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Analyzing scenarios and designing initiatives toward just transitions: coproducing knowledge with(in) the dried fish sector in the Indian Sundarbans

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The south-western fringe of the Indian Sundarbans hosts a number of fish drying collectives that are exposed to a bundle of mutually reinforcing social-ecological-institutional risks. Despite its wide contribution to local-regional food security and livelihoods, dried fish production has received little attention in research and policy circles so far. As part of the Social Sciences and Humanities Research Council (SSHRC) sponsored Dried Fish Matters global partnership project, our research team seeks to address this lack in two ways: (i) delineating knowledge base through a systematic literature review on intersecting social-ecological and sociohydrological dimensions of integrated fisheries and fish drying practices, and (ii) employing a knowledge co-production approach that involves participation of dry-fishers, researchers, fishworkers' forum (partner organization), and scientists for meaningful understandings about the constraints and potentials in the sector. In this essay, we applied a three-step methodology to arrive at a crisscrossing conceptual, empirical, and collective understandings on the 'invisible' dried fish value chain in the Indian Sundarbans. With detailed lessons from the field, our interdisciplinary research team acts as a liaison among the groups to build a collaborative space for interactions, recognize prevalent adaptive practices and identify pathways toward short-, intermediate-, and long-term co-interventions through which fish drying practices can be more effectively improvised upon and up scaled. The essay lays out detailed insights and sensible recommendations from the knowledge co-production workshop, organized as a part of solution-focused participatory research on climate-resilient and gender-aware dried fish practices in the Indian Sundarbans. In light of the collective observations on the complex problems and reflections on needs-driven initiatives, the authors advocate for collaborative research praxes in forging just transitions for the less explored dried fish sector.

KEYWORDS

dried fish, knowledge co-production, social-ecological systems, sustainability, sociohydrology, participatory

1. Introduction

A sizeable share of marine captured fish is preserved through various fish processing techniques that include drying, salting, smoking, and fermenting—collectively known as dried fish—which is an important source of food and livelihood for a large segment of the population in South and Southeast Asia. Notably, India's total contribution to processed products including dried and unsalted fish is 2.64 lakh¹ tons, whereas West Bengal state produces 0.04 lakh tons of processed fish, placing it sixth-highest in production after Gujarat, Kerala, Maharashtra, Telangana, and Karnataka ([Handbook on Fisheries Statistics, 2020](#)). Despite its unparalleled social, cultural, nutritional, and economic significance which is strongly manifested in the involvement of people in fish production, circulation, and consumption pattern, the dried fish sector has gained disproportionately scant attention in academic fora and remained invisible in policy debates so far. The social and ecological changes experienced by the dried fish value chain that extends from marine habitat to dried fish organizations, to market and finally to consumers, coincide with the magnifying challenges of small-scale fisheries (SSF), yet the former has generated only narrower understandings about its scale, importance, threats and potentialities across research and an official dossier on a sharp contrary to the SSF. While there is a growing scholarship on food safety, nutrition, and preservation technologies associated with dried fish, a wide gap remains in locating the elements of complexity in dried fish resource systems through integrating critical, analytical frames of interdisciplinary research such as social-ecological linkages, institutional dynamics, and governance. Threatened by a host of factors including fish stock reduction, frequent cyclones, land-water pollution, social inequities, and top-down governance methods—explicitly characterizing the combined footprints of political economy and Anthropocene—dried fish today requires more collaborative research approaches that effectively address the sustainability of the sector.

In recent decades, an emerging body of transdisciplinary research along with a cluster of approaches linking action research and sustainability research, have signaled the relevance of knowledge co-production and sound collaboration among different groups of actors (researchers, community, practitioners, government organizations, civil groups), probing into various social and ecological issues at local contexts ([Stange, 2017](#); [Norström et al., 2020](#); [Carter et al., 2022](#)). Compared to mainstream research ideologies which tend to perceive solutions either through sacrosanct scientific modeling or theoretical projections confined within specific research groups connecting loosely with messy societal upheavals, everyday lived experiences and community ethos, knowledge co-production engages multiple disciplines, perspectives and insights for a long-term inquiry into the processes, activities, values, needs, and interests of communities over a collaborative platform that reflects upon the sustained pathways and practices for solutions.

This essay responds to the significant research gap in dried fish by contributing to the understanding of social-ecological

systems (SES) in coastal fish production and highlighting the urgent menaces faced by this otherwise unsung social economy. Within the expanding realms of sociohydrology (SH) that throws light on water-society-policy interfaces for inclusive management of human-water systems ([Sivapalan et al., 2012, 2014](#)), the study advances the theoretical dialogues through coupling sociohydrological perspectives with practical nuances of the fisheries resource system. Drawing evidence from the dried fish organizations in the Indian Sundarbans, the essay explores how risk-prone ecologies shape the socioeconomic vulnerabilities and institutional contexts of dried fish. The Indian Sundarbans have been the focal area of the study because of three reasons: firstly, a great deal of coastal communities is reliant upon artisanal fishing and fish production for subsistence, making it a globally salient fish production region; secondly, the biodiversity-rich deltaic landscape who has observed the interplay of multiple legal cultures since historical times, is exposed to “disruptive risks” in the face of changing marine and deltaic environments, and thirdly, the exclusionary governance crafted within the logics of strategic self-financing methods has apparently limited the performance potentials of the fisheries economy in the Sundarbans.

Informed by our conceptual-empirical findings and with a deeper realization of the complexity emanating from changing economics and long-standing social-ecological risks to fish production, our research team employs a knowledge co-production approach as part of long-term, responsible practices for solutions. In line with facilitating a “deliberate collaboration between different people to achieve common goals” ([Lemos and Morehouse, 2005](#); [Norström et al., 2020](#)), knowledge co-production in dried fish attempts to address health and wellbeing of fishers within an improved fish drying environment and infrastructure, forged by locally tailored initiatives. Acknowledging that this inclusive approach produces “more than just knowledge” rather they foster mutual trust, build networks, create conversations, and unveil possibilities ([Wyborn and Bixler, 2013](#); [Norström et al., 2020](#)), a multi-stakeholder workshop was conducted with the participation of various academic and non-academic actors—collaboratively laying out solution-focused pathways for dried fish practices.

The next two sections describe the field sites and the three-step methodology applied in the present study. In the fourth section, we review the selected literature on SES and SH to situate fisheries and dried fish on their interlacing conceptual fabrics with examples from South and Southeast Asia. This is followed by a SWOT (Strength, Weakness, Opportunity, and Threat) matrix which enlists the SWOT factors, derived from the literature. We then explore fish processing activities and trade along the value chain and simultaneously, trace out social dynamics for dried fish production with regard to relationships, institutional norms, and inequities. The sixth section locates key sustainability challenges and livelihood issues within the dried fish value chain and delineates short-, intermediate- and long-term experimental roadmaps for solution-focused practices, an outcome of knowledge co-production with multi-stakeholder participation. On this front, the study implies how knowledge co-production to pin down areas seeking interventions, makes a novel entry in transdisciplinary research through its potential contributions to dried fish scholarship, policy, and practices.

1 1 lakh is equivalent to 100,000.

2. Familiarizing the field

An island archipelago with an impressive digitate configuration that hosts the world's largest mangrove forest, the Indian Sundarbans (21°30'–22°30'N and 89°–90°E) lies at the southernmost frontier of the Ganga delta in the state of West Bengal, eastern India. The Sundarbans Biosphere Reserve (SBR), as the Sundarbans is officially known in India, has assumed global attention due to its wide and exotic ensemble of biodiversity, wildlife, and marine resources. The eminence of the Royal Bengal Tiger coupled with several other wildlife species, mangrove species, and aquatic resources have acquired the region the status of a “reserved forest” since 1878. However, in recent years, climate emergencies and ecological crises have taken center stage and attracted scientists and large organizations from around the world to this conservation hotspot.

The region constitutes 48 forested and 54 inhabited islands which are connected and disconnected by a maze of rivulets, estuaries, and narrow creeks. In this shifting terrain, tidal waves reach up to three hundred kilometers inland with an average amplitude of 3.5–5 meters to dissolve the boundaries between land and sea, silt and water, people and forest. The relatively unstable, alluvial surface which mostly characterizes the “low” islands of the Sundarbans, still see the processes of being formed, fretted, and reformed through the agential functioning of tides, waves, and silts. The region's climate is characterized by high relative humidity between 70 and 88%, whereas June and January experience average temperatures of 34 and 11°C, respectively. Even though the Sundarbans experiences about 80% of annual precipitation occurring mainly during monsoon months (July–September), occasional showers prevail almost all through the year (Danda et al., 2011). Girdled by dense mangrove forest, the eastern islands are refined swampy beds whereas the western part of SBR encompassing Frasersgunj, Sagardwip, Jambudwip, and Mousuni island-villages observe powerful wave actions along the extensive sandy “chars”² (Nishat, 2019). The distal edge of this immense archipelago, these islands are distinctly exposed to climate change impacts in the forms of cyclonic hazards, coastal erosion, soil loss, embankment failure, and flooding.

While the inhabitants of easterly islands have adopted forest-based fishing, inland freshwater aquaculture, honey, and beeswax collection as predominant livelihood options (Chacraverti, 2014), dried fish production and small-scale marine fishing are prevalent in the western part of SBR. In the Sundarbans, the networked roots of mangroves on the clayey substrate, play a pivotal role in nitrifying water and harnessing the food web with invertebrates toward acting as nursery grounds for nearly 90% of the important commercial aquatic species including fish in the entire eastern coast of India (Chandra and Sagar, 2003). After agriculture, fisheries activities have been the most common and staple livelihood options for over 4.4 million people of the Sundarbans (Danda et al., 2011; Chacraverti, 2014). The rich biophysical world endowed with sandy shorelines and waterborne chars, has outfit grounds for fish drying practices which involve groups of people including small-scale marine fishers, fish producers, daily-wage workers, and traders.

To date, the south-western fringe of the Sundarbans harbors four dried fish production sites including Frasersgunj-Bakkhali, Sagardwip, Kakdwip,³ and Kalistan in between the mouths of the river Hugli and Harinbhanga. Each of these sites constitutes clusters of large- and small-sized dried fish camps, locally known as *shabar* (large- and medium-scale camp) and *khoti* (small-scale camp). Our study specifically focuses on three “transient” dried fish clusters in Frasersgunj village, namely Lalgunj, Lakshmipur, and Baliara (see Figure 1), encompassing a large number of *shabar* and *khoti* which are separated by flexible boundaries⁴ (see Table 1).

3. Methodology

The Dried Fish Matters global partnership project (www.driedfishmatters.org) is designed to bring together a diverse group of researchers and practitioners to produce landmark regional comprehension about the dried fish economy in South and Southeast Asia. As a part of the interdisciplinary team in this project, we navigated the repository of existing literature, became familiar with heterogeneous findings from case studies, delineated thematic areas for the research, and finally, incorporated these details into our core area of analysis. Over the span of 2021–2022, we carried out field surveys, collected secondary data, conducted interviews, and organized multi-stakeholder workshops to cultivate a synergistic space for interactions among different groups related, in a variety of ways, to the dried fish sector. Besides, our interdisciplinary team composition with expertise in environmental history, political ecology, human rights, cultural studies, and physical geography enabled us to capture the nuances in economic, institutional, and environmental flows shaping dried fish production and practices at the Indian Sundarbans.

We followed a three-step methodology in this research: (i) systematic literature review: fine-grained analysis of SES literature on small-scale fishing and dried fish in South Asia, facilitating a SWOT (Strength-Weakness-Opportunity-Threat) assessment for the integrated fisheries and dried fish sector, (ii) field-based ethnography: using ethnographic tools (participant observation, KIIs, focus group discussions, and focused interviews) to weigh the emerging threats, get acquainted with the people and their practices, and realize the potentials for partnerships in the field, and (iii) forge discussion on solution-oriented pathways: first-hand, participatory mapping of areas seeking solutions through multi-stakeholder engagement, knowledge co-production and practicable co-interventions (Figure 2).

In the first phase, a systematic literature survey was conducted to create a knowledge base providing theoretical guidance as well as case-specific evidence related to SES and SH dimensions of fisheries in South Asia. Four sequential steps were followed:

3 The Bengali, the word “dwip” denotes to islands. Hence, “Sagardwip” is also called Sagar Island.

4 The dried fish units remain operational during the four months of winter when fishers, fish processors and fish sorters from neighboring villages assemble and temporarily stay there. Hence, they are referred to as “transient” clusters. The camps are separated by thin bamboo fences; communication and exchanges take place among the processors of the camps. The camp arrangements and functions are discussed in Section 5.

2 River-dominated or wave-dominated islands in making.

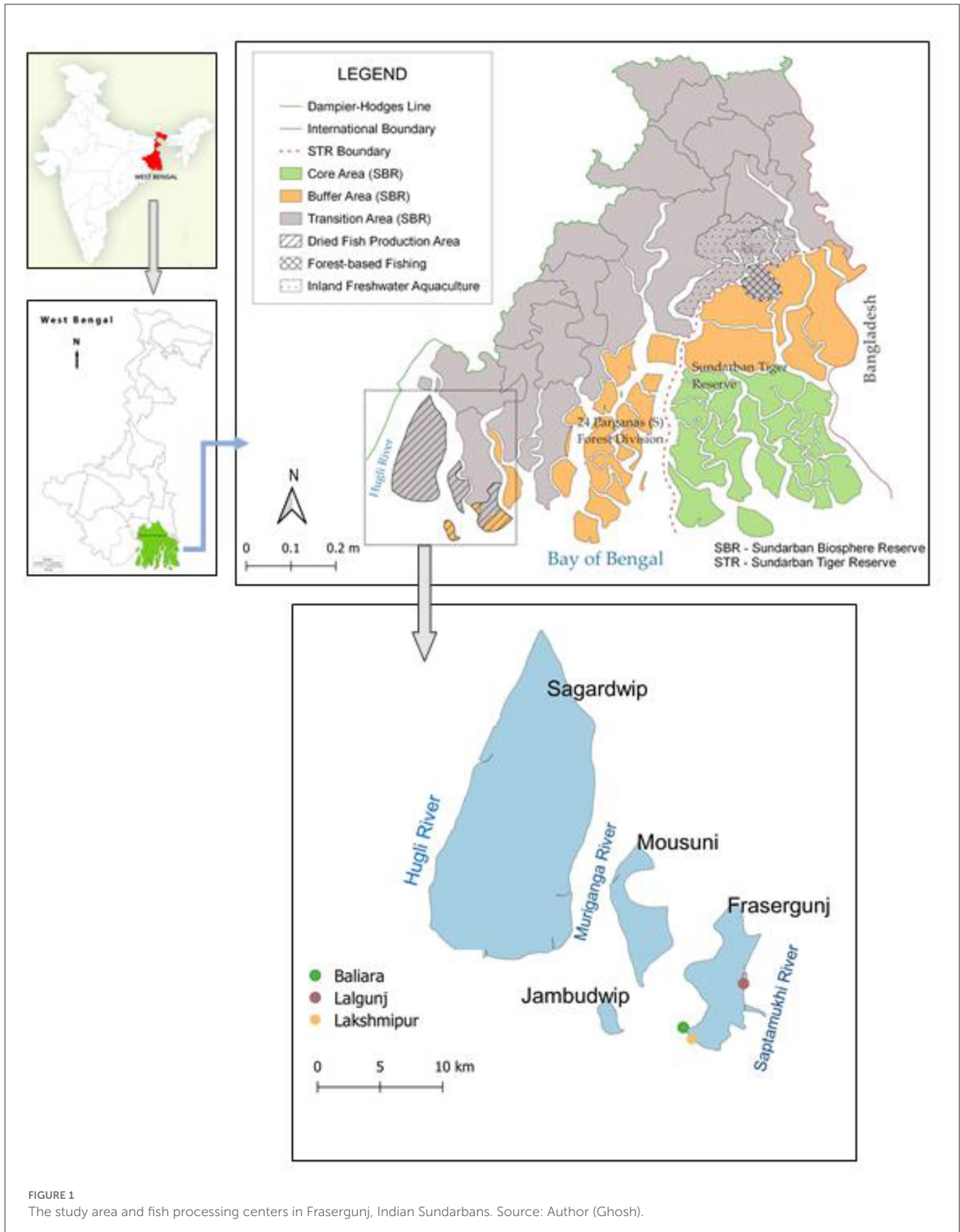


FIGURE 1
The study area and fish processing centers in Frasersgunj, Indian Sundarbans. Source: Author (Ghosh).

(i) application of key words and phrases as search criteria (Table 2) to derive both academic and gray literature from Google search, Web of Science and Academia database, (ii) consulting

Zotero open-source e-library of the DFM project (https://www.zotero.org/groups/2778295/dfm-v2v_west_bengal/library) to draw out publications based on seven thematic tags—social

relations, ecology, governance, gender, labor, culture and value chain, (iii) sieving duplicate files, (iv) preliminary scanning of abstracts and inclusion of SES and SH literature based on methodological approaches, theoretical intersections, research findings and geographies, and (v) full-text scanning and review of the literature (Figure 3). Iterative search and subsequent filtering, finally, yielded 115 publications. Through multiple rounds of scanning, examination, and synthesis of the insights from the literature, we mapped social and ecological dynamics in the institutional context of the fisheries resource system. Because fish processing is understood as a subset of the small-scale fisheries, there are some common concerns between the two, such as livelihood struggles, political influences, and ecological damages.

Through this first step of the three-step methodology, we—(i) learned about case study specificities pertaining to practices, relationships, challenges, and conflicts; (ii) theoretically comprehended institutional linkages, feedback mechanisms, sociohydrological aspects, and gendered roles with regard to transdisciplinary intersections (stakeholder involvements, management participation, social inclusion,

decision making), (iii) became acquainted with the historical backdrop, belief systems, and deltaic architecture of the study site; (iv) highlighted uncertainties, perilous threats, and opportunities as a comprehensive SWOT analysis, and (v) crafted survey designs and set questions for the interviews. With this prior vision and awareness, we embarked into the field.

Fieldwork took place in November 2021 and March 2022 at the Indian Sundarbans and Sheoraphuli (Hugli) dried fish markets, respectively. Surveys were conducted at Baliara, Lalgunj, and Lakshmipur dried fish sites in Frasergunj village by our team of eight researchers, accompanied by a representative of our partner Dakshinbanga Matsyajibi Forum (DMF), a small-scale fishworkers’ forum established in the early 1990s (Table 3). As participant observers, culturally and linguistically connected to the stakeholders in the field, we initiated friendly conversations with female daily-wage dry-fishers, male contractual laborers, fishers, and young girls who are involved in fish drying activities in the *shabar* and *khoti*. Our long, colloquial exchanges at the first meeting, created a congenial atmosphere which is crucial for deepening the bonds between communities and participant researchers. We probed into focus group discussions (FGDs) in which each targeted question was asked to individuals in a specific group to carve out diverse perceptions of their everyday affairs inside and outside of the dried fish camps. Five FGDs (60–75 min each) were arranged with *shabar* owners, women *hajira* workers, and fish processors of a household; the reflections were audio- and video-recorded. The FGDs took place at the camp compound, at a local club room, at the shacks in *shabar*, or at the shop of the dry-fisher family, depending on the convenience of the respondents. All respondents provided prior verbal informed consent. The *shabar*

TABLE 1 Approximate total numbers of *shabar* and *khoti* in the fish processing clusters of Frasergunj.

Fish processing clusters	Number of <i>shabar</i>	Number of <i>khoti</i>
Lalgunj	13	20
Baliara	15	50
Lakshmipur	Nil	30

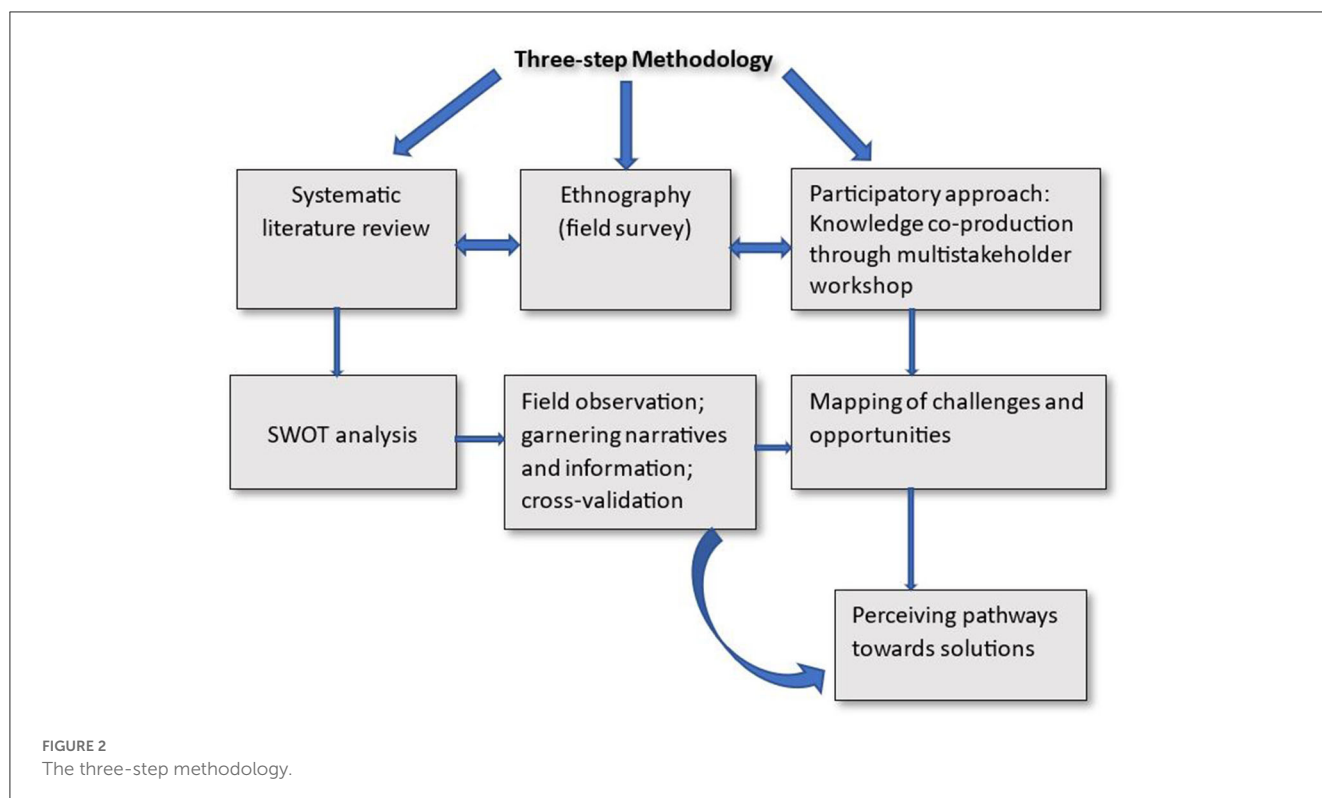
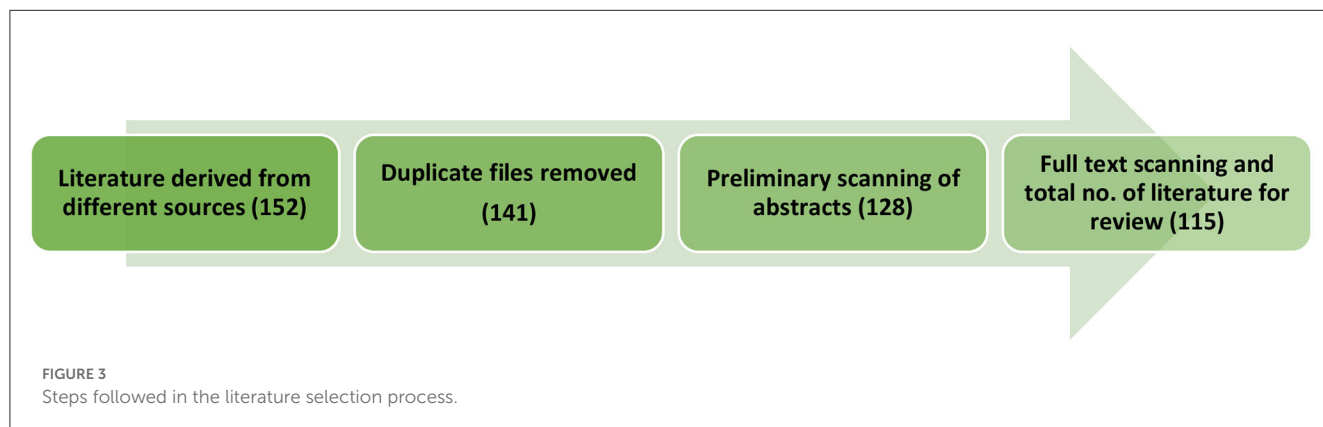


TABLE 2 Key terms, phrases, and Zotero tags used for searching the literature.

Review component	Search terms	Search phrases	Zotero tags
SES	Institution, adaptive	Ecological change, resource system, ecological knowledge	Social relations, ecology, governance, gender, labor, culture, and wellbeing
SH	Governance, management	Water-society relations, coastal flooding, water pollution, food production	
Fish/Fishery	economy, organization	Fish processing, dried fish, small-scale fishing, small-scale marine fishing, artisanal fishery, value chain	



owners were accompanied by members of the *shabar* committee and the DMF representative whereas *hajira* dry-fishers comprised women from various age-groups ranging between 25 and 60. Each group was formed of 8–10 participants who, in a spontaneous spirit, voiced disquietude, negotiations, and struggles with their lifeways and livelihoods that, seemingly, revolve around these makeshift organizations for four winter months. They reflected on how a multitude of socio-ecological risks are pouring into the dried fish practices and how they are replying to these threats. The FGDs were followed by ten focused interviews of experienced value chain actors including a fisher, a moneylender, a woman dry-fisher, a *khoti* owner, and a local wholesaler, who were asked open-ended questions in a quiet, private setting conducive to contemplating the questions and answers. An alternative to the standardized interview, focused interviews (Merton, 2008) are a form of semi-structured interview which is based upon broad themes chosen in advance, rather than using pre-settled questions (Bailey, 2008). The interviews unwrapped the observed facts, personal accounts, tussles, or consequences of a situation to which the actors are attached. Written notes were maintained throughout the discussions and interviews. Five key informant interviews (KIIs) were conducted with the former president of DMF, a representative of DMF, a principal scientist of CIFRI,⁵ a female representative of the local Self-Help Group, and the Associate Director of Fishers (Government of West Bengal), to procure their insights that have been accrued through their distinctive areas of associations. In addition, five semi-structured interviews of the wholesalers were conducted during a survey at Sheoraphuli market, one of the focal dried fish wholesale markets in Bengal. Along the

antique alleys of the once-French dominion of Sheoraphuli, we strolled and visited single-room shops of the local wholesalers who either buy dried fish directly from *shabar* owners or restore stocks through an intermediary wholesaler (or moneylender).

For the May 2022 workshop in Kakdwip village, we designed a knowledge co-production template to obtain individual-integrated perspectives on dried fish production in Bengal. The template facilitated cross-learning possibilities among groups (academia, users, NGO) and embraced a plurality of perspectives on risks and opportunities. Trust-building among the groups created an *in-situ* momentum for surpassing the divides between knowledge forms (local, academic, scientific, and practice-oriented) and for thinking about solutions from both individual and sectoral perspectives. By acknowledging the cultural values, concerns, and ideas brought by the stakeholders, the workshop ensured inclusivity in diverse forms of exchanges (Figure 4). The 7-h workshop consisted of two broad sessions and four interconnected sub-sessions, involving 40 participants from different corners of South 24 Parganas and Kolkata. The sub-sessions typically lasted for between 60 and 120 min. Through the literature review, field insights, and improvising on participatory systems mapping (Barbrook-Johnson and Penn, 2021), we outlined thrust areas and adjoining 'lead questions' that guided the facilitator researcher for the sub-session on "close interaction". This sub-session gleaned different views from the same phenomenon from the participants of a group, guaranteeing the richness of the information. Four tables were designated to the stakeholder groups: marine fishers, camp owners (including a DMF representative), women *hajira* workers (including a woman representative of the Self-Help group), and traders. It was followed by an informal conversation in which dried fish actors had open

5 CIFRI stands for Central Inland Fisheries Research Institute.

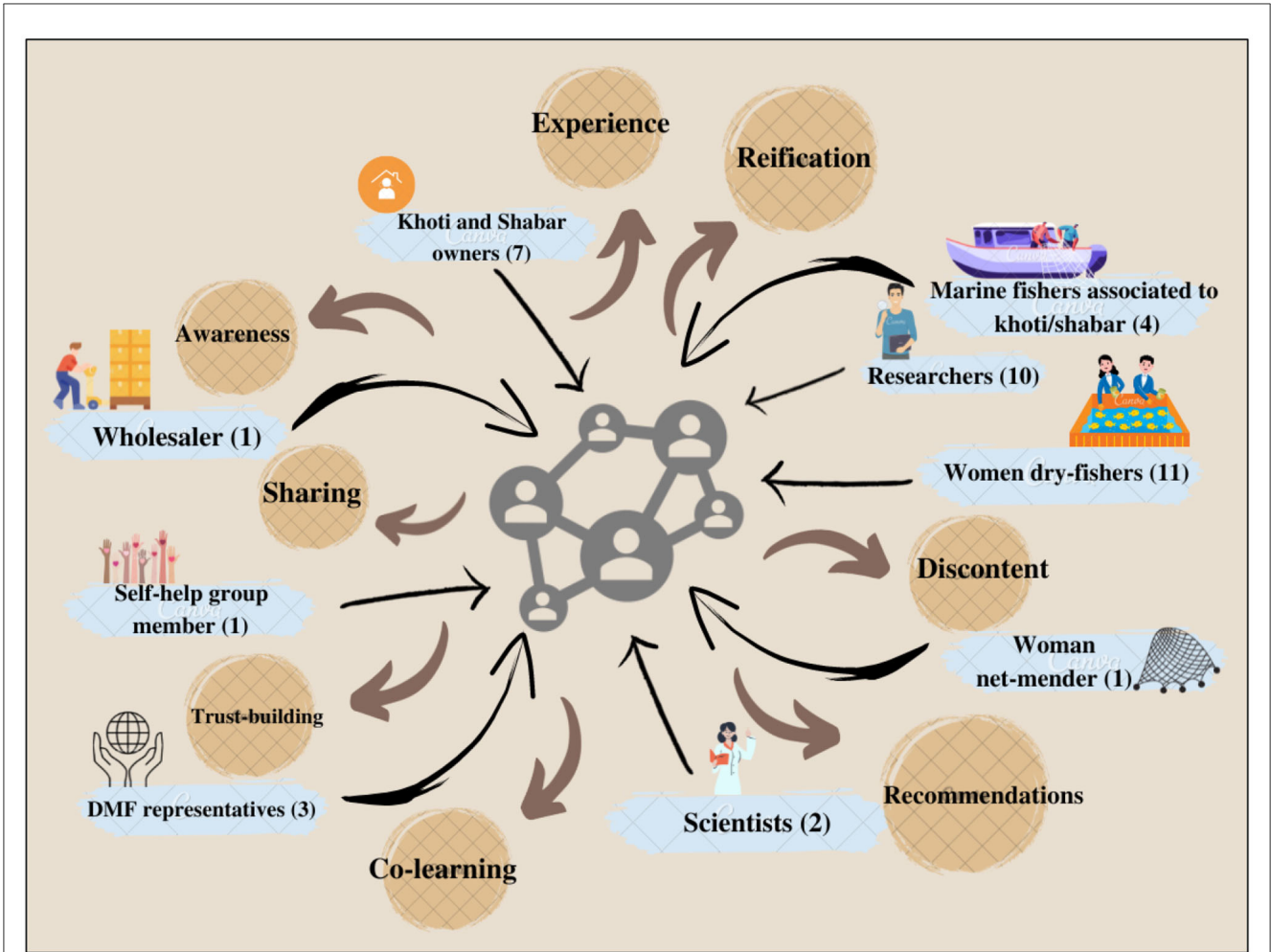


FIGURE 4 Knowledge co-production through dynamic exchanges among multiple stakeholders. Source: Author (Bandyopadhyay).

question-answer rounds with the scientists from Central and State Government institutions. While some researchers took charge of facilitating interactions during sub-sessions, some provided additional participant observation to record varying expressions (excitement, anxiety, anger, joy) of individuals during the sessions. The narratives were transcribed from discussions and sorted thematically to carve out diversity, linkages, and patterns in findings.

4. Systematic literature review

A total of 115 pieces of literature were reviewed, of which 68 deal with core and aligned theoretical aspects of SES, 17 relate to dried fish processing and value chains, and the remainder integrate sociohydrology (SH) with SES. Forty-six articles on fisheries appeared among the 68 pieces of SES literature (Figure 5). The bulk of the literature in our sample is geographically oriented to South Asia spanning Bangladesh, India, Sri Lanka, Nepal, while few others focus especially on small-scale fisheries in Cambodia, Vietnam, Thailand, Chile, Mexico, Sweden, Canada, South Africa, Australia, the Solomon Islands, and Tuvalu. While

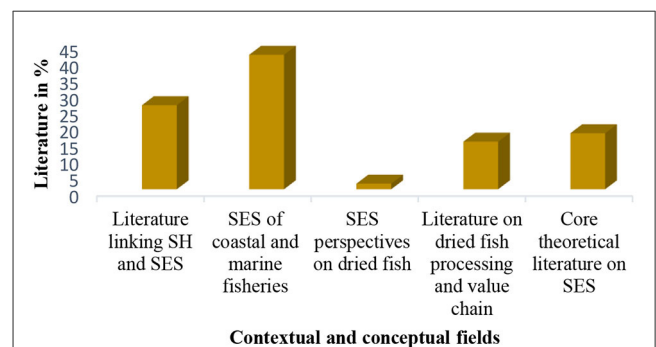


FIGURE 5 Percentage of literature accessed under relevant contextual and conceptual fields.

there is a dearth of research exploring SES scenarios in South Asian fisheries, it is even striking to note that only two of the studies provided a SES lens to dried fish. A systematic literature review performed earlier with dried fish literature in hand, submits that dried fish has been viewed from a diverse

TABLE 3 Overview of the places visited, and methods deployed for the survey.

Frasergunj fieldwork			Sheraphuli market survey	
Fish processing sites visited	Methods (Numeric in bracket indicates the number of times conducted)	Stakeholders consulted	Methods	Stakeholders consulted
Baliara	Participant observation, FGD (3), focused interviews (8)	Shabar owner, women <i>hajira</i> dry-fisher, contractual worker, moneylender, marine fisher, wholesaler, net mender	Focused interviews (6)	Wholesaler and a small trader
Lalgunj	Participant observation, FGD (3), focused interviews (7)	Shabar owner, women <i>hajira</i> dry-fisher, member of <i>shabar</i> committee, member of local Self-Help Group		
Lakshampur	Participant observation, FGD (2), focused interviews (4)	Independent wholesaler, member of a local Self-Help Group		

thematic arena including governance, gender, wellbeing, value chain, ecological change, and sustainability, which, according to their immanent conceptual ideals, cannot be studied separately from the assumptions of SES (Ghosh et al., 2022). However, these studies did not follow the fundamental conceptual arguments of SES. Here, a wide range of standard SES literature with core and crisscrossing conceptual frames has been considered for gauging the breadth of SES literature and recognizing feedback that operates at three interlinked institutions including social, market, and governance in coastal fisheries and dried fish. On the other hand, 30 publications were derived from a pool of scholarly works on sociohydrology (SH) whose expanding horizon has entailed SES elements to underscore nested theoretical and applied lenses on human-water systems, flood-risk management, seafood production, adaptive capacities, and ecosystem services. Out of the total SH articles in our sample, seven articles used instances from marine fishing practices.

4.1. Institutional linkages and feedback: using the SES lens

SES framework acknowledges the variants of ecosystems, the multiplicity of internal and external drivers, patterns of interactions, and institutional linkages shaping the complex, co-constitutive nature of tightly coupled social and ecological systems (Holling, 1973, 1992; Garcia and Charles, 2008; Rogers et al., 2013; Preiser et al., 2018). At the crux of SES, there are multiple actors, multiple species, and materials—maintaining the properties and behavior of the system through their interactions and change over time (Glaser et al., 2012; Binder et al., 2013; Preiser et al., 2018; Preiser, 2019). Several empirical works in our repository indicate that the framework, as a general tool, is suited to examining the diverse shades of sustainability and adaptive responses in a complex social-ecological landscape that cannot be studied by simplistic, universalized, or deterministic ideas of politics, environment, and culture (Ostrom et al., 1994; Ostrom, 2007; Basurto et al., 2013; McGinnis and Ostrom, 2014; Fischer et al., 2015; Marshall, 2015; Partelow, 2018; Stephenson et al., 2018). Built on the assumption that social actors and ecological resources are co-dependent, SES motifs capture the dynamic interplay between social and ecological processes with an eye to the feedback mechanisms through which

they are interlinked (Levin, 1998; Turner et al., 2003; Janssen and Anderies, 2007; Crona et al., 2010; Cinner and Barnes, 2019; Pradhan et al., 2022).

Dried fish production is a coastal resource system in which fish processing integrates marine fishing and land-based practices; a swarm of Bombay Duck (*Harpadon nehereus*) and other fish species form resource units; fishers and fish producers are resource users; and the governance exercises policies and regulations to set legal conditions (Agrawal, 2003; Anderies et al., 2004; Pramanik, 2004; Liu et al., 2007; Ostrom, 2009; Korlagama et al., 2021; Lu et al., 2021; Belton et al., 2022; Ghosh et al., 2022; Hossain et al., 2022). Ostrom (2009, 2011) states that these subsystems can be further defined by some variables (for example, size of the resource system, mobility of resource unit, level of governance, users' values and knowledge, nature's laws) which interact and co-act to produce a variety of responses and outcomes (also see Ostrom, 2005; Leslie and McCabe, 2013). Inside the intersecting physical and normative boundaries (Crona et al., 2015; Pradhan et al., 2022), the dried fish system is visibly contoured by resource sharing (groups of fishing communities converge on one fishing site or same species stock), economic substitutability (coastal and marine fishing as an alternative to fish processing during non-winter seasons), social connectivity (communication, coordination, mediation, negotiation among value chain actors), social-ecological links (access to the processing site, fishing ground, and market) (Shamsuddoha, 2007; Bodin and Crona, 2009; Bodin and Tengö, 2012; Hasan et al., 2016; Shyam et al., 2016; Society for Direct Initiative for Social Health Action, 2016a,b). Given the complex set of mutual links and bundles of interacting processes, whatever socio-economic, and legal drivers effect the fishing activities of communities, by extension, also effect marine ecosystems with which they interdependently interact (Charles, 1998; Ommer et al., 2012; Boonstra, 2016; Arthur et al., 2022).

Most of the case studies in our sample that pivot on coastal fishery and dried fish reported declining catch levels per household or organization, making it difficult to source raw materials for fish processing (Funge-Smith et al., 2005; Dey, 2008; Kehoe, 2011; Hossain et al., 2015; Nadanasabesan, 2015; Lokuge, 2021; Bandyopadhyay et al., 2022; Ghosh et al., 2022). Additionally, extreme weather events including cyclones, capricious rainfall, flood proneness, and water pollution have made for disruptive repercussions on the fisheries sector of maritime countries like

Cambodia, Sri Lanka, India, and Bangladesh (Kunwar and Adhikari, 2016; Galappaththi et al., 2020; Islam et al., 2020; Berenji et al., 2021). Peke (2013) research on Versova and Arnala areas of Maharashtra (India) unpacked how pollution, inadequate water supply, and a premium on coastal zones have pressured women fish processors. Simultaneously, Nayak (2014) presented that the Chilika lagoon on which the artisanal fishers are dependent for their economic and cultural needs showed signs of stress with the commencement of commercial aquaculture activities inducing fluctuation in biophysical processes and alterations of food webs (Nayak and Armitage, 2018). Further, dominant state policies often tend to marginalize social values in fisheries, as sharply reflected by policy incoherence and top-down management measures in various local contexts in India, Bangladesh, and Sri Lanka (Bhatta et al., 2003; Lebel et al., 2006; Shamsuddoha, 2007; Kumar and Mohanta, 2014; Hasan et al., 2016; Shyam et al., 2016; Jeyanthi et al., 2018; Johnson et al., 2018; Islam et al., 2020; Korlagama et al., 2021). Anyhow, institutional practices bear out this narrative of decline.

Everyday practices and social-ecological dynamics of the dried fish sector, are shaped by feedback mechanisms within the core components of three institutions: social (norms, beliefs, conventions), market (network, regulations), and governance (legislations, policies, agencies) (Acheson, 2006; De la Torre-Castro and Lindström, 2009; Crona et al., 2015) (Table 4). Acheson (2006) argues that the global crisis of fisheries resource degradation and sustainability challenges denotes a deep institutional failure. The result is of acute importance in poorer countries of the global South where coastal populations are heavily dependent upon marine resources for livelihoods (Kotchen and Young, 2007; Dey, 2008; Fabinyi et al., 2014). Identifying institutional logics within diverse organizational forms, agencies, and capacities is vital to obtain an accurate understanding of the intricacies of social-ecological changes, vulnerabilities, and management systems of coastal fishery (Westley et al., 2013; Hossain et al., 2015; Moshy et al., 2015; Hoque et al., 2017; Cole et al., 2018). For example, dried fish production is often tied to informal credit systems in which producers establish a connection to markets through a moneylender who provides credit as a means of securing priority access to product (Ghosh et al., 2022). Such unwritten credit sources seem to be attractive to producers in the face of uncertainties in production output and poor availability of financial support from the government. However, it stimulates the entry of new fishers resulting in overfishing. Moreover, it lowers selling prices for the entire stock, and restricts fishers' direct access to the market (Crona et al., 2010, 2015). In fact, the primacy of this credit system is indicative of how the government support (both central and state) has been distanced through projecting the sector as self-sustaining and thus beyond their responsibilities.

Drawing on their empirical studies in South Africa, Herrfahrtdt-Pähle and Pahl-Wostl (2012) maintain that institutional resilience is contingent on institutional continuity and change—how they interact, build, or degrade upon institutional processes during crisis situations. In that vein, institutional continuity refers to preserving key institutional contexts in which rules are made in keeping with social memory and relationships, providing transparency to reform processes, etc. (Tidball et al., 2010; Nykvist and Von Heland, 2014). Institutional changes, however, factor in flexible legislation, adaptation after implementation of regulations, regular

reviews, etc. Berkes and Folke (1998) underlined trust-building; monitoring environmental feedback; funds for responding to environmental change and remedial actions; a combination of various sources of information and knowledge; sensemaking and collaborative learning as essential features for adaptive, collaborative management of social-ecological systems (Adger, 2000; Olsson, 2003; Olsson et al., 2004; Folke et al., 2005; Andrew et al., 2007; Biggs et al., 2015; Jahan et al., 2017; Whitney et al., 2017; Ward, 2018).

4.2. At the interface of SES and SH: advancing discussions on human-water systems for coastal food production and livelihoods

Growing imperatives to understand the changing patterns of SES have coincided with the emergent trajectories of the SH field (Sivapalan, 2006; Sivapalan et al., 2012, 2014; Pande and Sivapalan, 2017; Konar et al., 2019) which sheds light on how marine water pollution and altered hydrological dynamics in coastal and riverine landscapes have adversely affected food production, ecosystem services, and human health (Sivapalan et al., 2012; Oki, 2016; Yu et al., 2017, 2020; Penny and Goddard, 2018) (Figure 6). Elshafei et al. (2014a; 2014b) also see Van Emmerik et al., 2014; Troy et al., 2015; Gunderson et al., 2017) hint at a lack of understanding on how socioeconomic processes are influenced by feedback between human activities and water systems at catchment scales (Schaeffli et al., 2011). However, Roobavannan et al. (2018) urge for linking socioecological attributes comprising institutional norms, ecological worldview, social values, and adaptive capacities in the ambit of place-based SH studies for reducing the threat with environmental decision-making (Wescoat, 2013; Yu et al., 2017) (Figure 6). Such ideas may be related to the ongoing debates around Marine Protected Area (MPA) decision-making that often overlooks social contours while implementing MPAs into local ecologies. Penny and Goddard (2018) presented a generic framework combining a range of macro-level contextual parameters from the larger sets of “community sensitivity” (perceived level of threat to a community's quality of life) and “behavioral response”. Haeffner et al. (2021) outline a lens of “representation justice” which keeps in view the participation of marginalized and minoritized stakeholders in the decision-making processes for the water sector. They explained how power, gender, and policy aspects can feed into the understanding and application of current SH framings and advocated for meaningful inclusion of diverse social groups, perspectives, and knowledge in the water governance agenda. Kumar et al. (2020) see also Van Emmerik et al., 2014; Mostert, 2018; Sung et al., 2018; Yu et al., 2020) acknowledged that the cumulative impacts of major factors like extreme weather events, flooding, anthropogenic contamination of water, and drinking water issues strike hard the Sundarbans delta-front in both India and Bangladesh where the factors of vulnerability settles in water resources. Exemplifying newly established local institutions based on community organizations for floodplain management in Bangladesh, Sultana and Thompson (2010) recommended more democratic and participatory guidelines that internalize the

TABLE 4 Feedback generating institutional components in fisheries.

Institutions	Components	Feedback/likely effects
Social	• Identity	- Differentiation among social groups and their engagements in fishing based on caste, gender, migration status - Chequered relationships and inequalities determine access to and exclusion from resources
	• Heterogenous involvements	- Some people with access to resources and capital perform managerial activities, seek profits whereas others are concerned with ensuring subsistence
	• Patrilineal taboos	- While financial, ownership, managerial activities are male-dominated, women perform nodal activities in value chain alongside household chores
Market	• Moneylender's existence	- Stimulates continuous entry of new fishers leading to overfishing and plays into social dynamics (values, relations, conflicts) - Fishers are bound to sell the produce at a lower price than the open market - By channelizing different market demands fishing pressure is exerted over seasons and extraction of specific species is targeted - Fishers receive financial support although they are forever indebted with minimum scopes to explore direct trade provisions
	• Globalized export	- Facilitates the functioning of (external) mobile agents looking for an access to local stocks for exploitation - Triggers profit maximization tendencies of middlemen, resulting in typical wage disparities
	• Increased competition	- Cutting down total production expenses that influence wage distribution; product quality is sacrificed in an effort to boost revenues; moral shifts
Governance	• Credit provisions and subsidies	- Poor credit and insurance disbursement system gives rise to informal agreements with local moneylender, an attractive insurance option for producers
	• Relations of power	- Differences in assets and income defining hierarchies and inter- and intra-community power relations create the narrative of contestation, marginalization and exploitation
	• Multiple agencies	- Regulations and interests of many governmental agencies and parastatal bodies converge to often initiate conflicts

reciprocal water, land, and fishery management in flood-prone coastal plains (Oshun et al., 2021; Thaler, 2021; Luu et al., 2022). In their research concentrating on the floodplains of Bangladesh, Di Baldassarre et al. (2015) developed an application-based SH approach, which noted two aspects i.e., adaptation and levee effects (embankment engineering) arising from the interplay of physical and social factors (Di Baldassarre et al., 2013). They observed the crucial role of the former in achieving trade-offs between local economy and flood-risk management through adaptive techniques for fisheries, housing, and agriculture. In a postscript to this article, Gober and Wheeler (2015) added the knowledge exchange component into the application insights and called for the dissemination of these outcomes to the floodplain “managers” (also see Loucks, 2015).

4.3. SWOT assessment

The following SWOT matrix (Figure 7) collates crucial strengths, weaknesses, opportunities, and threat factors from the case studies and conceptual interface. For instance, fish spawning grounds are threatened by water pollution and increasing turbidity as a result of microplastic contamination and upstream barrage construction, marking a sociohydrological influence in fisheries. Moreover, the matrix signals the relative influences among SWOT factors, which can often be hard to discern with discrete readings. The mien of fisheries warns that the actors' responses to different

circumstances may change the implications of SWOT factors to a considerable extent. If this is so, a strength may also be a weakness, whereas a weakness can indicate opportunities. In the absence of timely recognition and management, an opportunity can mutate into a risk. For example, livelihood diversification (see in “opportunities”) results in long-term livelihood sustainability and lessens pressures in the sea, but also erodes cultural values and knowledge (see in “threats”) attached to an age-old practice such as fishing.

5. Actors, actions, enactments—ground(ed) narratives

Fish processing entails elaborate arrangements with labor, equipment, and coastal land for drying throughout the winter season (November to February). It is conducted in three types of organizations situated along the shoreline: (i) medium- and large-scale fish drying unit or *shabar* (7–10 and 15–20 *kathas*,⁶ respectively), run by a relatively well-off fisher, locally called *bahardar*, who owns both motorized non-mechanical (2-cylinder) and mechanical (4-cylinder and 6-cylinder) fishing boats, (ii) small camp or *khoti* (5–7 *kathas*) run by household members having 2–3 2-cylinder fishing boats and often, a 4-cylinder boat, and

⁶ 1 *katha* is equivalent to 0.0165 acre.

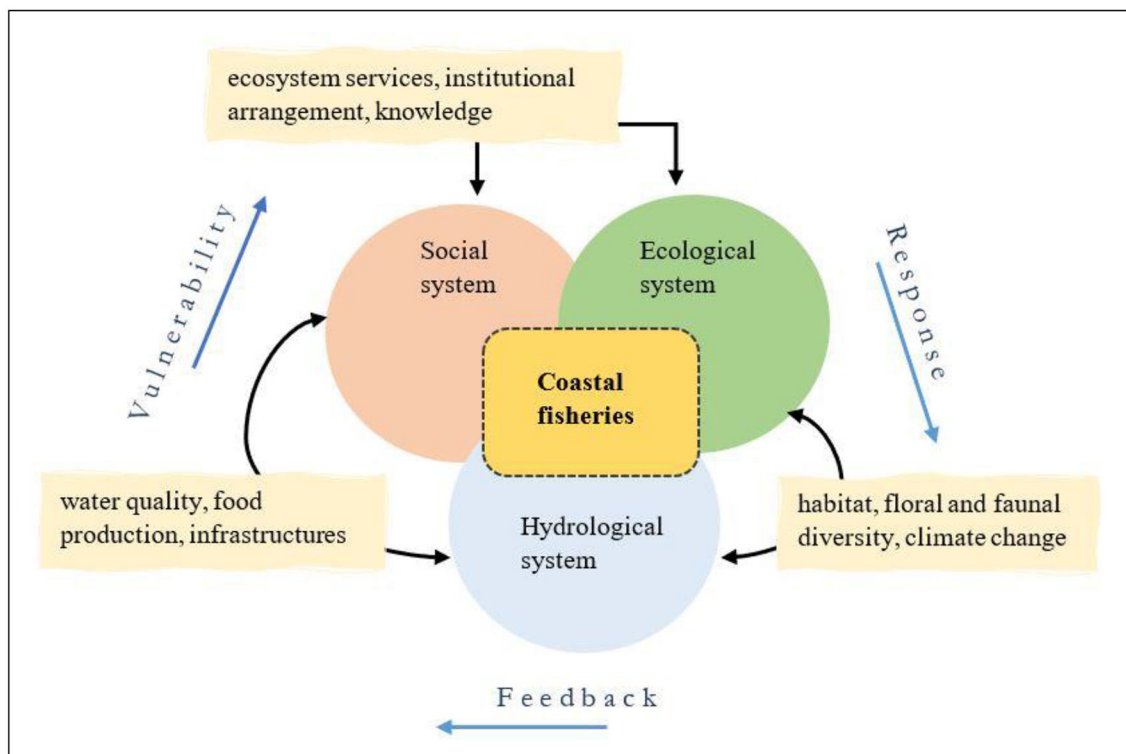


FIGURE 6

Constituents of SES and SH in fisheries: coupled social and hydrological systems are defined by water quality (habitat degradation, resource/fish availability), food production (nutrition, local economy and livelihoods), and infrastructures (dykes, dams, etc.) whereas intersecting SES attributes include ecosystem services (fish as the resource base), institutions (norms, policies, governance) and ecological understandings. Source: Author (Ghosh).

(iii) independent household business operated by family members without any access to fishing boats.

A *shabar* comprises a band of recruited persons who work under the leadership of the *bahardar*, for a common goal i.e., maximum fish production. To put otherwise, these privately operated fish processing units accommodate disproportionate interests and involvements of actors including *bahardar* (camp owners), marine fishers, net menders, fishing crew laborers, boatmen, traders, contractual male laborers, and daily-wage female dry-fishers (sorters and processors) who partake in various activities along the value chain. *Bahardars*, who live in the surrounding villages of Kakdwip, Namkhana, Kalistan, and Pathar Pratima, remain cautious while selecting a campsite. Extensive sandy *char* at the coastal Bay of Bengal is ideally suited for landing and drying fish. Substantial knowledge of topography, the lunar cycle, and tidal patterns is required to make an accurate selection, clearly highlighting the ecological and hydrological connections to the social practices. Three major factors are usually taken into consideration while setting up the camp: (i) proximity of the fishing ground to the camp, (ii) a natural creek where the boats can harbor, (iii) leveled land for a convenient drying and easy landing of fish carrier vessels. The *bahardars* make sure that there is enough space left between the camp-proper's habitation site and the sea line so that the tide level does not reach their temporary shelters even during the high tidal season. Hemmed by

an array of shacks that serve as kitchens and storerooms, these camps constitute an open drying courtyard, scaffolds, a shrine to the goddess Ganga, and elevated drying platforms. The racks and posts are made of bamboo sections, whereas tarpaulins and *hogla* grass leaves are used to raise the shacks. Once a spot is fixed by *bahardars*, camps are installed on the same plot for successive years. However, the tenancy right for the *shabar*, is not the same everywhere. *Bahardars* of Baliara reported that a charge between 10,000 and 50,000 INR is paid to a committee for using the land and the committee, formed by locally influential individuals and some *bahardars* with the consent of Panchayat, pays the Panchayat an annual rent. In such cases, the committees are meant to condition the distribution of land for setting up the *shabars* and *khotis*. Some camp owners pay a yearly rent to individuals who claim to inherit the property. However, the land rents vary depending on the size of the camps. In every situation, the agreements are informal and verbal. The *bahardar's* relationships with fishermen, their impression of individuals' activities, area of the drying ground, and the quantity of fish caught during different periods of the season all play a role in the recruitment of fishers and fish sorters. Contrary to such a specialized arrangement of *shabar*, a *khoti* is more subsistence-based household-run processing camp that is built upon informal relationships within family members and employed fish sorters from the locality. As it seems, many people in groups coordinate and engage with some sets of activities

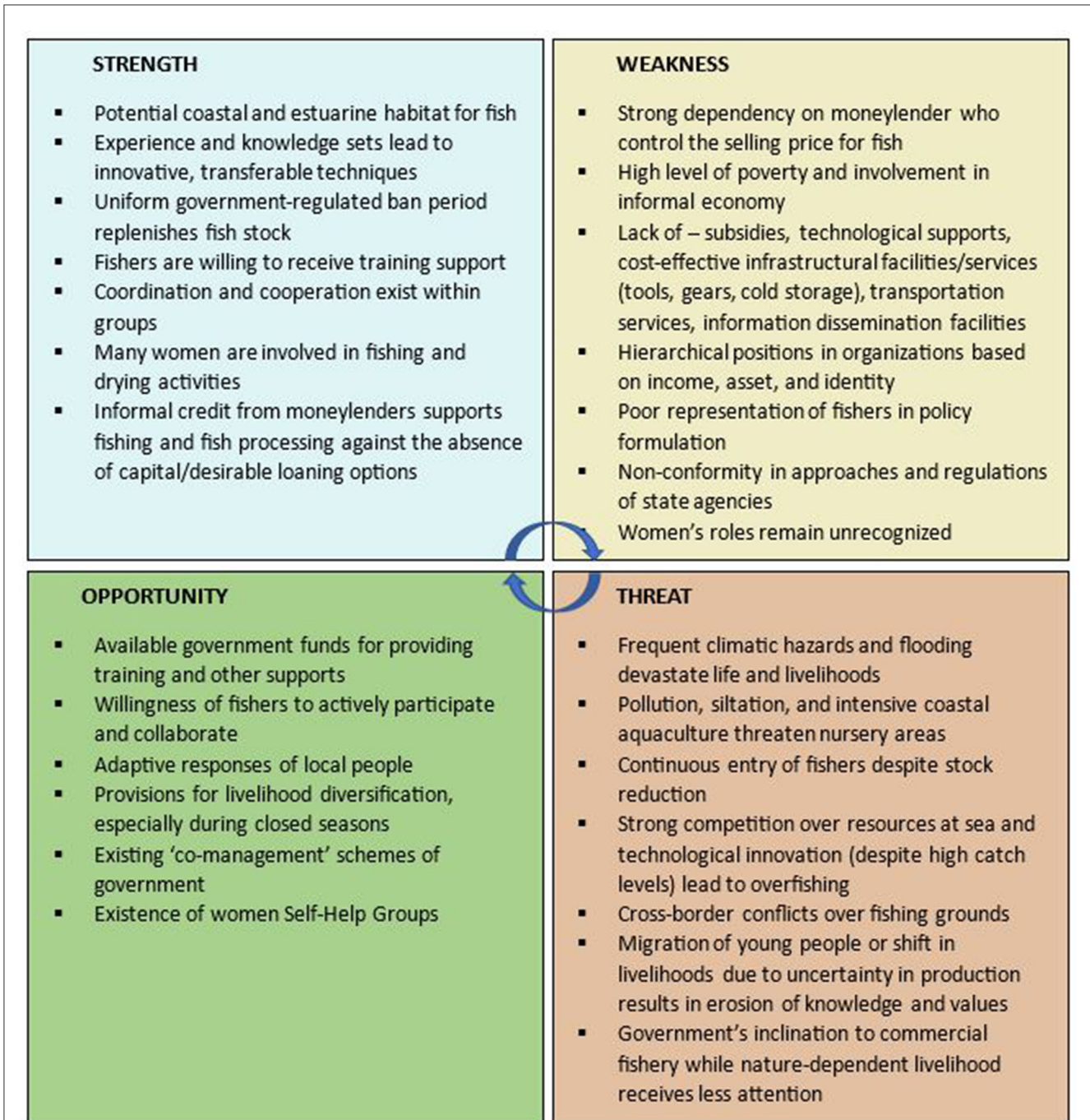


FIGURE 7
SWOT matrix on coastal fishing and fish processing.

in same camp and slowly, the professional relation turn into a physical association and then to, although transitory, a community attachment. A chequered pattern of inter-camp (*shabar* and *khoti*) relations is drawn by differential camp arrangements, resource sharing, affluence of camp owners and networking by the phrase among value chain players. A *shabar* owner's is a large *karbaar* with a higher capital investment, more personal boats, numerous workers in camps, good market connections, and in contrast, *khoti* members are deeply attached to the small family business while

having less influence in the locality and fewer assets. Intra-camp relational rhythm shows up along the spectrum of a communal bond to strict hierarchies.

We came to know from conversations that the *khoti* families are natives of the South 24 Parganas and Medinipur districts and acquired their knowledge of fish drying from Bangladeshi *bahardars* who have moved to the Indian Sundarbans following the partition. Throughout the 1950s and 1970s, marine fishers from the Chittagong district of East Pakistan (present Bangladesh)

migrated to the southwestern parts of the Sundarbans in India, leaving behind the deep scars of partition⁷ on their ancestral soil. The fish drying method in Chittagong district, Bangladesh, was popularly known as *rangabali* practice as the fishers used to travel long distances from their home to reach the *Rangabali char*⁸ whose expansive sandy swathe favored fish drying processes. Large-sized *behundi jaal* (a bottom-set bag net, also called *bindi jaal*) have remained historically emblematic of fish drying. During the post-partition period, the knowledge and experiences of offshore fishing, as well as *rangabali*, were transmitted to non-caste fisher people, shaping the socio-cultural tapestry of the Indian Sundarbans. At the beginning of the drying season, *bahardars* invest substantial capital to cover expenses which include fishing tool (net, boat) repairs, crew employment, fuel, food, transportation, and other essential articles for drying. Those who do not have their own boats, hire them from different sources, mostly from the Rajbanshis⁹ and Muslims. There is an agreement between a producer and a middleman who provides producers with capital on credit, locally called *dadand*, insuring his business against all expenditures and uncertainties in production output. The middleman, also known as *dadandar*, is generally a local wholesaler or a wholesaler of both fresh fish and dried fish from the city, lending advance money (*dadand*) ranging between 50,000 INR and 10 lakhs based on the requirements and size of the camp to ensure a steady supply of dried fish at a concessional rate. Taking *dadand* is a common and compulsory practice that has made fish processing affordable. Personal contact and local networks are the two means by which *bahardar* connects with *dadandar* for privately arranged trade exchanges. *Dadandar* sometimes visits the camp to check out the arrangements and get an idea about the amount of fish captured and fish produced. A monthly or bi-weekly private meeting is held between the producer and *dadandar* to decide on a payback amount which is negotiated over the cost of arrangement (salaries, maintenance), amount of fish produced, and the running market price. Three important outcomes are associated with such an established trade relationship: firstly, producers are committed to selling the dried fish at a heavily discounted price and, sometimes, they are obligated to supply and excess weight of fish; secondly, by generating market demands, the *dadand* forces the production of the organization—a larger catch; thirdly, if the producer fails to repay his *dadand*, the amount is added to the pile of debt for the following season, which further lowers the price he gets for his catch. However, such an informal trade relationship between producers and *dadandars* is planted on trust and negotiations against the absence of credit support and subsidies from the government. The producer and *dadandar* are both aware of the kind of mutual dependency they have, which partly explains why, notwithstanding occasional grievances of producers, there is no strong or sustained

effort to get rid of this otherwise shrewd practice. “There are so many *paikars* (wholesalers) involved in the trade. They will lose business if we do not collaborate with them”, expressed a *bahardar* of a *Lalgunj shabar*.

Fishers (*noukar lok*—who work in the sea) and fish processors (*kuler lok*—who work onshore) are appointed by *bahardars* on various short-term contracts from neighboring villages. The fishing crew of a *shabar* consists of 5–6 people, including a boatman (in charge of the boat and crew), fishers, and helpers who set a sail in 30 HP motorized boats (Box 1). With sufficient rations and 10–12 funnel-shaped bag-nets (*behundi jaal*), they travel toward the fishing grounds up to 30 km off the shore. It is important to note here that the high capacity 4- and 6-cylinder motorized boats are deployed to catch deep water fish such as Bombay Duck and Ribbon fish which are available in nearshore waters during September to January. As the months pass, they move into the deeper levels and therefore, small fish (such as Shrimp, Mullet, and Phasa) make up a large portion of the harvest from January onwards. The entire net is likened to a human body, and as such, some of the parts, such as the eye (*chokh*), hand (*hata*), cheilion (*kosa*), ear, and so on, are named in analogy to human body parts. Bag-nets are operated with the coordination of 2–3 4-cylinder trawlers (14–16 meters in length and 2–2.4 meters in depth), and small-sized vessels (about 10 meters in length), locally called *bhutbhuti*. *Bhutbhuti* collects the catch from nets, whereas trawlers with a capacity of 400–500 maunds¹⁰ carry it to the shore. On the other hand, the main asset of a *khoti* is a low-capacity 2-cylinder fishing boat that carries 2–3 fishers and travels for 1 h three times during high tide each day to gather fish from 8 to 10 foot deep seawater. During these short trips, they catch fish with 8 to 10 bag nets, which they set for their next trip as they return. Capturing fish through bottom-set bag nets is less aggressive as fish is not dragged or bottom-chased, rather groups of fish are entrapped in the floating layers of the nets during tides. The fishermen have a clear understanding of the lunar position (locally called *tithi*) which controls the velocity of the water currents according to the tide and ebb. They have learned from their experience and intimate association with the sea that the force of the seawater current gradually increases from the tenth and reaches its optimum either at *amabashya* (the new moon) or *purnima* (the full moon) whichever the case may be. The fishing trip can be a short or broken trip if the storms or cyclones occur in the sea or the trawler, locally understood as the “body”, is damaged or ill, or if a bountiful catch is obtained. Crew members earn between 15,000 and 20,000 INR per month during the 4 months of their contract. The *behundi jaal* is handwoven with cotton yarn (often sunn-hemp is also used) by experienced fishers who are either retired or involved in marine fishing as part of the *shabar*. Nowadays, as the *karbaar* allows in more commercial operations with larger amount of fish and many fishing units to be handled, rotproof nylon fibers are used for knitting *behundi jaal*. This arduous exercise would be in vain if the catch is scarce, as it has been lately due to water pollution, siltation, and overfishing.

Fish processing is carried out from dawn to dusk by men contractual fish sorters and women *hajira fish* sorters who are employed under a ‘no work no pay’ scenario (Figure 8). Labor demand for fish drying corresponds to the lunar cycle, with two

7 India became independent in 1947 with the painful saga of her partition marking the birth of the Muslim dominions of East Pakistan (later Bangladesh) and West Pakistan. In 1971, Bangladesh was formed as an independent country followed by a historic struggle called Bangladesh Liberation War.

8 Apart from *Rangabali*, the fishers practiced fish drying for six months (October to May) with the *khotis* settled in *Sonar char*, *Dhal char*, *char Mamtaz*, and *Andar char*.

9 A *hindu* fishing caste.

10 1 maund is equivalent to 37.3242 kilograms.

BOX 1 Marine fishing and fish processing methods in the Indian Sundarbans.

FROM FRESH FISH TO DRIED FISH

Fishing

- Fishing crew conduct the trip in the sea for 6–14 days
- The fishers select a suitable place, locally called *phar*, where they can operate bag-nets
- Wooden pole (*khunti*) is planted in the seabed which holds the net during tides
- When the current gets stronger, the net sinks and stretches. Fish drifts in with the current.
- During a subsequent intertidal period, the net comes up to the surface and the catch is emptied
- Bombay duck, Ribbon fish, Honey gourami, various species of phansa, pangas, chhuri, crab, shrimp etc. are captured and transported by the trawler to the shore

Processing

- Sandy courtyard of *shabar* is covered with three layers: tarpaulin at the bottom, thick straw layer at the middle and nylon nets at the top. The layers help to retain warmth for fish during daytime
- Fresh fish is cleaned in bamboo baskets and taken to the *shabar* yard by hand-driven cart
- The fish is laid over the straw bed. Often raised bamboo platforms are constructed for drying
- Natural drying i.e., the combined action of the sun and wind, is adopted. Full-sized fishes are dried without splitting or salting
- Long and soft fishes like Bombay duck are tied together with elastic threads and dried in groups on the bamboo scaffolds surrounding yard. Ribbon fish is fastened in pairs with the drying posts, standing at a height of 1 meter above the ground
- Women workers use locally available balloons to wrap their fingers while tying the mouths of *Bomla* which has sharp teeth. For flipping the fish, they use a knife-like tool called *patta*, made of bamboo. Fish is tended regularly and flipped as needed
- Small, thin fish take 3–4 days to get dehydrated, whereas long, fleshy fish such as Ribbon Fish are sun-dried for 5–7 days until the moisture is eliminated
- Polythene sheets are applied to protect the fish from dewdrops.
- Once the fishes are accurately dried, which is confirmed by their color, texture and odor, they are sorted according to species and stuffed into the gunny bags and kept in the storeroom

high and two low weeks. The camp starkly manifests a gender divide in labor and wage, revealing hierarchies in the dried fish value chain—while men are assigned to fish cleaning, packaging, applying pesticides to prevent infestation, loading product onto crates or trucks, and weighing the produce, female casual laborers are involved with courtyard cleaning, sorting, scaffolding, and tending fish. These “typical female activities” earn them around 200–250/- INR a day, that too depending on the profit margin of the owner. Only male laborers are offered 4-month contracts for around 60,000–70,000/- INR. *Bahardar* hires *hajira* workers through a local broker who charges 10 INR for each contact. A single drying operation may require the involvement of 8 to as many as 40 workers each day, depending on the size and volume of fish to be processed. At the sites of Lalgunj, Baliara, and Lakshmipur, around 35–40 dry-fishers work in *shabars*, whereas 10–15 dry-fishers including four or five family members, work in *khotis*. Fishing, fish sorting, and drying activities are mostly performed by family members and relatives in a *khoti*. However, these figures drop if there is fewer fish to dry. Depending on workloads or raw fish catches, *khoti* families employ daily-wage fish sorters (four to five) whereas a boatman and fishermen (one or two) are hired at the onset of the drying season. It is customary between *khoti* families to share each other’s workload by assisting with various tasks that include carrying bulky fish piles from the coast to the camp, setting up scaffolds, and tending fish. This illustrates how a collective of households practicing the same ‘everyday’ activities in a same rhythm, slowly transcends into a community with shared values. Landless, poor inhabitants of nearby villages, these women dry-fishers often belong to the same family where the younger generation learns from their mother or grandmother about different fish types, methods of drying, and fishing tools. Their husbands work as fishermen in marine fishing crews, as migrant laborers, or as agricultural laborers in the village or faraway cities. On top of carrying out household duties, women engage in activities (net mending, catching small

fish and tiger prawn seed, fish vending, laboring on others’ paddy farms) to earn additive income for their families while their husbands are away for work. Although *shabar* owners and *hajira* workers are from a same community or neighborhood, they share a professional, business-centric relationship that often limits them from voicing their concerns and discontents. Moreover, the caste-based identities of participants, particularly among those classified by the government as Scheduled Caste (SC) communities, influence relationships and roles within the organizations. A strong bonding prevails among the actors in the managerial group comprising of *bahardar*, lead fisherman, members working on a shared basis, and sometimes moneylenders, whereas the daily-wage processors work under a stern supervision of the *bahardar* whose aim is to augment profit.

While cyclone hitting the coastal villages of Sundarbans makes a more noteworthy story for frontline media houses, everyday risks and uncertainties of dry-fishers in an informally established social economy like dried fish, are naturalized and neglected. Following the hazardous Bulbul cyclone in November 2019, a media article reported that close to 57 houses and more than 30 *khotis* were razed to the ground by gushing winds and storm surges. In disaster-hit Sundarbans, people do not have a source of livelihood and they barely have food to eat. They keep waiting for the floodwater to go down and start again to struggle from somewhere. A cyclone’s impact does not pose the same challenges to men and women, nor it is same for all the members in a camp. Gender-specific social and economic positions of women, as imbricated in the structural relations and practices in the organizations, set conditions for ‘common yet differentiated’ implications of cyclonic hazards ravaging weak mud houses in the village, household resources (livestock, pond, fields through saltwater intrusion) and entire camp infrastructure at once. A *shabar* owner from Lalgunj mentioned that he had to pay a lot to arrange the camp again after the Bulbul cyclone (9 November, 2019) which caused damages worth INR 6 lakhs. “When cyclone occurs, we stay at the shelter



FIGURE 8
Various activities in a *shabar* of Frasergunj. Source: Fieldwork 2022.

for two-three days only to discover that our homes have been shattered to the ground, all our resources (stored rice, goat, cattle) are gone”, lamented Rina *di*, a *hajira* fish sorter of a Lalgunj *shabar*. Cyclonic upshots affect the owner’s business and consequently, fall heavily on the shoulders of women *hajira* workers and fishers who must protect both their livelihoods and households. Cyclone ramifications are shaped by the disparate, gendered vulnerabilities of residents who face them in different ways. *Shabar* owners remain concerned about reorganizing the camp and paying off *dadans* while *hajira* workers and fishers strive to get their livelihood back and rebuild mud houses that claims the little that they have saved.

The ‘downstream’ level (Kaplinsky et al., 2002) of the value chain involves a network of wholesalers, small traders, retailers and fish vendors. From drying camp (*shabar and khoti*), dried fish makes an onward journey to wholesale markets from where it is moved to retail centers. After buying dried fish from *bahardars*, intermediary traders, *paikers* or *dadandars* in popular terms, sell a major portion of the stock to wholesale traders of Balighai (in East Medinipur district) and Sheoraphuli (in Hugli district). Most often, *paikers* preserve a part of dried fish in *arats* (stockroom) for selling all year round. From these two export points, dried fish goes to Phuleshwar (in Howrah district), Koley (in Kolkata) and Territi Bazar retail markets. The *paikers* arrange small trucks and boats to transport dried fish from camps to the wholesale markets from where it is transported via trucks and trains to retail centers (see Figure 9). The manager of the *paikers* handle packing and loading of dried fish into trucks or boats. A marginal share of dried fish is sold by *bahardars* directly to local traders and wholesalers of Kolkata and Howrah (see Figure 9). Egra is the largest cooperative-based fish market and Phuleshwar is the largest

retail house in Bengal. Over 90% of the wholesalers in Sheoraphuli continue their ancestral businesses, ranging between 25-50 in age (see Figure 10). A slice of dried fish stock consisting of discarded remnants is sent to the Junput market of East Medinipur for distribution to poultry farms. About 20% of dried fish is used by fish meal industries to produce poultry feed. Retailers of Phuleshwar retail market, local small-scale traders, and local vendors, among whom women make up a small but significant segment, are the buyers of dried fish. They purchase 5 to 10 kilograms of dried fish for each variety. From the outlets of Sheoraphuli, dried fish is exported via train to the retail markets of Tripura, Odisha and Assam, whereas a portion is sent to neighboring markets in Barasat, Beldanga, Barrackpore and Katwa. Members of a home-based enterprise producing and selling dried fish in roadside stalls and local markets, stated that they do not depend on *dadans* as it obligates them to trade with *dadandars*. They purchase fresh fish from *bahardars* once the catch arrives onshore and dry them at home (on roofs and yard) for selling at their roadside stores.

6. Collaboration and knowledge co-production through interactive multi-stakeholder workshop

Knowledge co-production is situated within the voluntary commitments and collaborative settings of both academic and non-academic groups, bringing in context-specific knowledge, expertise, and perspectives for collectively exploring major drivers of changes, evaluating scopes for meaningful practices, and crafting avenues

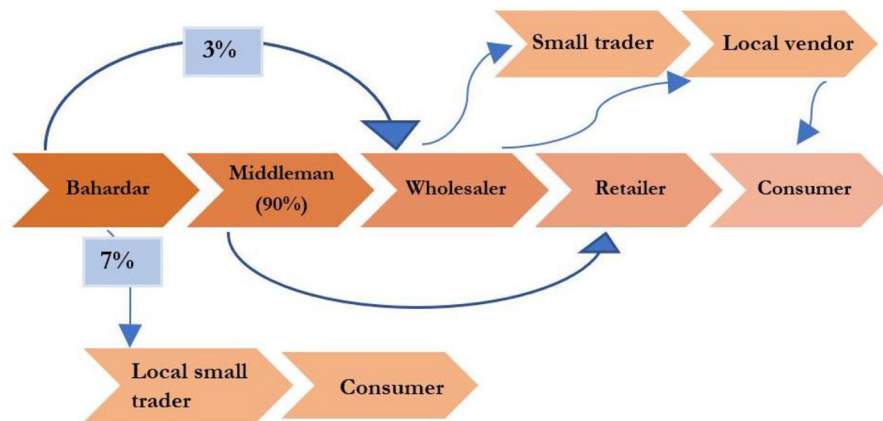


FIGURE 9
Market network within the dried fish value chain. Source: Modified after Society for Direct Initiative for Social Health Action (2016b).



FIGURE 10
Dried fish stores at Sheoraphuli. Source: Fieldwork 2022.

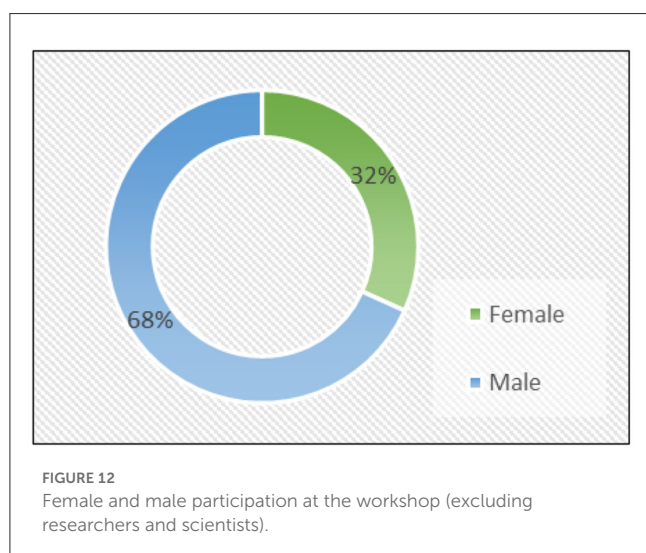
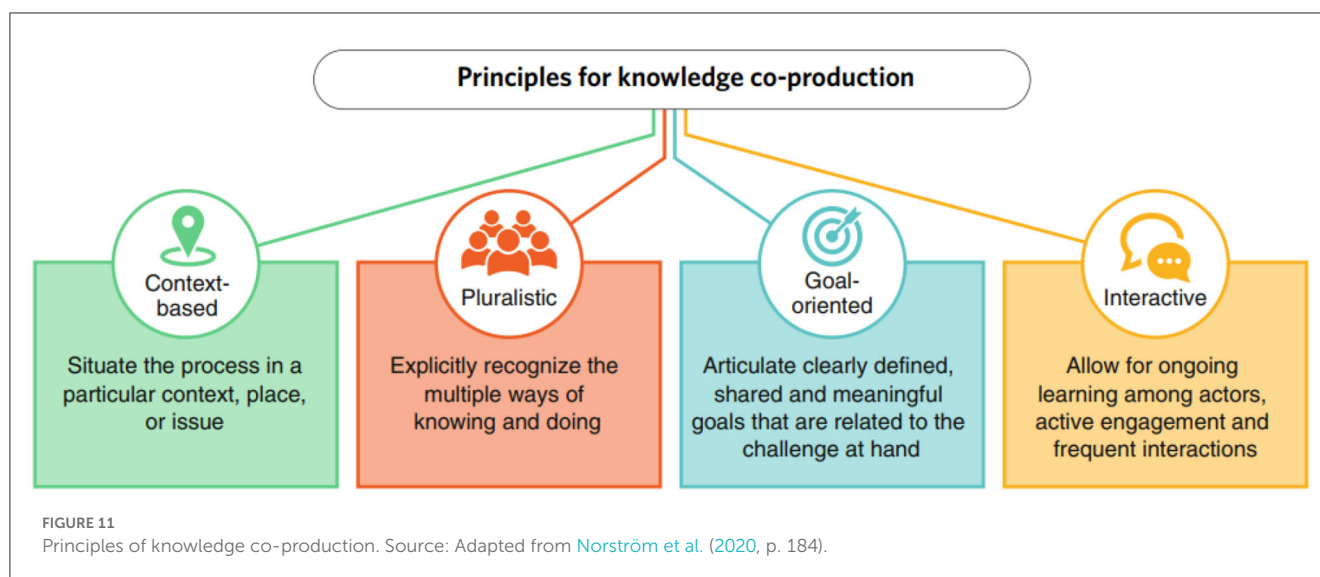
toward solutions (Norström et al., 2020). From a tangible starting point of recognizing stakeholders to asking relevant questions on how a specific challenge has precipitated, how it shapes the lives and livelihoods of people, which factors foster or restrain the activities, and where the policy windows are located the dynamic stages of knowledge co-production are premised on sensible involvements that prioritize trust-building and problem-framing through iterative exchanges.

The two previous sections of the article implied the need to adopt a more social, participatory approach that extends a wider space for interactions, consultations, and collaboration, steering a concerted decision-making process and mapping out solution-oriented trajectories for the dried fish economy in the Sundarbans. We pursued knowledge co-production across a multi-stakeholder partnership framework, prominently accentuating the urgent needs of those whose resources, knowledge, and values are at stake. In essence, the workshop was anchored on the four pillars of knowledge co-production, assumed by Norström et al. (2020)—context-specific, pluralistic, goal-oriented, and interactive (Figure 11). The workshop was context-specific in its focus on the livelihood dependencies, needs, and beliefs of different social groups in *shabar* and *khoti* accompanying various place-based issues (work conditions, flooding, wage

distribution, compensation, etc.) whereas the pluralistic workshop strung together a range of views from different backgrounds irrespective of gender, age and ethnicity. A common goal for all participants was to develop a collective understanding of the problems reflecting different inequalities, power hierarchies and the limitations in reaching out to agreed-upon measures of solutions. It paralleled persistent multi-pathway interactions among the participants, enabling a co-learning process through the exchange of experiences, aspirations and values. Most importantly, profound communications put forth individual choices, intimate or distant relationships, and clashes, which cloud the pre-imagined vision of ideal social groups and takes to the real-world conditions for life.

6.1. The workshop: toward climate-resilient fish drying techniques and livelihoods

Our frequent conversations (over two meetings and phone calls) with the representatives of DMF, resulted in a template specifying the stakeholder groups, duration, and location of the one-day workshop which took place on May 23 (see Figures 7, 12). The workshop was scheduled at Kaddwip which is conveniently



accessible by local train and bus from the villages of fish processors. The workshop began with a short video on dried fish processing in Frasergunj village, prepared by the research team (<http://toobigtoignore.net/>) (see [Supplementary material 1](#)). Woven with compelling visuals and narratives on everyday activities in the camps, the video effectively set the tone of the workshop and motivated the dry-fishers whose on-site accounts were depicted on-screen. Four teams were formed in the dynamic group interaction session, each with a discussion moderator and a note-taker: *hajira* workers (total 16 members including four researchers, one SHG representative, and one net mender), small-scale marine fishers (total six participants including two researchers), *shabar-khota* owners (total nine participants including one researcher and one DMF representative), and trader (total three participants including one researcher and one DMF representative).

6.1.1. Reflections on challenges

“After working for half an hour so as a new recruit the *shabar* owner may tell us to leave empty-handed”, stated *Shikha Di* (Figure 13). While more and more work-aspirant dry-fishers intend to join the camp, preferences based on experience, age, and camp requirements dominate their fate. Most often, the contractual male laborers are offered the roles usually assigned to female dry-fishers, further lowering chances of being recruited. Elderly women over 60, who are mostly widows and are losing their eyesight, have even fewer opportunities for employment. They do not have equal access to the state government ventures like pensions for senior citizens, known as *Bardhyokyo Bhata*.¹¹ The amount of work accomplished hardly varies between men and women workers, rather women’s contribution exceeds by time and toil that of the male workers. In reality, the complete processing operation runs seamlessly due to the meticulous effort that they put in every day from 5 AM to 6 PM. However, the wage they receive is lower than that of their male counterparts. It is not only their responsibilities at the camps that continue - during lunchtime they rush home to carry out household ‘duties’ that include meal preparation, livestock handling, taking care of children and elderly members. The increased pressure that comes with combining household chores with waged work is, clearly, faced by women. Some of them commute quite a distance by feet from the adjacent villages to reach the camp whereas those who had to manage accommodation in tiny shacks of *shabar*, throw themselves into grim living conditions. Low-quality drinking water is another major problem in coastal stretches of Baliara and Lalgunj. All the dry-fishers mentioned that the camps comprise a single bathroom, which too is unhygienic. All the hard toil under the scorching tropical sun brings them

¹¹ The West Bengal government provides a monthly pension to the senior citizens, a pension scheme which comes under the Department of women, child development, social welfare. As per the scheme, anyone aged over 60 is eligible to be enrolled for a pension irrespective of caste, ethnicity, and income.

is a poor diet comprising rice and fish as a reward. While the *hajira* workers from Lalgunj described how they swim across a tidal creek every day to reach the camps, women from Baliara were uneasy about flood risks during cyclones that wipe out the embankments along the rivers. Over 90% of the dry-fishers stated that the *shabar* yard and the shacks are filled with water during cyclonic storms, further exacerbating the situation. While cyclones and concomitant floods sweep away the entire set-up of the camp, unseasonal rains, and cloudy weather during winter lead to spoilage of dried fish hitting the business hard. During cyclones, they safeguard the dried fish with polythene sheets on raised platforms or in the storerooms. The dry-fishers further told us that the temporary flood relief centers are neither evenly distributed nor adequately equipped. During non-drying seasons, the women eke out a living by working as housemaids in cities, mending nets including *behundi jaal*, and capturing tiger prawn seeds from murky waters, all of which fetch out a low return. Furthermore, collecting tiger prawn seed is an onerous and hazardous activity as women have to partially submerge themselves for a long time into the water that is not only laden with sediments but also contaminated with various toxic pollutants causing acute health problems such as dermatological diseases, digestive issues, and orthopedic pain (see Chowdhury et al., 2017). While the researchers took a closer look at their opinions on the most urgent solutions (see Figure 14), the *shabar* owners, on the other table, pointed out the challenges they run into.

Shabar owners are unable to take loans from the banks which demand assurance upon a permanent business or assets. If the owner fails to repay his *dadan*, the *mahajan* (*dadandar*) allows him one chance to supply the entire amount next year, otherwise the deal is canceled. If an owner fails to pay off the *dadan* (e.g., 10,000/- dry fish is produced at a *dadan* of 2 lakhs), he asks the *dadandar* to withdraw the money so that the owners can take a loan from other sources; however, the *dadandar* does not encourage that as it would reduce his access to low-priced fish supplies from producers. In Frasergunj, there is no active cooperative society for dried fish, unlike the East Medinipur district. “We get a relief [sic] without the consent of *dadan*, but we are helpless as we need money”, mentioned a *shabar* owner. The conditions of *dadan* are inflated even further with declining fish quality and shrinking fish stock, which has been affecting the business in the course of the past few decades. Fish producers are concerned about the accumulation of heavy metals in fish and other aquatic resources due to increased water pollution, leading to various fish diseases, early spoilage of fish, reduction in fish diversity, and changes in fish habitat. Most of the metal elements¹² (Cadmium, Chromium, Lead, etc.) that transmit into fish are cumulative poisons causing severe health problems when consumed. The DMF representative, on the other

hand, set out how overfishing by industrial trawlers with bottom-chaser trawler nets and fish-finder equipment made inroads into the fish habitat of Bengal’s nearshore areas. “Motorized gears triggered the tendency to capture more fish resulting in fish stock depletion – the fishers who invest much time to fish with 1-cylinder or 2-cylinder, are now unable to catch a desired volume of fish at the same site in the sea” [sic], he explained. One of our interlocutors voiced, “diesel price is hiking like never before – we need subsidized diesel”.

In order to protect dried fish from infestations by flies, ant and microorganisms, formalin and *doom* (*trichloro organophosphate*) are applied at times by the producers and wholesalers. This lowers the quality of dried fish.¹³ It has been found that medicines applied during cloudy weather stiffen dried fish, which does not soften even after boiling for several minutes. “Without hygienic and healthy drying, the dried fish market will start to suffer, as it has already shown some signs of downfall in exports”, stated a wholesaler. Transporting dried fish to local or regional market centers is a dire challenge—police patrols and random bribes are commonplace.

Small-scale marine fishers, on the other hand, remain worried about their livelihoods for eight long months when *shabar* remain at closure. “Nobody wants to employ the *boro majhi* during non-drying season, as they have already earned a reputation with being tied to a *shabar* or *khoti*. So, they are replaced by small fishers”, reflected an experienced fisher at our discussion table. Large tidal waves caused by a sudden storm cause vessels to capsize, claiming the lives of fishers who stay on-board for days. A member of DMF mentioned that there is no accident benefit for fishers since 2017. “West Bengal once made a group insurance with 20,000 fishers to whom the government provided premium. As per the scheme, by showing *Panchayat*’s certificate or *Matsyajibi* identity card and the dead body (if it is not found, evidence should be provided by any crew members), the family members of the fisher used to receive a compensation of 2 lakhs”. However, this insurance plan is not enacted equitably. Such oversight is often the outcome of partisan vote-bank politics bringing about local contestations over funds, and inter-party conflicts on schemes that favor their populist agendas.

6.1.2. Trajectories of solutions

Informal conversations among four stakeholder groups, scientists, and researchers revolved around three broad areas—(i) hygienic and climate-resilient drying, (ii) livelihoods and training potentials, and (iii) everyday dwelling in the delta. Representatives from each ring spontaneously placed their views and ideas on a specific theme that emerged from the discussions themselves. Imperative, in this regard, is that the cross-group exchanges contained, either in hidden or direct articulations, the components of knowledge co-production (Table 5).

i) Hygienic and climate-resilient drying—technical measures

The senior scientist started with dried fish quality which, according to him, can be improved by applying an appropriate

12 For the last several years, the aquatic environment of Bengal’s nearshore region has been exposed to and harmed by floating microplastics, discharge of contaminated wastewater from commercial shrimp monoculture ponds, and non-point pollution from river-side industrial sites (see Rasul et al., 2020; Ghosh et al., 2022).

13 See Rasul et al. (2020) for details.



FIGURE 13 Snippets of knowledge co-production workshop at Kakkdip. Source: Authors.

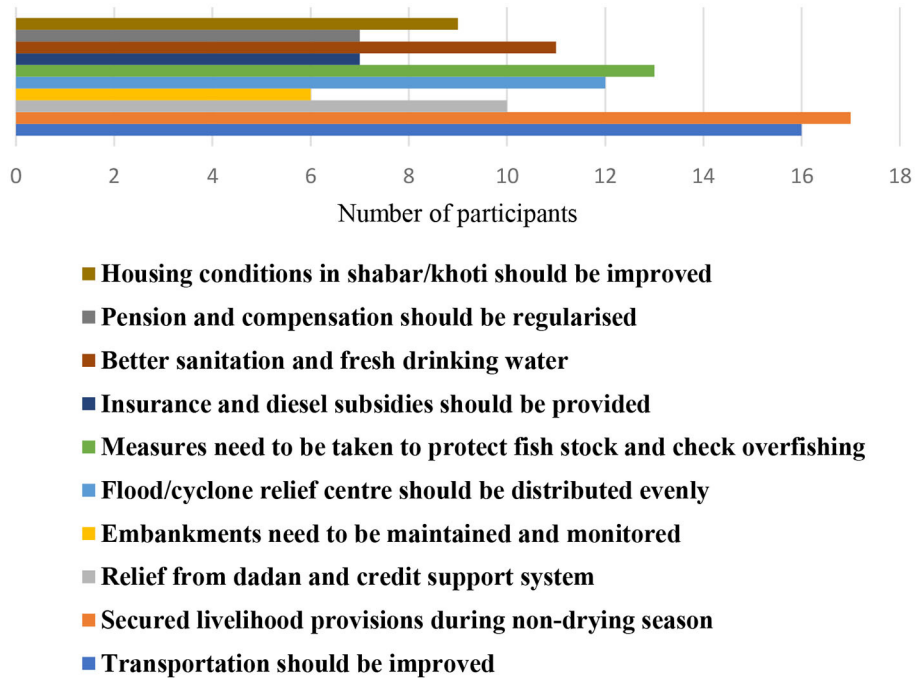


FIGURE 14 Areas in need of attention as indicated by the workshop participants.

amount of coarse common salt (*sodium chloride*). Salting can turn out to be a significant step, as salted fish last for many days without substantial storage and attract less infestation than unsalted

ones. High-quality coarse salt accelerates Oxidative stability (lipid oxidation process), an important pre-treatment procedure that reduces drying duration, extends shelf life, and increases product

TABLE 5 Components of knowledge co-production and corresponding examples from the conversations.

Component of knowledge co-production	Examples/quotes
Clarifying	“These days, our major challenge is humidity which remains almost constant throughout the year”
Proposing	“I suggest Solar Tent Dryer for greater uniformity and quality of the output”
Informing	“A similar initiative was once launched on Sagar Island in the Indian Sundarbans, but it failed due to the restricted size and quantity of tents”
Supporting	“It is encouraging to see how the livelihood issues of women dry-fishers are surfacing in these discussions”
Building	“We can take the help of technologies which will play a dual-role role of accelerating the hygienic drying as well as protect fish from rainfall and humidity”
Reifying	“I would think about plant-based propellants that may abate the chances of infestation by keeping ants and flies away without dropping the quality of dried fish”
Reiterating	“Providing proper training will also allow our family members to get involved in these practices for an income”
Collaborating	“Together with DMF, the research team and West Bengal University of Animal and Fishery Sciences (WBUAFS) that organizes training programs on preparation of various fish products, a training workshop for the <i>hajira</i> workers can be arranged”

yield. A *shabar* owner with contrary experiences remarked that local markets have less demand for salted fish, while demand for dried fish varies from one market to another across states and depending on the taste, texture, and flavor. According to him, salt gives the cured fish a yellow color and often effects the texture of the fish. The scientist replied, “that being the case, a small proportion of calcium and magnesium salts can be applied”. He continued that salted dried fish from Bengal can generate demand in local markets and the Anganwadi centers of Assam and Tripura. On a parallel note, the DMF representative reflected, “air direction and amount are crucial contributors to a good quality dried fish. These days, our major challenge is humidity which remains almost constant throughout the year. Hence, fish takes a long time to dry” (Table 5). Concerning insect infestation in dried fish, the scientist stated, “I would think about plant-based propellants that may abate the chances of infestation by keeping ants and flies away without dropping the quality of dried fish”.

The junior scientist pointed out, “we can take the help of technologies that would play a dual-role role of accelerating the hygienic drying as well as protect fish from rainfall and humidity. I suggest Solar Tent Dryer for greater uniformity and quality of the output”. When drying fish artificially, some factors can ensure optimum drying conditions, especially during humid winters, such as the initial drying temperature (25–45°C) in tropical regions, relative humidity (initially 50–65%) that controls the drying rate and texture (hard or soft) of the dried fish, and faster air flows.

Different from a conventional solar dryer which contains solar cells, the tent dryer (Figure 15) is structured as a tent made with wooden or bamboo frames that are covered with transparent polythene, allowing sunlight to get in. Solar tent dryers assure fish drying in any weather condition and a clean environment; it also preserves the nutritional quality of fish. The scientist also acknowledged that solar tent dryers will not be able to produce

more dried fish in large-scale arrangements which extend to many *kathas* of land.

“Would it facilitate equal drying at every side?” asked a *shabar* owner. The scientist stressed tending the fish properly while drying. On this front, the *shabar* owner cautioned, “we cannot over-dry the fish so that the smell is gone. In Tripura, people often soak the fish in water to add smell as they prefer a pungent odor”. Drawing evidence from experimentation conducted by the Bangladesh Fisheries Research Institute (BFRI), the DMF representative reminded the group that the solar tent dryer can stand out as a successful low-cost fish dryer made up of locally available materials, but the model would not function in the absence of sun. He maintained that a similar initiative was once launched on Sagar Island in the Indian Sundarbans, but it failed due to the restricted size and quantity of tents. He further described a transparent version of a solar tent dryer called a BFRI model which is constructed by using two layers of thin (0.20 mm) celluloid allowing for better insulation and effective utilization of heat energy. The model has been successful in capturing sensory qualities, nutritional properties, and water absorption capacity in dry fish.

ii) *Livelihood and training*

The junior scientist emphasized livelihood diversification, especially for the 8-months non-drying period. Some dried fish (such as dried shrimp) could be further processed to prepare different fish products, such as dried fish pickles, sauces, and *papad*. Dry-fishers could produce shrimp pickles as a collective business during the non-drying season—local Self-Help Groups (SHG) of which they are part, could be mobilized to that end. She continued, “together with DMF, the research team, and West Bengal University of Animal and Fishery Sciences (WBUAFS) that organizes training programs on preparation of various fish products, a training workshop for the *hajira* workers can be arranged”. She added that packaging should be considered important for product safety

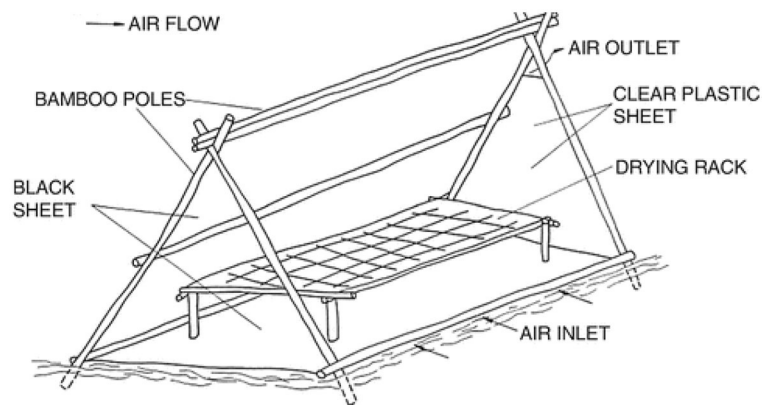


FIGURE 15

Model of small solar tent dryer. The tent's top must have a circular vent for air circulation. Inside the tent, a bamboo platform covered in dark polythene sheets lies for drying the fish. The temperature can be controlled by opening air vents permitting free air circulation while tarpaulin sheets protect the fish from dewdrops and sporadic rains (Source: Banout, 2017).

and successful sales. “I would request the senior scientist to think about how the market connection could be established for these products, which have potentials to be directly sold to urban retail stores”. The senior scientist replied that a scientist team of CIFRI will initiate a conversation with NFDB (National Fisheries Development Board) and NABARD about the market connections, low-interest loans, and implementation of two FPOs (Farmers Producers Organization) at Sagar and Frasergunj. Also, as a nodal loaning agency, NABARD guarantees an interest subvention of up to 3% per annum to the SHGs which can be mobilized for the training program.

iii) *Everyday dwelling in the delta*

Chandana Das, a woman *hajira* dry-fisher from Lalgunj, expressed “it is encouraging to see how the livelihood issues of women dry-fishers are surfacing in these discussions. Considering the risk involved in crossing a tidal channel, I urge everyone to pay adequate attention to the transport of women from their villages to processing centers. Insufficient access to safe drinking water is another significant issue, especially for the *hajira* workers of Kalistan and Lalgunj. A tube well near the *shabar* would resolve the water-related problems”. A fish sorter from Lakshimpur added, “trainings on duck and goat farming are often provided by the government jointly with NGOs; however, the results are not achieved due to the lack of monitoring and disconnected efforts. Providing proper training will allow our family members to get engaged in these practices for an income.” “We need to convey these issues more formally to the fisheries department. Sanitation infrastructure and cyclone relief centers should be prioritized”, said the DMF representative. In foregrounding the consequences of repeated cyclones and attendant flooding of the camp areas, the senior scientist said, “I have already placed a proposal in my network at IMD,¹⁴ Alipore regarding the

installation of a cyclone forecasting station at the eastern side of Sundarbans—it will be beneficial for people living in the western islands too”.

From audio-visual presentations (short-term dissemination) to a concrete policy brief (intermediate plan), from co-organizing training programs (intermediate plan) to mobilizing SHGs (long-term intervention)—this collaborative pursuit, characterized by what Norström et al. (2020) describe as “open, deliberative, and reflexive” attributes, pledges to promulgate the calibrated results for cross-departmental attention and seeks to create space for voices that have remained inaudible so far. Our experiences of the workshop underlined four aspects: firstly, there are intersecting spaces of discontent and community ethos differently influencing the perspectives of the stakeholders—tracking and sensitizing these overlaps is essential for designing future plans; second, women’s contributions, living conditions, and accessibilities (to markets, credit, and other resources) did not find room for discussion to date, whereas a major focus has been channeled to fish production processes and nutritional aspects of the product; third, the sector strives for “right-based” conversations placing priorities upon “multiple rights”, insurance, and tenurial rights issues; fourth, it is necessary to build awareness through policies, trainings and support about safe drying conditions with regard to hygienic sanitation practices, improved packaging and adoption of organic pest prevention measures; fifth, sustained communication among actors might allow a trustful monitoring of change, and keep open the possibilities for more inter-sectoral engagements.

7. Conclusions

The “three-step” methodology, used in the article, reveals the granular complexities and potentialities in the dried fish sector. The following points summarize what makes up the article:

¹⁴ IMD stands for Indian Meteorological Department.

- By drawing in the sociohydrological features of coastal environments and livelihoods, we note an indelible influence of water dynamics on food production in general and fisheries in specific. SES provides a fuller understanding about the institutional effects on social-ecological setting of fisheries in the Southern countries by underlining the operational principles of local economic organizations, management approaches to coastal fisheries, unequal access to market and resources and so on. Relatedly, it looks into how institutional processes respond to evolving social-ecological scenarios and crises situations while both SES and SH lenses stress upon the significance of collaborative learning about and management of vulnerable coastal resource systems.
- We applied various ethnographic methods to grasp the complex nature of dried fish 'social economy' in terms of differential relationships, practices, everyday struggles and emergent risks that characterize dried fish organizations. The study also draws in locally tuned understanding about the increased biophysical threats, slow-onset social and economic shifts, and adaptive 'tactics' in the delta. Our observations make visible how the political economic forces coupled with social dynamics in organizations have shaped collective involvement in local economies through instilling competition and undermining claims over resources and benefits.
- Grounded on the assumption that relationships, policies, and practices are multi-way and complex, our take of knowledge co-production was to incorporate inputs from local people in order to perceive opportunities for co-interventions (training, SHG mobilization, knowledge dissemination) through which knowledges may transfer into solution-oriented practices. Here, 'knowledge' derived from 'pluri-voice', transcends an established, theory-driven, scholarly idea to take into account perspectives, concerns and experiences arising from lived realities of local people in shifting social, ecological and economic circumstances.

We further believe that the buzzing policy discussions on some popularized connotations such as 'welfare', 'wellbeing', and 'resilience' only legitimize the capitalist interests by appropriating the very notion of 'sustainability' and thereby, remaining fallaciously lop-sided, myopic, and redundant. This essay on dried fish sector of the Indian Sundarbans indicates the potential of participatory-transdisciplinary approach in reinforcing 'sustainability' through blurring west-borne dichotomies between social and ecological, vulnerability and resilience, normative and real, and finally, theory and practice.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

RG designed the research, conducted field surveys, performed data analysis, developed the article structure, and led the writing and revisions. JM supervised the research and field surveys, provided advice on the conceptualization of the research and article design, and contributed to the writing and revised the manuscript. PG transcribed a part of the write up. AB, AC, PG, SP, AS, and PS contributed to the fieldwork and workshop. The manuscript is the outcome of the collaborative efforts of all authors. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.youtube.com/watch?v=aR6tC_aLPgQ&t=87s.

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