

Traceability in India's Fisheries and Aquaculture: Concepts, practices and emerging pathways

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India's fisheries and aquaculture are entering a phase where market access is increasingly shaped by proof. For decades, competitiveness was largely associated with production growth, processing capacity and logistics. Today, however, both international buyers and domestic consumers are asking a more basic question: Can the origin, handling history and legality of a fish product be reliably verified when required? This shift is no longer limited to premium export destinations; it is also evident in India's expanding organized retail, cold-chain distribution and online seafood platforms, where consistent quality and safety assurances are becoming part of routine purchasing behaviour.

Globally, traceability has gained prominence as markets, regulators and consumers demand greater transparency in fish and aquaculture supply chains. Owing to high perishability, complex multi-stage marketing channels and diverse production systems, fish and aquaculture products are particularly sensitive to concerns related to quality, safety and authenticity. Issues such as species substitution, uncertain origin, improper handling and sustainability claims have reinforced the need for reliable traceability systems. Effective traceability strengthens trust among supply-chain actors and consumers, reduces public health risks and enables rapid, targeted recalls when contamination or non-compliance is detected. Consequently, in many international markets, traceability has become a prerequisite for meeting food-safety regulations and import requirements aimed at protecting consumer health and ensuring fair trade.

India, as one of the world's leading producers,

consumers and exporters of fish and seafood, is increasingly confronted with these expectations. Recurrent export rejections and recalls linked to antibiotic residues, concerns over disease outbreaks in aquaculture, growing scrutiny of fishing sustainability and rising domestic awareness of food safety have brought traceability to the forefront of fisheries discourse. Given the sector's critical role in livelihoods, employment and nutritional security, traceability has emerged as a key dimension of supply chain management and modernization. At the same time, rising domestic demand for safer, higher-quality fish products together with stringent compliance requirements in major export destinations highlights the need for coherent and inclusive traceability approaches that can serve India's diverse fisheries and aquaculture value chains. Against this backdrop, the present article outlines the basic concepts and operational logic of traceability in fisheries and aquaculture, with emphasis on its relevance to Indian conditions and emerging policy directions shaping fisheries governance, market access and sustainability.

Concept and scope of traceability in fisheries and aquaculture

Traceability in fisheries and aquaculture refers to the ability to systematically follow a fish or aquaculture product as it moves through defined stages of production, processing, and distribution. It enables access to information on the identity, origin, history and handling of a product, as well as its subsequent movement and destination within the supply chain. In

addition to this, traceability also provides details on the materials and ingredients incorporated at different stages of production and processing, thereby enabling verification of inputs used and their compliance with food safety and regulatory requirements.

stage of the supply chain. Equally important is the organization and secure storage of these data, so that information can be retrieved quickly and accurately when required. A unique identification code assigned

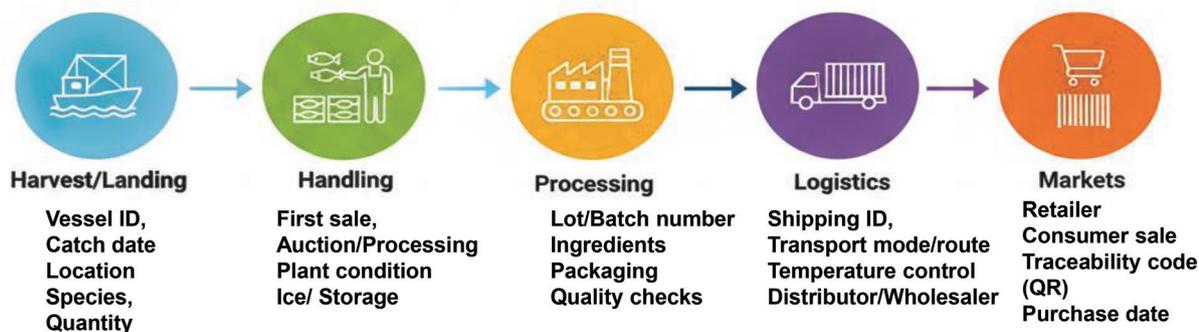


Fig. 1. Schematic representation of the key components of traceability in the capture fisheries supply chain

Traceability operates through two complementary processes: tracking, which follows the forward movement of a product from harvest or farm to markets and consumers, and tracing, which reconstructs the product's journey backward from the point of sale to its source (Fig. 1.). In the fisheries sector, traceability information is primarily used for food safety assurance, enabling operators and regulators to verify safe origin and to undertake timely withdrawal or recall actions when risks are identified. It also plays an important role in verifying the sustainability and legality of harvests, including compliance with conservation measures and catch certification requirements.

Operational logic of traceability systems

A functional traceability system is established through a disciplined operational logic that links the physical movement of fish or aquaculture products with reliable and verifiable records. The essential components include a unique product identity, continuity of information flow across supply chain nodes and proper record keeping and retrieval mechanisms when required.

A traceability system requires systematic recording of data related to inputs, production, batch separation, mixing or combination and outputs at each relevant

to each lot or batch is essential to maintain the link between the physical product and its associated records.

Input data: For all physical inputs, details such as the date of receipt, supplier identity, product description, quantity and batch or lot code must be systematically documented. In capture fisheries, primary input information generally relates to water and ice used during handling and storage, whereas in aquaculture systems, detailed records of seed, feed, medicines, and health interventions are required. Where processing is involved, input records must additionally include information on raw fish lots, ingredients, additives, and processing aids, ensuring that all components incorporated into the final product can be identified and traced back if necessary.

Production data: In capture fisheries, production data typically include vessel registration number, date of fishing, fishing location, gear used, and time of capture. In aquaculture systems, data relate to the location of production (pond or cage number), date of production, quantity and type of feed applied, and use of supplements or medicines. Where processing is involved, all processing steps must be recorded, including treatments applied, storage locations and conditions and quantities produced at each stage. Batch separation is essential to maintain traceability throughout production and processing and any mixing or combination of batches must be clearly documented.

All production, processing and batch mixing information should be linked to the original identification code to ensure continuity, traceability and retrievability of data across the supply chain. In marine capture fisheries, where fish may be derived from a large number of small-scale vessels and some degree of mixing is unavoidable, efforts should be made to preserve data integrity by limiting aggregation to a practical level, for example, by adopting landing centre-based identification and clearly labelling fish boxes or crates with appropriate traceability codes.

Output data: Output data must also be systematically recorded and linked to information collected in the earlier stages of the supply chain. Details of the receiver or customer, including identity and date of dispatch, should form an integral part of output data, ensuring that each outgoing consignment can be clearly linked to its corresponding batch or lot.

Data storage and retrieval: All traceability data generated across stages should be stored in an organised data retrieval system that allows rapid identification of both suppliers of inputs and receivers of outputs. At a minimum, the system should support “one-up, one-down” traceability, whereby each operator can identify from whom a product was received and to whom it was supplied. With advances in information technology and artificial intelligence-based tools, data storage and retrieval have become more efficient. However, records must be retained for appropriate durations depending on the shelf life, processing level, and regulatory requirements associated with the product.

Advanced traceability tools in fisheries and aquaculture: Advanced traceability systems increasingly rely on a combination of digital technologies to enable end-to-end visibility across fisheries and aquaculture value chains. A range of identification, location, and sensing technologies are commonly used to support traceability across fisheries supply chains. These include Radio Frequency Identification (RFID) systems, which use tags, readers, and scanners for data capture, along with barcodes and Quick Response (QR) codes for batch and product identification. Environmental monitoring tools such as time–temperature and humidity sensors are increasingly used to ensure cold-chain integrity. Location tracking is supported through Global Positioning Systems (GPS), while Near Field

Communication (NFC) and wireless sensor networks enable short-range data exchange and real-time monitoring. For data storage and management, digital platforms based on cloud infrastructure, blockchain, and standards such as Electronic Product Code Information Services (EPCIS) are being adopted to ensure secure, interoperable, and auditable records. Mobile applications, web-based services, and sensor-enabled Internet of Things (IoT) solutions facilitate data collection and exchange across different stages of the fisheries and aquaculture value chain. Tools such as blockchain-based ledgers can be used to securely record key transactions thereby reducing the risk of data tampering. In capture fisheries, GPS, vessel monitoring systems, and transponders facilitate spatial tracking of fishing activity and verification of compliance with fishing zones and regulations, while in aquaculture, geo-tagging and batch-wise digital documentation support farm registration and input traceability. QR codes act as simple yet powerful digital identifiers, linking physical products or batches to their traceability records and enabling access to information by regulators and consumers. More recently, artificial intelligence and machine-learning tools are being integrated to automate quality checks, detect mislabeling or anomalies, and improve logistics and decision-making, further strengthening the efficiency and credibility of traceability systems in the fisheries and aquaculture sector.

Importance of traceability for food safety, market access and sustainability

Fisheries and aquaculture value chains are inherently diverse and complex, involving multiple actors, products and marketing channels that link producers to both domestic and international consumers. Meeting the expectations of an increasingly discerning global and domestic consumer base therefore represents a significant challenge. Broadly, the importance of traceability in fisheries and aquaculture can be viewed in the following key dimensions, i.e., food safety and hygiene, market access and sustainable and responsible fishing and farming practices.

Traceability plays a critical role in strengthening both the forward and backward linkages of the supply chain. By enabling verification of product origin, compliance

with safety standards, and rapid action in the event of contamination or non-compliance, traceability directly addresses concerns related to food safety and hygiene. When safety issues such as contamination, residue violations, or quality failures occur, this enables rapid trace back to identify the source and track forward to locate affected products. This facilitates targeted withdrawal and precision recalls of specific lots or batches, rather than blanket removal of products from the market, thereby reducing economic losses and protecting the reputation of the sector. In addition, traceability contributes to improved process control, greater supply chain efficiency, and enhanced internal and external visibility across the value chain.

Adherence to internationally accepted standards is increasingly non-negotiable from a market access and buyer confidence perspective. In both domestic organized retail and international trade, buyers increasingly demand verifiable information on origin, handling, and compliance with food safety and sustainability standards. For Indian seafood exporters, compliance with global food safety management systems such as ISO 22000 and related certification schemes like FSSC 22000 is often a mandatory requirement for accessing major markets, including the European Union and the United States. Traceability underpins these standards by providing documented evidence and without these, certification and verification process becomes weak, exposing exporters to the risk of rejections, additional inspections or loss of market confidence.

A further dimension of traceability relates to sustainability and responsible fishing and farming practices. By linking products to documented harvesting or production activities, traceability supports verification of legality, adherence to conservation measures, and responsible resource use.

Global traceability practices and key stakeholders in the fisheries value chain

Globally, traceability systems in fisheries and aquaculture operates as coordinated information networks that link multiple stages of the value chain and a wide range of stakeholders. While the design and level of sophistication may vary across countries

and commodities, the core principle of reliable information flow across nodes of the supply chain remains the same. In many countries, traceability systems combine regulatory requirements, industry practices and technology enable data capture to achieve this objective.

Multiple stakeholders are involved across the value chain. At the production and harvest stage, the primary stakeholders are fishers, aquaculture farmers, and vessel or farm operators, who generate the first layer of traceability data. In marine capture fisheries, this stage often involves additional actors such as landing centre authorities and auctioneers, who play a critical role in aggregating catches and assigning lots. In aquaculture, hatcheries and input suppliers also form part of the upstream traceability ecosystem, as their records also influence the credibility of farm level data. The midstream segment of the value chain includes processors, cold storage operators, transporters and distributors. Globally, this stage is where traceability systems are often most rigorously implemented, as processing and export facilities are subject to formal audits and certification requirements. At the downstream end, wholesalers, retailers, exporters and food service operators are key stakeholders. Their role is to ensure that the traceability information is properly associated with the product until it reaches the consumer and can be retrieved when required. In many countries, retailers and large buyers act as strong drivers of traceability adoption by setting procurement conditions that require suppliers to demonstrate verifiable origin and handling practices. Consumers, although not direct data generators, increasingly influence traceability systems through demand for transparency and access to product information via labels and digital interfaces.

In addition, regulatory authorities, certification bodies, and research and extension institutions play a crucial enabling role in global traceability systems. Regulators establish minimum data requirements and compliance frameworks, certification agencies verify adherence to standards and research institutions contribute protocols, methodologies and capacity building. Effective traceability systems thus function as multistakeholder arrangements, where responsibility for data accuracy, continuity and use is shared across the fisheries and aquaculture value chain.

Traceability in India: Present status and policy direction

In India, traceability in the fisheries and aquaculture sector is presently at a transitional stage, evolving from fragmented and commodity-specific practices towards a more coordinated and digitally enabled approach. Recognizing the growing importance of traceability in the Indian capture fisheries and aquaculture sector, the Government of India has recently introduced the National Framework on Traceability in Fisheries and Aquaculture 2025. The framework responds to the urgent need for an integrated and unified digital traceability system that facilitates real-time tracking of product movement and transactions across the fisheries value chain. It aims to establish a national, IT-enabled traceability system covering both capture fisheries and aquaculture, ensuring product safety from catch/farm to fork and enabling continuity of food safety and quality assurance throughout the supply chain. The framework is envisaged as a transformative initiative benefiting a wide range of stakeholders, including small-scale fishers and farmers, processors, exporters, regulators, and consumers. Its objectives include strengthening regulatory compliance, accelerating certification and audit processes, enhancing product credibility, and promoting inclusive growth and sustainable resource management across the fisheries and aquaculture sector.

The traceability framework is structured around globally accepted traceability principles, particularly the concepts of Critical Tracking Events (CTEs) and Key Data Elements (KDEs). CTEs represent specific nodes in the supply chain where data must be captured to ensure traceability, while KDEs define the nature of information to be recorded at each stage. These concepts provide the operational backbone of the framework, ensuring that data capture is both systematic and relevant across diverse fisheries and aquaculture value chains.

Development of an IT-based traceability system is a core pillar of the framework and is proposed to be implemented through the National Fisheries Digital Platform (NFDP). The system is envisaged to leverage advanced digital technologies such as artificial intelligence and blockchain for risk

flagging, trend analysis, and creation of immutable traceability records. It proposes the use of digital tools including QR codes, GPS, IoT devices, cloud-based platforms, and blockchain protocols, and advocates a phased implementation strategy. Importantly, the framework emphasizes integration with existing digital systems such as the SHAPHARI certification by Marine Products Export Development Authority (MPEDA), digital vessel permits platforms, and related fisheries information systems to avoid duplication and ensure interoperability.

At the same time, the framework explicitly acknowledges key Indian challenges associated with traceability implementation. These include regulatory gaps and lack of data cohesion, multi-species fisheries and mixed marine landings, the dominance of a large number of small-scale fishers and fish farmers, variability in physical and cold-chain infrastructure, and the need for low-burden data capture mechanisms that do not exclude smallholders. The existing systems therefore require dedicated efforts towards standardization, interoperability, and integration with public digital infrastructure to make traceability workable at scale.

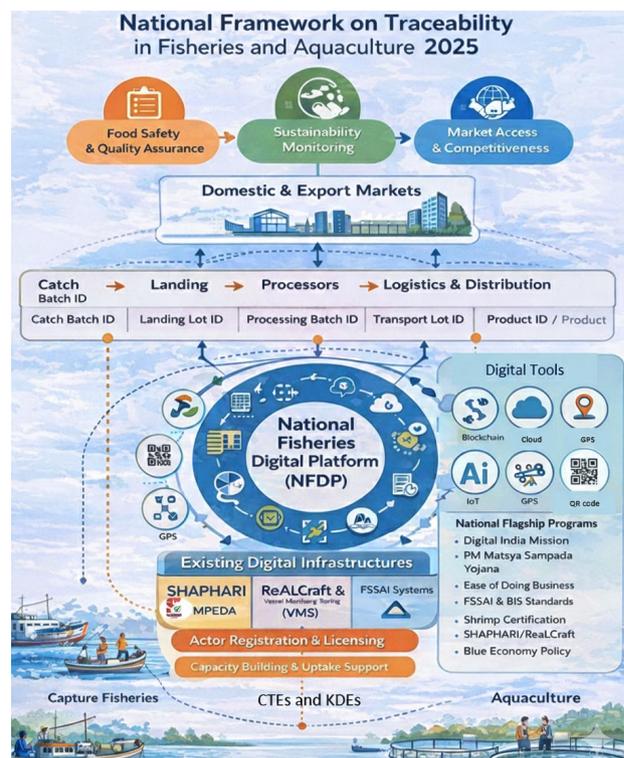


Fig. 2. National Traceability Framework for Fisheries and Aquaculture in India (2025)

The National Framework on Traceability in Fisheries and Aquaculture 2025 is strategically aligned with several national flagship programmes and policy initiatives, including the Pradhan Mantri Matsya Sampada Yojana (PMMSY), Digital India Mission, Ease of Doing Business, implementation of Food Safety and Standards Authority of India (FSSAI), Bureau of Indian Standards (BIS) standards, the Blue Economy policy, and existing shrimp certification schemes such as SHAPHARI implemented by MPEDA, along with Real Craft and Vessel Monitoring Systems (Fig.2). At the global level, the proposed traceability framework aligns India with international trade expectations and standards, positioning the country to meet evolving requirements of key export markets and international bodies. Successful implementation of the framework will, however, require active participation of stakeholders across fisheries and aquaculture value chains, supported by systematic registration and licensing, digital readiness, and sustained capacity-building efforts as a SWOT Analysis indicates (Fig. 3).

opportunities. Recent efforts towards digital governance in fisheries, including the proposal of a national traceability framework, reflect a broader recognition that transparent and reliable supply chains are central to sustainable fisheries management, biosecurity preparedness, and continued access to domestic and international markets. More importantly, traceability offers a practical pathway to ensure that claims related to quality, safety, and sustainability are supported by verifiable evidence, rather than assumption. By safeguarding livelihoods while strengthening the credibility of Indian fisheries and aquaculture in an increasingly demanding global marketplace. By strengthening confidence among regulators, buyers, and consumers alike, traceability has the potential to safeguard livelihoods, reduce avoidable risks, and enhance the credibility of Indian fisheries and aquaculture in an increasingly demanding and competitive global marketplace.

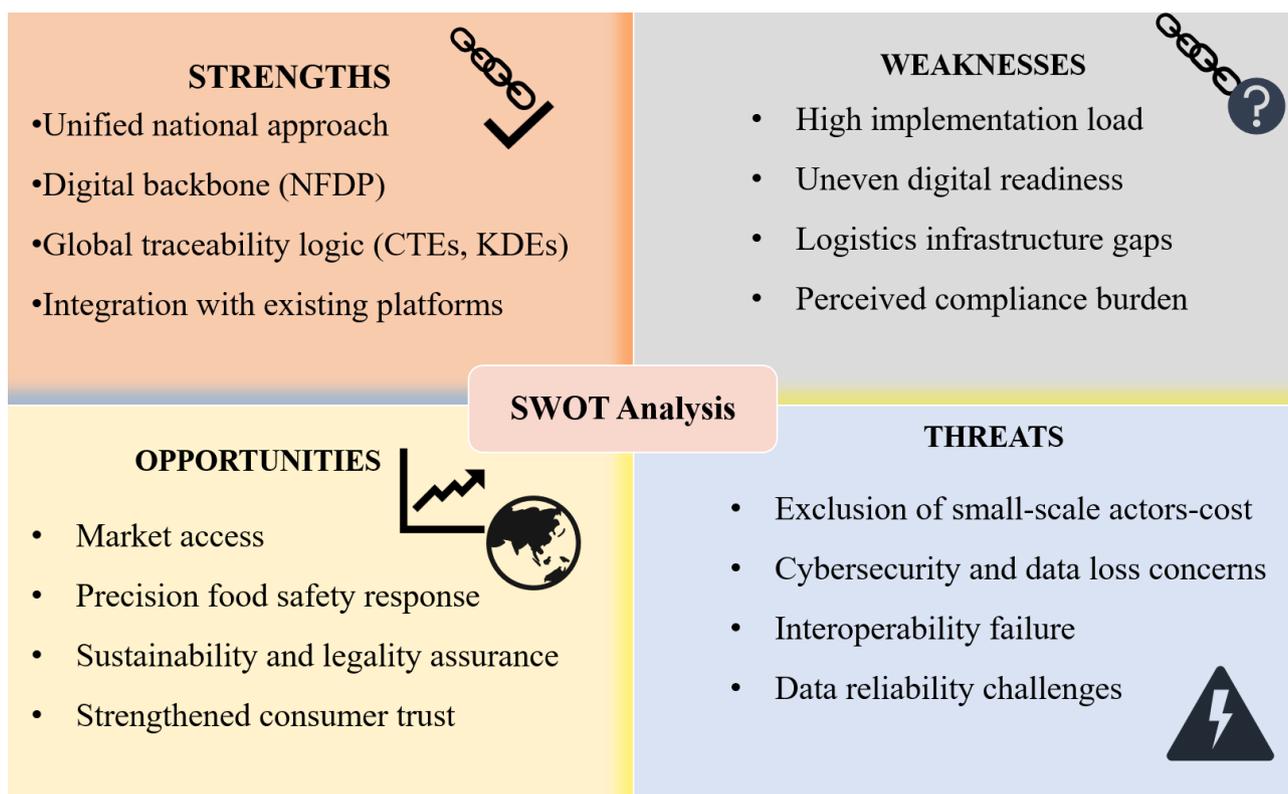


Fig. 3. SWOT Analysis of the Traceability initiative in Indian marine fisheries sector

Conclusion

For a country like India - with its diverse fisheries, large number of small-scale producers, mixed landings, and complex marketing channels - establishing effective traceability systems poses unique challenges as well as

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