coasts

MDPI

Article

Mapping Social-Ecological-Oriented Dried Fish Value Chain: Evidence from Coastal Communities of Odisha and West Bengal in India

Sisir Kanta Pradhan [1,*], Prateep Kumar Nayak [1] and C. Emdad Haque [2]

[1] School of Environment, Enterprise and Development, Faculty of Environment, University of Waterloo, Waterloo, ON N2L 3G1, Canada
[2] Natural Resources Institute, University of Manitoba, Winnipeg, MB R3T 2N2, Canada
* Correspondence: sisir.pradhan@uwaterloo.ca

Abstract: The production and trade of dried fish are important sources of livelihood and employment for poor people engaged in the dried fish value chain. More importantly, half of them are women. Dried fish makes a significant contribution to the food and nutrition security of the poor because it is high in calcium and other vital micronutrients. Despite its importance, work on the dried fish value chain (DFVC) continues to focus on financial value creation and linear interactions among market actors that impede the recognition of human rights, justice, food security, and power across the entire value chain. Such a neoclassical perspective on DFVC tends to undermine the complex human-nature interactions that are contingent upon specific histories, people, places, and practices. Poor fishers and dried fish processors placed at the extractive end of the value chain hold low power in the market and remain vulnerable to changing social-ecological system dynamics. The recent work on a hybrid framework of social-ecological system-oriented dried fish value chain (SESDFVC) makes a departure from the conventional dried fish value chain framework. It values dynamic resource contexts, considers upstream actors as active collaborators, and expands the notion of value to include the social-ecological wellbeing of the value chain actors. This paper, with a mixed method research framework, provides an empirical outlook of the dried fish value chain in relation to SES attributes in the context of the eastern Indian coast of the Bay of Bengal, including Odisha and West Bengal, India.

Keywords: dried fish; value chain; social-ecological system; social-ecological wellbeing

Citation: Pradhan, S.K.; Nayak, P.K.; Haque, C.E. Mapping Social-Ecological-Oriented Dried Fish Value Chain: Evidence from Coastal Communities of Odisha and West Bengal in India. *Coasts* **2023**, *3*, 45–73. https://doi.org/10.3390/coasts3010004

Academic Editor: Erin J. Burge

Received: 20 November 2022
Revised: 5 February 2023
Accepted: 8 February 2023
Published: 20 February 2023

1. Introduction

Dried fish as a subsector of small-scale fisheries (SSF) has received little academic and policy attention despite its significant contributions to the nutritional and social wellbeing of the poor [1,2]. Dried fish is an important source of livelihood, income, and employment for millions of people engaged in fishing activities. More importantly, half of them are women. Drying fish is one of the oldest methods of fish processing [3]. The livelihood contribution of dried fish production and trade is immensely important for low-income consumers [1,4]. In maritime eastern Indian states like Odisha and West Bengal, the dried fish production is higher than all of India's average. While 6.32% of the total fish catch in Odisha is used for drying, the corresponding data for West Bengal is 6%. However, the share of dried fish in the marine fish catch is relatively high. For example, in Odisha, it is about 15% [5].

Current research on the dried fish value chain (DFVC) continues to focus on financial value creation and linear interactions among market actors. However, such an approach impedes the realization of human rights, justice, food security, and power distribution and sharing across the entire value chain. Such a neoclassical perspective on DFVC tends to undermine the complex human-nature interactions that are contingent upon specific histories, people, places, and practices [6]. It places the poor and vulnerable fishers and

small-scale processors at the extractive end of the value chain, marginalizing them in value chain decision-making. Globally, the low level of power holding in the market along with dwindling fish stocks is leading to growing concerns about the continued viability of SSF and dried fish communities.

The trade and technology focus in value chain interactions have changed the dynamics of SSF, with increased attention to aquaculture, commercial fishing, and frozen live fish marketing. In recent years, in India, there has been a sharp rise in the production of inland fisheries, with a cumulative annual growth rate (CAGR) of about 8.57%. Over the last decade, the production from marine fisheries has remained almost constant, with a marginal increase in CAGR of 1.53%. The share of the dried fish trade is 4.27%, with a negligible change of 2.6% in CAGR in the marine, brackish water, and inland sectors over the last decade. The CAGR of the frozen and live fish trades has grown by 9.66% and 4.56%, respectively, in terms of their volumes. Over the last decade, the export of the fisheries sector in India has been dominated by frozen fish, with a CAGR of 17.61% in terms of quantity and a CAGR of 16.26% in terms of value over the last decade. The corresponding figures for dried fish are 0.73% and −4.4%, respectively [5,7,8]. These figures reflect that the driving factor of the SSF value chain is to gain a competitive advantage in the global commodity market and readjust the production systems accordingly [9].

A social-ecological system-oriented dried fish value chain (SESDFVC) was recently proposed by Pradhan et al. [6]. The SESDFVC framework underpins multiple realities and links to our understanding of the social, cultural, and economic dynamics and implications of the value chain over time and space. It considers fisheries resources to be a critical node rather than an enabler of the inbound logistics function of the value chain. Such reconfiguration of value chain nodes helps elevate the role of upper segment actors(fishers and small dried fish processors) as active collaborators rather than passive contributors to the DFVC [6]. In light of the above backdrop, the primary objective of this study was to empirically test the social-ecological system-oriented dried fish value chain (SESDFVC) along the Bay of Bengal coasts of Odisha and the West Bengal states of India.

2. The Conceptual Foundation of SESDFVC

Value chain analysis is considered a progressive approach to explaining trade barriers for the poor. Such an analysis offers an understanding of multi-layered interactions and economic exchanges between actors in various market nodes and systematic competitiveness across scales [9,10]. A value chain is governed by a notion of circulation (i.e., exchange relations and the politics of buying and selling) among economic agents and the distribution of financial benefits across those agents in the chain [11]. Interdisciplinary scholars have contested such a neoclassical economic perspective that singularly considers natural resources as commodities [12–14]. In the case of dried fish, the interactions within the value chain and with resource systems are quite dynamic. The resource system refers to the ecological resource base that is comprised of multiple resource units and multitier users [15]. For this paper, we posit coastal fisheries as the resource system.

Fishing and fish processing practices are characterized by strong social norms, kinship, and other unique relationship networks with context specificities that are inherently varied [13]. It embodies multiple social and ecological processes, dynamics, and relationships [6,16,17]. The complex relationship in DFVC is manifested by the competing interests of economic agents operating in different value chain nodes. The price, convenience, and quality of a product are of particular interest to lower-end value chain actors, including traders, retailers, and consumers. Their concerns for environmental sustainability and the wellbeing of the fishing community are low. Further, the quest for high-value seafood products often causes social-ecological disruptions [4,6,18]. The upper-end value chain actors (fishers, small curers, and dried fish workers) are often challenged by factors like a lack of quality measures, improper market information, and a lack of power in the market [19,20]. The lack of trade investment in both fishing and fish processing is accentuating the problem of overfishing, loss of traditional jobs, and added value for the local popula-

tion [20]. There is documented evidence of the relationship between resources and resource communities and their connections with all subsystems at different scales and levels [21,22]. Sustainability science also recognizes the importance of interactions among resources and resource-dependent systems [23,24].

In contrast to the economic value chain analysis, SESDFVC helps to analyze value chain structure, conduct, and performance considering the concerns of fishers and small-scale dried fish processors at the upper segment of DFVC [6]. The value chain segment signifies the distribution of the actors based on their role in the chain. Two segments, viz., the upper segment (fishers, small processors, and dried fish workers), and the lower segment (larger processors, traders, wholesalers, and retailers), are relevant to the present study. The actors in the upper segment often have mixed identities, with overlapping roles as fishers, dried fish processors, and even the local traders. The SESDFVC recognizes the fishery resource system as a critical node in the value chain that has stronger cross-scale feedback across the chain actors [6]. If the fisheries system is not included as a key node in DFVC, it can lead to a skewed view that favors economic and market mechanisms and makes it difficult to consider "value" in ways other than money. The principle "if there is no fish, there is no dried fish" becomes a reality if the fishery ecosystem is placed outside the value chain nodes as an enabler for the provisioning of raw materials [14,17,25]. SESDFVC perceives the value chain structure, conduct, and performance in a two-way dynamic relationship. It includes the resource system and helps redefine value chain conduct with social-ecological systems attributes. The interplay between value chain structure and conduct helps in reimaging value chain performance as social-ecological wellbeing of upper segment actors which is beyond revenue gains across value chain nodes [6].

Analysis of SES attributes (Figure 1) such as feedback, linkages, uncertainties, and emergence with a clear understanding of subsystems and different parameters associated with these attributes offers a novel perspective that has stronger conformity to an inclusive value chain perspective [6]. An inclusive value chain approach calls for a balanced approach that takes equity issues into consideration without ignoring competitiveness. The desired outcome of such an approach typically manifests as higher earnings and participation of the vulnerable and poor in the value chain process [26].

The resource node is a dynamic entity as it determines essential value chain processes, including the price, product, livelihoods of resource-dependent communities, and regulatory frameworks [6]. The SES attributes of nonlinear feedback, dynamic linkages, uncertainties, and emergence provide a comprehensive understanding of both horizontal and vertical interactions across value chain nodes. The dynamic interplay of SES attributes, variables, and their expressions vis-a-vis the structure, conduct, and performance indicators in the DFVC offers a strong departure from the conventional value chain perspective. Examination of the human and natural system feedback in dried fish operations using variables like intensification, diversification, and social interactions is needed here. These variables offer a nuanced understanding of primary and secondary feedback loops often observed in small-scale fisheries value chains [6,14,27–31]. The linkages are understood by analyzing the dynamic interplay of rules, resources, relationships, and roles of value chain actors that determine processes of collaboration and competition for the production, distribution, and consumption of goods and services. An understanding of the ecological product value chain is incomplete without considering aspects of uncertainties in terms of random fluctuations, surprises by nature, and structural uncertainties emanating from governance and environmental factors.

The SES-oriented dried fish systems are understood by analyzing the variables, including demand variability, supply variability, and process uncertainties. Uncertainties are seen as an inherent system attribute of the value chain [32], which creates the opportunity for innovation and new equilibrium. It offers a different management possibility than the typical risk management framework which deals with efficiency parameters like base stock policy, inventory management, and forging collaborations [6,33]. In complex systems like DFVC, continuous human-nature interactions result in new emergences. Emergence is un-

derstood as the advent of novel properties that cannot be anticipated from the knowledge of the parts of the systems alone [34,35]. Emergence is critical for value chain analysis to make it adaptive, resilient, and have a competitive advantage in terms of being culturally, ecologically, and socially relevant. All these variables not only influence the vertical interactions in the value stream but also help in building a nuanced understanding of horizontal interactions in each node of the value stream.

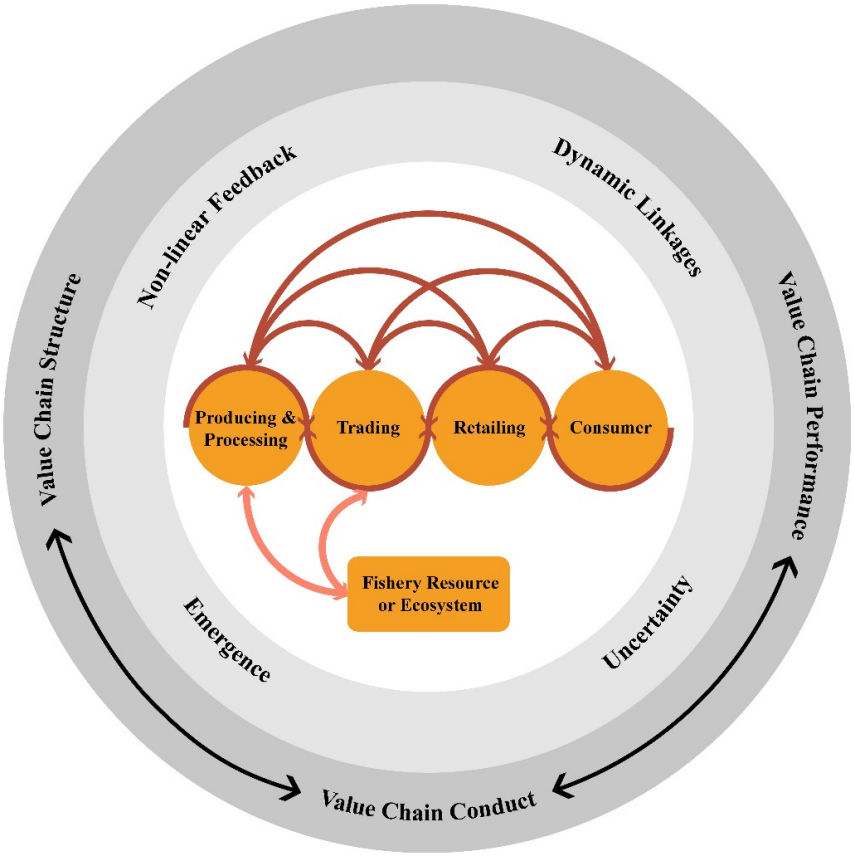

Figure 1. Social-ecological systems oriented dried fish value chain (SESDFVC) conceptual framework. Source: Pradhan et al., 2022: p. 8 [6].

3. Research Methods and Study Locations

We employ a mixed methods approach with a complementary research design that combines a systematic scoping literature review and field studies. We used a systematic scoping literature review instead of a full-scale systematic review due to the dearth of academic literature on the dried fish value chain. A scoping review allows for mapping the essential concepts underpinning a study topic as well as the main source and categories of data available [36,37]. The search was guided by two broad considerations that include (a) SES attributes of value chains (dried fish, food value chains), and (b) wellbeing perspectives of fishers and small-scale dried fish processors. A total of 72 peer-reviewed papers were assessed along with other relevant literature and applied sources of information.

Field research was implemented through a case study approach, which provides the scope for a comprehensive, holistic, and in-depth investigation of a complex phenomenon within its context, having a stronger participants' perspective [36–39]. The case study approach helped to examine the "real world setting" of DFVC on the eastern coast of the Bay of Bengal, India, where the boundary between issues, actors, and contexts is relatively unclear [39]. Further, the case study research approach was helpful in accommodating both qualitative and quantitative methods and could provide better insights into the how and why questions of the research [37–39].

Considering the emerging constraints of the COVID-19 pandemic, the case study sites were strategically decided by having had strong interactions in both Odisha and West Bengal in terms of dried fish operations (Figure 2). Both sites have varied social-ecological characteristics. The first site is in the Jagatsinghpur district near the Bhitarkanika Marine National Park. The site has unique features as it has a large estuarine area that is highly significant for conservation with strong floral and faunal diversity. It is a habitat for IUCN red list species like sea turtles, crocodiles, and rare species of white crocodiles, besides having a rich mangrove forest. Sociologically, the area is also quite dynamic with a large influx of Bengali fishers, who have permanently migrated from the neighboring state of West Bengal and Bangladesh. The people who have migrated from Bangladesh are mostly second-time migrants. First, they settled in West Bengal and then moved to Odisha from there. Except for two households, all the families have permanent residence on the study site and have an electoral identity. Only four families are early settlers who belong to the Odia community, and they hold political and social power in the village.

The second site is NM Padia village, which is about 10 km from the Digha border of West Bengal. Though the site belongs to Odisha, fishing and trade relationships are mostly with the Digha-Mohana market. The people here are permanent settlers and belong to a fishing caste. They practice in-shore fishing and also work as crew members on West Bengal trawlers operating through the Digha-Mohana fishing dock. These communities have adopted drying practices from West Bengal fishers who used to visit and stay for about five months a year; they have been engaged in drying operations. With repeated natural calamities and growing interstate fishing vigilance, the annual migration from West Bengal has stopped and the local fishers have started the drying practice. The area is experiencing a strong expansion of culture fisheries with the regular intrusion of West Bengal trawlers into the artisanal fishing area earmarked for artisanal fishers of Odisha.

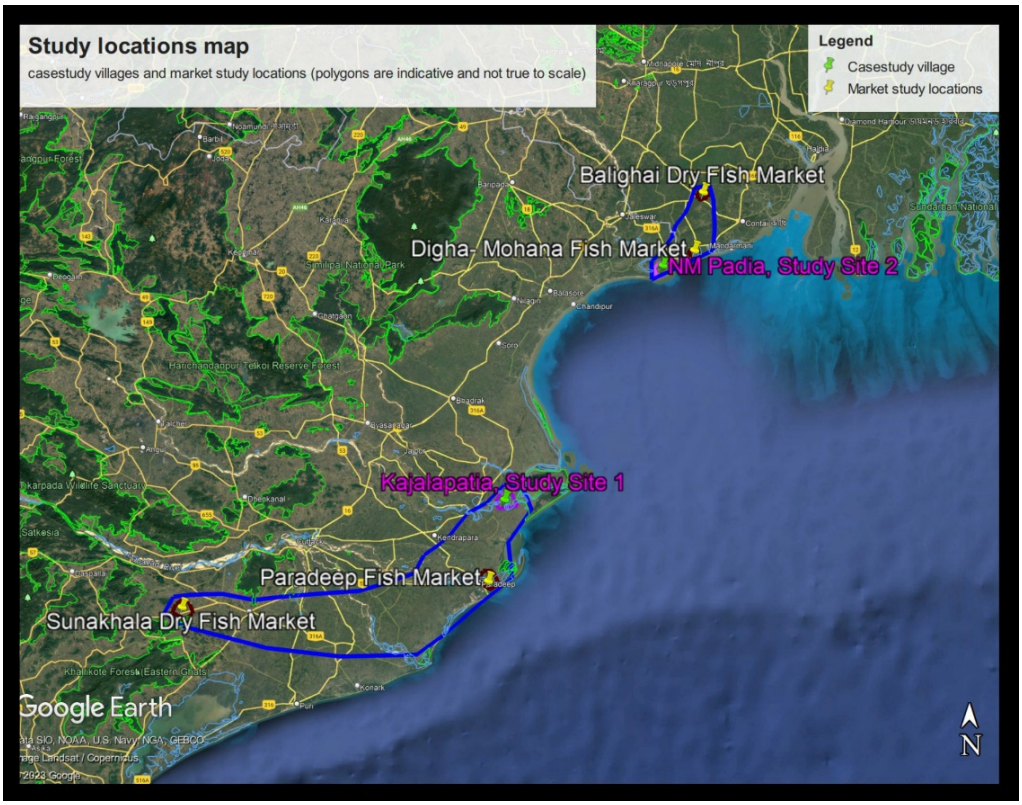

Figure 2. Map of study locations and case study sites indicating survey villages and dried fish markets [Source: Google Earth Pro version 7.3.6.9345, (December 2022). Bay of Bengal Cost. Earth Versions—Google Earth (https://www.google.com/earth/versions/#earth-pro, accessed on 27 January 2023)].

We have combined the village household survey method with semi-structured interviews with actors operating in fishing, processing, and trading nodes. The census provided key information about demographic composition, community-level institutions, the interaction of fisheries, gender roles in fisheries operation, processing, and trading of fish in general, and dried fish in particular. The semi-structured interviews provided an in-depth understanding of the social, economic, and ecological interactions of specific value chain actors in the value stream. Along with primary data, an extensive literature review, including the literature on value chains, small-scale fisheries, DFVC, SES, and wellbeing, helped in building the conceptual and analytical framework of the research. Secondary data were also obtained from the Department of Fisheries and other government departments to collect their published reports (e.g., the Government of Odisha and the Government of India).

The village household survey covered 110 households from both study sites; a "fisher household" was considered the primary sampling unit. With fishing being considered the new critical node in the SESDFVC, we have taken 20 samples from each fishing community, which is marginally above 30% of the total number of fisher families in the village. From the processing node, we have taken 10 samples from each site, and from the trading and wholesaling node, we have taken eight samples covering both sites. The village survey provided critical information about actors and segments of the value chain. From each of the actors in the value chain, we randomly selected the respondents for semi-structured interviews. The information obtained from the semi-structured interviews with fishers and dried fish processors helped select respondents from other segments using the snowball sampling method.

In addition, secondary data used in this study were obtained from published and unpublished sources. Unpublished sources mainly include fisheries department statistics, outcome budgets, and mandi records. The published sources include the fisheries handbook, websites of the national disaster management authority, state disaster management authority, Central marine fisheries research institute, Central Institute of Fisheries Technology (CIFT), Marine Products Export Development Agency (MPEDA) Department of fisheries and animal resources of the Government of India, Government of Odisha, and Government of West Bengal. The analysis is performed by combining qualitative coding and descriptive statistics with the help of SPSS software.

4. Results and Discussions

4.1. A Contextual Outlook on Dried Fish Operations on the Eastern Coast of the Bay of Bengal

Odisha and West Bengal are the two most critical maritime states of India. Odisha is the fourth largest fish-producing state with a production of 816,000 metric tons of fish, which constitutes 6% of India's fish production [40]. West Bengal ranks second with 17.82 million tons of fish production. The decadal trend shows that while the marine production is more or less constant, the inland fisheries have registered about 161% growth during the same period in Odisha and 42% growth in Wet Bengal. However, the primary data collected through the household surveys (n = 110), semi-structured interviews with fishers (n = 40), and small-scale dried fish processors (n = 20) suggest that there is a general observation about the decline of fish production, mostly for people engaged in artisanal fishing operations. About 94% of the respondents mentioned low catch per unit with an increasing number of vessels operating in the artisanal fishing area. Data on marine fish production and fishing crafts for the last decade corroborates the primary data. Marine production remained constant in Odisha and West Bengal with a mean annual production of 0.1384 million tons and 0.1783 million tons, respectively, over the last decade [5,7]. Fish is an integral part of the diets of the local communities of these two states. While there is a higher consumer preference for fresh water and live fish, about 6.3% of fish is used as dried fish in Odisha and 6% in West Bengal [5]. There is wide variability in terms of the choice of species for drying.

4.1.1. Characteristics of Dried Fish Operations

Low-value fish are caught and processed by small-scale operators, working in labor-intensive, mostly self-employed enterprises [41,42]. The key characteristics of SSF and dried fish operations in the study sites are presented in Table 1. While site 1 is more ecologically diverse and has a greater degree of vulnerabilities emanating from social, economic, and governance factors, site 2 offers an interesting picture of the transition from the artisanal sector to the motorized sector with a greater interplay of inter-state actors and processes (Table 1). From a social and economic perspective, site 1 provides a fragile societal position, with 96% of migrated communities having different linguistic identities, a lack of access to land and resources, and relatively weak integration into local social-cultural processes. In contrast, site 2 offers a different picture of caste-based identity, permanent settlement, and stronger interactions with the social and political processes of the region. However, the common issues of both sites are widespread poverty, a lack of access to capital, and recurring losses due to frequent extreme weather events, including cyclones and severe depressions.

Table 1. Key characteristics of study location.

	Site 1: Kajalpatia and Batighar	**Site 2: NM Padia**
Fishing area	Estuarine fishing and artisanal area fishing	On shore fishing
	Only 5.7% of fishers fish beyond artisanal area	Only 37% of people fish beyond artisanal area
Fishing Crafts	7% use traditional manual boats 90% use motorized boats (less than 8.5 m) 3% use Sona boats	10% use traditional boats 53% use motorized boats (less than 8.5 m) 37% use motorized boats above 8.5 m in length
Traditional norms and practices	Uthia and padia fishing Mutual respect for fishing area	Uthia and padia fishing
Actor roles	Mixed identity	Mixed identity and specialized operators
Time of fishing trips	89% fishers go on one-day fishing trips	35% fishers go on one-day fishing trips
Social relations	79% of the fishers and small-scale processors migrated from West Bengal and Bangladesh Lack of permanent land tenure Low political power Intergenerational knowledge and practice of fish drying	Permanent habitations with caste identity Active participation in the local political process. Greater Market access having interaction with both Odisha and West Bengal markets Acquired knowledge of fish drying
Workforce dynamics	90% boat owners hired crew from same communities Shared fishing boats Annual contract for boat drivers Monthly contract for other crew members Shared labor for processing 89% of processors employ hired labor 5% are self-employed enterprises	50% boat owners hired crew from same communities Shared fishing boats Annual contract for boat drivers Monthly contract for other crew members Shared labor for processing 47% of processors employ hired labor 53% are self-employed enterprises
Work division	Male members do fishing, female members engaged in fishing, processing, and selling	Male members do fishing. Women do processing. Men and women participate in selling
Fish Production trend	Production has marginally increased, but share of artisanal fishing is declining	Production has increased but share of artisanal fishing is declining
Production of preferred dried fish species	High catch unpredictability of preferred species. Competition for space by mechanized and power boats with motorized and non-motorized boats. 'C' class species availability for dried fish processors from the trawlers is inconsistent. Higher prevalence of household-based self-employed processing units	Decline in catch of dried fish species

Table 1. *Cont.*

	Site 1: Kajalpatia and Batighar	Site 2: NM Padia
Weather vulnerability	Increased frequency of weather events including floods, cyclones, and depressions	Weather events cause severe damage to processing infrastructure like drying racks, curing tanks, nets, boats, etc.
Policy induced vulnerabilities	Restriction of marine protected areas and sea turtle conservation along with monsoon fishing ban (7 months) causing long lean season for fish availability for drying. The season advantage is lost	Growing emphasis on aquaculture, changing labor, and catch dynamics for inshore fishing

Source: Primary data collected by the first author through household surveys and semi-structured interviews.

4.1.2. Steps in Dried Fish Value Chain Operations

Dried fish value chain operations consist of six steps (Figure 3). The first step in the drying process is to either catch or obtain suitable species. The second step is the cleaning of the stock, which is followed by sorting fish as they typically get mixed stock of different species. The third step involves curing in the salt tank. It is noticed that, depending on the size of the processing unit, tank size varies from 100-L to 1000-L. Since there is a strong demand for unsalted dried fish, a few species like Indian anchovy, prawns, and flat fish are dried unsalted. Though in small quantities, larger fish like Hilsa, Snapper, and Silver Mullet require a complex process of intestine removal and salt application. The next step is drying. Smaller fish are sun-dried on the drying floor, and midsize fish like Bombay duck, Eel, and Indian mackerel are dried on the bamboo rack. It is also observed that processors with higher capacities have opted for permanent infrastructure like cemented floors and bamboo racks, as well as bigger salting tanks. The tiny fish are being dried on the used fishing net and directly on the ground. Access to land is one of the determining factors for having the necessary infrastructure for drying. The drying period and drying types are subjective to the types of species being dried. Bigger fish treated with salt are sold in semi-dried condition, whereas other small and medium-sized fish are sold in fully dried condition.

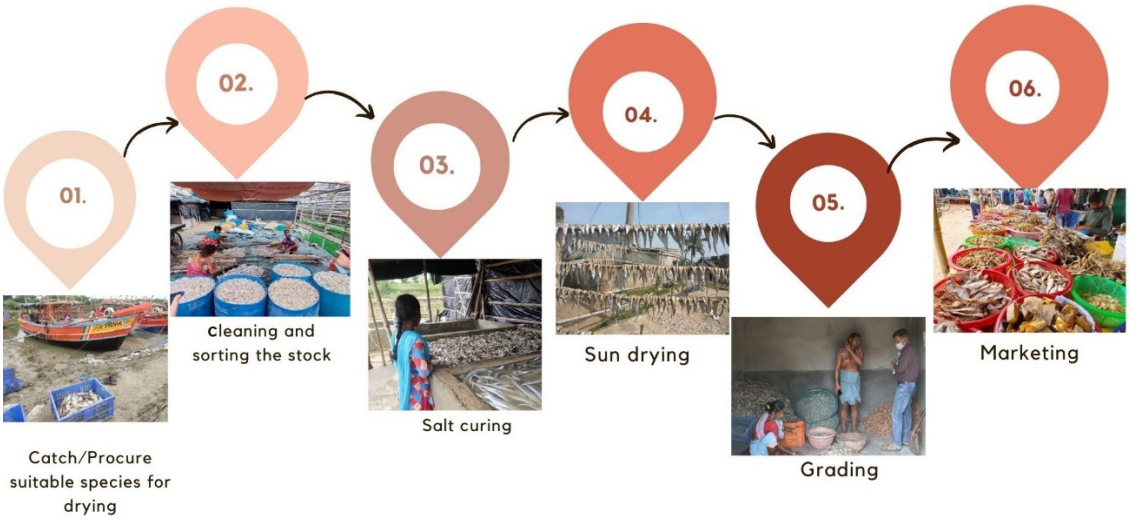

Figure 3. Process steps involved in the dried fish value chain from fish catch to final disposal in the market in the case-study locations as shown in Figure 2.

The fifth step involves grading the fish. Grading is performed either at the processing point or at the paikars/market agents' point. It is carried out according to the size and color of the fish. Ninety percent of the respondents emphasized that there is a positive color, price, and market correlation. It helps not only in fetching differential prices but

also in targeting different rural, urban, and international markets. Though most of the processors have denied the application of pesticides while drying, during the study it was observed that relatively larger processors were using pesticides to avoid damage through pest infestation and also to get rid of flies, which are the main source of fecal contamination. Finally, the product moves from the processors to market agents and actors further down the chain, including traders, wholesalers, and retailers.

4.1.3. Dried Fish Value Chain Structure:

The dried fish value chain is quite complex in terms of exchange relations, networks, and product movements. In the Kajalapatia and Batighar (site 1) regions, the DFVC is strongly characterized by self-employed household enterprises run with their own labor and catch, and small dried fish units operationalized through household and hired labor. During the lean fishing period, besides their own catch, they buy "C" class fish from Nehru Bangala and Paradeep through auction. Based on the species, the price is negotiated. It varies from INR 0.14 (INR 10/-per kg) to INR 0.80 (INR 60/-per kg). They process it at their facility and generally, after drying, the weight reduction is to the tune of 50 to 70%, depending on the type of fish. For example, raw chauli (Indian anchovy) fish is purchased for INR 0.28 (INR 20/-) to INR 0.55 (INR 40/-) per kg, and dried fish is sold for INR 0.55 (INR 40/-) to INR 2.40 (INR 180/-). The small shrimp are purchased for INR 0.28 (INR 20/-) to INR 0.80 (INR 60/-) and the dried shrimp are sold for INR 1.25 (@INR 100/-) to INR 2.50 (Rs 200/-) by the processors.

As shown in Figure 4, the dried fish moves through different means to the wholesale market and reaches the retail chain. A small portion of the dried fish that meets international quality standard specifications is procured by exporters in Odisha and West Bengal. Exporters have their own commission agents and wholesalers who supply by performing additional grading at their end. Few exporters also procure directly from processing units with appropriate standard specifications. It is also found that there is a stronger connection between lower-end value chain actors in terms of product procurement and marketing across Odisha, West Bengal, the Northeastern states, and Andhra Pradesh.

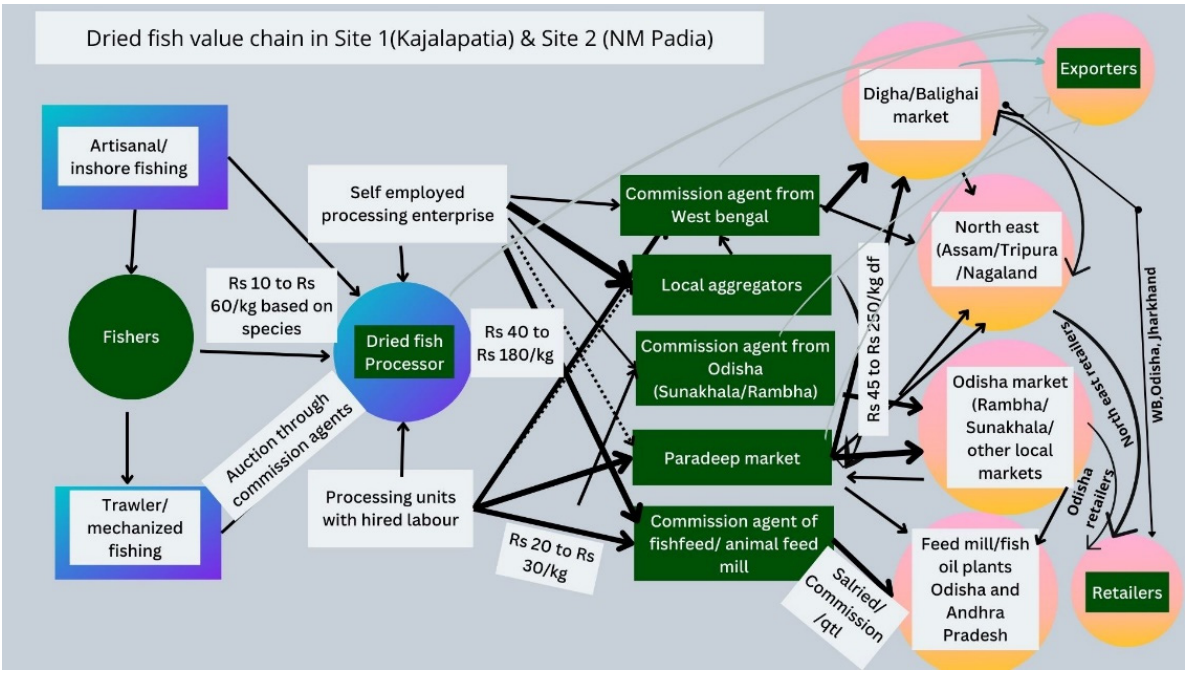

Figure 4. A schematic presentation of the dried fish value chain operation indicating value chain nodes and actor interactions in the case-study location (weight of arrows signify the level of interaction among actors and the interaction with exporters is shown through different color arrows).

The dried fish value chains in both locations suggest that fishers are the mere suppliers of the raw fish that proceeds for processing. The real market interactions start at the processing nodes. In Figure 4, the deep arrows show the exchange process, and the dotted arrow shows opportunistic exchanges. The value chain and market system are determined by the economic logic of price relationships and incremental benefits along the value chain. There is evidence of adjusted vertical integration where only one actor dominates the chain. Feed mills, which constitute about 30% of the dried fish market, are dominated by feed millers and their agents. In the case of dried fish for human conservation, market consolidation takes place across four levels and the interactions are quite intense. The direct connection between wholesale markets with resource systems and processors is quite sketchy. They mostly operate with an inductive logic of commodity value chain that is determined by competitive advantage offered by different market agents and market channels in terms of price and product quality.

4.2. Dried Fish Value Chain Analysis with SES Perspective

Died fish operations in the study sites are mostly managed by small-scale operators in the marine fishing sector (Table 1). There is little contribution by the inland sector, mostly limited to river mouths and estuarine regions. Feedback, linkages, uncertainties, and emergences as critical attributes of SESDFVC are understood with empirical evidence from the case study sites.

4.2.1. Feedback in Dried Fish Value Chain Operations

The dried fish value chain in the study region witnesses non-linear feedback from within and outside the fishing sectors. Feedback loops are shaped by multiple factors. As a system feedback, intensification is observed in production, technology and gear, competition for fishing areas, and changing habitat characteristics at the bio-physical resource node. The processing and marketing node also experienced multiple feedback with an expanded bill of materials (BOM) structure, greater mobility of fish catch, and blurred geographic division in terms of procurement of desired dried fish species. Similarly, diversification and change in societal interactions are manifested with increasing labor mobility within and outside the fishing sector and a deeper understanding of place-based factors such as the lunar cycle.

The dried fish operation is determined by the production of selected marine species used for drying. The marine production trend over the last decade in the study area provides a discouraging trend. The decadal data suggest that there is impressive growth with a cumulative annual growth rate (CAGR) of 8.69% in Odisha and 2.03% in West Bengal. However, the share of marine production in Odisha has dropped from 34.56% in 2010–11 to 19.32% in 2019–20. Similarly, the marine production share in West Bengal has declined from 15.82% to 10.07%. The standard deviation in marine production in Odisha (S = 0.17) and West Bengal (S = 0.12) for the same period suggests a fairly constant production trend (Table 2).

Table 2. Production Dynamics of Marine and Inland Fisheries in the Study Region.

Production of Marine and Inland Fisheries in Odisha and West Bengal (2010–11 to 2020–21 in 100,000 tons)					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Marine Pdn_Od	10	1.14	1.59	1.3840	0.17102
Inland pdn_Od	10	2.53	6.60	4.0690	1.47069
Total Pdn_Od	10	3.82	8.18	5.4540	1.62372
Marine pdn_WB	10	1.52	1.97	1.7830	0.12667
Inland pdn_WB	10	12.46	17.70	14.6680	1.59976
Total pdn_WB	10	14.43	19.52	16.4510	1.58507

Pdn. Production Od-Odisha, WB-West Bengal (Source: GoI [5] and GoI [7]).

The discouraging marine catch has triggered an intensification of fishing activities with increasing numbers and rate of vessel upgradation, and as a result, the catch per unit effort (CPUE) has been declining. There is a steep rise in fishing vessels with a 163% rise in Odisha and a 41% increase in West Bengal over the last decade [5,7]. In particular, the share of the non-mechanized motorized sector is about 41%, and traditional crafts are about 44% in the region, including Odisha and West Bengal. However, the CPUE is on a steady decline. These sectors are critical for DFVC as the primary data from both field sites suggest that dried fish production is heavily dependent on them.

Further, the craft-wise production data from Odisha (Figure 5) suggest that the CPUE in the non-mechanized sector is on a steady decline as the fish landing is more or less constant with a standard deviation of 0.03 (S = 0.03). The mechanized sector has registered impressive growth, accounting for 6.58% of the total vessel (GOO, 2021), 47.6% of the total catch, and a CAGR of 6.47% over the last ten years. The non-mechanized, motorized sector has a share of 45.51% of vessels and 35.38% of catch, with a CAGR of 4.28% over the last decade. In contrast, the traditional sector is facing a serious challenge with 47.89% of vessels sharing 17% of the catch and a CAGR of 3.13% for the same period of time. Eighty percent (n = 40) of the respondents from the fishers' segment and 64% of the processors (n = 24) segment also corroborate the fact that there is a strong decline in the availability of fish for processing and drying in the study location.

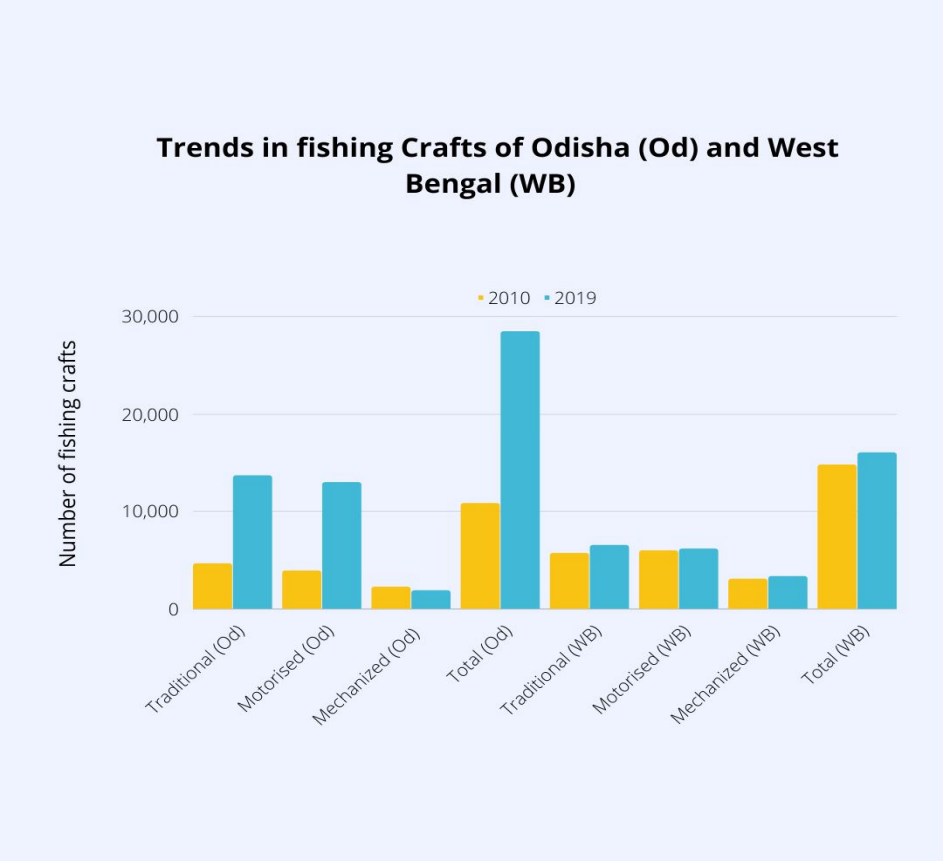

Figure 5. Analysis of fishing crafts (traditional, motorized, and mechanized crafts) in Odisha and West Bengal compared between the years 2010 and 2019 scenario. (Source: GoI [5] and GoI [7]).

The gear used in all three sectors also experienced a major shift, with an emphasis on catching small fish [43]. In the study sites, 75% of the households have upgraded their fishing gear and boats to higher capacities with the intention of covering more fishing space and targeting a greater volume of catch. Large trawling nets used by mechanized boats are exploiting juvenile fish stocks and larvae. Bottom trawling is causing serious

destruction to fish habitats [44]. By-catch has grown significantly due to prolonged fishing trips with improved capacity vessels (up to 40 tons), emerging markets for by-catch as fish feed and poultry feed, and the fertilizer industry. In addition, there is a significant illegal catch by trawlers in artisanal areas due to weak law enforcement. The estimated volume of illegal catch in artisanal fishing areas on the Odisha coast alone is between 2100 and 4100 tons [45,46]. Illegal fishing refers to, inter alia, "activities by a foreign vessel in the waters of a coastal state without its permission, and fishing activities by vessels flying the flag of a non-member in waters regulated by an RFMO" [47]. The overemphasis on shrimp and aquaculture in this region is also adding the problems of releasing toxic water, catching juveniles, and generating a considerable volume of by-catch. In Odisha, freshwater aquaculture has grown 2.3 times since 2010–11 with a CAGR of 9.67%. Brackish water aquaculture has shown a 7.5-times growth with a CAGR of 25.14% during the same period.

The species-wise landing data from the study site indicates a marginal increase in the production of preferred dried fish species (Figure 6). The primary axis suggests the decadal mean production in 1000 tons and the secondary axis represents the CAGR in percentage terms, which is negligible for most of the species. At the same time, CPUE is negative owing to the increased number of vessels and improved gears.

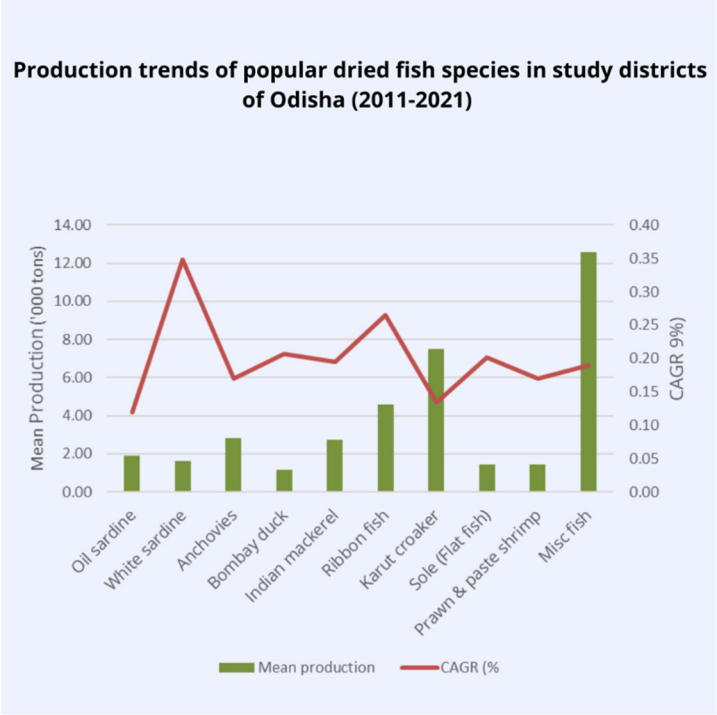

Figure 6. Decadal mean production and cumulative annual growth rate of select dried fish species over the period from 2011–12 to 2021–22 (Source: GoO [48]).

The respondents were asked about their top five preferences for dried fish based on production and marketing, as can be seen from the data presented in Table 3. As revealed in Table 3, fifteen species have received the maximum number of responses. Species such as Indian mackerel, oil sardine, ribbon fish, prawn, Indian anchovy, and croakers are found to be the most preferred species for drying. Mini Chandi (*White sardine*) is primarily processed for the fish mill and poultry feed industries.

Table 3. Dried fish species preference matrix.

Dried Fish Preference Frequency									
Sl. No	**Type**	**Common Name**		**P-1**	**P-2**	**P-3**	**P-4**	**P-5**	**Mean Preference Frequency**
1	Moti/Marua	Indian mackerel	*Rastrelliger kanagurta*	19	9	19	4	8	11.8
2	Kokali	Oil sardine	*Sardinella longiceps*	16	18	3	3	12	10.4
3	Sankha	Golden anchocy	*Coilia dussumieri*	1	24	5	12	2	8.8
4	Borei	Karut croaker	*Johnious carutta*	1	8	17	8	6	8
5	Jagar	Small Bengal siver-biddy	*Gerres setifer*	4	5	5	14	12	8
6	Ruli	Ribbon fish	*Lepturacanthus savala*	23	2	0	7	2	6.8
7	Chingdi	Indian prawn & paste shrimp	*Acetes indicus & Penaeus indicus*	15	3	1	6	8	6.6
8	Chauli	Indian anchovy	*Atherinomorus lacunosus*		5	8	8	3	6
9	Lahada	Bombay duck	*Harpadon nehereus*	3	2	8	4	12	5.8
10	Chandi	White sardine	*Escualosa thoracata*	2	8	7	5	6	5.6
11	Manohari	Commerson's anchovy	*Stolephorus commersonnii*	0	5	12	5	6	5.6
12	Phaasi	Mustached thryssa	*Thryssa mystax*	9	2	6	5	2	4.8
13	Tauri	Barred spiny eel	*Macrognathus pancalus*	0	0	0	12	10	4.4
14	Polagara	Indian glassy fish	*Parambassis ranga*	0	8	6	3	2	3.8
15	Hilisa	Hilsa	*Tenualosa ilisha*	4	1	4	2	5	3.2

Source: primary data collected by the first author (household survey).

The decline in CPUE has not only enhanced the vulnerabilities of fishers and small processors but has also reduced their negotiating power in the value chain. One old man, during a semi-structured interview, said that "*Dariare machha thile sina ame raja.*" "*Machha Kamile Beparinka Raj*". This means when there are fish in the sea and the catch is good, small-scale processors have stronger bargaining power. When there is a scarcity of fish, they rely on commission agents and trawler crews for inputs and prices of the dried fish. This clearly suggests that resource conditions in terms of small fish availability play a greater role not only in demand and supply equations but also in determining the power in the market.

The feedback loop is also influenced by the new market opportunities in the fish meal and animal feed industries. The processors are diversifying their portfolio by expanding their BOM, especially with the emerging feed industry. About 50% of the total production at the processing unit level is used in fish and animal feed. The declining CPUE and low availability of dried fish species, mostly in self-employed household enterprises, are also resulting in families opting for various non-fishery-related livelihood options. Generally, the opportunity for livelihood diversification for fishers is limited due to lower levels of education. Sixty percent of males and 13% of females are educated up to primary school (grade V). Twenty-six percent of males and 20% of females have attained secondary school, and 0.06% have moved up beyond secondary education. However, the younger generation of fishers is seeking employment in fishing fleets and opting for wage-migration to cities. They are also taking up higher value chain roles such as community-level aggregators and commission agents. From the survey, it is also found that some people prefer to migrate to nearby cities for wage employment on a daily basis and go fishing during the peak fishing periods of the month. For example, more fish is available during the *uthia* times which corresponds to the waxing and waning of the moon (12-day period during the lunar cycle). This leaves women and older members of the household to undertake processing activities, and they mostly depend on local aggregators and market agents for the sale of their produce. On the market front, with greater investment and mobility, the traditional boundary of geographical separation of landings and procurement patterns is changing.

There is a greater exchange of products between the south and north Odisha coasts and the West Bengal coast due to technological and communication advancements. Traders from the Digha-Mohana market have agents in Paradeep and the traders from Sunakhala are also procuring select dried fish species like *Karut croaker* and *Indian anchovy* from the Paradeep region. Paradeep traders are procuring *Indo-Pacific tarpon* and *Flat head mullet* from the south coast. Further, with the expanded BoM structure, dried fish traders are tapping new market opportunities. They specialize in various activities like animal feed, frozen fish, and processing, other than drying.

The commodity orientation of traders and large-scale processors fuels extractive fishing practices mostly in motorized and mechanized sectors. It has negative implications for artisanal fishers and small-scale dried fish processors. Fishers recalled past incidences of collective struggles against large operators violating fishing norms and transgressing into artisanal fishing areas. The protests resulted in an organized move by trawler owners to stop supplying "C" class fish to small-scale processors. They are increasingly opting for trade in the sea among the trawlers of neighboring states. Due to high overhead costs, the low scale of processing operations limits the capability of small-scale processors to tap distant markets. Hence, the dependency on local aggregators is high even with low bargaining power. One respondent said, "Kankadaku *golia pani suhae*". It means "crab loves muddy water", and here it is implied that the market agents are taking advantage of the situation.

Ninety-seven percent of respondents (n = 110) raised their concerns about the feedback from external drivers including industrialization and the prolonged fishing ban. The region, (particularly the people of Kajalapatia), is facing a conservation ban for Olive Ridely protection for seven months (November 1 to May 31) overlapping with a monsoon ban for 45 days (April 15 to June 15). There is a critical influence of other terrestrial, freshwater, and near-shore interventions on the bio-physical characteristics of the marine resource system and thereby causing threats to fisher's livelihoods [48]. While fishers succeeded in receiving INR 106.66 (INR 8000/-) as compensation for loss of employment during the fishing ban, it is grossly insufficient to run the family. Moreover, the compensation is provided only to active fishers. Many women engaged in fish processing do not qualify as active fishers and therefore, are excluded from getting any support from the fisher's welfare and social protection programs of the state.

4.2.2. Linkages in the Dried Fish Value Chain

The linkages in the DFVC in the study region are dynamic as they are influenced by biological flows, customary norms, social interactions, formal national and international provisions, and blurred divisions in actor roles in the value chain. It is evident from the field observations that the fish catch is dynamic and not well distributed across the month and year. Fishers catch more fish during the *uthia* period, and hence the availability of fish processing is quite high. Other natural factors, such as seasonality, and weather conditions influence the fish catch as well. Fishers obtain a higher catch in the rainy season, winter season, and before the cyclonic storms. However, due to a prolonged fishing ban, fishers at site 1, are unable to take advantage of seasonal opportunities.

Such a dynamic flow of fish makes value chain linkages dynamic as well. People engaged in processing use part of the lean patch of the month for processing and marketing dried fish. Hence, most of the small-scale fishers are also engaged in processing, as it offers employment for a longer period of time in a month. During the lean season, dried fish processors depend on commission agents and landing site auctions for buying "C" class fish (low-value small fish or fish, whose shelf-life cannot be increased even with ice application) from trawlers operating in the EEZ (Exclusive Economic Zone) and processing them as dried fish. According to the guidelines for fishing operations in EEZ, 2014, deep sea fishing is allowed in areas up to 200 nautical miles beyond the shoreline and territorial water i.e., 12 km from the shoreline. The dried fish at site 2, is slightly different from that at site 1. Here, mixed responses are found. Processors close to Digha and Mohana depend on

the Digha market committee auction for procuring fish for drying, and the artisanal fishers who are also engaged in the processing are using their own catch and buying fish from their fellow boat owners. Below, we analyze rules, resources, relationships, and actor roles to understand the dynamic linkages that determine the structure and conduct of the DFVC.

a. Rules and Resources

Rules and provisions regarding resource access and trade often influence power dynamics and vertical and horizontal interactions among value chain actors [49]. Empirical data from the field reveal a complex mosaic of interactions and linkages as the dried fish operation is influenced by both formal and customary rules (Table 4). The federal and state-level policies have differential implications for people operating in the dried fish value chain.

Table 4. An overview of formal and informal rules that influence different nodes of SESDFVC.

Rules	Fisheries (Relevant Dried Fish Operation	Processing (Dried Fish)	Trading and Wholesaling (Dried Fish)
Formal rules	• Priority on aquaculture, export promotion, high-value fish, creation of infrastructure for mechanized fishing, live and frozen fish marketing • Incentives for the upgradation of traditional crafts • Cage culture fishing in the sea is practiced to improve marine production • Restriction on mechanized fishing in artisanal fishing areas • Fishing restrictions in Bhitarkanika marine protected area (site 1) • Fishing ban from 1 November to 31 May for Olive ridley conservation (Site 1 & 2). • Monsoon fishing ban (April 15 to June 15) • One-time compensation of $100 (INR7500/-) for marine card holders for fishing ban (Site 1 & 2). • Savings and relief scheme with 50% beneficiary contributions (Site 1 & 2)	• Higher incentives for frozen and processed fish like fish fillets, fish fingers, etc. • Capacity building of women's SHGs for hygienic fish drying and post-harvesting practices. The expansion of poultry and aquaculture results in a demand for feed • Import subsidies on value species under the ASEAN trade agreement are not favorable to small-scale processors	• GST waiver • A little thrust on the eco-leveling of dried fish • The ASEAN agreement helps diversify trade Under the automatic route, 100 percent FDI is allowed in the pisciculture and aquaculture sectors in India Under the automatic route, the non-resident investor or the Indian company does not require any approval from the government of India for the investment
Informal rules	• Demarcation of fishing area on mutual consent • Sharing of labor for fishing • In the case of trawler drying, 90% of the receipts from dried fish are shared with crew members • Annual contract with crew member with advance payment • The cleaning boat after every fishing trip	• Annual booking of boat owners for fishing with advance payment • Shared labor for drying operation • Rs.500/- commission per quintal sale of dried fish	• Booking of boats on an annual basis with advance payment for assured supply • Credit to small, dried fish fishers and processors • Loyal commission agents operating in the village

Source: Primary data collected by the first author through household surveys and semi-structured interviews.

A growing emphasis on the blue economy has created a complex policy environment with multiple priorities. The fisheries policy framework in the study region places greater emphasis on exports, candidate species like shrimp, aquaculture, mechanized fishing, and new market access for live, frozen, and processed items. Such an environment has differential implications for the structure and conduct of value chain actors operating in different nodes of the DFVC. Small-scale fisheries are also regulated through customary rules and collective choice arrangements that are co-evolutionary in nature. Communities have collective rules for the sharing of labor, unwritten agreements, and partnerships ratified by village institutions and caste federations, for example, determining fishing areas in the river and sea through mutual consent. At the meso level, they have fishers' federations and boat associations to protect their member's mutual interest. Though there is no exclusive dried fish processors' federation, in both the study sites, due to their mixed identity, they are members of the fisher federation and boat owners' association. The traders are also members of the regulatory marketing cooperative society. However, these institutions are experiencing transitions under the influence of macro-policy drivers.

The capital-intensive fisheries with greater programmatic impetus are sabotaging the interests of the poor. Poor fishers are still suffering from depleting CPUE despite the mechanized fishing restriction in artisanal areas. At site 2, the labor-relation is also changing as fishers are seeking employment in aquaculture farms. The composition of the fishing community is changing, with non-fishers and private investors assuming a greater role in trade and even fishing activities. It is no longer a caste-based operation, and hence the customary norms are losing ground. The change in power is causing value chain decisions to be fisheries-centric, with a focus on marketable species and products rather than fisher-centric, which are mostly driven by skill, competence, and local ecological knowledge systems. At the same time, interactions with traders suggest a greater collaboration of large players from different states, and the landing dynamics have changed due to the exchange of fish in the sea among trawlers.

Processors from study site 1 are experiencing fewer landings of C-class fish as they protested against mechanized fishers for intruding into areas beyond the EEZ and the pricing of trash fish. Site 2 offers a different trade equation. Due to repeated natural disasters that occur very frequently, the basic infrastructure for drying is severely damaged or destroyed. Hence, the community switches in and out of the dried fish processing activities. The people who run small drying units often switch to the live fish trade till they rebuild their infrastructure. For example, the dried fish processors at site 2 have temporarily suspended drying activities after the repeated cyclones of Fanni in 2019 and Yash in 2020. They are now selling live fish to market agents from Balasore and Digha.

There is provision for contributions and relief schemes to tide over the ban period. The poor fishers are not participating in this scheme as they are unable to manage beneficiary contributions. The following depiction of a respondent from site 1 explains the reason for the low uptake of the scheme: "*We live on our daily earnings. Whatever little amount is saved is paid to the money lender, from where can we get additional money to save?*"

Under a group insurance scheme, fishers are covered for accidental and death benefits while on duty in the sea. Women, small processors who do not go into the sea, and small market agents who are frequently rushed to catch the timing of fish landing and auction are also excluded from the scheme. About 55% (N = 64) of the fishers and dried fish processors availed themselves of the informal credit sources. Only 7% of respondents in site 1 and 12% in site 2 have received credits from the bank. Twenty-five percent of respondents do not have marine identity cards and residential proof, which are mandatory for institutional credit as they are migrants. In Site 2, fishers are small-scale dried fish operators who are denied credit by banks due to irregular payment of loan installments for earlier advances.

As per the sequence of preference, friends and peers, advances from traders and market agents, SHG groups, and money lenders are considered major credit sources. In the event of availing credit from market agents, they have little room to negotiate on the price because they are forced to sell their produce only to the agents as a way to

pay back the credit. The interest rate for loans from micro-finance institutions and local money lenders is about 24 to 36% per annum. Many SHG groups in the study region have received seed capital, solar infrastructure, and bank linkage support for establishing group enterprises for hygienic dried fish production. However, these institutions are facing serious challenges of high transaction costs, low inventory data support, lack of transparency in business transactions, and low market support. Such processes often lead to market and institutional failure.

The fish processing units in India are functioning at 32% of their capacity [50] and they are consuming most of the fish catch. International trade agreements such as the SAARC preferential trading agreement (SAPTA) and ASEAN framework of trade agreements change the trade linkages in the post-harvesting and fish processing sectors. The ASEAN framework provides for import duty exemption on species including mackerel, sardines, anchovies, and crabs from member countries like Thailand and Vietnam. Such trade raises the apprehension of further marginalization of small-scale fishers and processors with low bargaining power and heavy price competition. The study region is gradually gearing up for these changes in the market economy as it is conveniently positioned for trade interactions with southeast Asian countries. As a welfare measure, the government of India has exempted goods and service tax (GST) on dried fish as it is practiced by poor fishers. While this is a welcome step, it is leading to manipulation with non-transparent business processes and manipulated data by traders.

b. Roles and Relationships

There are fuzzy boundaries across value chain nodes due to strong overlaps in the functioning of different economic agents. The broad suit of simple indicators and rules in practice by the community evolves through time and has built-in adaptability with fuzzy logic. Fuzzy logic offers flexibility in the interpretation-based use of collective mental models. It helps in analyzing the system across geographic scales, from global to local. The value chain follows a scientific model with a relative emphasis on higher-scale issues. However, it is necessary to have a local level understanding as it complements science precisely where information is poor. Analysis of local practices offers a stronger understanding of system feedback as such practices and engagement pathways evolve with the gradual understanding of the environment and collective learning process [51].

Out of 110 respondents in the study village, 76 respondents (69%) have mixed identities as boat owners, fishers, and processors. We define mixed identity to explain the multiple, overlapping, and simultaneous roles that actors play within a value chain according to their capacity, in some contexts, and their precarious social-economic situation, elsewhere. The following table (Table 5) summarizes the roles of respondents obtained from the village survey covering 110 households.

Table 5. Distribution of respondents according to their role in the upper segment of the value chain (n = 110).

Roles	n = 110	Site-2	Grand Total	
Only Boat Owner	2	7	9	
Only Fishers	1	15	16	nn
Only Fish Workers	0	9	9	
Boat Owner + Fishers	0	2	2	
Fishers + Boat Owner + Dried Fish Processors	53	0	53	
Fishers + Boat Owner + Dried Fish Processors + Trader	2	0	2	
Fishers + Dried fish Processors	1	12	13	
Fishers + Workers	0	6	6	
Grand Total	59	51	110	

Source: Primary data collected by the first author (household surveys).

In 93% of households, while male members work as fishers, female members are primarily engaged in small-scale processing activities and also work as wage laborers in relatively bigger processing units in the village. Six percent of fishing and processing households, which have additional human resources but a limited capital base, are simultaneously operating as local aggregators and traders. In the case of upper-segment actors, the relationships are complex and not always driven by financial return. In one of the interactions, a fisherman from NM Padia village narrated their association with the value chain in an interesting fashion. He said, "*From our childhood, we have been fishing in the sea. We have learned this from our forefathers. What else can we do? Even if it is difficult to meet the daily needs today, how can we leave our occupation?*" This statement speaks about the cultural and emotional attachment to the occupation, which drives them to continue with the activity in spite of innumerable challenges. Therefore, they are exploring various options within the sector to earn a living.

Beyond the processing node, the transaction takes a dynamic path with multiple exchange patterns. It is determined by the volume of produce, the processor's financial strength, and access to market actors. In the case of self-employed processing enterprises, the chain is typically longer than that of a mid-size processor with a volume of production. With the growth in the fish mill and poultry feed markets having opened, organized trade interactions are observed in the study location. Companies appoint collection agents to procure materials from processors, and hence, all processors, regardless of size, have access to such market actors. As a result, price asymmetries in the feed industry are not severe. However, due to the length of the supply chain, price disparities are greater in the case of dried fish for human consumption. As seen in site 2, there is better access to export and a larger terminal market, such as the Balighai dried fish market. Approximately 25 to 30% of the produce is exported to neighboring countries. However, processors in site 1 do not have direct access to terminal markets or exporters. They rely on market agents and intermediary markets to sell their goods. Hence, the share of consumer rupee at the processing and fisher level is lower in site 1 than in site 2.

Trade links are becoming more complex as communication and transportation facilities improve. Traders are now operating on a larger scale, targeting different markets for specific species and better price realization. They used to have commission agents at the community level, but with higher fluctuations in supply, they are diversifying their procurement base. Such horizontal material exchange has resulted in the emergence of a new set of market actors. Because of the expanded BOM structure of preferred species for dried fish production, there is a greater alignment and consolidation of actors. In Sunakhala, for example, 45% (9 out of 20) of dried fish wholesalers have shifted their trade focus to other activities such as frozen fish, fish mill, and animal feed. This suggests that the inter and intra-node linkages are becoming dynamic with varied implications for different actors in the chain.

4.3. Uncertainties

Uncertainty is a critical attribute in the social-ecological system [52]. It is characterized by random fluctuations, surprises by nature, and structural uncertainties [53]. It includes multiple micro and macro factors that influence demand and supply variability in the value chain in terms of product, process, price, people, and place relationships. The study area is frequented by natural disasters. Such surprises by natural forces have a strong influence on DFVC. The structural uncertainties in the study area are also influenced by policy and programmatic dimensions related to the prolonged fishing ban and blue economy drivers.

Responses from value chain players across nodes, including fishers and dried fish processors (Figure 7), indicate a decrease in catch, prolonged fishing trips resulting in high input costs, a decrease in CPUE, and greater fish/fish product mobility. Furthermore, macro drivers such as zero import duty on low-value fish, expanded BOM structures, and blurred geographic divisions are acting as triggers for strong market fluctuations and less control over resource flows to optimize the enterprise's use of fixed and variable costs. The

perishability of fish, combined with the low financial capacity of the fishers and dried fish processors, adds to the complexities of management decisions. The impacts of climate change are also felt on fisheries. Changing climate vectors are resulting in impacts at two levels; first, on fish stocks, and second, on the critical marine and coastal ecosystems on which they depend [54].

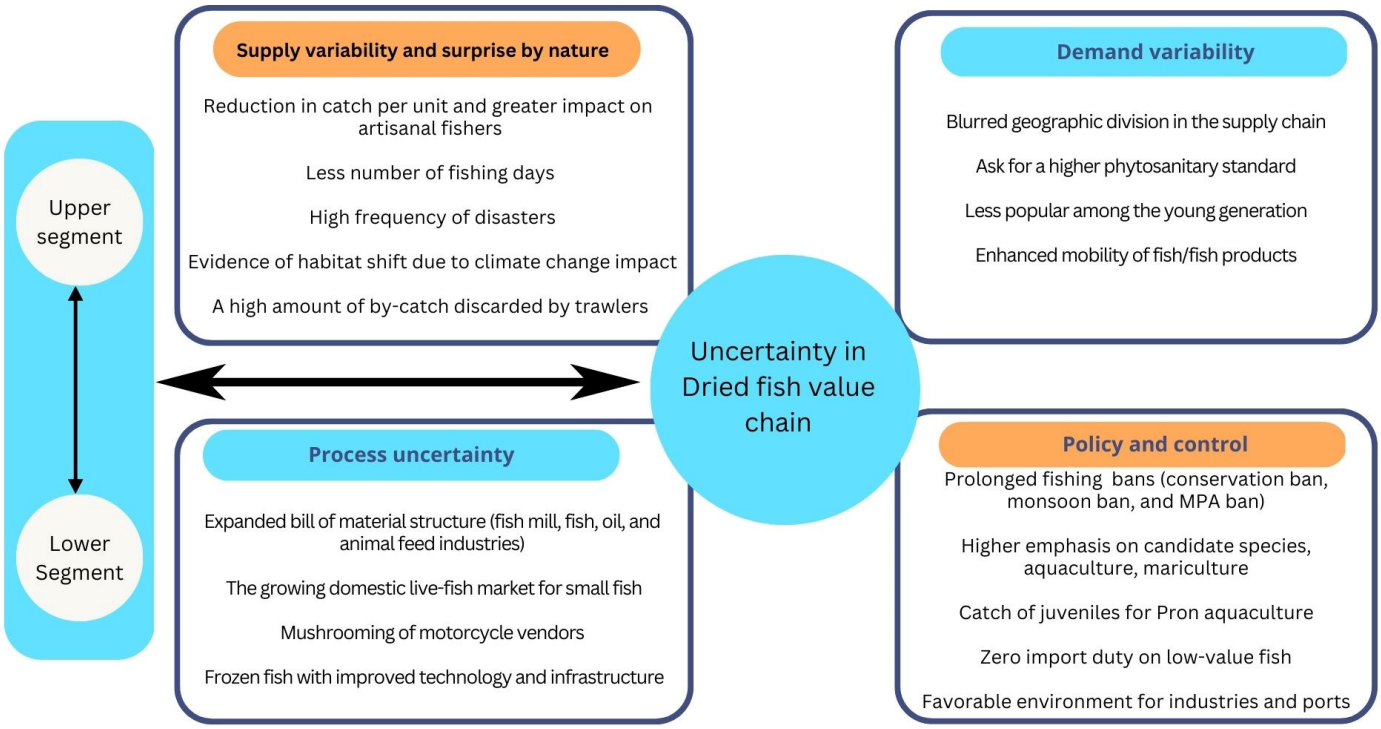

Figure 7. Matrix of key characteristics of uncertainties in the study location.

The feedback from environmental factors is causing market system distortion in the study location. The region is experiencing increasingly severe weather events. Because of its flat terrain and deltaic plain formations, India's east coast is considered more vulnerable [5]. According to the Indian National Centre for Ocean Information Services (INCOIS) study, the study region, which includes Jagatsinghpur, Kendrapada Balasore, and neighboring areas, has a high to medium coastal vulnerability index (CVI value of 4.5 to 9.5 is considered as medium and above 9.5 is high) [55]. According to the Intergovernmental Panel on Climate Change (IPCC) the frequency and intensity of tropical cyclones in this area are expected to increase [56–58]. Over the last 100 years, the region has experienced 262 cyclonic disturbances, including 69% of depressions, 22% of storms, and 9% of severe cyclonic storms [56,57]. According to a spatiotemporal study conducted by Bandopadhyay et al. [59], 80% of the storms that occur in the North Indian Ocean hit landfall in the Bay of Bengal, of which 40% hit Odisha and the West Bengal Coast (Figure 8). The graph below depicts the occurrence of cyclonic storms in the study region over seven time periods. The sixth assessment report of the IPCC indicates greater uncertainty with a higher frequency of severe cyclones [59].

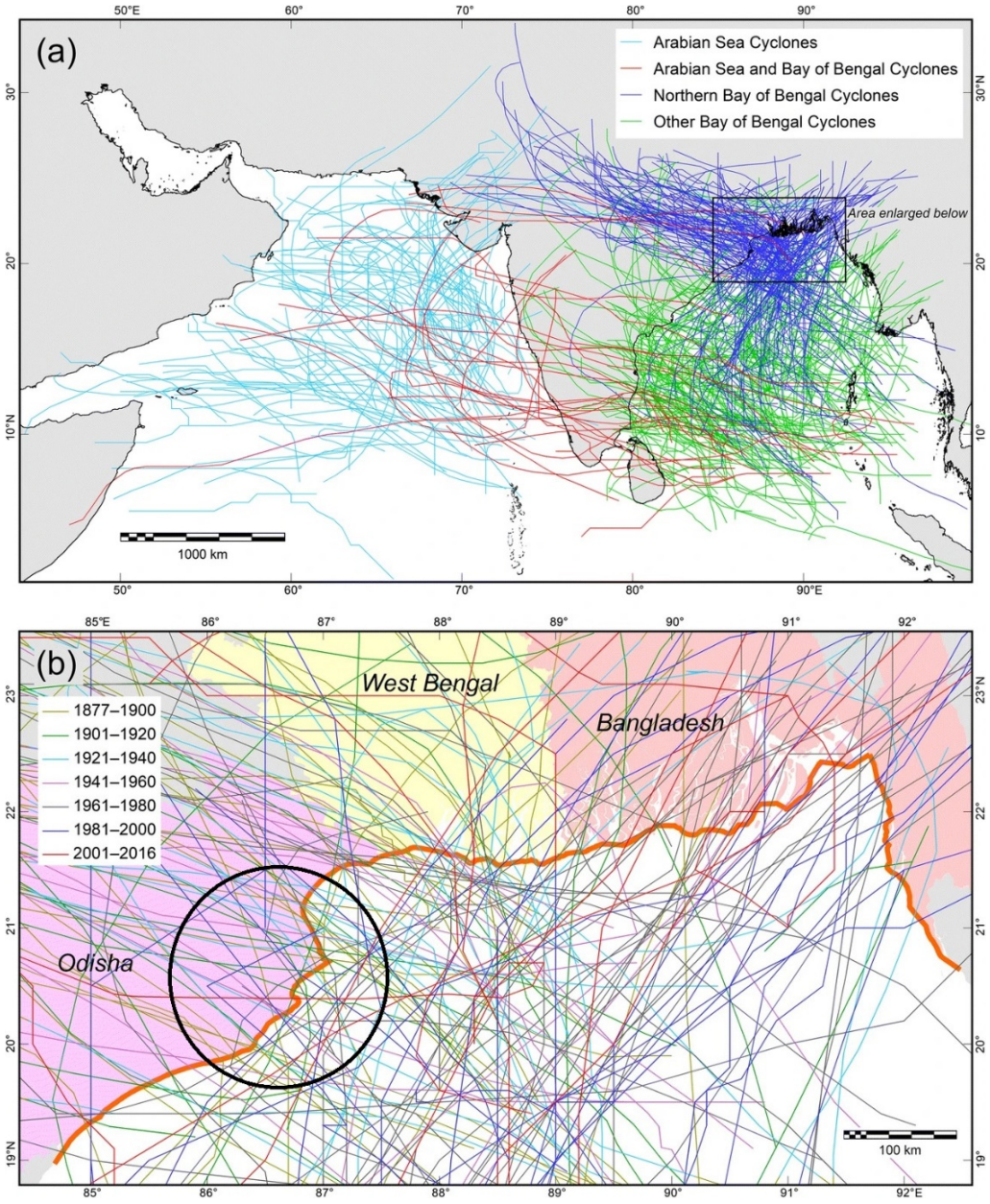

Figure 8. Storm and landfall analysis in the northern Bay of Bengal from 1877 to 2016 based on storm track data from IBTrACS and IMD; (**a**) Cyclone landfall in Northern Indian Ocean basin and (**b**) landfalling in Northern Bay of Bengal basin including Odisha, West Bengal and Bangladesh coasts. (Adapted from Spatiotemporal Analysis of Tropical Cyclone Landfalls in Northern Bay of Bengal, India, and Bangladesh by Bandyopadhyay et al., 2021 p. 802 [59]). Black circle indicates the case study location.

There is also evidence of habitat shifts of different species due to variability in climatic as well as oceanographic parameters. Changes in marine species migration patterns have been observed in two important dried fish species, including Indian mackerel and Oil sardine, over the last 50 years [55]. One 54-year-old person from Kajalapatia village narrated one incident that justifies such scientific analysis. He said at his young age, "*During blue moon time, once he caught 70 bags of Indian sardines in one day. Now it is a dream. Even after two days of fishing, they are returning with 50–100 kg of fish during the blue moon period.*"

According to the study community members, they have never experienced such a situation of three cyclones in successive years. Cyclones Fanni, Amphan, and Yash hit the coast back-to-back within three years. The frequency of weather warnings for refraining

from fishing due to weather disturbances has also increased. While the information system is helping them to a great extent to save lives and assets, such weather disturbances cause a reduction in fishing days. In the case of dried fish operations, the small-scale operators are taking much longer periods, say for several months together, to resume their work as most of their assets, like racks, containers, and sheds, are often lost to such events. The fishers who are doubling up their roles with drying have revealed that in such events they first look for resources to resume their fishing operations so that they can have some earnings instead of focusing on drying activities. At site 2, with back-to-back cyclones, they had to temporarily suspend drying activities as their basic infrastructure was completely destroyed. However, they are now selling fish to live-fish traders in Digha, Chandanpur, and Balasore. The environmental vulnerability, production, and trade uncertainties are multiplied due to the prolonged ban for seven months, including the conservation and monsoon ban periods. The supply is erratic as the conservation ban prohibits fishing by artisanal boats within a five km radius, by motorized boats within 10 km, and by trawlers within a 20 km radius.

As far as the demand side uncertainties are concerned, respondents' order of importance varied considerably. The growth of the domestic live-fish market for small fish, the mushrooming of motorcycle vendors, and the low preference by the younger generation for dried fish were cited as the main reasons that had also been impacting the dried fish sector. However, people also said that there is an emerging new market for selective species like anchovy, dried prawn, and Khainga through online trade if it is processed with the desired phytosanitary measures and with less ordure. Such demand uncertainties call for value chain support in terms of common infrastructure facilities, quality control assistance to small-scale processors, and creating an enabling environment for dried fish processors to access the new markets.

Uncertainties have also multiplied under the influence of various government policies. The prolonged fishing ban has a disproportionate impact on the fishers operating in non-mechanized boats who contribute most to the dried fish. Besides this, the higher emphasis on aquaculture, industrialization, and ports causes pollution and adverse impacts on the near shore catch. According to a few respondents, "*Due to pollution, the fish movement has changed significantly; they are not found in or near the shore area.*" "*We are noticing that large quantities of fish are dying when they enter into polluted waters.*" (Respondents 2 and 4 from site 1). Additional challenges are stemming from the recent import duty relaxation for small fish imports by some Asian countries; this changes pricing and product mobility dynamics.

4.4. Emergence

SESDFVC with non-linear system feedback, dynamic linkages, and inherent uncertainties provides for multiple equilibria. It embraces new adaptations through its emergent properties [6]. The dried fish operations in the study region exhibit emergent properties across the value chain nodes. The dynamic resource and policy context triggered multiple changes and adjustments in the value chain operations. Changes and new adaptations have been observed in both the lower and upper segments of the DFVC. When asked about changes in dried fish operations, varied responses have been obtained. A maximum number of respondents cited various threats that are causing adjustments and changes in dried fish practice. Table 6 provides the response matrix of processors on the first reasons cited for changing dried fish operations.

Table 6. Response matrix on reasons for change in dried fish practice mentioned by the respondents (N = 24).

Reason for Change in Processing Sector	1st Reason Cited (% of Response)
Low catch per unit	25
Restriction on fishing in estuarine area and artisanal fishing area	20
Bottom trawling Sona boat and trawlers	17
High by-catch discarded by mechanized boats	13
Pollution	17
Fish mill and animal feed	8

Source: Primary data collected by the first author through semi-structured interviews of dried fish processors.

The volatility and unorganized nature of the dried fish market exert a higher financial burden on self-employed dried fish processing units, which mostly depend on their own catch for drying. The spatial features of the study area (Table 7) imply a greater appetite for the motorization of traditional crafts by lower-end value chain actors. The policy preference for aquaculture, candidate species, together with the emerging market in the sea and subgroup collaborations among value chain actors are leading to novel fishing practices and labor dynamics. This also triggers intracommunity conflicts (e.g., mechanized boat owners vs. artisanal fishers). Self-employed enterprises are also adjusting their roles as live fish sellers or dried fish processors and sellers, based on the type of fish catch and weather conditions.

Table 7. Spatial features of emergence in SESDFVC.

Variables	Emergent Properties in SESDFVC	
	Upper Segment	**Lower Segment**
Fishing and processing modalities Collaborations and integration Species preferences	• Higher uptake of motorization of crafts, more value to bycatch and trash fish • The export potential and trade signals altered fishing practices towards candidate species like shrimp • Stronger subgroup collaboration prompts intra-community conflicts • Growing market in the sea • New labor dynamics with focus on aquaculture, mechanized fishing, and expanded BOM.	• Regionalization of trade • Blurred geographic division in fish movement • Higher imports of Indian mackerel and Oil sardine from neighboring countries • Species-focused trade arrangement and climate-induced shift in fish habitat • Greater consolidation and specialization as a result of enlarged domestic live fish market, frozen fish, other fish products like fish mill, and animal feed.

Source: Primary data collected by the first author (household surveys and semi-structured interviews).

By adopting such a situation-specific strategy, they are both ensuring employment and coping with financial stress on a day-to-day basis. Mechanized boat owners are also keeping small boats to cope with the seven-months conservation ban, as mechanized boats are not allowed within 20 km of the coastline. The lower-end value chain actors are adjusting their operations with a greater focus on capacity optimization through various strategies. The traders (n = 8) reported that the species-based geographic advantage has been blurred with the expansion of the sourcing base by the traders, which increased product movement from one state to the other. There is a growing importance of regionalization of trade by consolidating actions on specific value streams like frozen fish, live fish, fish products, and dried fish as per local consumer preference. The procurement agents from West Bengal are relying more on Paradeep and Huma markets. All the dried fish processors on sites 1 and 2 said that they sell their produce to West Bengal agents. According to a trader from the Sunakhala market, "*Getting a type of dried fish is not a big problem, but the real problem is*

cost, and assurance of availability based on demand. Now they have to maintain a greater stock with their own secondary processing facilities like second order sorting, grading, and drying." Such processes add to the cost, and according to him, the emerging feed market is really helpful as, in the case of spoilage of stock, they are not completely on the losing side.

At practice and skill levels, there have been multiple adaptations both at the upper and lower ends of DFVC (Table 8). The adoption and upgradation of technology in fishing, drying, improving safety, and disaster risk reduction are changing the dynamics in the upper segment of the DFVC. However, most of the traditional craft owners and small-scale producers so far do not have access to such technological options. In the case of lower-end value chain actors, the new emergences are seen in terms of tapping new markets with a greater focus on odorless packaging, popularization of e-market platforms, greater use of communication technology for price discovery, and e-governance platforms to facilitate trade.

Table 8. Technology and skill dimensions of emergence in SESDFVC.

Variables	Emergent Properties in SESDFVC	
	Upper Segment	**Lower Segment**
Adoption of new tools, gears, business processes	• Adoption of new technology like underwater cameras to track fish movement • Gradual transition in crafts from manual to small engine fitted boat to high engine power, Sona boat, etc. Gill nets and bag nets are increasingly used in all sectors except manual boats due to shift in target catch • Families having more human resources are assuming the role of aggregator within the village • Small solar driers mostly promoted through government projects (ICZMP, NRLM, PMMSY) • Sporadic cases of certification • Better preparedness through reliable weather forecasting and warning system • Improved safety features with pucca housing and multi-purpose cyclone shelters	• Better packaging techniques • Use of e-marketing platforms • Stronger communication platforms for price inventory • E-governance platforms to facilitate activities related to trade and export

Source: Primary data collected by the first author through household surveys and semi-structured interviews.

The dried fish value chain is diverse and has been strongly influenced by place-based values [1,6]. In the face of higher levels of marginalization, blurring caste and community-based identity, and the collapse of the geographical division of fish input and labor, the value chain actors are continuously realigning themselves to meet the challenges (see Table 9). At study site 1, fishers and dried fish processors are mostly migrant workers from West Bengal. According to our village survey, 57% of households settled here between 1920 and 1970, and they are immigrants from neighboring places and elsewhere in the state of West Bengal. They migrated with a motivation related to higher fish availability. Further, immigration was accentuated after the 1971 Bangladesh war.

Fishers are attempting to broaden their social networks as a coping mechanism despite low CPUE and increased financial stress. They are prioritizing community relationships over individual financial gain. Such social ties also help in sharing labor, capital, and assets with a higher trust level. Eighty-four percent (n = 40) of respondents stated that it strengthens their identity and political positioning as they share similar vulnerabilities. At the same time, women have started playing a greater role in dried fish value chain operations.

Table 9. Place-based values and dimensions of emergence in SESDFVC.

Variables	Emergent Properties in SESDFVC	
	Upper Segment	**Lower Segment**
Place-based values	• Strengthening community voice by facilitating immigration in site 1 as most of the fishers and dried fish processors are migrants from West Bengal and other coastal areas of Odisha • Women are assuming greater control with higher government patronage through self-help groups, producer groups, etc. • The traditional knowledge of Uthia, Padia, and fish habitats aids to recalibrate labor and finance for process optimization. They migrate to nearby towns for wage labor during the dry spell of the month and year • With growing mechanization and motorization, fishers are opting for co-ownership of vessels due to low individual investment capacity • The prolonged ban for seven months in site 1 is forcing people to opt for jobs in mechanized fishing sectors and other unskilled jobs. • Many fishers and dried fish operators particularly in site 2 are seeking labor opportunities in aquaculture farms • External and internal factors like conservation bans, MPAs, monsoon bans, high bi-catch discards by trawlers are recalibrating the occupation in terms of skill, technology, and identity. However, 72% of respondents consider fishing as their first choice and resilient force to deal with uncertainties at the workplace • The new trend of women going into the river and sea is found in site 1 to manage economic stress and labor scarcity	• Traditional supply chain is unreliable with high fluctuation of catch. The traders are no longer solely dependent on community-level agents in coastal villages • The interaction with markets like Balighai in West Bengal and Huma has changed. • There is stronger coordination with these markets for product mobility • The traders in Sunakhala were earlier dependent on Huma on buying of dried fish and trading in interior pockets of Odisha. Now there is circular movement of produce. If they are not getting better prices in local market, they are reselling the stock in the Huma market itself.

Source: Primary data collected by the first author through household surveys and semi-structured interviews.

Due to rising costs and altered labor dynamics, women at site 1 have begun boarding the boat alongside their spouses. The other factor is that many women prefer spouses who are in stable employment. It is encouraging young people to work in both the fishing industry and in other sectors. On the other hand, the processors in site 2 have acquired skills from migrant dried fish processors from neighboring districts of West Bengal and started practicing the same to expand employment and income opportunities. They are now compensating for the effort with a higher amount of by-catch and small fish, about which they were not very concerned earlier.

The lower-end value chain actors are adopting corporate value chain integration models wherein they are trying to reduce externalities by investing in all nodes of the value chain, tapping favorable national and international trade regulations in favor of mechanized fishing, and creating processing and export facilities. For example, Falcon Marine exports, India, having a base in Odisha, has investments in the entire fish value chain, including inbound logistics.

A widespread practice in the dried fish market space is what is known as "adjusted vertical integration." Such practice allows one of the value chain actors, mostly the wholesalers and traders, to exercise greater control over the value chain through the engagement of commission agents and middlemen. They also control the marketing infrastructure through membership-based cooperatives. Many fishers and small-scale processors are not allowed to be members of the cooperative due to low volume of production, identity, and access issues. While all the fishers are members of the Kharinasi (site 1) and Kirtania (site 2) boat associations, the processors do not have membership in the fisheries association. There has also been a growing incidence of horizontal integration, mostly between banks, the

financial sector, and the insurance sector. Such integration is mostly financial in nature. Additionally, it has been noticed that there is an increase in investment toward safeguarding the procurement base through advanced payment, deploying area and species-specific commission agents, and improving the quality of the produce.

4.5. SESDFVC: A Novel Framework for Analysing the Dried Fish Value Chain

The SESDFVC approach illustrates a novel perspective where the value chain structure, conduct, and performance need to be reimagined with a new set of attributes and factors influencing horizontal and vertical interactions in the value chain [6]. The nonlinear interplay of knowledge, technology, policy, biological flows, customary norms, social interactions, and blurred division in actor roles are critical features of the dried fish value chain in the Bay of Bengal region [4–6]. It is evident that the resource system plays a critical role and has a stronger influence over the production, market and labor dynamics in the DFVC [6]. There is a positive correlation between fish production and dried fish production through small-scale operators, their power in the market in terms of price, access to different markets, and credit structures. A historical study from Myanmar also suggests that there is a direct correlation between the intensification of coastal fishing, declining catch per unit effort, and a reduction in daily quantities of fish dried by women workers [60].

The analysis offers a new lens to analyze the DFVC. The effective mapping of feedback, linkages, uncertainties, and emergences within and across value chain nodes has greater implications in removing trade barriers in terms of dried fish processing infrastructure, access to fair credit systems, uptake of welfare schemes, transparency in trade transactions, greater buyer-seller interface, structured price discovery mechanisms and gender and caste-based inequalities [16].

The attribute level analysis also implies that there are multiple horizontal and vertical feedback loops between and within different value chain nodes (Figure 9). The feedback is non-linear, and has a stronger spatial, temporal, and scale dimension. The non-linear view of feedback has the potential to reimagine value chain efficiency and effectiveness pathways that are critical for ideal value chain conduct. The departure of thinking from profit and market logic to system logic that involves social, economic, and ecological interactions provides a comprehensive understanding of place-based and actor-based issues in a disaggregated manner. This has greater implications for analyzing the issues and structural barriers with upper-end value chain actors and enabling them to participate in the value chain decision-making process.

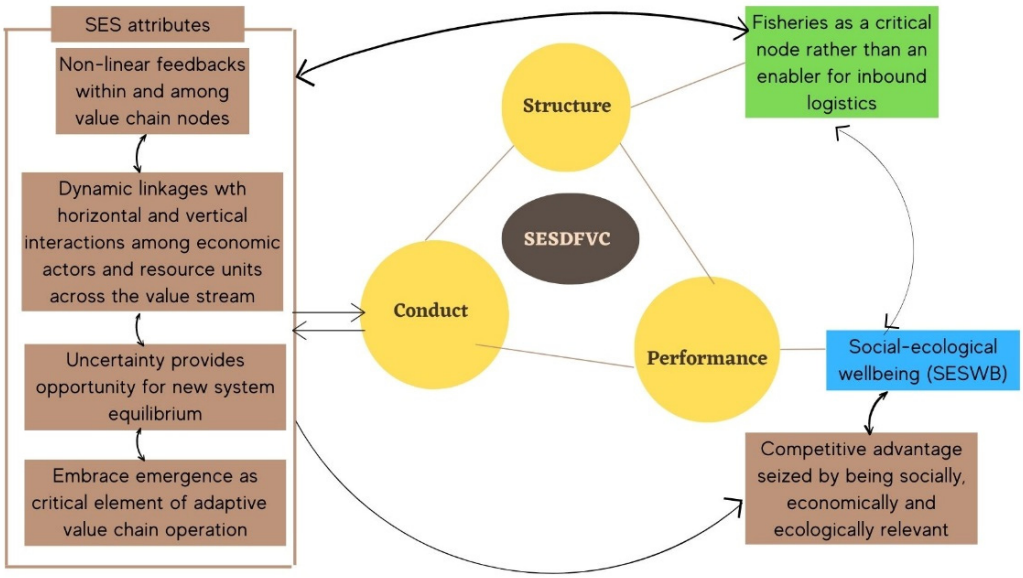

Figure 9. Mapping interactions of SES attributes in SES dried fish value chain having fisheries resource as critical value chain node.

Scholars working on pro-poor value chains consider the power of the poor in the market and their active participation in the value chain, as the most critical aspect of the value chain's functioning. The lack of access and agency of the poor often serves the interests of the people in power [61]. DFVC is also witnessing fuzzy boundaries across the nodes, and the interactions among economic agents are evolving on a temporal and spatial scale. Conventional value chains, in their quest for risk minimization and efficiency, often fail to appreciate such dynamism and tend to promote vertical integration. The adjusted vertical integration limits the scope of upper-end value chain actors to participate in the value chain as equals. However, the SESDFVC, by appreciating dynamic nature-human interactions, has greater potential to positively influence value chain connection with social-ecological wellbeing issues.

Another way to look at this system connection from an ethics and justice perspective is a critical pathway for achieving environmental and social sustainability [62]. Redressal of social inequalities and improved access to resources can enhance the actors' ability to benefit fully from their participation in the value chain [4,63]. SESDFVC analysis provides for greater discussion on justice in terms of access and interactions with both the ecosystem and affected human communities through a multi-scalar perspective. The study region is exposed to a high level of uncertainty associated with natural hazards and market and policy processes. Conventional value chain processes are tuned towards engaging with uncertainties through a risk minimization framework governed by organizational and supply chain efficiency logic [6,33]. In contrast, SESDFVC recognizes uncertainty as a critical attribute that brings in emergences and makes the system adaptive to constant change. Competitive advantage is seized by being culturally, ecologically, and socially relevant. Therefore, SESDFVC is better placed to promote community stewardship and attain sustainability standards and certifications such as MSC (Marine Stewardship Council) or ASC (Aquaculture Stewardship Council). Such certification has the potential to strengthen reinforcing feedback loops by incentivizing fair trade practices.

The research was challenged by the limited literature on dried fish value chains and dried fish social-ecological systems. At the same time, the COVID-19 pandemic posed several restrictions, and the application of methods that involved interactions in a group setting was avoided. Even though the study benefited from the insights gained through the situational presence of the principal investigator in the research location, the group interaction tools would have added further value to this research. The positionality of the research on analyzing the dried fish value chain from the perspective of upstream actors including fishers and dried fish processors should therefore be considered within a constrained mobility scenario. This leaves future research scope to advance a fuller understanding of the entire dried fish value chain by incorporating insights from varied place-based operational practices and chain actors in the larger product geography.

5. Conclusions

In this study, we posit that the Dried Fish Value Chain (DFVC) analysis with neoclassical economic framing is inadequate to explain the value that is understood beyond financial flows. It has provided an empirical ground for the social-ecological system-oriented dried fish value chain (SESDFVC) framework as a new tool to perceive value chain structure, conduct, and performance with a greater understanding of system feedback, linkages, uncertainties, and emergences. Such a perspective appreciates dried fish as a diverse, relational, place-based practice with continuous adaptation at different scales and levels. Our empirical mapping of DFVC in Odisha and West Bengal coastal communities revealed that it is also marked by dispersed production systems having a large number of self-employed enterprises. Often, people involved in dried fish operations have mixed identities. SESDFVC with consideration of bio-physical resources as an important value chain node is capable of reimagining an actor's role in the value chain and establishing the higher significance of upper-segment actors in value chain decision-making.

SESDFVC has an inherent capacity to shift the narrative to understand value chain conduct and performance by appreciating the social-ecological connections of the value chain actors with dynamism in the fisheries resource system. It prioritizes material, relational, subjective, and ecological wellbeing over a narrow financial value framework. Therefore, material, relational, subjective, and ecological wellbeing hold greater importance over mere financial return as value. Value is accrued through diverse ways in a social-ecological system context [12].

In addition, further research is required to evaluate SESDFVC for facilitating macro processes such as sustainable development pathways and attaining a code of conduct for responsible fisheries (CCRF) compliance.

Author Contributions: Conceptualization, S.K.P.; Methodology, S.K.P.; Formal analysis, S.K.P.; Data curation, S.K.P.; Writing—original draft, S.K.P.; Validation, P.K.N. and C.E.H.; Writing—review & editing, P.K.N. and C.E.H. All authors have read and agreed to the published version of the manuscript.

Funding: International Development Research Centre: 109120-021; Dried fish Matters Project; V2V global partnership project (Grant Number: 895-2020-1021), SSHRC and World Fish.

Institutional Review Board Statement: The research complied with the University of Waterloo Statement on Human Research (2018) and was consistent with the Tri-Council Policy on Research Involving Living Human Participants (TCPS 2, 2014). The core principles of this policy—respect for people, concern for welfare, and justice—were maintained while conducting research. The approved Ethics Protocol for the field research (ORE # 41888) addressed all relevant considerations and risk mitigation, including, informed consent during participant recruitment; protecting privacy, anonymity, and confidentiality; data storage and password protection; reciprocity, trust, and relationships.

Informed Consent Statement: Necessary consent has been obtained from the study particpants as part of University of Waterloo ethics board (ORE # 41888).

Data Availability Statement: The data and literature sources used in this paper are available from the corresponding author with reasonable interest.

Conflicts of Interest: The authors declare that they have no conflict of interest.

References

1. Belton, B.; Johnson, D.S.; Thrift, E.; Olsen, J.; Hossain, M.A.R.; Thilsted, S.H. Dried fish at the intersection of food science, economy, and culture: A global survey. *Fish Fish.* **2022**, *23*, 941–962. [CrossRef]
2. Thilsted, S.H.; James, D.; Toppe, J.; Subasinghe, R.; Karunasagar, I. *Maximizing the Contribution of Fish to Human Nutrition*; FAO: Rome, Italy, 2014; 16p.
3. Vidaček, S.; Janči, T. Safety of Fish Products. In *Regulating Safety of Traditional and Ethnic Foods*; Academic Press: Cambridge, MA, USA, 2016; pp. 79–97.
4. Belton, B.; Hossain, M.A.R.; Thilsted, S.H. Labour, Identity and Wellbeing in Bangladesh's Dried Fish Value Chains. In *Social Wellbeing and the Values of Small-Scale Fisheries*; Johnson, D.S., Acott, T.G., Stacey, N., Urquhart, J., Eds.; MARE Publication Series; Springer International Publishing: Cham, Switzerland, 2018; Volume 17, pp. 217–241, ISBN 978-3-319-60749-8.
5. *GoI Handbook on Fisheries Statistics, 2020*; Department of Fisheries, Ministy of Fisheries, Animal Husbandry and Dairying, Governmetnt of India: New Delhi, India, 2020.
6. Pradhan, S.K.; Nayak, P.K.; Armitage, D. A Social-Ecological Systems Perspective on Dried Fish Value Chains. *Curr. Res. Environ. Sustain.* **2022**, *4*, 100128. [CrossRef]
7. *GoI Hand Book on FIsheries Statistics, 2014*; Department of Fisheries, Ministy of Fisheries, Animal Husbandry and Dairying, Governmetnt of India: New Delhi, India, 2014.
8. *Odisha State Action Plan on Climate Change (2015–20)*; Government of Odisha: Bhubaneswar, India, 2015.
9. Kaplinsky, R.; Morris, M. *A Handbook for Value Chain Research*; University of Sussex: Brighton, UK; Institute of Development Studies: Falmer, UK, 2000; Volume 113.
10. Gereffi, G.; Humphrey, J.; Sturgeon, T. The Governance of Global Value Chains. *Rev. Int. Political Econ.* **2005**, *12*, 78–104. [CrossRef]
11. Attaie, H.; Fourcadet, O. *Guideline for Value Chain Analysis in the Agri-Food Sector of Transitional and Developing Economies*; ESSEC Business School: Cergy, France, 2003.
12. Fabinyi, M.; Dressler, W.H.; Pido, M.D. Moving beyond Financial Value in Seafood Commodity Chains. *Mar. Policy* **2018**, *94*, 89–92. [CrossRef]
13. Johnson, D. *Social Well-Being and the Values of Small-Scale Fisheries*; Springer: Berlin/Heidelberg, Germany; New York, NY, USA, 2017; ISBN 978-3-319-60749-8.

14. Nayak, P.K.; Berkes, F. Commonisation and Decommonisation: Understanding the Processes of Change in the Chilika Lagoon, India. *Conserv. Soc* **2011**, *9*, 132. [CrossRef]
15. Ostrom, E. A Diagnostic Approach Going beyond Panaceas. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 15181–15187. [CrossRef]
16. Adger, W.N. Vulnerability. *Glob. Environ. Chang.* **2006**, *16*, 268–281. [CrossRef]
17. Jentoft, S. The Community: A Missing Link of Fisheries Management. *Mar. Policy* **2000**, *24*, 53–60. [CrossRef]
18. Ferguson, C.E.; Bennett, N.J.; Kostka, W.; Richmond, R.H.; Singeo, A. The Tragedy of the Commodity Is Not Inevitable: Indigenous Resistance Prevents High-Value Fisheries Collapse in the Pacific Islands. *Glob. Environ. Chang.* **2022**, *73*, 102477. [CrossRef]
19. De Silva, D.A.M. *Value Chain of Fish and Fishery Products: Origin, Functions and Application in Developed and Developing Country Markets*; Food and Agriculture Organization: Rome, Italy, 2011; pp. 1–53.
20. Schuurhuizen, R.; van Tilburg, A.; Kambebwa, E. Fish in Kenya: The Nile-Perch Chain'in. In *Agro-Food Chains and Networks for Development: Issues, Approaches and Strategies*; Ruben, R., Slingerland, M., Nijhoff, H., Eds.; Springer: Dordrecht, The Netherlands, 2006; ISBN 9781402046001.
21. Berkes, F.; Colding, J.; Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2003; ISBN 978-0-521-81592-5.
22. Nayak, P.K.; Armitage, D. Social-Ecological Regime Shifts (SERS) in Coastal Systems. *Ocean Coast. Manag.* **2018**, *161*, 84–95. [CrossRef]
23. Kates, R.W.; Parris, T.M.; Leiserowitz, A.A. What Is Sustainable Development? Goals, Indicators, Values, and Practice. *Environ. Sci. Policy Sustain. Dev.* **2005**, *47*, 8–21. [CrossRef]
24. Nayak, P.K.; Oliveira, L.E.; Berkes, F. Resource Degradation, Marginalization, and Poverty in Small-Scale Fisheries: Threats to Social-Ecological Resilience in India and Brazil. *Ecol. Soc.* **2014**, *19*, art73. [CrossRef]
25. Nayak, P.K.; Berkes, F. Interplay Between Local and Global: Change Processes and Small-Scale Fisheries. In *Transdisciplinarity for Small-Scale Fisheries Governance*; Chuenpagdee, R., Jentoft, S., Eds.; MARE Publication Series; Springer International Publishing: Cham, Switzerland, 2019; Volume 21, pp. 203–220. ISBN 978-3-319-94937-6.
26. Haggblade, S.; Theriault, V.; Staatz, S.; Dembele; Diallo, B. *A Conceptual Framework for Promoting Inclusive Agricultural Value Chains*; Michigan State University: East Lansing, MI, USA, 2012.
27. Berkes, F.; Ross, H. Panarchy and Community Resilience: Sustainability Science and Policy Implications. *Environ. Sci. Policy* **2016**, *61*, 185–193. [CrossRef]
28. Binder, C.R.; Hinkel, J.; Bots, P.W.G.; Pahl-Wostl, C. Comparison of Frameworks for Analyzing Social-Ecological Systems. *Ecol. Soc.* **2013**, *18*, art26. [CrossRef]
29. Cash, D.W.; Adger, W.N.; Berkes, F.; Garden, P.; Lebel, L.; Olsson, P.; Pritchard, L.; Young, O. Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World. *Ecol. Soc.* **2006**, *11*, art8. [CrossRef]
30. Kooiman, J.; Bavinck, M.; Chuenpagdee, R.; Mahon, R.; Pullin, R. *Interactive Governance and Governability: An Introduction*; Edward Elgar Publishing: Cheltenham, UK, 2005; 11p.
31. Sundkvist, Å.; Milestad, R.; Jansson, A. On the Importance of Tightening Feedback Loops for Sustainable Development of Food Systems. *Food Policy* **2005**, *30*, 224–239. [CrossRef]
32. Biggs, R.; Rhode, C.; Archibald, S.; Kunene, L.M.; Mutanga, S.S.; Nkuna, N.; Ocholla, P.O.; Phadima, L.J. Strategies for Managing Complex Social-Ecological Systems in the Face of Uncertainty: Examples from South Africa and Beyond. *Ecol. Soc.* **2015**, *20*, art52. [CrossRef]
33. Simangunsong, E.; Hendry, L.C.; Stevenson, M. Supply-Chain Uncertainty: A Review and Theoretical Foundation for Future Research. *Int. J. Prod. Res.* **2012**, *50*, 4493–4523. [CrossRef]
34. Sawyer, R.K.; Sawyer, R.K. *Social Emergence: Societies as Complex Systems*; Cambridge University Press: Cambridge, UK, 2005; ISBN 0-521-84464-9.
35. Moore, M.-L.; Olsson, P.; Nilsson, W.; Rose, L.; Westley, F.R. Navigating Emergence and System Reflexivity as Key Transformative Capacities: Experiences from a Global Fellowship Program. *Ecol. Soc.* **2018**, *23*, art38. [CrossRef]
36. Creswell, J.W.; Creswell, J.D. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*; Sage Publications: New York, NY, USA, 2017.
37. Harrison, H.; Birks, M.; Franklin, R.; Mills, J. Case Study Research: Foundations and Methodological Orientations. *Forum Qual. Sozialforsch.* **2017**, *18*, art19. [CrossRef]
38. Merriam, S.B.; Tisdell, E.J. *Qualitative Research: A Guide to Design and Implementation*, 4th ed.; The Jossey-Bass higher and adult education series; John Wiley & Sons: San Francisco, CA, USA, 2015; ISBN 978-1-119-00365-6.
39. Yin, R.K. *Discovering the Future of the Case Study. Method in Evaluation Research*; JAI Press Inc.: Stamford, CT, USA, 1994; 8p.
40. *Fisheries Department Anual Activity Report, Odisha*; Government of Odisha: Bhubaneswar, India, 2021.
41. Béné, C. Are Fishers Poor or Vulnerable? Assessing Economic Vulnerability in Small-Scale Fishing Communities. *J. Dev. Stud.* **2009**, *45*, 911–933. [CrossRef]
42. Kourkouliotis, K.; Olomu, K. The SFLP Project Guidelines. In *SFLP Liaison Bulletin*; FAO: Rome, Italy, 2002.
43. Devadasan, K.; Boopendranath, M.R. Fishing Craft and Gear for Small Pelagics. In Proceedings of the National Conference on Marine Fisheries and Fisheries Harbour Infrastructure, Mumbai, India, 7–8 February 2009; pp. 7–8.
44. Ghosh, R.; Mukherjee, J.; Pathak, S.; Choudry, A.; Bhattacharya, S.; Sen, A.; Patnaik, P. *A Situational Analysis of Small-Scale Fisheries in the Sundarbans, India: From Vulnerability to Viability 2022*; University of Waterloo: Waterloo, ON, Canada, 2022.

45. Pramod, G. *Illegal, Unreported and Unregulated Marine Fish Catches in the Indian Exclusive Economic Zone*; University of British Columbia: Vancouver, BC, Canada, 2010.
46. Pramod, G.; Pitcher, T.J. In Defence of Seafood Import Analysis: Credulity Bamboozled by Supply Chain Laundering. *Mar. Policy* **2019**, *108*, 103651. [CrossRef]
47. *Fisheries Statistics of Four Districts 2022*; Government of Odisha: Bhubaneswar, India, 2022.
48. *SIWI World Water Week 2019 Impact Report*; SIWI: Stockholm, Sweden, 2019.
49. Salim, S.S. *Indian Seafood Industry and Post WTO—A Policy Outlook*; Central Marine Fisheries Research Institute: Kochi, India, 2012.
50. Ommer, R.E.; Perry, R.I.; Murray, G.; Neis, B. Social–Ecological Dynamism, Knowledge, and Sustainable Coastal Marine Fisheries. *Curr. Opin. Environ. Sustain.* **2012**, *4*, 316–322. [CrossRef]
51. Berkes, F.; Berkes, M.K. Ecological Complexity, Fuzzy Logic, and Holism in Indigenous Knowledge. *Futures* **2009**, *41*, 6–12. [CrossRef]
52. Charles, A.T. Living with Uncertainty in Fisheries: Analytical Methods, Management Priorities and the Canadian Groundfishery Experience. *Fish. Res.* **1998**, *37*, 37–50. [CrossRef]
53. World Bank (Ed.) *The Sunken Billions Revisited: Progress and Challenges in Global Marine Fisheries*; Environment and sustainable development; World Bank Group: Washington, DC, USA, 2017; ISBN 978-1-4648-0947-7.
54. Zacharia, P.U.; Gopalakrishnan, A.; George, G.; Muralidhar, M.; Vijayan, K.K. *Climate Change Impact on Coastal Fisheries and Aquaculture in the SAARC Region: Country Paper–India*; CMFRI: Kochi, India, 2016.
55. Kumar, T.S.; Mahendra, R.S.; Nayak, S.; Radhakrishnan, K.; Sahu, K.C. Coastal Vulnerability Assessment for Orissa State, East Coast of India. *J. Coast. Res.* **2010**, *263*, 523–534. [CrossRef]
56. Barik, S. *Odisha Fishermen Vulnerable Due to Frequent Cyclonic Events*; The Hindu: Chennai, India, 2019.
57. *OSDMA State DM Plan 2019, Odisha 2019*; OSDMA: Bhubaneswar, India, 2019.
58. Bandyopadhyay, S.; Dasgupta, S.; Khan, Z.H.; Wheeler, D. Spatiotemporal Analysis of Tropical Cyclone Landfalls in Northern Bay of Bengal, India and Bangladesh. *Asia-Pac. J. Atmos. Sci.* **2021**, *57*, 799–815. [CrossRef]
59. Belton, B.; Marschke, M.; Vandergeest, P. Fisheries Development, Labour and Working Conditions on Myanmar's Marine Resource Frontier. *J. Rural Stud.* **2019**, *69*, 204–213. [CrossRef]
60. Arthur, R.I.; Skerritt, D.; Schuhbauer, A.; Ebrahim, N.; Friend, R.M.; Sumaila, U.R. Small-scale Fisheries and Local Food Systems: Transformations, Threats and Opportunities. *Fish Fish.* **2021**, *23*, 109–124. [CrossRef]
61. Nayak, P.K.; Dias, A.C.E.; Pradhan, S.K. Traditional Fishing Community and Sustainable Development. In *Life Below Water*; Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Wall, T., Eds.; Encyclopedia of the UN Sustainable Development Goals; Springer International Publishing: Cham, Switzerland, 2021; pp. 1–18, ISBN 978-3-319-71064-8.
62. Blanchet, T.; Biswas, H.; Dabu, M.H. *Slaves for a Season: Bonded Child Labour in the Dry Fish Industry*; Save the Children Sweden-Denmark: Dhaka, Bangladesh, 2006; ISBN 978-984-32-3615-9.
63. Jansen, K.B. Child Slavery and the Fish Processing Industry in Bangladesh. *Focus Geogr.* **2013**, *56*, 54. [CrossRef]