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Adoption of Sustainable Production Process to Bring Forth Value Addition in the Indian Seafood Products

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Abstract

Value addition refers to enhancements made to a product before it reaches customers, altering its nature to command a higher price. Currently, the fishing sector grapples with economic challenges like market fluctuations, Illegal, Unreported, and Unregulated (IUU) fishing, and global access constraints. One issue is that fish processors often prioritize maximizing the value of primary products, neglecting potential gains from by-products. The Indian seafood industry faces sustainability, value addition, and market access challenges, particularly in utilizing by-products effectively due to insufficient investment in enhancing their value. This study examines the fish value chain involving fishermen, cooperatives, wholesalers, retailers, and processors. Qualitative analysis sheds light on industry practices, regulatory dynamics, and socio-cultural influences, enhancing resource management considerations. Integration of qualitative insights with quantitative data promises advancements in fishery science and management. Key findings highlight opportunities in value-added exports, seasonal variability impacts, and the critical role of food safety training. Wholesalers in India enjoy higher profit margins, while retailers could enhance profitability through cost reduction and increased sales. Retailers in India could enhance profitability through cost reduction and increased sales. Sustainable practices and efficient supply chains are imperative for the long-term sustainability of India's seafood sector.

Keywords: *Sea Food, Value Addition, Food Safety, Sustainability and Qualitative Analysis.*

Introduction

In the Global North and Global South, the development of seafood supply chains and product cycles has progressed at different rates. Generally, discussions regarding the role of seafood in the Global South concentrate on ensuring food security. Conversely, in the Global North, where sustainability issues are prioritized, discussions about seafood consumption emphasize the attainment of overall food security. The discussion of sustainable intensification has recently converged on this topic (Belton et al., 2020). For over 150,000 years, seafood has been essential to human survival and has significantly influenced the evolution of the species. As a valuable source of accessible minerals, vitamins, essential fatty acids, and animal protein, seafood's importance in food and nutrition security cannot be overstated. Many countries incorporate seafood into their diets; in fact, some Small Island Developing States obtain more than half of their animal protein intake from seafood (Farmery et al., 2022). The term "value addition" is frequently used in the fish processing sector due to its potential for earning foreign exchange. Furthermore, the fish processing industry, which now places a stronger emphasis on quality assurance, could enhance its profitability through value addition. The export of value-added fish products presents a favorable opportunity for India to increase its share in the international fish trade. Various fish products, including shrimp, lobster, squid, cuttlefish, bivalves, farmed fish, and affordable minced fish flesh, have been identified as valuable additions to both export and domestic markets, providing quality and diversity. The production technology for these products is readily accessible. The preparation of by-products involves repurposing waste fish and non-edible trash fish that have undergone value addition (Aditi and Varsha, 2020).

The aquaculture and capture fisheries sectors of the seafood industry collaborate to supply consumers with their preferred finfish and shellfish. In 2018, the total amount of seafood produced worldwide was 178.5 million tons (MT). The seafood from the sea includes finfish (mackerel, pollock, tuna, whiting, herring, and others), crustaceans such as crab, lobster, shrimp, and krill, bivalves including oysters, clams, mussels, and scallops, cephalopods such as cuttlefish and squid. Aquaculture expanded at an annual rate of 5.8%

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between 2001 and 2018, reaching a production of 95 million tonnes (MT) in 2022. The main components of freshwater aquaculture include shellfish species, tilapia, and carp, while mariculture commonly involves Atlantic salmon, sea bream, and sea bass. Approximately 78% of the crop is processed by the industry into a variety of goods, including frozen, smoked, chilled, dried, marinated, and fermented products, among others. To increase the availability of seafood for nutrition and health benefits, capture fisheries and aquaculture play complementary roles (Venugopal and Sasidharan, 2021). To protect the environment, most nations have enacted sensible laws and regulations. Aquaculture is often overseen by multiple authorities, primarily dealing with agriculture, water resources, coastal management, capture fisheries, and environmental protection. Although these complex regulatory frameworks are not always perfect, they reflect the country's legal understanding of environmental sustainability. Business owners and managers often interpret sustainability as their company's ability to succeed and persist over time, with predictability and profitability being fundamental to this approach. While most leaders understand that a healthy environment is necessary for effective operations, environmental health is not typically the primary motivation for enterprises. Demands for seafood produced with social and environmental responsibility in mind are increasing among seafood buyers and consumers. The search for and application of techniques intended to manage the environmental impact of aquaculture have become more conscious and improved as a result of these guiding requirements (Boyd et al., 2020).

Governments, organizations, and merchants need to explore alternative strategies if sustainability labeling fails to deter consumers from purchasing unsustainable seafood. Governments can impose regulations on seafood sales, while retailers may establish policies requiring them to sell only seafood bearing sustainable labels to diminish demand for unsustainable products (Mansoor et al., 2020). Public regulations restricting the sale of unsustainable seafood have not been extensively studied in previous research on sustainable seafood. Therefore, public attitudes towards laws regulating the sustainability of seafood sales remain largely unknown (Alfnes, 2017).

Seafood production and consumption have increased dramatically over the past century, with global averages exceeding 20.0 kg per person per year and surpassing 22.0 kg annually. This trend poses challenges to sustainable resource utilization, particularly for fisheries reliant on wild catches in many parts of the world. In addition to rising consumption levels, the concentration of seafood consumption around a few popular species in Western countries exacerbates issues related to sustainable fishing and aquaculture practices. The complex evolution of these developments is influenced by factors such as demand, supply, technological advancements, and economic efficiency. Sustainable progress necessitates recognition and consideration of the interconnectedness among these driving forces.

Furthermore, a stringent and comprehensive definition of sustainable seafood is introduced, applicable across various sectors including legislation, production, and consumption. This study focuses primarily on consumers' roles as significant stakeholders in marine resource utilization. Globally, consumers emerge as crucial agents of change. Consumer behaviour stands out as a primary driver of global resource exploitation. Despite increasing Western consumer awareness about sustainability and environmental conservation, significant behavioural shifts among customers remain uncommon (Richter and Klöckner, 2017).

The rest of this paper is divided into several sections. Section 2 provides a review of the literature, while Section 3 discusses the study methods. Section 4 explores the value chain of the fish industry in India, and Section 5 presents the results and discussion. Section 6 encapsulates the conclusions drawn from the findings presented in this paper.

Literature Review

Various techniques have been developed in the fisheries sector, with value-added products playing a crucial role in marketing. However, some concepts aimed at adding value encounter drawbacks affecting fisheries. Recent research in the fishing sector addresses these issues. Large amounts of by-products are generated by the fishing industry, often discarded or used in animal feed as cheap ingredients. (Al Khawli et al., 2019) introduced "Innovative Green Technologies of Intensification for Valorization of Seafood and their by-

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products," focusing on supercritical fluid extraction (SFE) and ultrasound-assisted extraction (UAE). These technologies aim to extract bioactive compounds from fish and shellfish by-products, enhancing their functional and nutritional properties. The extraction of bioactive compounds using UAE and SFE is effective, but they have drawbacks such as high power consumption, complexity, cost, and restrictions on compound range and scalability.

In order to overcome these limitations, (De Aguiar Saldanha Pinheiro et al., 2021) examined the recovery of proteins, lipids, and carotenoids during the processing of crustacean by-products. Supercritical fluid extraction (SFE) and high-pressure extraction (HPE) are two sophisticated techniques they utilize to separate bioactive compounds. While HPE reduces contaminants, SFE aims to restore substances like vitamins, antioxidants, and essential oils. SFE has some drawbacks, such as a small sample size, difficulties in condition optimization, and expensive equipment. According to (Venugopal, 2016), during fish processing, up to 50% of the raw materials—which include enzymes like lipases and proteases—are thrown away. The rapid putrefaction of fisheries waste presents environmental problems despite its promise. Because of their potential effects on the environment and consumer attractiveness, proper waste management and enzyme recovery procedures are difficult but necessary.

The social, economic, and local environmental implications were incorporated into fisheries management by (Ziegler et al., 2016), but the global environmental impacts are frequently ignored. Fish supply chains' effects on the environment are assessed using life cycle assessment (LCA) models, which show both the advantages and disadvantages of various implementation strategies, including higher implementation costs, stakeholder resistance, and environmental variability. Overall, even while the sustainability of fish production has improved, promises of "100% sustainable" goods sometimes oversimplify continuous efforts. Producers should prioritize highlighting ongoing improvement, educating customers about sustainability problems and accomplishments, and showcasing concrete steps toward resilience and health in the food system (Tlusty and Thorsen, 2017).

Method of Study

To create a fish value chain that is both efficient and sustainable, it is crucial to understand the roles and interactions of the actors. Value chain development begins with chain mapping, which involves identifying and understanding the distinct responsibilities of many parties in the chain, including merchants, seafood operators, input suppliers, and others. Traceability of product flow, from input to the final destination, is crucial for effective chain management. Input suppliers play a significant role by providing essential inputs, such as feed for aquaculture, to support seafood production. In order to make it easier for fishermen to sell their catch, fishermen's cooperatives serve as intermediaries between fishermen and traders. Shared resources and improved market access are further benefits provided by these cooperatives. For the fish value chain to be both sustainable and effective, it is essential to comprehend these functions and relationships.

Fish Value Chain

The value chain development process starts with chain mapping. In order to support for the recognized participants in the chain, the responsibilities they play and the information ad financial flows that occur inside the chain. The chain's map allows for the differentiation of product flow traceability from input to destination. Retailers, Input suppliers, fishermen's cooperatives, fish operators, wholesalers, end users, processors, and support providers are the main participants in this chain.

Input Suppliers

The input supplier for Indian seafood plays a major role in the industry. This industry plays a crucial role in supplying feed for aquaculture. Various service industries, such as retail trade, transportation, and wholesale trade, provide essential goods and services to support seafood production. These suppliers contribute significantly to the overall value chain, ensuring the success of the seafood industry in India.

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Fishermen

Those who work in the fishing sector can be either individuals or households. They utilize a range of fishing equipment and tools, relying on their own labor, as well as that of family members and hired laborers, for fish capture. Additionally, many fishermen participate collaboratively as members of cooperatives.

Cooperative Associations of Fishes

Fishermen associations, also known as fishermen cooperatives, serve as intermediaries between fishermen and traders, facilitating collective sale of their catch or other items in the fish market. These cooperatives are granted licenses by government agencies. They leverage shared assets such as refrigeration facilities and enhanced market access, which individual fishers cannot easily access, to promote further development.

Distributors

Wholesalers are independent retailers who distribute wholesale goods sourced from various landing locations. They possess knowledge of popular species in the market and track average daily catch trends at landing places. Additionally, wholesalers establish contractual agreements with fishermen's cooperatives.

Retailers

Retailers in the seafood market are small traders who contribute to market stability, typically operating from nearby or local areas. They are individuals or groups that purchase small quantities of fish products and sell them either directly to consumers or through small businesses (Kamaylo et al., 2021).

Processors

Freezing and chilling are the most reliable methods for preserving farmed fish, particularly in India. It maintains the optimal frozen storage conditions to ensure the quality and safety of the fish products (Syanya et al., 2023).

The Value Chain of Fish Industry in India

The entire sequence of steps involved in taking a product from conception to delivery to the end-user and disposal after use is known as the value chain. In the context of the Indian fish business, this encompasses the consecutive stages from catch to processing to retail sales or export, and ultimately to consumption. Due to substantial losses of raw material, the value chain does not progress linearly in relation to the fish wet weight. At each stage of the value chain, raw materials are discarded, resulting in significant resource wastage that could otherwise be utilized for human or animal food and other products. Figure 1 illustrates the value chain of the fish industry in India.

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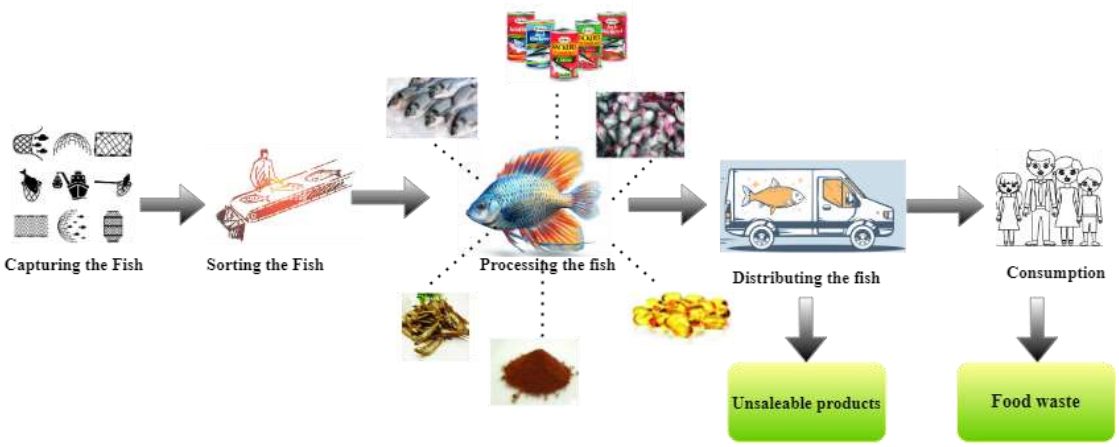

Figure 1. The Value Chain of the Fish Industry in India

Harvesting and Processing the Fish in India

The estimated marine fish landings in India for 2023 were 3.53 million tons, a 1.2% increase from 2021. Including the Andaman and Nicobar Islands, the total was 3.55 million tons. Gujarat led with 8.23 lakh tons (23.31% of total landings), followed by Kerala (6.33 lakh tons) and Karnataka (6.04 lakh tons). The top landed species were Indian mackerel (3.43 lakh tons), Ribbon fishes (2.70 lakh tons), and Oil sardine (2.45 lakh tons). Mechanized fishing crafts contributed 79% of the total landings, motorized crafts 20%, and non-motorized crafts 1% (CMFRI, 2023). Due to high tropical temperatures, fish degrade rapidly, accelerating bacterial activity, enzyme action, and chemical oxidation of fats. Immediate processing post-capture is crucial to maintain high quality for consumers. Value addition plays a critical role in the fish processing industry, facilitating foreign exchange earnings and enhancing profitability. Various value-added products such as shrimp, lobster, squid, and minced fish from lower-priced species are discussed. Waste materials from fish processing can be repurposed to produce valuable by-products like gelatin, insulin, fish albumin, fish protein concentrate, squalene, and fish oil.

Effective marketing strategies are essential for successful export and domestic sale of value-added fish products, encompassing packaging, advertising, and identifying viable markets (Aditi and Varsha, 2020). Hurdle Technology is employed for fish processing, utilizing a combination of preservation techniques to extend shelf life. This method integrates physical, chemical, and biological approaches, with common hurdles including temperature control, pH adjustment, reduction of water activity, and use of preservatives. Hurdle Technology helps preserve the sensory and nutritional quality of fish, ensuring products remain appealing and nutritious for consumers. Integration of multiple preservation techniques can be more cost-effective than relying on a single method, thereby reducing overall preservation costs (Tsironi et al., 2020).

Challenges Faced by Seafood Export Processing Industry

The seafood export processing industry in India faces several challenges. Some of the challenges are,

- To reduce foodborne illnesses, achieve the Sustainable Development Goals (SDGs), and expand into foreign markets, agro-food businesses must adhere to food safety standards (FSS). It may be challenging to follow FSS, but export success depends on it.

- Implementing FSS involves costs related to restructuring facilities, training, and certification. Uncertainties associated with standards can hinder adoption.

- Factors like budget constraints, organizational resistance, and environmental factors (such as lack of consumer demand) can hinder FSS implementation.

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- Despite benefits, some firms fail to get certified or discontinue after a point. FSS implementation affects export performance, but the dynamics are complex (Yadav et al., 2021).

Description of Area of Study

India, situated in South Asia, is formally referred to as the Republic of India. It ranks seventh in terms of area and has the highest population as of June 2023. Since obtaining independence in 1947, India has come to be acknowledged as the democracy with the largest population worldwide. Surrounding India are the Bay of Bengal to the southeast, the Arabian Sea to the southwest, and the Indian Ocean to the south. India ranks third in the world for fish production. Among the countries that create the most jobs in the marine fishing industry is India. Mariners perform a unique role as the principal source of livelihood for a segment of the population entrenched in tradition and skill, and they also help to boost the foreign exchange rate. A primary purpose of the Central Marine Fisheries Research Institute (ICAR-CMFRI) is to monitor and assess India's exploited marine fish resources. Furthermore, it will yield management strategies to maintain resource extraction at sustainable levels. In keeping with current practices, a two-stage stratified random sampling technique was employed to perform a nationwide sample survey in order to monitor the utilization of resources. This was made possible by the Fish Catch Survey and Analysis (FCSA) online data collection program. Indian marine fisheries have a significant role in employment, food, nutrition, and export revenues. Over 7,500 kilometers, India has a vast coastline and has abundant inland water resources. Millions of fishermen who engage in fishing, marketing, processing, and other related companies depend on these resources for their livelihoods. A major role for the Indian economy is fishing and aquaculture. They made up around 9.7% of the primary sector's Gross State Value Added (GSVA) in 2019–2020. Improvements in technology have completely transformed the marine fishing industry. Improved fishing systems, mechanized fishing, adoption of echo sounders, and GPS have enhanced efficiency over time.

Sampling and Size Determination

Multi-stage sampling was employed to create the sample of respondents. Initially, due to the large number of fishermen, India's territory was systematically partitioned. In the second stage, fishermen from each selected landing site were identified and categorized into different companies (such as Aqua Star, Benchmark Seafood, DailyFish India, India Fish Co, School of Fish Technologies Pvt Ltd, Silver Sea Food, etc.). At the third step, a random selection of fishermen's companies was conducted from each district. Following the application of the sampling methodology and the calculation of the proportion of fishermen's companies, a sample of 560 fishermen was ultimately chosen.

$$\mathrm{M} = \frac{m}{1 + m\,(N)^2}$$

$$= \frac{1000}{1+1000(0.09)^2} / 560$$

Where M = needed sample size (560), m = entire fishermen (1000), N = Level of precision (9%)

Furthermore, using the snowball sampling technique, interviews with 15 merchants, 11 processors, and 10 customers of the sampled respondents were conducted in order to address the scope of the study (Kamaylo et al., 2021).

Procedure for Gathering Data

To gather the data from the participants, both qualitative and quantitative approach were utilized. Data were gathered from various sources using these methodologies. Both data precision and dependability were taken into consideration prior to the creation of survey tools (checklists and questionnaires) and data collecting. Semi-structured questionnaires, KII (Key Informant Information), focus group choices, field observation, and literature studies are some of the used survey instruments.

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Data Collection

Some of the major questionnaires were posed to participants during the group discussions. They are:

- What is the nature of your establishment in India? (Q1)
- What is your annual turnover? (Q2)
- Does your establishment produce and export value-added seafood? (Q3)
- What kind of production processes do you engage in? (Q4)
- Describe the businesses related to fish and their functioning in the research region. (Q5)
- Explain how various parts of the organization interact. The group discussions also focused on identifying the variety of fish or fish product providers, purchasers, and transporters ?. (Q6)
- List and explain the individuals involved in each business component of the chain, along with the various fish species they handle, fish products, and value-adding techniques? (Q7)
- Explain the climatic differences among the various stakeholders and supply areas? (Q8)
- What is the seasonal and temporal analysis of fish supply inputs, patterns within different components, estimation of gender distribution among the population, and product flow within a specific component? (Q9)?

A Researcher Observation Checklist (ROC) was utilized to evaluate 50 fish farms, 10 fish markets, and 30 fish processing facilities to detect food safety problems such as structural issues and sanitary risks and potential hygiene. The food safety risk analysis handbook for national food safety authorities (2006) by the FAO/WHO was used to identify and analyze the hygiene and sanitary concerns in the research area.

- The structure was situated in an area free from pollution, well-ventilated, and with ample natural light.
- Access to clean water, reliable electricity, and an efficient cold chain system are essential for a sustainable and healthy environment.
- The washing area and designated trash bin are both available.
- Toilet facilities are available within the work environment.
- Staff members must wear personal protective gear (PPE) while on duty.
- Consumption patterns of food and drinks at the workplace are monitored.
- Domesticated animals are not allowed in the workspace.
- Mixing expired and fresh fish is prohibited.
- Fish dressing slabs should be cleaned frequently.
- Hands and fish must be washed after the evisceration process.

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Various techniques were employed to collect data, including flow charts, open-ended questions, and matrix scoring and ranking. Participants were tasked with creating flow charts to elucidate the diversity of fish types within the value chain, detailing aspects such as personnel involved, product types, supply sources, distribution pathways, and quantities. Decisions were made based on comprehensive evaluations of participant viewpoints, facilitated by matrix ranking and probing through open-ended questions. Interviews with key informants provided insights into proportional estimates, seasonal variations across different geographic areas, and gender distribution among participants, ranked on a scale from low (1) to high (3). Additionally, qualitative data were captured through audio recordings and detailed notes during focus groups and key informant interviews, following informed consent procedures explained during the research process.

Data Analysis

By cross-referencing notes with recordings and repeatedly listening to them, the data was compiled into a Word document. Thematic analysis of the audio data revealed patterns, sequences of specific activities, and interconnections among various components. Themes identified were used to develop templates that structured components such as processed fish species, types of suppliers, stakeholder interactions, geographical locations of suppliers, seasonal variations in the supply chain, and more. Flowcharts supported the data by illustrating these aspects.

To establish operational linkages between marketing systems and fish production, preliminary sequences were set up, including "artisanal suppliers," "local distributors from other states," "wholesale," and "fishermen" and retail marketers." Three tiers of the value chain's components were analyzed: profiling people, gender, and products; studying geographical flow patterns; and examining seasonal variations and annual production estimates. Flowcharts were utilized to visually represent different fish types, product varieties, individuals, and locations within each market and processing facility, as well as connections between various components and personnel. System maps derived from these flowcharts illustrated chain flows, characteristics of individuals and products within specific components, and available proportional estimates. In cases of conflicting information, the most reliable data was prioritized. To enhance diagram clarity, individuals like middlemen and transporters, who are part of the system but not directly involved in fish handling, were omitted from the charts but referenced in the outcome description (Grema et al., 2020).

Qualitative Analysis

In research aimed at enhancing the use of marine residual resources, qualitative evaluations present an intriguing option that can provide valuable information alongside quantitative data, offering a well-rounded perspective. By employing qualitative analysis, the fish industry in India can gain valuable insights into the underlying mechanisms of its current practices and the reasons behind the low degree of utilization, thus facilitating a better understanding of the industry's dynamics. Valuable insights on opportunities and challenges in implementing suitable technology and new practices can be obtained from qualitative research data. Fishery science and management development can advance significantly by combining quantitative research with the qualitative research-obtained experiential views of individual contributors in the fish business. Analyzing the fisheries of Australia and the islands that are part of it led to a deeper comprehension of the subject and revealed problems that were previously undiscovered and missed by more conventional study methods. Since regulations, realities, customs, attitudes, and values are all interconnected, the authors propose that qualitative research could improve resource management. In contrast to quantitative investigations, a qualitative method makes use of empirical data analysis to investigate and fully comprehend a given environment. A deductive process can also be used to explain how technology advances, moving from controlled tests in research settings to real-world observations in companies. Analogously, technology adoption can be seen as a logical step from the lab to real-world implementation in a variety of businesses. The qualitative analysis of information and data from the fish

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sector can help with successful technology research and development. Qualitative analytical data can be obtained from the fish industry using two methods: observational studies and in-depth interviews. These methodologies offer significant insights into the perspectives and practices of the sector. Ethnographic observational studies require the researcher to become a part of the daily activities associated with a specific case, actively participating either openly or covertly for a designated period of time. The researcher gathers all accessible information to shed light on the research subject, encompassing details of events, interactions, and responses to inquiries posed by the researcher. In-depth interviews utilize a semi-structured approach to gather data, aiming to facilitate an open and unrestricted dialogue with the interviewed. The discussion revolves around subjects chosen by the researcher, but the questions are not restricted to closed-ended formats commonly found in surveys. In-depth interviews serve as a valuable method for uncovering opinions, attitudes, and experiences held by participants. Qualitative analysis, regardless of the approach used, shows promise in generating knowledge that could aid in the development of a more sustainable consumption of fish raw material in India (Hjellnes et al., 2020).

Data Validation

The initial results were disseminated to professionals in the fields of fish farming and marketing, such as seasoned fishermen, fish transporters, fish farmers, traders, and academic and field fisheries specialists. Further data were gathered from group leaders and key informants to address any discrepancies or missing information. As a result, the data profiling and mapping were updated (Yadav et al., 2021).

Result and Discussion

There are four primary actors who are directly involved in the handling of fish in India's relatively simple fish value chains.

- Fish farmers: The group included fishermen and fish farmers who were identified as the suppliers of fish to various markets in India.

- Fish transporters: Actors within the value chain have the exclusive responsibility of transporting live (raw) fish from neighboring states to fish traders in India.

- Suppliers of raw seafood (raw-fish-wholesalers and -retailers): In this research, the term pertains to individuals who handle fish, selling them either alive or dead, as well as fish products that have not been processed for resale or direct consumption by customers. In India, raw-fish wholesalers and retailers procure their supplies from markets abroad and distribute them locally, either to fish processors or directly to household consumers.

- Processed-fish-sellers (retailers and processed-fish-wholesalers): Fish vendors who sell processed or preserved fish products are categorized as either processed-fish wholesalers or retailers, based on their clientele. Processed fish sellers primarily export seafood to various countries, with international trade being a significant aspect of their business. The domestic sales of processed seafood are relatively minimal compared to the volume of exports. Freezing is the main method used for processing fish, which helps in preserving the seafood for export purposes.

Establishment of India (Q1)

In order to improve fish productivity and production in the nation and to coordinate fishery development in an integrated and comprehensive manner, the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, established the National Fisheries Development Board (NFDB) in 2006 as an autonomous organization. In 2024, Andhra Pradesh is projected to be the leading

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state in India in terms of fish production, expected to exceed four million metric tons. Following Andhra Pradesh, West Bengal, Gujarat, and Kerala will rank in terms of production. Our company was established as a private limited company with a focus on fisheries. It promotes and develops fishing activities, both inland and marine, including activities beyond territorial seas. The company also engages in related activities such as institutional arrangements, infrastructure development, marketing, and exports, aimed at enhancing the well-being and livelihoods of fishermen and their communities.

Annual Turnover (Q2)

Between 2014–2015 and 2021–2022, the Indian fisheries sector grew at a consistent 8.61% annual average growth rate (at constant prices). In 2021–2022, inland fisheries produced 75% of fish production, while sea fisheries contributed the remaining 25%. Farming of fish is done in rivers, lakes, oceans, and ponds. The fish farming business is one of the most profitable businesses in India, as 60 percent of the Indian population prefers consuming fish and its products. The annual turnover of the private limited company in the fisheries department is Rs 100 crore to Rs 300 crore.

Establishment Producing and Exporting Value-Added Seafood (Q3)

The geographical distribution of seafood, both raw and processed, generated in each Indian region shows that 3.1% of the region's total raw fish production is sold to the fish processing sector, while 0.1% is sold to the region's raw fish-producing industry. 63.8% of the nation's raw fish supply goes toward non-seafood sectors, such as restaurants. 6.5% of sales are sent overseas, with 24.8% going to the region's end customers.

Each region that exports seafood gains value added from two distinct sources: (i) its own seafood exports, and (ii) the seafood exports of all other regions. This occurs when all regions create seafood exports. A measure of the economic gain from a region's exports is the regional value added that the region receives as a result of its exports. Nevertheless, since all regions produce and export value-added seafood and buy inputs from one another, regional value addition is only a partial indicator of the wealth that each region generates.

Kind of Production Process (Q4)

The final processing of fish products involves four main techniques: heating, freezing, controlling water activity with chemical additions or drying, and radiation. These methods, taken together, increase the fish's shelf life by impeding the processes of deterioration and spoiling.

Business Related to Fish and the Activities Conducted in the Study Area (Q5)

The segments of fish marketing and their roles in the value chains of fish in India include "Raw Fish Markets" (RFMs), "Local Fish Farms" (LFFs), and "Fish Processing Units" (FPUs).

- Some raw fish markets sold live and dead fish, most of which had been killed and gutted before being picked up by clients.
- The majority of traders were independent individuals with a variety of fish proportions, processing techniques, and buying habits.
- Fish and fish products were exchanged and marketed according to personal assessments of weight and quality, showing a noticeable absence of distinction among various fish varieties.
- Value addition to products was not widely practiced, and dealers and consumers tended to concentrate on unbranded basic materials.

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Crawford Market is one of the oldest and largest fish markets in India. It has a vast variety of fish, ranging from fresh to dried seafood in the study area. The products were mostly supplied from outside the study area. During high catch periods (particularly in rainy season) indicates that wild fish catch supply may be as high as around 150,000 kg per week due to catches characterized by huge sizes and body weights

Interactions Between Business Components, and the Group Discussions Were Focused About the Understanding the Diversity of Buyers, Suppliers and Transporters of Fish or Fish Product? (Q6)

In any business ecosystem, various components interact to create a cohesive whole. These components include suppliers, buyers, and transporters. Suppliers provide raw materials, goods, or services to businesses. For fish-related products, suppliers could be fishermen, fish farms, or seafood wholesalers. Buyers are the consumers or other businesses that purchase fish or fish products. These could be restaurants, grocery stores, or individual customers. When it comes to getting seafood from suppliers to customers, transporters are essential. They guarantee prompt delivery and preserve the condition of the goods while in transit.

Cultural Diversity Impact

- Communication Norms: The norms of communication vary throughout different cultures. Operations cannot function properly without effective communication between customers, sellers, and carriers.

- Decision-Making: Cultural nuances affect decision-making. Some cultures prefer consensus-based decisions, while others rely on individual authority.

- Hierarchical Structures: Different cultures have different views on authority and work ethics. Cooperation is facilitated by knowledge of these standards.

- Language: Accurate comprehension is ensured and misunderstandings are reduced through clear communication. For businesses to successfully cultivate connections with suppliers, buyers, and transporters, they must adjust to local cultural norms.

People Involved in Each Chain's Business Component, along with the Many Fish Species They Handle, Fish Products and Value-Adding Techniques (Q7)

The value chain of fish and fishery products involves a series of activities that create and build value. These activities span from fish production to consumption, and they play a crucial role in shaping the competitive strength of the business.

- Fishermen and Aquaculturists: Fishermen catch fish from the wild (wild-capture fisheries), while aquaculturists cultivate fish in controlled environments (aquaculture). They handle a variety of fish species, from familiar favorites like salmon and tuna to lesser-known species. Techniques such as proper handling, chilling, and preservation enhance the quality and value of the catch.

- Fish Processing Plants: These facilities process raw fish into various products. They may fillet, smoke, can, or freeze fish. Processing techniques transform raw fish into market-ready products, such as fillets, fish sticks, or canned fish.

- Wholesalers and Distributors: They transport processed fish products from processing plants to retailers or other intermediaries. Efficient distribution ensures timely delivery and maintains product quality.

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- Supermarkets, Fish Markets, and Restaurants: These are the points of sale where consumers purchase fish. Retailers offer a wide range of fish products, including fresh fillets, frozen fish, and ready-to-eat seafood dishes. Proper display, packaging, and marketing enhance the appeal of fish products.

- Consumers: Demand for fish products is based on their preferences, lifestyle, and culinary choices. Factors like convenience, year-round availability, nutritional content, safety, and environmental considerations influence their choices. Fish products are consumed within the country of production or traded globally. Export quality standards, certifications, and compliance with international regulations facilitate trade.

- Supply Chain Bottlenecks: These can occur at any stage due to inefficiencies, lack of infrastructure, or market fluctuations. Addressing these bottlenecks ensures a smoother flow of fish products from production to consumption.

Explain About the Climatic Difference Among the Various Stakeholders and the Supply Areas? (Q8)

Focus group discussions and key informant interview data were analyzed to create a geographic map that showed the primary places and routes that fish used to reach various markets. The market was reached by connecting several starting points and ending points as a single route along a comparable road network. The main destination areas as indicated by fish sellers, fish transporters, or intermediaries in every market were highlighted to illustrate the movement of items within the research area.

Fish Supply Inputs, Patterns Within the Various Components, Estimations of The Proportion of People by Gender and Product Movement Within a Certain Component Are All Seasonal and Temporal Factors? (Q9)

We carried out seasonal and proportional mappings by analyzing the contribution of fish suppliers to the principal markets during the rainy (June, July, August, September) and dry (January, February, March, April, May) seasons. The existing fish market data was converted to monthly units for comparative analysis. To plot and evaluate seasonally changes of trade volume, data from raw-fish-sellers was utilized. By analyzing the findings of the observation by the interviewer collected from the numerous value chain components, the hygienic and structural difficulties were found.

Demographic Summary

The Table 1 shows the average value addition for various fish products. The cost of Dried Fish production per piece is Rs.21.50, and the selling price per piece is Rs. 25.00. The profit per piece is Rs. 3.50, which translates to a profit margin of 16%. The cost of Salted Fish production per piece is Rs. 37.50, and the selling price per piece is Rs. 40.50. The profit per piece is Rs. 3.00, with a profit margin of 8%. The cost of production Fish Paste per piece is Rs.50.00, and the selling price per piece is Rs. 60.00. The profit per piece is Rs.10.00, resulting in a profit margin of 20%. The cost of Fish Pickle production per piece is Rs. 289.00, and the selling price per piece is Rs. 300.00. The profit per piece is Rs. 11.00, with a profit margin of 22%.The cost of Chilled Fish production per piece is Rs. 1,029.00, and the selling price per piece is Rs. 1,035.00. The profit per piece is Rs. 6.00, yielding a profit margin of 9%.The cost of Fermented Fish production per piece is Rs. 999.00, and the selling price per piece is Rs. 1,100.00. The profit per piece is Rs. 101.00, resulting in a profit margin of 10%.The cost of breaded seafood products production per piece is Rs. 700.00, and the selling price per piece is Rs. 800.00. The profit per piece is Rs. 100.00, with a profit margin of 14%.The cost of Fish Balls production per piece is Rs. 220.00, and the selling price per piece is Rs. 250.00. The profit per piece is Rs. 30.00, yielding a profit margin of 13%.The cost of Fish Sausage production per piece is Rs. 460.00, and the selling price per piece is Rs. 470.00. The profit per piece is Rs.

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10.00, resulting in a profit margin of 2%. The cost of Fish fingers production per piece is Rs. 45.00, and the selling price per piece is Rs. 50.00. The profit per piece is Rs. 5.00, with a profit margin of 11%.The cost of Fish Wafers production per piece is Rs. 80.00, and the selling price per piece is Rs. 90.00. The profit per piece is Rs. 10.00, yielding a profit margin of 12%. The cost of Fish cutlet production per piece is Rs. 100.00, and the selling price per piece is Rs. 110.00. The profit per piece is Rs. 10.00, resulting in a profit margin of 10%.The cost of Tray Pack Fish production per piece is Rs. 240.00, and the selling price per piece is Rs. 250.00. The profit per piece is Rs. 10.00, with a profit margin of 4%.The cost of Fish Powder production per piece is Rs. 25.00, and the selling price per piece is Rs. 35.00. The profit per piece is Rs. 10.00, yielding an impressive profit margin of 40%.The cost of Fish Soup production per piece is Rs. 530.00, and the selling price per piece is Rs. 550.00. The profit per piece is Rs. 20.00, resulting in a profit margin of 3%. The cost of Fish Oil production per piece is Rs. 400.00, and the selling price per piece is Rs. 450.00. The profit per piece is Rs. 50.00, with a profit margin of 13%.The table represent the profitability of different fish products, with varying levels of value addition. Some products, like fish powder, have significantly higher profit margins compared to others.

Table 1 Average value addition for fishes

The value addition of fishes	Cost of production / piece	Selling price / Piece	Profit / Piece	Profit in %
Dried fish	21.50	25.00	3.5	16%
Saltered fish	37.50	40.50	3	8%
Fish paste	50.00	60.00	10	20%
Fish pickle	289.00	300.00	11	22%
Chilled fish	1,029.00	1,035.00	6	9%
Fermented fish	999.00	1100.00	101	10%
Breaded seafood products	700.00	800.00	100	14%
Fish balls	220.00	250.00	30	13%
Fish Sausage	460.00	470.00	10	2%
Fish fingers	45.00	50.00	5	11%
Fish Wafers	80.00	90.00	10	12%
Fish Cutlet	100.00	110.00	10	10%
Tray pack fish	240.00	250.00	10	4%
Fish powder	25.00	35.00	10	40%
Fish soup	530.00	550.00	20	3%
Fish oil	400.00	450.00	50	13%

Table 2. Demographic And Socioeconomic Characteristics of Fishermen

Fishermen's age (Average)	Educational status				Fishing experience (In year)	Practicing time	
	No schooling	Only sign	Primary education	Secondary education		Any time	Sometimes
29 Years	10	15	560	535	3 years	75%	25%
30 Years	17	85	403	495	4 years	85%	10%
31 years	125	235	405	235	4 years	75%	25%
32 Years	123	215	329	333	4 years	85%	15%
33-35 Years	231	286	359	124	5 years	90%	10%
36-40 Years	301	215	215	269	10 years	90%	10%
41-45 Years	325	302	258	115	10 years	95%	5%

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This table 2 provides a comprehensive overview of the demographic and socioeconomic characteristics of fishermen, including their age, educational status, fishing experience, and time of practice. The average age of fishermen ranges from 29 to 45 years. The number of fishermen with no schooling ranges from 10 to 325 and who can only sign ranges from 15 to 302 also the number of fishermen with primary education ranges from 215 to 560 finally, with secondary education ranges from 115 to 535. The experience of fishing ranges from 3 to 10 years. The time of practice is divided into two categories: The percentage of fishermen who practice fishing at any time ranges from 75% to 95%. The percentage of fishermen who practice fishing sometimes ranges from 5% to 25%.

Table 3. Profit Share of the Actors

Actors	Average marketing production cost (Rs/kg)	Average total return per Kg (Rs/kg)	Profit (Rs/kg)
Fishermen	64.6	93.0	28.4
Fishermen cooperatives	84.2	89.2	4.0
Retailers	94.93	99.53	3.25
Processors	132	159.4	95.5
Wholesalers	-	345	165.2

Table 3 provides the profit share of different actors involved in the fish marketing chain. Fishermen's average marketing production cost is 64.6 Rs/kg and the average total return per kg is 93.0 Rs/kg. The Profit is 28.4 Rs/kg. The cooperatives of fishermen's average marketing production cost are 84.2 Rs/kg and the average total return per kg is 89.2 Rs/kg. The Profit is 4.0 Rs/kg. The Retailer's average marketing production cost is 94.93 Rs/kg and the average total return per kg is 99.53 Rs/kg. The Profit is 3.25 Rs/kg. Processor's average marketing production cost is 132 Rs/kg and the average total return per kg is 345 Rs/kg and the profit is 95.5 Rs/kg. Due to the high infrastructural investments and production cost the table shows that the wholesalers have the highest profit, while fishermen cooperatives and retailers have the lowest profit margins. For retailers, to improve their profit margins they have to focus on reducing the average marketing production cost, which is currently 94.93 Rs/kg. Also, it aims to increase the average total return per kg, which is currently 99.53 Rs/kg. Improve operational efficiency to minimize wastage and optimize resource utilization. To attract more customers and increase sales volume, fishermen must implement effective marketing strategies. Retailers can reduce their production costs through several techniques. Streamlining the supply chain can significantly reduce transportation and handling expenses, while buying in bulk allows retailers to take advantage of discounts and lower per-unit costs. Implementing efficient inventory management practices helps to minimize waste and overstocking. Additionally, leveraging technology to automate processes can improve operational efficiency. By adopting these strategies, fishermen and retailers can enhance their market appeal and profitability.

Table 4. Using Semi-Structured Questionnaires, Demographic Analysis and Operational Characteristics of Processed Fish Dealers in India (N = 40) Were Conducted

Variables	Description	No of respondents	In percentage
Gender	Men	25	62%
	Women	15	37%
Age	20-35	23	57%
	36-55	17	42%
Educational status	No education	12	30%
	Primary	13	32%
	Secondary	15	37%
	Territory	-	-
Formal food safety training	Yes	35	87%
	No	5	12%

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Years of business experience	1-5 yrs	27	37%
	More than 5 years	13	32%
Fish forms sold	Frozen fish	22	55%
	Chilled fish	12	30%
	Dried fish	6	15%

Based on Table 4, the demographic and operational characteristics of processed fish sellers in India are as follows: There were 25 male respondents and 15 female respondents. In the age group of 20-35 years, there were 23 respondents, while in the age group of 36-55 years, there were 17 respondents. Among them, 12 respondents had no formal education, 13 had primary education, and 13 had secondary education. 35 respondents had received formal food safety training, whereas 5 had not. In terms of business experience, 27 respondents had 1-5 years of experience, while 13 respondents had more than 5 years of experience. These factors play significant roles in influencing business strategies, market access, and operational decisions. Formal food safety training is particularly crucial as it enhances practices among fish sellers in India, improving awareness about hygiene, contamination risks, and safe handling practices including storage and sanitation procedures.

Conclusion

This article provides a comprehensive analysis of the Indian seafood industry, focusing on key areas such as value addition, sustainability, and market access. It highlights how enhancing value addition not only improves product quality and production but also boosts profitability across the sector. The discussion covers a range of value-added products derived from fishery resources, addressing challenges related to sustainability, market access, and regulatory frameworks. By integrating qualitative analysis with quantitative data, the study offers insights into industry practices, regulatory landscapes, cultural values, and consumer preferences. Emphasizing sustainable practices and efficient supply chains, the article underscores the industry's evolution in meeting changing consumer demands, including the growing preference for sustainably sourced seafood and its associated health benefits. The profitability analysis of various fish products reveals differing profit margins, with fish powder achieving the highest profit margin at 40% and fish sausage the lowest at 2%. Wholesalers in India typically enjoy higher profit margins, while retailers face challenges in cost reduction and sales enhancement. Ultimately, the article underscores the critical role of sustainable practices and streamlined supply chains in advancing India's seafood sector towards greater resilience and market competitiveness. Future work could focus on further enhancing sustainability measures and exploring innovative value addition techniques in the Indian seafood industry.

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