

# Blockchain Application in Fishery Supply Chain

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## Abstract

With 1.07% of the country's overall GDP coming from fishing, the fishing industry has huge significance in India. The supply chain and overall exports to foreign nations will be improved by revolutionizing this sector of the economy. Consumers are nowadays very much concerned about their health and in knowing about the quality of the goods they purchase or consume, particularly when it comes to nutrition. Fish must be consumed within a certain time frame and under the right circumstances because it is a perishable food. The government officials must also keep an eye on illicit fishing, which is another serious problem that disrupts ecosystems in many different places. In other words, consumers, the government, and society in general demand transparency throughout the entire value chain of fish products. In this research, the use of blockchain using Ethereum-based smart contracts to trace fish packages back and forth throughout the entire fisheries value chain is explored.

**Keywords:** Blockchain, Ethereum, Supply chain, Smart contracts, Fishery.

## 1. Introduction

In India, the fishing industry provides a living for more than 28 million people, many of them are members of disadvantaged and at-risk populations. Fish production is projected to be 14.73 million metric tons in the fiscal years 2020–21. The value of the fishing industry's exports, according to the National Fisheries Development Board, is Rs 334.41 billion., 55% of

all catches of fishes are made about in fresh waters. Globally, most fish trade takes place between wealthy and developing countries. Most countries that produce fish have significant domestic markets as well as sizable populations that eat fish. Fishery supply systems are therefore typically complicated. A chain of independent fishers, agents, processors, distributors, wholesalers, retailers, and food services that cooperate to provide a consumer with fish or a product derived from fish is known as the fish supply chain. Within the fish supply chain, there is no independent organization or entity. They are related because one member's actions can have an impact on the whole supply chain as well as the livelihoods of fishermen who depend on fishing as their primary source of revenue. In addition to differences in socioeconomic, environmental, and cultural factors between various countries and regions, fish supply chains vary widely based on factors like fish species and products, harvesting techniques, and end users.

Blockchain is essentially just an unchangeable, distributed digital ledger of transactions that enables users to measure, record, and exchange value more efficiently. Blockchain is a technology that works to improve a system's trust and transparency by decentralizing the storage of all transactions. Consensus mechanisms, like Proof-of-Work, ensure network reliability, and data integrity. The correctness of the transactions may be checked by anybody using the system. [1]

Blockchain technology eliminates centralized intermediaries, saving time and reducing manual verification costs. With no third-party needed, transactions become faster and cheaper, thus increasing its efficiency. All entries are visible and permanent, fostering trust and reducing errors or fraud, and every step is documented, easily traceable, and tamper-proof, thus providing end-to-end transparency.

Beyond cryptocurrencies, blockchain finds applications in supply chain management, healthcare data recording, and voting systems, offering transparency, traceability, and enhanced security. The Economist rightfully refers to blockchain as "the trust machine," and it is frequently described as the "next development of the internet." [2]

## 1.1 Background

Even with ongoing changes and restrictions in the fishing supply chain, several issues still need to be resolved. The main obstacles to efficiency are challenges in obtaining supplies and assembling them from many manufacturing sites, a broad range in costs and arrival times and locations, a dearth of forecasting tools, a lack of roads and transportation infrastructure, etc.

Fish preservation and handling procedures are dependent on outdated cold storage technology due to structural inefficiencies in the way the supply chain is now divided into several roles. Other problems include indirect quality responsibility for fishermen, price gouging by suppliers, startling waste, and monetary losses for suppliers and distributors when flows of supply and demand for fresh fish are not coordinated.[3]

Roadblocks to traceability occur when accurate information about a fish's species, origin, or method of capture is not routinely provided as it moves through the supply chain, despite the fact that all parties in the chain agree that traceability is essential for ensuring sustainability, preventing fraud, and ensuring food safety. [4]

Blockchain is a technique for storing data that makes it difficult or impossible for the system as a whole to be altered, hacked, or otherwise interfered with. A distributed ledger known as a blockchain copies and distributes transactions among the network of computers involved in the blockchain. A blockchain supply chain can assist players in keeping track of pricing, time, location, area, quality, certification, and other pertinent information to manage the supply chain more efficiently. The availability of this data within blockchain could enhance visibility and compliance over outsourced contract production, lower losses from counterfeit and grey market products, increase the traceability of material supply chains, and potentially strengthen a company's reputation as a pioneer in ethical manufacturing.

## 1.2 Motivation

Increasing fish consumption and persisting supply chain problems have influenced the implementation of blockchain in the fishery supply chain. Besides, there are many concerns that need to be addressed and can be perfectly managed using the general properties of Blockchain. This integration helps address some of the given issues.

One of the main concerns of both the industry and the customer is security, which offers assurance that the fish they have purchased is the right kind. Most aquaculture businesses spend extensively on environmentally friendly farming since they can't afford to sell subpar goods.

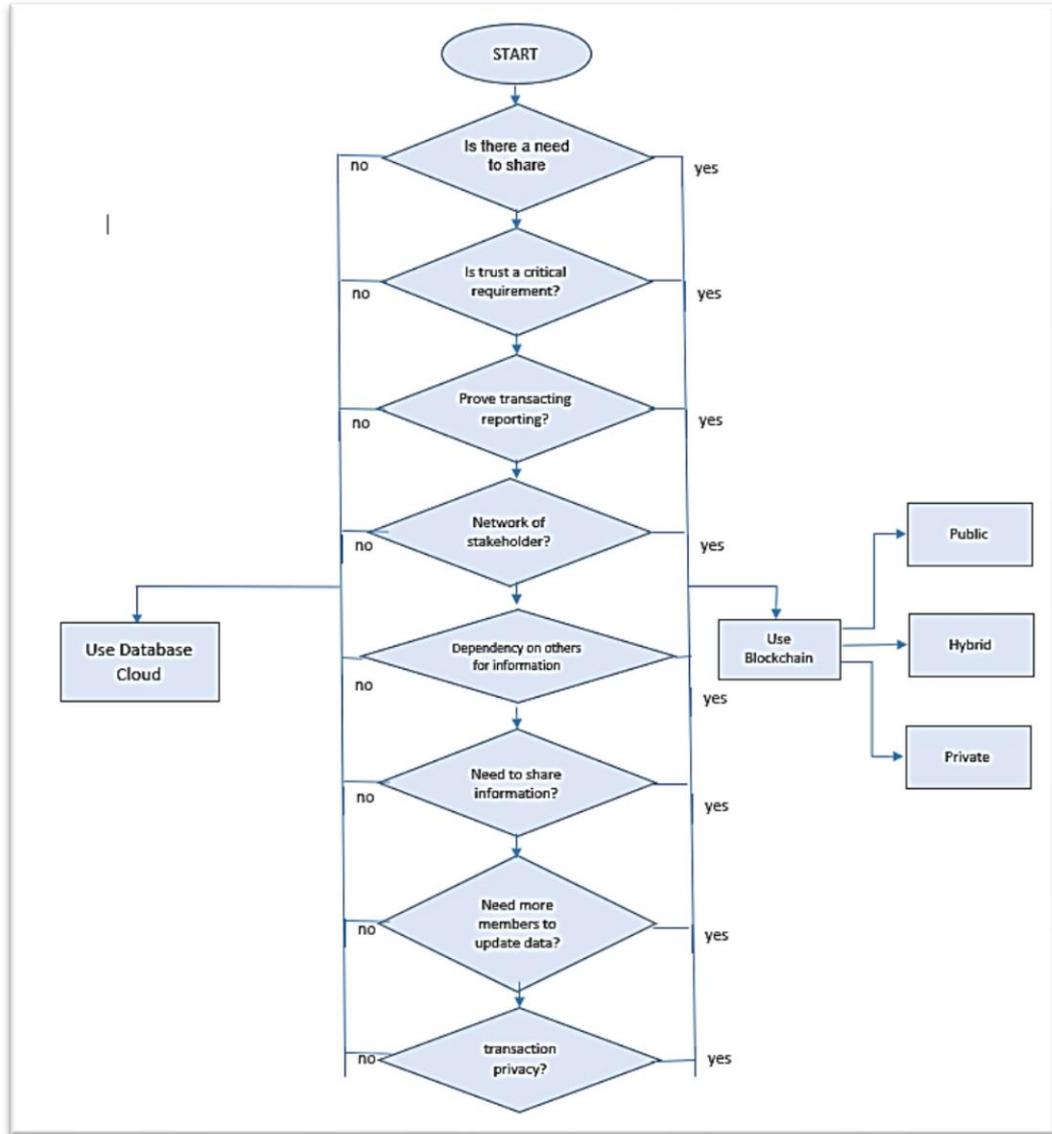
Large merchants and supermarket chains require documentation of the origin of the product (fish) due to high market demands.[5]

Traceability is the main factor in the supply chain, which both food retailers and consumers demand in order to get adequate information.

For regulating illegal fishing activities in banned or sensitive zones of the ecosystem, the authorities can keep a check on the source of fish, which can prevent the fish from continuing in the supply chain if it does not follow the prescribed regulations for catching and supplying.

The scope of addressing the above issues makes the implementation of blockchain in the fishery supply chain viable and hence a topic of exploration for further study.

Figure 1 shows different parameters considered to incorporate blockchain in the fishery supply chain.



**Figure 1.** Need for Blockchain Integration in Fishery Supply Chain

## 2. Objectives

- 1. Increasing Transparency in Fishery Supply Chain:** Traditional supply chains often lack transparency, making it challenging to trace the origin, journey, and conditions of products. Blockchain provides a transparent and immutable ledger, allowing real-time tracking and visibility into every step of the supply chain.

- 2. Reduce Inefficiencies and Delays:** Paper-based and manual processes in traditional supply chains can lead to inefficiencies, errors, and delays in the movement of goods. Blockchain's automation through smart contracts streamlines processes, reducing delays, errors, and operational costs.
- 3. Avoid Data Fragmentation and Inaccuracy:** Data in traditional supply chains is often stored in disparate systems, leading to fragmentation and the potential for inaccuracies. A decentralized and shared ledger in blockchain ensures that all participants have access to the same, accurate, and up-to-date information, reducing data discrepancies.
- 4. Enhance Traceability of Fish Products:** It can be challenging to trace the origin and journey of products in traditional supply chains, making it difficult to address issues like contamination or recalls promptly. Blockchain enables end-to-end traceability by recording each transaction on an immutable ledger, allowing quick identification and resolution of issues.
- 5. Minimizing Costs of Intermediaries:** The involvement of multiple intermediaries, such as banks and third-party service providers, can lead to high transaction costs. Blockchain's decentralized nature reduces reliance on intermediaries, cutting costs and streamlining transactions by enabling peer-to-peer interactions.
- 6. Build a Secure Supply Chain System:** Traditional supply chains are susceptible to fraud, counterfeiting, and unauthorized access due to centralized data storage and vulnerabilities. Blockchain's cryptographic techniques and decentralization enhance security, making it difficult for malicious actors to alter data or compromise the integrity of the supply chain.
- 7. Handling Compliance Challenges:** Ensuring compliance with regulations across a complex supply chain can be cumbersome and prone to mistakes. Smart contracts on the blockchain can automate compliance checks, ensuring adherence to regulations and reducing the risk of non-compliance.

The current supply chain faces challenges related to transparency, inefficiency, data accuracy, traceability, high costs, security, and compliance, which blockchain technology aims to address by providing a decentralized, transparent, and automated solution.[6]

### 3. Methodology

Implementing blockchain in fishery supply chain involves various interlinked steps. It starts with blockchain integration in initial supply chain, deciding on the consensus mechanism based on the application and use case, followed by ensuring the implementation of smart contracts and installation of IoT devices for real-time data capture.

**1. Define Requirements:** Identify the specific requirements for traceability, transparency, and automation in the fishery supply chain. Consider aspects like batch tracking, compliance checks, and data transparency.

**2. Choose Ethereum as the Blockchain Platform:** Select Ethereum as the blockchain platform due to its widespread adoption, smart contract functionality, and support for decentralized applications (DApps).

**3. Develop Smart Contracts:** Design Ethereum smart contracts to automate and enforce agreements within the fishery supply chain. Consider creating contracts for:

- **Batch Creation:** Smart contract to create a new batch of fish, assigning a unique identifier and capturing relevant details.
- **Ownership Transfer:** Smart contract to facilitate the transfer of ownership as fish move through the supply chain.
- **Compliance Checks:** Implement smart contracts to automate compliance checks based on predefined rules and regulations.

**4. Implement Unique Identifiers:** Assign unique identifiers or RFID tags to each batch of fish. Link these identifiers to the smart contracts to ensure a one-to-one mapping between physical batches and blockchain records.

**5. Connect IoT Devices:** Integrate IoT devices such as sensors on fishing vessels, storage facilities, and transport vehicles. These devices capture real-time data like temperature, location, and quality of the fish.

**6. Data Recording on Ethereum Blockchain:** Utilize Ethereum's decentralized ledger to record each transaction and data point. For example:

- **Batch Creation Transaction:** Records the creation of a new batch with details stored on the blockchain.
- **IoT Data Transactions:** Record real-time data updates from IoT devices, providing a comprehensive history of each batch's journey.

**7. Set Up Nodes:** Establish nodes within the fishery supply chain network. Nodes are participants that validate and store transactions on the Ethereum blockchain, enhancing decentralization.

**8. Define Consensus Mechanism:** Ethereum primarily uses a Proof-of-Stake (PoS) consensus mechanism. Understand the consensus model and its implications for validating transactions and maintaining the integrity of the blockchain.

**9. Integration with External Systems:** Integrate the blockchain solution with external systems used in the fishery supply chain, ensuring seamless communication and data exchange.

**10. Implementing Traceability:** Leverage the immutability of the Ethereum blockchain to ensure traceability. With every transaction recorded, stakeholders can trace the origin, conditions, and movements of each batch of fish throughout the supply chain.

**11. Testing and Deployment:** Thoroughly test the entire system, including smart contracts, IoT device integration, and data recording. Once validated, deploy the blockchain solution to the fishery supply chain.

**12. User Training and Adoption:** Provide training to users and stakeholders involved in the fishery supply chain on how to interact with the blockchain system, emphasizing the benefits of transparency and traceability.

This step-by-step implementation on the Ethereum blockchain focuses on the technical aspects of smart contract development, IoT integration, and ensuring traceability within the fishery supply chain.

#### 4. Process

The whole supply chain is divided into various steps, which are critical in any fishery supply chain. To track the status of fish in all the phases, we have to store all the details of the fish as well as the process in the form of a transaction in the blocks. This will be visible to each and every actor in the supply chain and will be immutable to avoid any tampering by any malicious actor in the process.

**1. Analysing Fishery Supply Chain Stages:** Different phases include Source tracking, transport, collection from primary production, logistics, and finally sales. Attributes of the fish to track in each phase include fish name, color, temperature, size, weight, nutrition value, etc. Moreover, different phases have their own defined attributes.

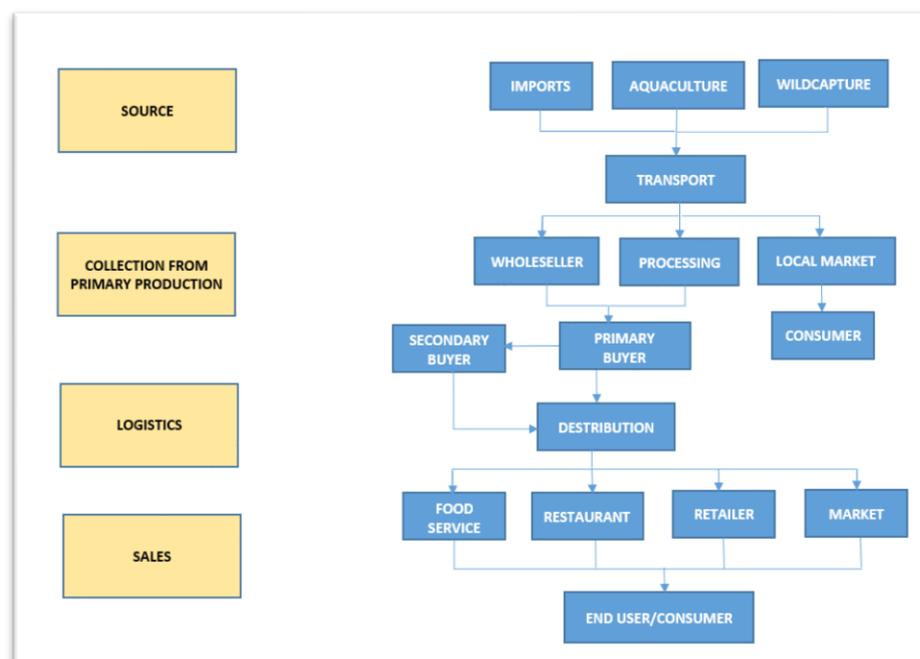
For source, imports include Country, Time, Date, Transport, Transport ID, Price, Quantity, etc. Aquaculture includes the name of aquaculture, country, state, or city, time or date of production, quantity, etc. Wild capture includes water body type (river, lake, or sea), fresh water or sea water, time of catching, name of fisherman, etc.

For collection from primary production, the wholesaler has attributes like lot number, quantity, wholesaler name, age, Agency name, address, phone, email, etc. Processing has process types (drying or salting), methods, machines, factory names, etc. Local markets include Buying price, location, vendor name, lot number, quantity, age, phone, email, etc.

Logistics will have all the mediator buyers with attributes like their name, contact information, email, purchase quantity, purchase type, buying price, date/time, place, etc.

Finally, it will be transferred to the local retailers for food service, Restaurants, and Markets. In restaurants, even the added ingredients and steps of the recipe can be tracked down for the end consumer. [7]

Figure 2 shows basic structure of fishery supply chain implemented in India.



**Figure 2.** Fishery supply Chain

## 2. Collecting and Processing Data in Fisheries Value Chain

**2.1. IoT Device Integration:** Deploy IoT devices on fishing vessels, storage facilities, and transport vehicles to capture real-time data. These devices may include sensors for temperature, location, quality monitoring, and other relevant parameters.

**2.2. Unique Identifiers and Blockchain Integration:** Assign unique identifiers or RFID tags to each batch of fish, linking them to the blockchain. This ensures a secure and traceable connection between physical batches and digital records.

**2.3. IoT Data Transactions:** Set up transactions within the smart contract to record real-time data from IoT devices. This includes continuous updates on temperature, location changes, and any other data points critical to the quality and traceability of the fish.

**3. Drafting Smart Contract:** Creating a complete smart contract for a fishery supply chain involves multiple functionalities and considerations, and the actual code would depend on specific requirements

Smart contracts can facilitate batch creation, ownership transfers, compliance checks, and other functions, enhancing efficiency and reducing manual errors. Below is a simplified

smart contract for tracking fish batches on the Ethereum blockchain. This example focuses on batch creation and ownership transfer as shown in the Figure .3 and 4. When a new batch is created, relevant data such as origin, species, quantity, and timestamp is recorded on the blockchain, ensuring an immutable and transparent ledger.[8]

```
Solidity
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract FisherySupplyChain {
    address public owner;
    struct FishBatch {
        uint256 batchId;
        address currentOwner;
        string origin;
        string species;
        uint256 quantity;
        uint256 timestamp;
    }
    mapping(uint256 => FishBatch) public fishBatches;
    uint256 public totalBatches;

    event BatchCreated(uint256 indexed batchId, string origin, string species,
        uint256 quantity, uint256 timestamp);

    event OwnershipTransferred(uint256 indexed batchId, address indexed
        previousOwner, address indexed newOwner, uint256 timestamp);
}
```

**Figure 3.** Batch Creation

This simple smart contract includes functions to create fish batches and transfer ownership. It uses events to emit information about batch creation and ownership transfers. Below is a basic example, and in a real-world scenario, we would likely need additional features, security measures, and compliance checks based on your specific requirements and industry standards.

```

function createFishBatch(string memory _origin, string memory _species,
uint256 _quantity) external onlyOwner {
    totalBatches++;
    FishBatch storage newBatch = fishBatches[totalBatches];
    newBatch.batchId = totalBatches;
    newBatch.currentOwner = msg.sender;
    newBatch.origin = _origin;
    newBatch.species = _species;
    newBatch.quantity = _quantity;
    newBatch.timestamp = block.timestamp;

    emit BatchCreated(totalBatches, _origin, _species, _quantity,
block.timestamp);
}

function transferOwnership(uint256 _batchId, address _newOwner)
external {
    FishBatch storage batch = fishBatches[_batchId];
    require(msg.sender == batch.currentOwner, "Only the current owner
can transfer ownership");
    batch.currentOwner = _newOwner;
}

```

**Figure 4.** Ownership Transfer

The blockchain can also be utilized as the payment mode for various transactions, which can be traced to avoid money laundering and malpractices in the business.[9]

**4. Blockchain Node Distribution:** Distribute nodes across the fisheries value chain network to ensure decentralization. Nodes validate and store transactions, enhancing data integrity and reducing the risk of a single point of failure.

**5. Data Verification and Consensus Mechanism:** Leverage Ethereum's consensus mechanism (Proof-of-Stake) to verify the validity of transactions. This ensures that only authentic and authorized data is added to the blockchain, enhancing the reliability of the collected data.

**6. Data Analytics and Reporting:** Integrate data analytics tools to process and analyze the collected data. This can include trend analysis, predictive modelling, and reporting features, providing valuable insights into the fisheries value chain.

By combining IoT devices, blockchain technology, and smart contracts, this approach aims to create a robust and reliable system for collecting and processing data throughout the fisheries value chain, ultimately improving traceability, transparency, and overall efficiency.

## 5. Advantages

Implementing blockchain in the fishery supply chain offers several advantages:

**1. Enhanced Traceability:** Blockchain enables end-to-end traceability, allowing stakeholders to track the origin, supplying, and distribution of fish batches. This transparency improves accountability and helps identify the source of any issues or discrepancies.

**2. Reduced Fraud and Counterfeiting:** The immutable nature of blockchain records makes it difficult for malicious actors to tamper with data. This significantly reduces the risk of fraud, counterfeiting, or misrepresentation of the fishery products.

**3. Improved Transparency:** Blockchain provides a decentralized and transparent ledger accessible to all authorized participants in the supply chain. This transparency builds trust among stakeholders and ensures that information is shared in a secure and verifiable manner.[10]

**4. Efficient Compliance Management:** Smart contracts on the blockchain can automate compliance checks, ensuring that fishery products adhere to industry regulations and standards. This reduces the risk of non-compliance and associated legal issues.

**5. Streamlined Transactions:** Blockchain facilitates secure and efficient transactions within the supply chain. Smart contracts automate processes such as ownership transfers, payments, and quality assessments, reducing paperwork, delays, and errors.

**6. Data Integrity and Security:** The decentralized and cryptographic nature of blockchain ensures the integrity and security of data. Once information is recorded on the blockchain, it cannot be altered, providing a tamper-resistant record of all transactions.

**7. Cost Reduction:** By eliminating intermediaries and streamlining processes, blockchain reduces transaction costs associated with traditional supply chains. This cost-

effectiveness is particularly relevant in global fisheries where multiple parties are involved in the supply chain.

**8. Real-time Monitoring with IoT Integration:** Integration with Internet of Things (IoT) devices, such as sensors, allows for real-time monitoring of environmental conditions, transportation, and product quality. This data enhances decision-making and ensures the freshness and safety of fishery products.

**9. Decentralization and Resilience:** The decentralized nature of blockchain mitigates the risk of a single point of failure. In the event of a system failure or cyber-attack, data remains accessible through distributed nodes, ensuring continuity in the supply chain.

**10. Consumer Confidence:** Increased transparency and traceability provided by blockchain instill confidence in consumers. They can access accurate and trustworthy information about the fish they purchase, fostering a positive reputation for the fishery industry.

**11. Sustainability Monitoring:** Blockchain can be used to record sustainable practices and certifications along the supply chain. This allows consumers to make environmentally conscious choices and supports the promotion of sustainable fishing practices.

Looking at the increasing advantages of implementing blockchain in fishery supply, many projects are being implemented globally. Some of them are:

**Food trust** is Hyperledger based project initiated by IBM, which serves Walmart, Nestle, Sustainable Shrimp Partnership (SSP), Unilever, etc and has huge share in sea food procurement.[11]

**Fish coin** is based on Stellar distributed ledger technology which provides traceability solution designed to encourage data exchange across the fishing supply chain.[12]

**Bumble Bee** is a complex blockchain service on SAP Cloud Platform that enables improved food safety and traceability. The first project focused on tracking yellowfin tuna products from fishing villages in Indonesia to production facilities in nearby port cities and ultimately to grocery stores in the United States.[13]

**Treum** is Ethereum based project that tracks assets and models supply chains for fishing firms in the South Asian countries.[14]

## 6. Conclusion

Supply chains built on blockchain technology are in high demand because consumers want to know the specific origin of their products and whether they were created ethically. It has the potential to solve difficulties with traditional supply networks especially the time taken in paper documentation. Additionally, it may be possible to track things from their manufacturing facility to the delivery destination, giving a more transparent and traceable supply chain. This is made possible by an organization's digitizing physical assets and maintaining a decentralized, unchangeable record of every transaction.

Even though the fish distribution business still faces many unresolved issues, several positive breakthroughs have been made that are projected to improve the country's fish distribution environment through blockchain integration. Better monitoring of fish perishability will lead to lower post-harvest losses and greater prices for the fishermen.

Blockchain still has room to be used for cryptocurrency (Ethereum)-based transactions that are paid for in order to improve monitoring and communication transparency. IoT implementation is required to improve scanning technologies, eliminate human labor, and increase precision.

Because it takes a lot of expertise to appreciate the benefits, blockchain adoption in the supply chain hasn't yet become widely accepted. Additionally, because blockchain technology is still in its infancy, it is governed by a variety of laws in developing countries, which would influence supply chains. Many issues have been resolved, and others will be resolved in the future for improved control of the Indian fisheries value chain.

Despite this, it's likely that present fisheries supply chain networks and practices may eventually be replaced by blockchain-based solutions.

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