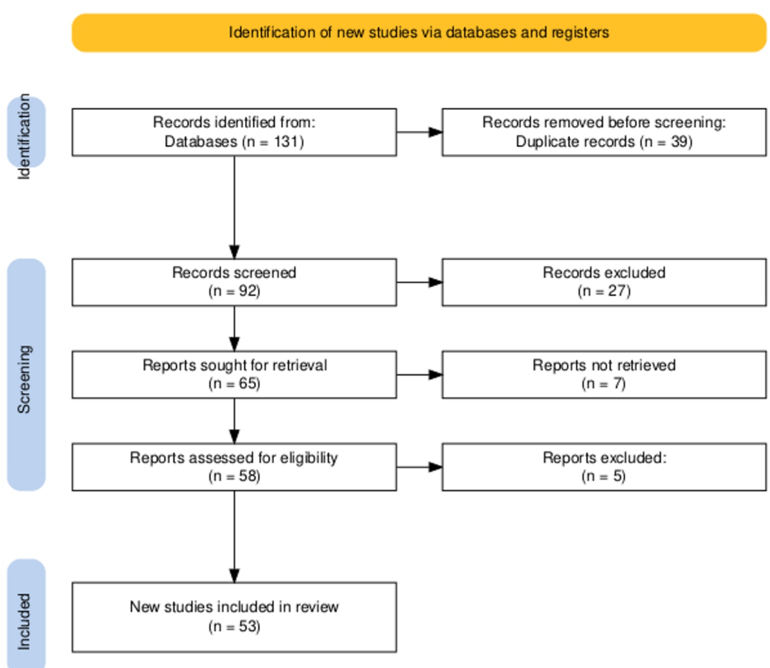


**Fig. 2.** The PRISMA selection procedures.

# 5 Results and Discussions

## 5.1 Traceability and Transparency

**Table 1.** Traceability and Transparency of Blockchain Accross Studies.

| Authors | Findings |
|---|---|
| Mohamed Ben Farah, Yussuf Ahmed, Haithem Mahmoud, Syed Attique Shah, M. Omar Al-kadri, Sandy Taramonli, Xavier Bellekens, Raouf Abozariba, Moad Idrissi, Adel Aneiba [57] | Traceability<br>1. Enhanced Cargo Tracking:<br>– Blockchain technology facilitates real-time tracking of cargo throughout the supply chain. Each transaction and movement of goods is recorded on an immutable ledger, ensuring that stakeholders can trace the path of shipments from origin to destination.<br>– This improved traceability helps verify the authenticity and provenance of goods, reducing risks related to fraud and counterfeit products.<br><br>2. Supply Chain Integrity:<br>– The ability to trace shipments accurately contributes to the overall integrity of the supply chain. Stakeholders can access detailed records of every transaction, enhancing their confidence in the information shared among parties involved.<br>– This traceability is particularly crucial in complex maritime operations, where multiple entities (such as customs agents, freight forwarders, and shipping companies) are involved in the logistics process.<br><br>3. Regulatory Compliance:<br>– Improved traceability through blockchain can help organizations comply with regulatory requirements that mandate tracking and reporting of goods. This compliance is vital for maintaining operational legitimacy and avoiding legal issues.<br><br>Transparency<br>1. Shared Access to Information:<br>– Blockchain creates a transparent environment where all participants in the supply chain have access to the same information. This shared view reduces information asymmetry and fosters collaboration among stakeholders.<br>– With every transaction recorded on a public or permissioned blockchain, stakeholders can see the history of goods, leading to increased accountability.<br><br>2. Reduction of Documentation Fraud:<br>– The transparency offered by blockchain minimizes the chances of documentation fraud, which is a significant issue in maritime operations. The immutable nature of blockchain ensures that once a record is created, it cannot be altered or deleted without consensus from the network.<br>– This transparency helps prevent discrepancies in shipping documents, such as bills of lading, and reduces the potential for disputes among parties involved in the supply chain.<br><br>3. Informed Decision-Making: |

<table>
<tr><td></td><td>– Access to transparent, real-time data allows stakeholders to make more informed decisions. Enhanced visibility into shipping operations enables better planning and responsiveness to changing conditions in the supply chain.<br>– The transparency provided by blockchain can lead to more efficient operations, as stakeholders can identify issues more quickly and take corrective actions when necessary.</td></tr>
<tr><td>Ebru Surucu-Balci, Çağatay Iris, Gökcay Balci [58]</td><td>Traceability<br>1. Enhancing Visibility:<br>– DIS platforms, equipped with Internet of Things (IoT) technologies and smart contracts, allow for real-time tracking of shipments, including the location and condition of cargo. This capability enhances supply chain visibility and credibility.<br><br>2. Data Integrity:<br>– The immutability feature of blockchain technology supports real-time tracking of goods, ensuring that the information shared among supply chain participants is accurate and tamper-proof. This leads to better management of the supply chain and helps in identifying discrepancies in data.<br><br>Transparency<br>1. Operational Transparency:<br>– The paper highlights that DIS platforms facilitate transparency in operational processes, such as transport routes and business transactions. This transparency is essential for efficient operational planning and helps minimize risks related to cargo damage or loss.<br><br>2. Data Sharing:<br>– The adoption of DIS platforms allows for extensive data sharing among supply chain members, ensuring that everyone has access to the same information regarding transactions and ownership transfers. This leads to improved collaboration and trust among stakeholders.<br><br>3. Enhanced Decision-Making:<br>– With increased transparency, stakeholders can make more informed decisions based on the readily available data, leading to improved operational efficiency and reduced risks.</td></tr>
<tr><td>Naif Alsharabi,<br>Jalel Ktari,<br>Tarek Frikha,<br>Abdulaziz Alayba,<br>Abdullah J. Alzahrani,<br>Amr jadi,<br>Habib Hamam [59]</td><td>Real-Time Tracking:<br>– Blockchain allows for real-time monitoring of fishery activities. Each time a fish is caught or processed, relevant data is logged onto the blockchain immediately. This ensures that all transactions are up-to-date and can be tracked throughout the supply chain, from capture to market.<br>Data Transparency :<br>– All stakeholders in the supply chain, including fishermen, processors, distributors, and consumers, can access the blockchain to verify the authenticity and origin of fish products. This transparency helps to build trust among participants and discourages illegal practices like unreported fishing.</td></tr>
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Blockchain technology improves traceability in the fisheries industry by creating an immutable, transparent, and decentralized record of every step in the supply chain. This ensures that stakeholders—from fishers to consumers—can trace seafood products back to their origins, confirming their legality, sustainability, and quality [51]. Blockchain provides a tamper-proof ledger where every transaction and event in the seafood supply chain is recorded. This can include information such as catch details (species, time, and location of the catch), processing data (handling, storage, and packaging information), transportation records (movement from processor to distributor or retailer) [49].

Blockchain enables real-time sharing of data across the entire supply chain, ensuring that all stakeholders (fishers, processors, regulators, and retailers) have access to the same updated information. For instance, fishers can upload catch data to the blockchain immediately after a catch, which is then verified by processors and regulators before the fish enters the market. This transparency reduces errors, inefficiencies, and delays in verifying the origin and handling of seafood [59].

## 5.2 Sustainability

**Table 2.** Sustainability of Blockchain Accross Studies.

| Authors | Findings |
|---|---|
| Naif Alsharabi, Jalel Ktari, Tarek Frikha, Abdulaziz Alayba, Abdullah J. Alzahrani, Amr jadi, Habib Hamam [59] | Biodiversity Conservation:<br>– The paper notes that sustainable fisheries management should promote biodiversity. By using advanced technologies to monitor fish populations and their habitats, stakeholders can make informed decisions that protect marine ecosystems.<br><br>Reducing Environmental Impact:<br>– The integration of AI and IoT with blockchain is presented as a means to minimize the environmental impact of fishing activities. For example, AI can optimize fishing routes to reduce fuel consumption and prevent overfishing in certain areas.<br><br>Smart Contracts for Sustainability:<br>– The use of smart contracts can automate processes that enhance sustainability, such as ensuring compliance with fishing quotas and facilitating fair compensation for fishermen who adhere to sustainable practices. |
| Mojtaba Enayati, Sudha Arlikatti, Maneesha Vinodini Ramesh [60] | Livelihood Resilience:<br>– The paper emphasizes the challenges faced by rural fishermen, including issues related to trust, transparency, and exploitation by intermediaries. It suggests that blockchain technology can improve the livelihoods of these fishermen by providing a more direct and transparent connection to markets, which can lead to better profit margins and enhanced livelihood resilience.<br><br>Innovative Framework:<br>– The authors propose a blockchain-enabled e-commerce framework specifically designed to address the unique challenges faced by fishermen in the coastal village of Alappad, Kerala. This framework aims to empower fishermen by reducing their dependence on middlemen, thus increasing their profitability and sustainability.<br><br>Community Empowerment: |

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| | – The integration of blockchain technology is presented as a way to empower the local community, particularly through the involvement of literate women who can assist fishermen in navigating the digital marketplace. This not only promotes gender equality but also enhances the overall resilience of the fishing community.<br><br>Reducing Exploitation:<br>– By eliminating the intermediary role of middlemen, the blockchain framework aims to ensure that fishermen receive fair prices for their catch, thereby reducing exploitation and promoting economic sustainability. |

Blockchain enables the tracking and verification of fishing practices, ensuring that fishers comply with sustainability standards and regulations, such as fishing quotas, legal fishing zones, and species conservation [61]. By recording each catch on a tamper-proof ledger, blockchain ensures that all fishing activities are transparent and traceable to their source [62]. This real-time recording helps monitor compliance with sustainability regulations and prevents illegal or overfishing activities from entering the supply chain. For example, fishers operating in protected marine areas can have their fishing activities monitored using GPS data recorded on blockchain. This ensures that only fish caught legally and within sustainable limits are brought to market. Overfishing is a significant threat to marine biodiversity, and blockchain helps address this issue by providing traceability and accountability throughout the fisheries supply chain [14]. Blockchain records can provide verifiable proof of where, when, and how fish were caught, making it difficult for illegally caught or overfished products to enter the market [14,63].

Blockchain supports sustainable supply chains by providing consumers, retailers, and regulators with detailed information about the environmental impact of seafood products. By ensuring transparency from the moment fish are caught to their arrival on the consumer's plate, blockchain allows consumers to make informed choices about sustainably sourced seafood. Companies can also use blockchain to certify that their supply chains adhere to environmental standards, building trust with eco-conscious consumers [64]. For example, smart contracts on blockchain can automate the verification of sustainable fishing certifications and enforce contractual obligations related to environmental regulations [65–67]. This reduces the risk of unsustainable practices being used in supply chains and ensures that all stakeholders follow agreed-upon sustainability measures.

Blockchain enables better inventory management and waste reduction in fisheries by providing real-time data on the movement and handling of seafood products [21]. This reduces spoilage and ensures that fish is transported and processed efficiently, minimizing the environmental impact of overproduction or improper handling. Furthermore, blockchain's ability to can reduce carbon footprints by cutting down on unnecessary transportation and delays [68].

### 5.3 Economic Efficiency

**Table 3.** Economic Efficiency of Blockchain Accross Studies.

| Authors | Findings |
|---|---|
| Mojtaba Enayati, Sudha Arlikatti, Maneesha Vinodini Ramesh [60] | Reducing Transaction Costs:<br>– The adoption of blockchain technology is expected to reduce transaction costs associated with fishing operations. By enabling direct interactions between fishermen and consumers, the framework minimizes the need for intermediaries (such as middlemen), who typically take a substantial cut of the profits. This reduction in intermediaries can lead to better profit margins for fishermen, enhancing their overall economic efficiency.<br><br>Streamlining Processes:<br>– The proposed blockchain-based e-commerce framework aims to streamline business processes by automating transactions through smart contracts. This automation can lead to faster transactions, reducing delays and inefficiencies that typically plague traditional fishing market transactions. For instance, payments can be processed immediately upon sale, improving cash flow for fishermen.<br><br>Improving Market Access:<br>– The framework is designed to enhance market access for fishermen, allowing them to reach a broader range of customers beyond their local markets. By leveraging blockchain, fishermen can showcase their products to consumers directly, potentially leading to increased sales and revenue. This expanded market access contributes to greater economic efficiency by aligning supply with demand more effectively. |
| Payam Hanafizadeh, Maryam Alipour [69] | Impact on Transaction Costs:<br>– The paper notes that blockchain technology can significantly reduce transaction costs associated with business processes. By providing a decentralized platform that eliminates intermediaries, blockchain facilitates direct transactions, thus lowering the costs of search, monitoring, bargaining, and enforcement.<br><br>Cost Structure Implications:<br>– It emphasizes that blockchain can positively or negatively affect firms' cost structures. The authors analyze various costs, including those related to verification, storage, and control of information, indicating that blockchain can lead to more efficient cost management in operations.<br><br>Operational Efficiency:<br>– The framework presented in the paper points to blockchain's ability to enhance operational capabilities, particularly through improvements in transparency, traceability, and visibility of operations. These enhancements contribute to greater efficiency in managing resources and processes.<br><br>Strategic Competitiveness:<br>– The paper suggests that the adoption of blockchain can improve strategic competencies and relational rents by facilitating collaboration among firms, enabling innovation, and ultimately enhancing overall economic efficiency. |

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| | Economic Application Areas:<br>– The authors categorize economic efficiency within the broader application areas of blockchain, analyzing how its adoption aligns with economic theories and frameworks. They discuss the implications of blockchain for resource allocation and how it can enhance competitive performance. |

Blockchain technology plays a vital role in enhancing economic efficiency in the fisheries industry by optimizing supply chains, cutting transaction costs, removing intermediaries, and fostering trust among stakeholders [69,70]. Accurate and timely transaction data facilitated by blockchain can optimize inventory management, leading to reduced waste and better resource utilization [54]. For instance, blockchain facilitates end-to-end visibility in fisheries supply chains, reducing the reliance on manual record-keeping and minimizing miscommunications among stakeholders. This, in turn, cuts operational costs and enhances overall efficiency.

In traditional fisheries supply chains, multiple intermediaries such as brokers, processors, and distributors drive up costs. Blockchain allows for direct peer-to-peer transactions between producers, retailers, and consumers, thereby reducing the need for intermediaries [15]. By eliminating middlemen, blockchain lowers transaction fees and commissions that would typically be incurred at each stage of the supply chain [71]. Furthermore, smart contracts, which are self-executing contracts on the blockchain, can automate payment processes based on predefined conditions, such as confirming the delivery of fish to a retailer [65–67]. This eradicates the need for third-party verification and reduces the administrative burden of processing payments, further cutting costs.

Significant economic losses due to fraud, such as seafood mislabeling or species substitution, can be prevented with blockchain, as it creates an immutable record of all transactions. Consumers and retailers can track each product back to its source, verifying its authenticity and legality. By reducing fraud, blockchain ensures that high-quality and legally sourced seafood products command a fair market price. Through automating processes like compliance checks, payment systems, and inventory tracking, blockchain reduces the need for human intervention in routine tasks, resulting in lower operational costs [64,72]. For instance, smart contracts on the blockchain can automatically enforce fishing quotas or regulatory standards, reducing the need for manual enforcement and minimizing the risk of fines due to non-compliance [73,74].

## 5.4 Blockchain and IUU Fishing

The global catch includes 20 percent from illegal, unreported and unregulated (IUU) fishing, and in certain regions, this percentage can reach up to 50 percent [75]. This sector frequently exploits bonded labor, engages in harmful fishing methods, and employs deceitful practices to generate income while negatively impacting local fisheries, coastal states, and the marine ecosystem [75]. Illegal, unreported, and unregulated (IUU) fishing is a significant global issue, with an estimated one-fifth of all wild-caught fish being illegal or unreported [25]. This equates to substantial economic losses, estimated between $10 billion and $23.5 billion annually [25].

**Table 4.** Blockchain and IUU Fishing Accross Studies.

| Authors | Findings |
|---|---|
| Tony Long, Sjarief Widjaja, Hassan Wirajuda and Stephanie Juwana [25] | Secure Documentation:<br>– The use of blockchain can facilitate secure and tamper-proof documentation of fishing licenses, catch certificates, and other relevant documents. This reduces the potential for fraudulent documentation, which is a common practice in IUU fishing.<br><br>Real-Time Monitoring:<br>– Blockchain can enable real-time monitoring of fishing activities, making it more challenging for IUU operators to hide their actions. By tracking the movement of fishing vessels and their catches, authorities can better enforce regulations and identify illegal activities.<br><br>Data Sharing and Collaboration:<br>– Blockchain fosters collaboration and data sharing among various stakeholders in the fishing industry, including governments, NGOs, and private companies. This collective approach can enhance enforcement efforts and improve the overall governance of fisheries.<br><br>Building Trust:<br>– The transparency provided by blockchain can help build trust among consumers, regulators, and fishermen. When consumers can verify the legality and sustainability of their seafood products, it encourages responsible sourcing and supports legitimate fishing operations.<br><br>Integration with Other Technologies:<br>– The paper suggests that blockchain can be integrated with other technologies, such as IoT devices and satellite monitoring systems, to provide a comprehensive solution for monitoring and managing fishing activities. |
| John Virdin, Tibor Vegh, Blake Ratcliff, Elizabeth Havice, Jack Daly, Jack Stuart [76] | Role of Technology:<br>– The paper highlights that advances in electronic information technology, including blockchain, are critical for providing the necessary information and infrastructure for traceability in seafood supply chains. This technology can facilitate better monitoring and reporting of fishing activities.<br><br>Transparency Initiatives:<br>– Various transparency initiatives in seafood supply chains have been introduced to combat IUU fishing, and blockchain is viewed as a promising tool to enhance these initiatives. By enabling secure and tamper-proof documentation, blockchain can ensure that information about fish catches is accurately recorded and accessible.<br><br>Comparative Lessons:<br>– The authors draw comparisons between transparency initiatives in seafood and other industries (like apparel, extractives, and timber) to inform seafood transparency efforts. They suggest that the lessons learned from these other sectors, including the integration of blockchain for improved traceability, could be beneficial in addressing IUU fishing. |

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| | Future Potential:<br>– The paper indicates that while there is potential for blockchain to enhance supply chain transparency and accountability, there remains a need for empirical studies to evaluate its effectiveness in combating IUU fishing. The focus should be on how blockchain can complement existing regulatory frameworks and enhance the overall sustainability of seafood supply chains. |

## 6 Conclusion

– The fisheries industry plays a critical role in ensuring global food security, fostering economic growth, and providing livelihoods, especially in developing nations. Nevertheless, it encounters major obstacles such as overfishing, pollution, and the impact of climate change.

– Challenges encompass the inability to authenticate the origins of seafood, illegal unreported and unregulated (IUU) fishing, inefficient processes in the supply chain, and a lack of trust among stakeholders (suppliers, buyers, and regulators).

– Traceability: Blockchain has the potential to enhance the traceability of seafood products, enabling stakeholders to authenticate the source and legitimacy of products. This transparency can minimize fraud and enhance food safety.

– Sustainability: Through providing real-time data and ensuring adherence to fishing regulations, blockchain can support sustainable fishing methods and the conservation of biodiversity.

– Economic Efficiency: Blockchain has the capability to reduce transaction costs by removing intermediaries, thereby boosting profit margins for fishermen and enhancing overall supply chain efficiency.

– Existing solutions such as IBM's Food Trust and other blockchain platforms showcase the potential for enhancing transparency and accountability in the fisheries supply chain.

– Despite its advantages, the widespread adoption of blockchain in fisheries encounters barriers such as integration issues, limited resources, and the necessity for organizational readiness. Collaboration among stakeholders is crucial for successful implementation.

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