

Dried fish at the intersection of food science, economy, and culture: A global survey

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Abstract

Dried fish—here defined broadly as aquatic animals preserved using simple techniques, such as sun-drying, salting, fermentation, and smoking that permit storage as foods at ambient temperature for extended periods without specialized packaging—have received little direct attention in fisheries research. This lack of visibility belies their historical and contemporary importance. Prior to the introduction of refrigeration, dried fish were the main form in which fisheries catches were traded and consumed. Dried fish products remain a core component of production, trade, diets, and cuisines across the world, particularly in the Global South. The dried fish sector provides employment for millions of people, particularly women, who comprise most of the fish-drying workforce in many locations. However, the sector also confronts and creates significant challenges including food safety concerns and exploitative labour conditions. This paper is the first systematic assessment of the global literature on dried fish, comprised of a sample of >1100 references. In contrast to the general fisheries literature, which is dominated by studies of ecology and governance and focusses mainly on primary production, the dried fish literature is dominated by studies from food science and concentrates on the processing segment of fish value chains. As such, it offers valuable reference point for fisheries research, which is becoming increasingly attentive to food systems. This paper uncovers a wealth of insights buried in this largely unheralded literature, and identifies key thematic intersections, gaps and research questions that remain to be addressed in the study of dried fish.

KEYWORDS

fermented fish, fish processing, food and nutrition security, foodways, smoked fish, value chains

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1 | INTRODUCTION

A large share of global fisheries catches, particularly those landed in the Global South, are preserved using simple techniques including sun-drying, salting, fermentation, and smoking. These processing practices may be combined (e.g. Essuman, 1992). We use "dried fish" as a catchall term for this category of foods, broadly defined here as any aquatic animal product that has undergone processing that enables it to be stored as food at room temperature for extended periods of time without specialized industrial packaging. Our definition thus excludes industrially produced canned fish and cold smoked fish that require refrigeration. It includes product types like fermented fish that are not actually dried, but which share the property of storage at room temperature.

Prior to the introduction of ice-making technologies and cold chains, dried fish were the main form in which fisheries catches were traded and consumed, and the global historical record is replete with evidence of widespread dried fish production, storage, trade, and consumption, going back millennia (Fagan, 2017). But dried fish does not constitute a residual category. It remains a core component of diets and cuisines across much of the world, and is one of the main forms in which fish is sold and eaten in regions including Sub-Saharan Africa (e.g. Liverpool-Tasie et al., 2021) and South East Asia (Hortle, 2007).

The processing practices that we include under the umbrella of fish drying result in various material changes including dehydration, weight reduction, concentration of nutrients, and inhibition of growth of undesirable microorganisms. The ease with which dried fish can be stored and transported means that it reaches hinterland areas where fresh fish is not readily available. Preservation also permits the smoothing out of seasonal fluctuations in the abundance and scarcity of fish throughout the year (Ruddle, 1987b). These qualities, along with ready divisibility into small portions, intense flavour, and prices per unit of nutrient that are often low compared with fresh fish, make dried fish products widely and readily available, accessible, and of disproportionately great importance to the nutrition of the most vulnerable (Belton & Thilsted, 2014).

On the supply side, production of dried fish provides a source of livelihood, income, and employment to millions of people. Actors involved include small- and larger scale fishers and processors, and traders at various scales from large urban wholesalers to small urban and rural retailers. Women dominate the fish-drying workforce in many locations, including regions such as South Asia where women's work outside the home has traditionally been heavily circumscribed (e.g. Pramanik, 1996).

However, the dried fish economy confronts and contributes to multiple sustainability challenges. These include the following: First, many labourers in dried fish value chains belong to marginalized groups (widows, refugees, religious minorities, and lower castes, for example) and are vulnerable to a variety of forms of exploitation and exposure to health and personal safety risks and hazards (Belton et al., 2019; Deb & Emdad Haque, 2011). Second, the use of pesticides during the drying and storage of fish to protect against insect infestation is thought to be widespread, and may imply serious health risks

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for producers and consumers exposed to these contaminants on a regular basis (Khan et al., 2002). Sanitary conditions at production sites are also often poor (Amuna, 2014; Majumdar & Basu, 2010). Third, the ecological integrity of some fisheries on which dried fish production is based is threatened, resulting in fish shortages and price shocks (Hall et al., 2013). Fourth, utilization of marine small fish in the production of feeds for a growing aquaculture and livestock industry may divert dried fish away from human food chains (Funge-Smith et al., 2005; Isaacs, 2016). Fifth, in many locations, high levels of informality and marginality mean that the dried fish economy falls outside the purview of formal governance structures and policies, and lacks political representation, rendering it vulnerable to development processes that may threaten longer term sustainability (Hossain et al., 2013; Salagrama & Dasu, 2021).

Despite the evident importance of the diverse and complex economy that produces and distributes dried fish, and the challenges that it faces, that economy has been almost invisible to many researchers and policymakers. The fisheries literature tends to emphasize fish, fishers, and fishing. It pays far less attention to land-based activities, such as processing and trading that may account for half or more of fisheries-related livelihoods, including those of most of the women involved (Weeratunge et al., 2010). Fresh products are often assumed to be the primary, or only, form in which fish is consumed. Post-harvest segments of dried fish value chains are often overlooked, and undocumented in official statistics. Accounts of the dried fish economy are thus partial and highly fragmentary.

The Dried Fish Matters project (www.driedfishmatters.org) was designed to bring together an interdisciplinary team to address this major lacuna in fisheries research. In this paper, as members of that project we map the shape of the existing literature and identify key themes and gaps through, to our knowledge, the first comprehensive global survey of the literature on dried fish. This comprises 3141 publications identified through systematic searches made using Google Scholar, of which 1132 pertain directly to dried fish. We have made this database of references publicly available to encourage further research in this field (see Data Availability Statement).

The first part of the paper outlines the methodological basis of the literature survey. Our findings are divided into two sections. First, we provide an overview of the literature using quantitative indicators of geography, theme, value chain segment, and product type. To emphasize the distinctive characteristics of the dried fish literature, we contrast it with a small, comparative sample drawn from the broader fisheries literature. Second, we offer a detailed qualitative thematic examination of the literature. We then synthesize insights from preceding sections in a discussion that sets out an agenda for future interdisciplinary research on dried fish economies.

The dried fish literature provides a point of connection to a range of disciplinary perspectives, particularly in the food sciences and food technology fields, that to date have received little attention in mainstream fisheries research. The literature is also filled with hidden pearls; contributions that reveal the diversity of ways in which fisheries contribute to society. It shows, for example, the importance of inland fisheries for nutrition in Asia and Africa, but also their importance for the cuisines of those regions. However, many of these insights have to be sifted out of studies that are mainly technical in orientation. As this paper shows, there are ample opportunities to bring forth the vibrant contributions to knowledge made by the dried fish literature, and to expand it to better represent areas including the social sciences and humanities, governance, economics, and ecology.

2 | METHODOLOGY

The literature survey was conducted using Google Scholar as our search engine and Zotero as our reference manager. Google Scholar was selected over other academic search engines due to its inclusion of both academic and grey literature resources. Zotero was chosen as an open source, collaborative platform that supports collating, organizing, annotating, and tagging search results for analysis. In addition to its collaborative features, Zotero provides an application programming interface (API) that allowed us to develop custom software tools to retrieve, modify, and process tag combinations in bulk (see scripts under “Data Availability Statement”).

Our literature search was based on an inductive, iterative learning strategy. We organized search terms by dried fish product type (i.e. dried, fermented, smoked, etc.) and geography. Geographical search terms included every country in the world (see tag lists in Appendix S3). Search terms and theme tags were developed initially

based on a preliminary scan of the literature. We subsequently conducted searches, tagged and analysed results, refined search terms and tags, and conducted further cycles of searching, tagging and analysis to address insights and gaps emerging from each successive round. This process took place from 2018 to 2021 and generated a shared Zotero library and database (see methodological notes and search query list in Appendix S1).

Through multiple rounds of analysis and discussion, our tag list was refined to cover five dimensions: (1) whether the reference pertained directly or indirectly to dried fish, (2) geography (country and region), (3) theme, (4) value chain segment (production, processing, trading, retail, consumption), and (5) product type. After initial screening, references identified as mentioning dried fish products, production, trade, or consumption, but providing little or no additional information on these subjects, were tagged as indirectly relevant and excluded from further attention. Our criteria for considering a reference directly relevant were thus quite broad. Individual references could be assigned multiple tags from a single tag category where relevant (i.e. a reference pertaining to multiple countries, product types, or value chain segments, would be tagged accordingly).

Our searches generated a total of 3141 items pertaining to dried fish. Of these, we tagged 1399 as of direct relevance to the topic of dried fish. After excluding items for which no source text or abstract were available, we established a fixed sample (“Dried Fish Sample”, $N = 1132$) used as the basis for our quantitative analysis below. The term *dried fish literature*, as deployed throughout this paper, refers to this sample of the literature.

For basic comparative purposes, in 2019, we also established a much smaller “General Fisheries Sample” ($N = 89$), compiled by selecting every fifth record from Google Scholar searches using the terms “fisheries”, “fishers”, and “fishing” until a total of 33 references had been retrieved for each term (Figure 1). Ten of the original items in this sample were subsequently discarded due to being duplicate or non-relevant results. Each of the remaining items was tagged with at least one theme, as well as a value chain segment and area of geographic focus if applicable, using the same tags as employed in the Dried Fish Sample (Appendix S2).

3 | QUANTITATIVE FINDINGS

This section summarizes results of our quantitative analysis in terms of: (1) geography; (2) product type; (3) value chain segment; and (4) theme. We also compare the occurrence of geography, segment, and theme in the dried fish literature with a smaller sample of publications indicative of the general fisheries literature.

3.1 | Geography

The primary orientation of the dried fish literature is towards countries from the Global South, reflecting the importance of

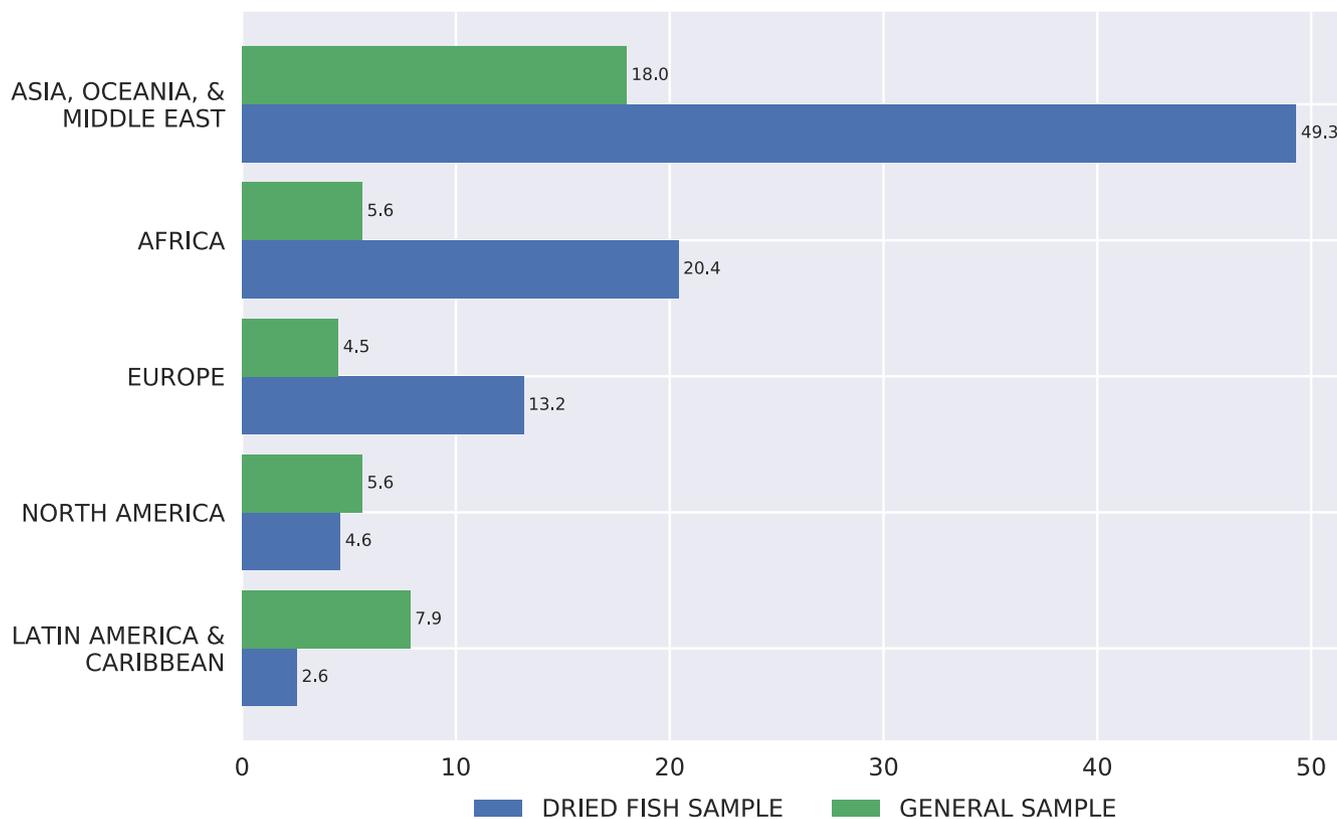


FIGURE 1 Geographical coverage of the dried fish and general fisheries literature (percentage of total publications in each sample identified as relevant to each indicated geographic region). In this and subsequent figures, individual publications within each sample were assigned to zero or more categories based on manual analysis of their content; each publication may thus be counted in more than one category. Publications of global coverage or with no geographical focus are excluded. Links to the online graphing tool showing query parameters for figures 1-6 are listed in Appendix S5

preservation techniques that are not dependent on cold chains, and the enduring importance of preserved fish products in diets. Fifty-nine percent of items in our sample concerned the Global South, with 21% focused on countries in the Global North. The remainder (14%) either had no specific geographical focus or, in a few cases, were global in scope. This represents proportionately greater coverage of the Global South than is apparent in the general fisheries literature sample (Figure 1), suggesting that the literature on dried fish mirrors global geography of fish production and consumption more closely than the general fisheries literature.

The literature on dried fish in Asia accounts for nearly half of tagged references. Africa and Europe also each have substantial literatures, while references on the Americas are much smaller proportionately (Figure 1). It is likely that significant literatures in Chinese, Japanese, Korean, Spanish, and Portuguese languages also exist. These would have been missed due to the English language focus of the literature survey.

3.2 | Product type

There is considerably ambiguity and inconsistency in how dried fish product types are defined, reflecting the use of multiple, overlapping,

and often un-standardized methods in their production. For example, dried fish are often salted prior to drying and some products usually considered salted may also be partially fermented. At the broadest possible level of product type categorization, all products may be categorized as either dried or fermented. Smoked fish, for example, are dried using smoke rather than sunlight, whereas fish sauce is a by-product of fish fermentation. Here we differentiate product types into six categories (Figure 2) that are sufficiently fine-grained to capture important geographical variations in production practices.

The four main product types addressed in the dried fish literature are dried fish (36% of all publications), salted fish (27%), fermented fish (24%), and smoked fish (20%). The relatively even spread of attention to different product types at the global level obscures major continental and sub-continental differences, seen in Figure 3. The Asian literature emphasizes dried and fermented fish; the main focus in Africa is on dried and smoked products; and salted fish is most important in Europe and the Americas, reflecting the prominence of salted cod products.

There are further major regional distinctions at the sub-Asian scale, with literature from South Asia dominated by dried fish, while that from South East Asia and East Asia pays greater attention to fermented fish (Figure 4). These major geographical

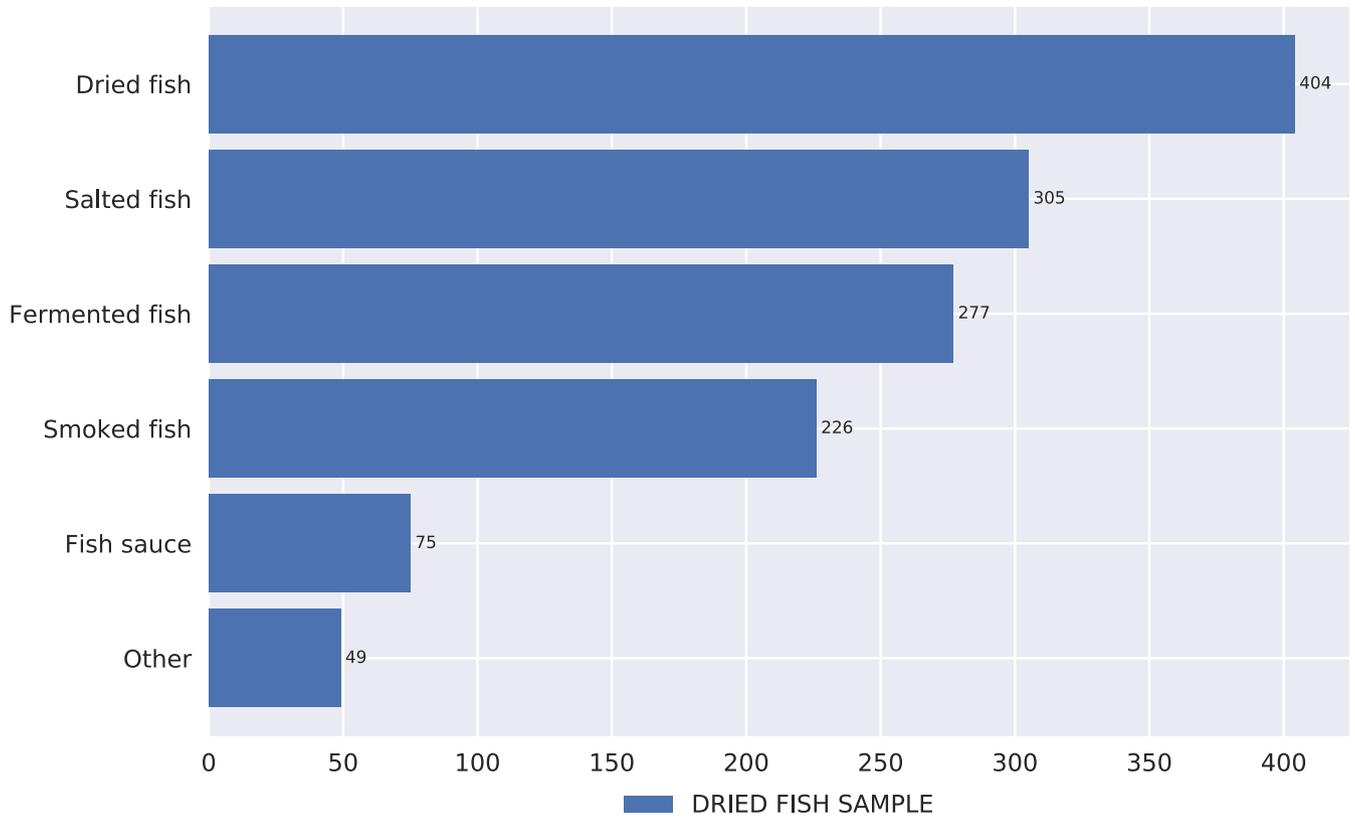


FIGURE 2 Representation of product types in dried fish literature (absolute number of publications in the sample, by product type)

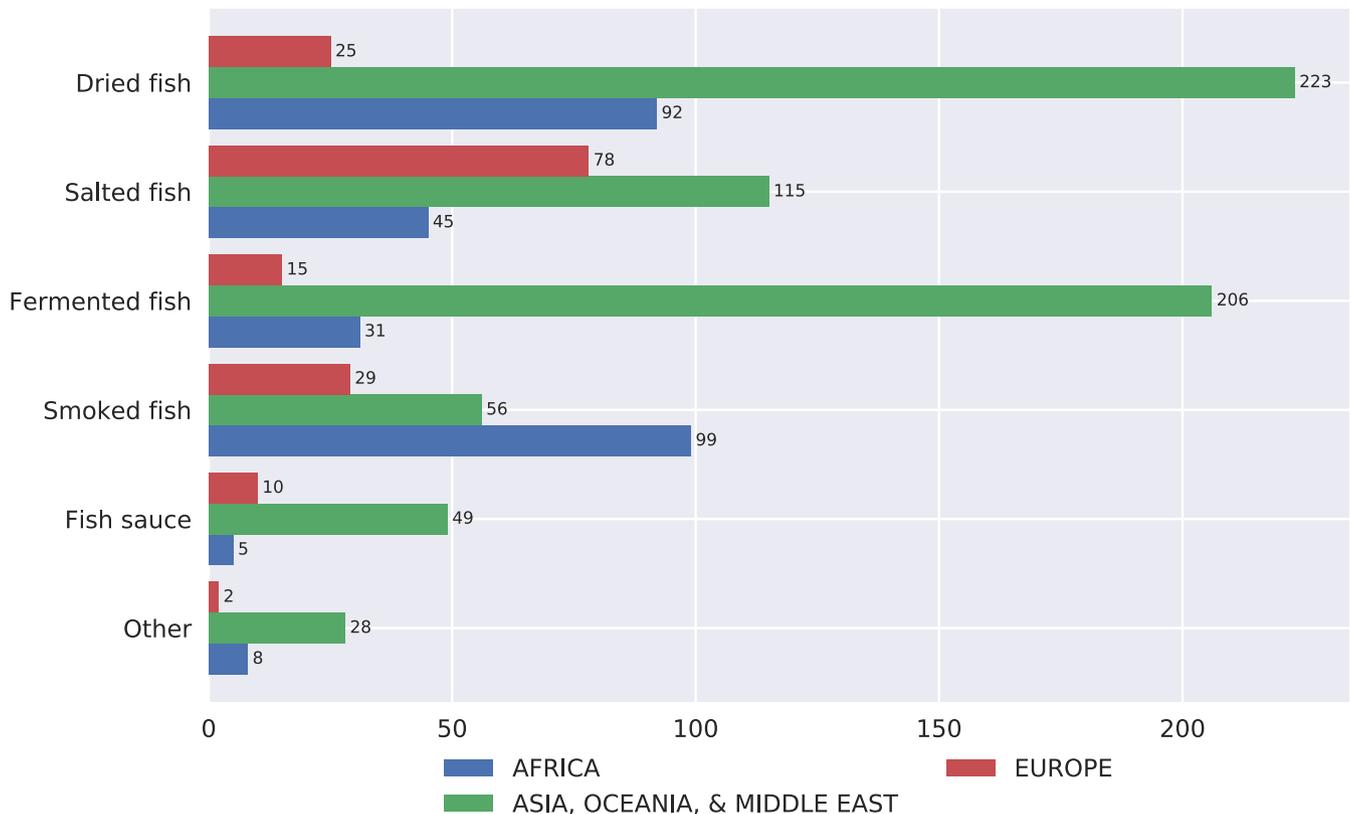


FIGURE 3 Representation of dried fish product types in the dried fish literature, by major geographic region (absolute number of publications in the sample identified as relevant to each indicated combination of product type and geographic region)

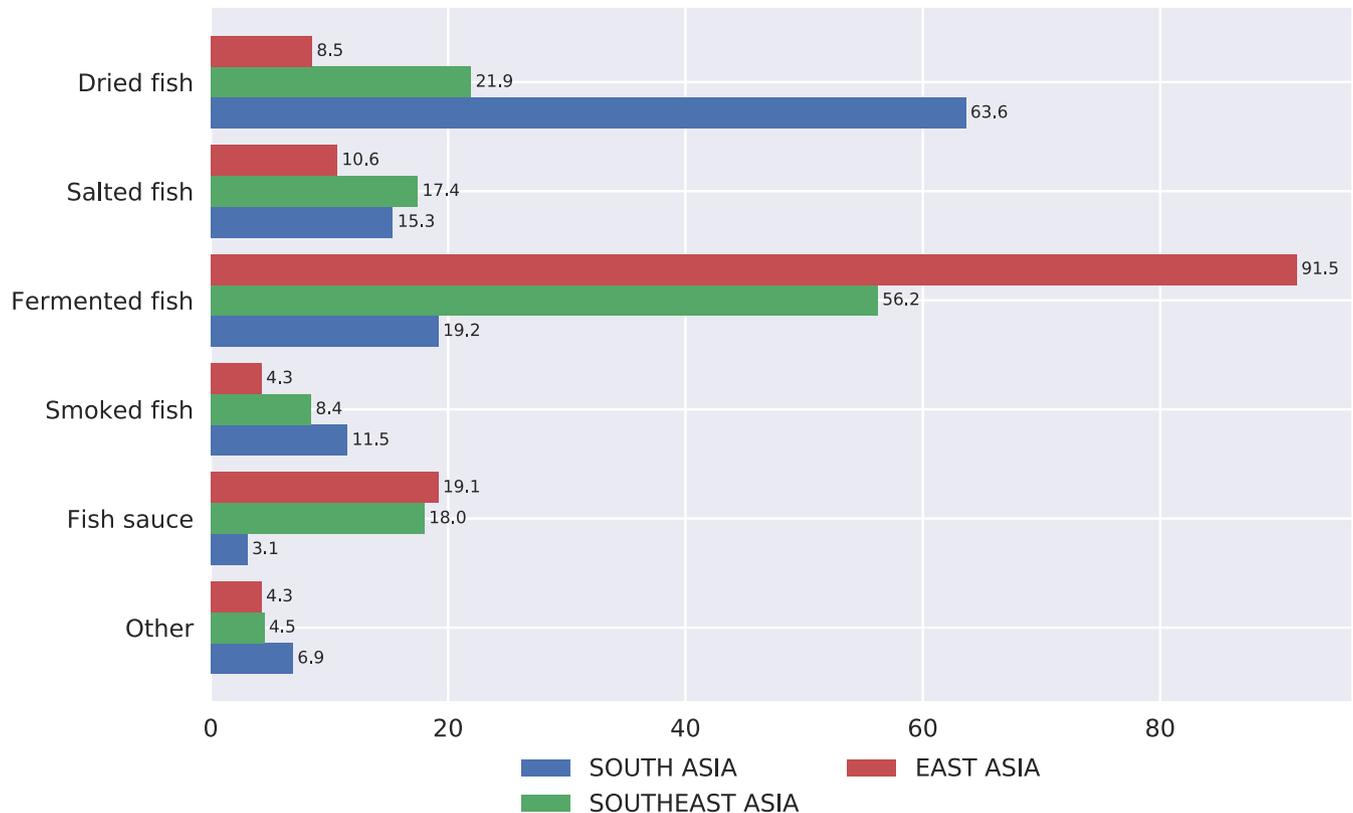


FIGURE 4 Representation of dried fish product types in dried fish literature, by Asian sub-region (publications pertaining to each product type, as a percentage of total publications within the sample concerning the indicated geographic region)

distinctions in product type raise fascinating questions for ecology, geography, and anthropology about what underpins these distinctions.

3.3 | Value chain segment

The general fisheries literature is highly productivist, focusing mainly on fishing activities and fisheries resources (i.e. primary production) (Tezzo et al., 2021); we identified 54% of the publications in our General Fisheries Sample as explicitly concerning the “production” value chain segment (i.e. fishing). Forty-four percent did not refer explicitly to any other segment (Figure 5). In contrast, the processing segment attracts most attention in the Dried Fish Sample (55% of publications). In this respect, the dried fish literature goes further in addressing the imbalance in the broader fisheries literature. Traders (7% of items in the Dried Fish Sample), retailers (6%), and consumption (15%) all receive proportionately more attention in the dried fish literature than in the general fisheries literature (1% each). However, the level of attention to other segments is still small relative to processing. In common with the broader literature on agri-food value chains, the dried fish literature thus fails to fully address the trader segment in the “hidden middle” of the value chain (Reardon, 2015). This broad pattern is replicated across geographies, and the degree of attention afforded to each value chain segment varies little by continent.

3.4 | Themes

Figure 6 presents the overall thematic shape of the dried fish and broader fisheries literatures (definitions of these themes are presented in Table 1 and discussed below). The dried fish literature is dominated by the theme “food science”, which we defined as encompassing research from the disciplines of food chemistry, food microbiology, food safety, and food engineering. This thematic area accounts for 72% of all tagged items. Over 90% of the journals in our sample that had published multiple articles on dried fish represented food science disciplines (Appendix S4). “Food and nutrition security and health”, and “value chains, economy, and labour” are the second and third ranked thematic categories, each featuring in a little over 20% of references. Many references categorized as part of these themes are also tagged under the food science theme.

The dried fish literature is thus oriented foremost towards the improvement of health and economic outcomes. Remaining themes (“culture and social relations”, “policy and governance”, and “ecology”) that we contend are important to a holistic appreciation for the dried fish sector, represent a small minority in the literature. Non-food science contributions tend to be more wide-ranging thematically than those in the food science literature.

The contrast in thematic emphasis in the dried fish literature and general fisheries literature is striking. The two least addressed themes in the dried fish literature, “ecology” and “policy and

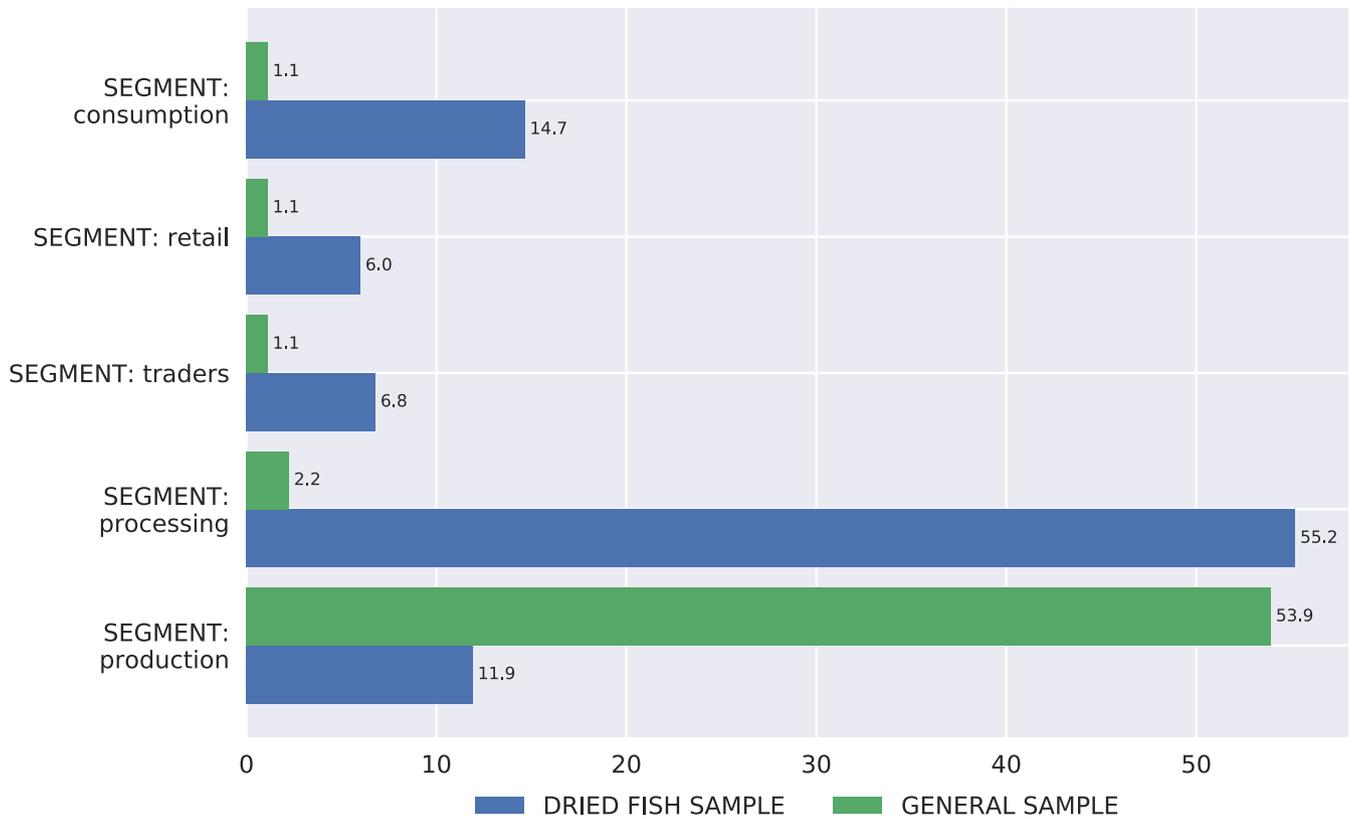


FIGURE 5 Representation of value chain segments in the dried fish and general fisheries literatures (percentage of publications in each sample identified as relevant to each indicated value chain segment). Overall, 56% of the General Fisheries Sample and 68% of the Dried Fish Sample publications are identified explicitly with one or more value chain segments

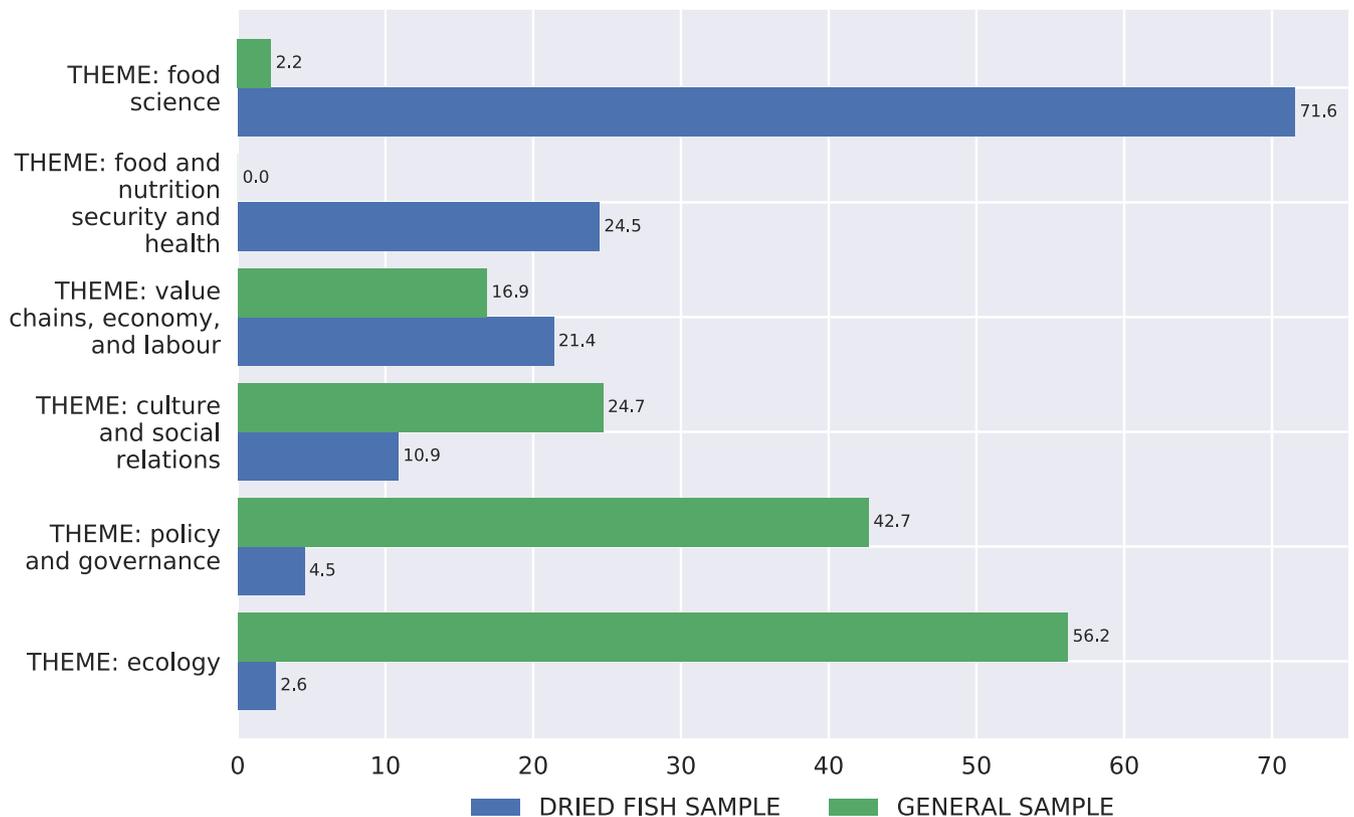


FIGURE 6 Comparison of themes in the dried fish and general fisheries literatures (percentage of total publications each sample identified as relevant to each indicated theme)

TABLE 1 Description of thematic tags

Theme	Number of publications	Description
History/change	119	Publications describing the history or evolution of the dried fish economy; older works of historical interest due to their date of publication
Economy	70	Macro-economic analyses of dried fish production, consumption, employment trends, or trade at the aggregate regional or national scale
Labour	30	Studies of labour relations, the social organization of work practices, or quality of work in dried fish processing and trade
Policy and governance	51	Studies discussing policy or governance related to dried fish value chains, including fisheries resource management, economic development, poverty reduction, price controls, and food safety regulations
Value chain/microeconomics	191	Microeconomic analyses of dried fish value chain segments, addressing resource, capital, and labour flows and value addition; household consumption and food preference studies
Culture, social relations and well-being	77	Research addressing the socio-cultural dimensions of dried fish production and consumption, including: well-being; the cultural value of dried fish or practices to sustain and promote dried fish for cultural objectives; social relations; and cultural understandings of health
Ecology	29	Analyses of the place of dried fish within ecosystems and the environment
Gender	40	Studies of women's labour, gender relations, or masculinities in dried fish economies
Food and cooking	48	Publications describing dried fish cooking and eating practices, food categorizations, or commensality
Health	151	Studies linking dried fish consumption to health outcomes
Food and nutrition security	14	Publications that promote or assess the contribution of dried fish to food security and nutrition outcomes, typically drawing on food chemistry research
Food engineering	26	Publications documenting the development of new fish products or new technologies for fish processing, storage, and packaging; patents; reports on experimental, development-oriented technologies such as solar dryers
Food chemistry and microbiology	762	Food chemistry research (analysis of proteins, carbohydrates, lipids, vitamins, minerals, and enzymes) or food microbiology research (analysis of pathogens, bacteria, or probiotics) involving dried fish products
Food safety	166	Publications that address threats to human health caused by unhygienic processing, handling, or storage of dried fish; publications discussing labelling requirements and other food safety policies

TABLE 2 Thematic hierarchy. Percentages indicate the proportion of all references that are tagged with themes that fall within the thematic cluster. As references may be given multiple tags from across the thematic areas, percentages in this column do not total 100%

Thematic cluster	Themes	Examples of subthemes	Items in dried fish sample
Food value	<ul style="list-style-type: none"> • Food science • Food and nutrition security and health 	<ul style="list-style-type: none"> • Food safety • Chemical analysis • Derivative product development 	75% (N = 851)
Economic value	<ul style="list-style-type: none"> • Value chains, economy, and labour • Ecology 	<ul style="list-style-type: none"> • International trade • Labour • Value chains • Microeconomics • Political ecology 	23% (N = 264)
Cultural heritage value	<ul style="list-style-type: none"> • Culture and social relations • History and change 	<ul style="list-style-type: none"> • Culture • Social relations • Well-being • Food and cooking • Gender 	18% (N = 208)

governance”, are by far the most important themes in the general fisheries literature. Conversely, the two most important themes in the dried fish literature (“food science” and “food and nutrition security and health”) receive least attention in the general fisheries literature. The theme “culture and social relations” receives somewhat greater coverage in the general fisheries literature, while “value chains, economy, and labour” receive comparable levels of attention in both. These observations reflect the orientation of the general fisheries literature towards fisheries management and the dried fish literature towards food science.

4 | QUALITATIVE FINDINGS

The ways in which the value of dried fish is represented vary across disciplines. Perspectives range from the purely instrumental—where dried fish is discussed as a means to improve health or material outcomes—to more intrinsic framings of value that foreground the sensorial and aesthetic qualities of dried fish. While these distinctions broadly reflect the methodological and epistemological contrasts between the natural sciences and humanities, instrumental and intrinsic approaches cannot easily be separated. Motivations for studying dried fish also are often entangled in broader narratives or critiques such as cultural revitalization.

Following this logic of values that motivate research on dried fish, we broaden our thematic categorization of the literature outlined above into three thematic clusters, each representing an overarching value orientation: (1) the intrinsic value of dried fish as food, (2) the economic value of dried fish, and (3) the cultural heritage value of dried fish. The relationship of these clusters to the thematic categories in the quantitative section of the paper and to more fine-grained themes in the Zotero dried fish library is indicated in Table 2. We address findings from our qualitative analysis for each thematic cluster in this order below.

4.1 | Food value

Development initiatives and actors have frequently made the case that dried fish can play an essential role in reducing malnutrition among the world's poor. For instance, Kent (1987, 1988) provided prescient early policy-oriented overviews of the role of fish production and consumption (including dried products) in alleviating malnutrition throughout the Global South, along with recommendations for maximizing their potential to contribute to this goal. Consumption surveys have indicated that dried fish contributes a significant proportion of animal source food intakes in many parts of the Global South (e.g. Dey et al., 2005). Small fish—which are often processed and consumed whole—provide the majority of calcium intake among the poorest in some geographies, as captured in appellations for small fish such as “the milk of South-East Asia” (Jensen, 2001).

Applied research in this area has been driven by the goal of improving the accessibility or nutrient density of dried fish products. The FAO has promoted sun-dried fish production to tackle food insecurity in Somalia, for instance (Savins, 2018), while nutrition scientists funded by DANIDA (Danish International Development Assistance) have developed nutrient-dense food supplements that include dried fish, designed for consumption by the poor in Cambodia (Skau et al., 2014) and Kenya (Konyole et al., 2012). Dried fish powder intended to meet the nutritional needs of the extremely poor has been developed using by-products from fish processing factories in Ghana (Abbey et al., 2017).

As indicated in the quantitative section above, food science studies dominate the dried fish literature. Most food science research pertains to: (1) the chemical composition of dried fish products, and (2) risks associated with their consumption.

Nutrient content analyses have demonstrated the nutritional value of dried and fermented fish products, typically by profiling the micronutrient, protein, fatty acid, fibre, ash, and moisture contents of products available in local markets (Abeywickrama & Attygalle, 2015; Hassan et al., 2014; Koo et al., 2016; Majumdar et al., 2015; e.g. Ormanci & Colakoglu, 2015; Sanath & Nayak, 2015). Other studies have tested the effects on nutritional profiles of factors such as temperature and other environmental storage conditions (Al-Asous & Al-Harbi, 2017); methods of fish handling and evisceration (Vasconi et al., 2016); degree of fermentation (Anggo et al., 2015); salt concentration (Uddin & Reza, 2017); or smoking and drying techniques (Aremu et al., 2013; Ochieng et al., 2015). This research suggests different possibilities for enhancing the nutritional quality of dried fish through various processing techniques.

Several research groups have isolated and characterized lactic acid bacteria strains in fermented fish products, supporting the goal of improving production technologies or developing mixed starter cultures for industrial processing of products with optimal sensorial, probiotic, and microbial safety characteristics. Such research has examined products as varied as *hentak*, a fermented sun-dried powdered fish from India (Aarti et al., 2017); *adjuevan*, a condiment produced from spontaneously fermented fish in Côte d'Ivoire (Koffi-Nevry et al., 2011); *suan yu*, a Chinese fish snack made by mixing fermented then dried fish pieces with spices and corn meal (Zeng et al., 2016); and *ngachin*, small fish fermented with boiled rice in Myanmar (Moe et al., 2015).

The nutritional value of dried fish may be offset by contamination or spoilage, which are well recognized issues of concern in areas where dried fish is widely traded and consumed. Microbiological studies of dried and fermented fish products have identified unsafe bacteria or fungi in commercially available products from local markets, occasionally measured in relation to variables such as storage temperature (Al-Asous & Al-Harbi, 2017), the use of improved technologies, such as solar dryers (Immaculate et al., 2012), ingredients and processing conditions (Begum et al., 2012; Zeng et al., 2013), or starter cultures used in fermentation (Zang et al., 2018). The survival of zoonotic parasites in fermented

fish products is also of potential concern (Bušelić et al., 2018; Onsurathum et al., 2016), but has not received much research attention.

Food quality analyses have identified multiple forms of contamination in traditionally produced dried fish. In addition to physical contaminants such as sand (Vijayan & Surendran, 2012), dried fish has been found to be contaminated with heavy metals, such as lead and mercury (Adekunle & Akinyemi, 2004; Al-Mughairi et al., 2013) or microplastics (Hasan et al., 2022; Karami et al., 2017). A significant and widespread source of contamination involves application of hazardous pesticides directly to fish by processors and traders to prevent losses due to blowfly and beetle infestation. Although the application of controlled or banned toxins, such as DDT and dichlorvos in fish drying or storage has been a recognized problem since the 1980s (Ames, 1990; Walker & Greeley, 1991), safe alternatives have yet to be adopted on a wide scale. Hazardous pesticide levels continue to be detected in dried and smoked fish samples, including from Nigeria (Musa et al., 2010), India (Payra et al., 2016), and Bangladesh (Bhuiyan et al., 2008; Chowdhury et al., 2010; Hussain et al., 2018; Siddique & Aktar, 2012).

An additional set of studies has measured genotoxins, notably the carcinogenic polycyclic aromatic hydrocarbons (PAH) that commonly occur in smoked foods, with recent analyses of product samples from sub-Saharan Africa, Eastern Europe, and Asia finding PAH levels far in excess of limits set in food safety standards (Ingenbleek et al., 2019; Mahugija & Njale, 2018; Malika et al., 2017; Zachara et al., 2017). Concern for the creation or better enforcement of food safety standards is an underlying theme in much of this research.

Overall, research on food safety and nutritional aspects of dried fish addresses several long-standing challenges. As early as the 1970s, field experiments were conducted with the use of improved fish-drying methods such as elevated racks (Waterman, 1976) or the application of less hazardous pesticides (such as pyrethrins) to control blowfly and beetle infestations during sun-drying (Meynell, 1978). Other examples of such initiatives include promoting fish smoked in kilns rather than on bamboo racks in India (Barman et al., 2014); introducing dried fish production using solar tent driers in Nigeria to replace low-quality imported dried fish (Omodara et al., 2016); and using a new starter culture for fish sauce production in India to reduce fermentation time and improve nutritional quality (Akolkar et al., 2010). The poor adoption of safe and effective processing technologies indicates a need for greater attention to the socio-economic factors that may limit their uptake.

4.2 | Economic value

The next largest subgroup of literature consists of assessments of value chains and markets. Such studies are often outputs of projects funded by overseas development assistance, and typically have an exploratory and diagnostic orientation, geared towards identifying technical or institutional challenges that could be addressed through interventions. These studies are of highly variable quality and rigour

and pertain to a wide variety of dried fish value chains. We summarize a selection of the most significant examples below.

A small number of detailed diagnostic studies compare dried fish production, marketing and consumption across multiple countries in the Global South (Essuman, 1992; Moen, 1983; Reynolds, 1993). On a smaller geographical scale, examples of thorough diagnostic value chain studies for Sierra Leone and Odisha (India) are provided by Kassam et al. (2017) and Salagrama (2004), respectively. Upadhyay et al. (2017) offer a particularly rigorous analysis of dried fish value chains in Northeast India, including a quantitative survey of marketing margins and credit utilization, while Hossain et al. (2013) provide a comprehensive qualitative scoping study of dried fish value chains in Bangladesh. More specific topics covered include: the market for low monetary value fish products around Lake Victoria (Kabahenda & Hüskén, 2009); the production and marketing of fermented fish in Côte d'Ivoire (Kouakou et al., 2013); trade in fish products in Tonle Sap, Cambodia (Ou, 2012); and financial analysis of the snakehead value chain in Vietnam and Cambodia (Sinh et al., 2014).

A subset of studies applies a business management lens to dried fish value chains, focused mostly on the salt cod trade between northern and southern Europe. These studies tend to have both strong conceptual framings and an applied focus on solving problems encountered by businesses. Examples of the types of question addressed include: how to institute a traceability system in the salt cod supply chain (Donnelly & Karlsen, 2010); appropriate methods for instituting efficient supply chain management in the face of fluctuating product volumes (Hameri & Pálsson, 2003); and objective and subjective dimensions of quality assessment deployed by businesses in the stockfish industry (Korneliusson et al., 2007). Other studies in this group focus on applied consumer research linked to marketing initiatives (Haugnes, 2010; Larsen et al., 2015; Lindkvist et al., 2008).

A small number of studies evaluate the extent and causes of loss and waste in dried fish value chains in countries including India, Zambia, Nigeria and Malawi (e.g. Eyo, 1999; Kefi et al., 2017; Sharma et al., 2016; Torell et al., 2020). King (2003) offers an unusual assessment of artisanal containers used for transportation of smoke-dried fish in Nigeria, in relation to loss and waste. Salagrama (1998) is notable for providing an important evaluation of changing bycatch utilization in Indian fisheries, linking bycatch use to technological change and evaluating the food security implications including impacts on dried fish supply.

A varied set of publications originating mainly from the fields of anthropology and geography address the social dynamics of markets with a predominant focus on the Global South. Important themes covered include fish vendors' livelihoods and the political ecology of fish marketing in Namibia (Abbott et al., 2007, 2015); the changing social organization of fishing and fish marketing in Zambia (Imai, 1985, 1998); the impacts of globalization on the fisheries of Lake Victoria and associated changes in social relations and market power in the value chain for dried small fish (Medard et al., 2014, 2019); the influence of socio-political and cultural forces on "foodways" involved in the smoked tuna trade in Ambon, Indonesia (Hayward &

Mosse, 2012); the role of migration in dried fish marketing around Lake Lindu, Sulawesi (Acciaoli, 2000); and the role of social capital in the formation of Norwegian fish processing clusters (Fløysand & Jakobsen, 2001).

A subset of more descriptive studies focus on the behaviour and livelihoods of women and men marketing intermediaries in diverse locations, including urban Mumbai (Wavare, 2015), coastal Andhra Pradesh (Venkatalakshmi et al., 2015), Odisha (Salagrama, 2006), the Philippines (Oracion, 1998), and Borno State, Nigeria (Usman et al., 2009).

Social inequalities can limit actors' ability to benefit fully from their participation in dried fish value chains. Several publications document exploitative working conditions associated with dried fish production in Bangladesh's fish drying industry, including bonded labour and slavery, (BBS & ILO, 2010; Belton et al., 2018; Blanchet et al., 2006; Jensen, 2013). In a similar vein, Pramanik (1996) investigates arduous working conditions of women employed in dried fish processing in the Indian Sundarbans.

The highly gendered nature of fish processing work means that such inequalities are experienced particularly keenly by women. Women are deeply engaged in the preparation of dried, smoked, and fermented fish worldwide. The economic value and social status ascribed to the labour of women in these roles are typically low (Hassan & Sathiadhas, 2005; Simasiku et al., 2018; Swathi Lekshmi & Dineshbabu, 2011; Sympaku & Mafimisebi, 2012; Venkatalakshmi et al., 2015).

Various authors have examined the social and economic structures that shape women's participation in fish processing and marketing. Cole et al. (2018), applying a social-ecological systems approach to the Barotse Floodplain fisheries in Zambia, argue that gender inequality contributes to a maladaptive path dependency they describe as a social-ecological trap. Other studies of women's labour in fisheries identify technical or material barriers to economic inclusion or productivity. Sympaku and Mafimisebi (2012), contrasting the gender balance at each node in Zambian fish value chains, suggest that women lack access to higher profit segments due to their limited access to financial capital. Osarenren and Ojor (2014) argue that Nigerian fish processors are constrained by a lack of capital, cost of storage, and price fluctuations. Simasiku et al. (2018) describe Namibian processors as confronting challenges related to cold storage facilities, poor weather, and packaging.

Several valuable studies have focused on the gendered nature of work in South Asia's fisheries. Hapke (2001) is a classic study of gender and household survival in fishing communities in a Kerala. Others have addressed aspects of the lives, labour, and livelihoods of women involved in fisheries, fish-vending, and dried fish value chains in several coastal states (e.g. Hassan & Sathiadhas, 2005; Rabbanee & Yasmin, 2011; Rajan & Biju, 2014; Salagrama, 2001; Swathi Lekshmi & Dineshbabu, 2011). In Cambodia, Kusakabe (2016) examines social relations, gender, and collective action in fish marketing.

Aswathy and Kalpana's (2018) study of gender in a Muslim fishing village in Kerala is a particularly notable contribution on

gender ideologies in dried fish value chains. This research analyses how women engaged in fish drying and vending tactically negotiate competing ideological expectations of feminine domesticity and women's entrepreneurship, set against a context of rapid socio-economic changes (see also Hapke, 2001; Hapke & Ayyankaril, 2004).

Notably, although 29 articles were tagged under the theme "ecology", few of these drew direct connections between the production and consumption of dried fish products and the health of the aquatic environments and biodiversity on which they depend. Neither, conversely, did these articles do much to link ecological changes with economic, nutritional, or cultural outcomes in relation to dried fish. This suggests an important area for further exploration. Notable exceptions include the article by Cole et al. (2018) mentioned earlier in this section; arguments for how increased efficiency in processing and storage can reduce demand and thus fishing pressure (e.g. Champ & Highley, 1994); a methodologically innovative study using data on volumes of dried *bêche-de-mere* and shark fin products traded through Hong Kong wholesale markets to evaluate pressure on fisheries resources (Clarke, 2004); research documenting deforestation linked with use of mangrove wood for smoking fish in Cameroon (Feka & Manzano, 2008); and a historical study of the intensification of coastal fishing activity in Mon State, Myanmar, that resulted in declining catch per unit effort and a reduction in daily quantities of fish dried by women workers (Belton et al., 2019).

4.3 | Cultural heritage value

Research from history and other social science and humanities disciplines draws attention to the historical and cultural importance of dried fish. Archaeological studies have demonstrated the existence of salt-making sites for fermented fish production in Asia during the Iron Age (Yankowski et al., 2015) and widespread salted fish processing in European antiquity (Carusi, 2018; Slim et al., 2007). Van Neer and colleagues have reported on fish bone assemblages indicating the presence of sun-dried, salted, and pickled fish at several Roman sites located in Egypt (Neer & Depraetere, 2005; Neer et al., 2006, 2010, 2013).

Global trade in salt cod had a particularly important role in shaping colonial ties between Europe and the New World (Kurlansky, 1998) and geopolitical relations in Atlantic Europe and Iceland (Matsumoto, 2010). Some research has addressed the role of dried fish trade in European settlement, investigating topics such as how proximity to fish and salt resources shaped settlement patterns in Ancient Greece (Carusi, 2018); how fish trade contributed to Greek colonization of the Black Sea region (Bekker-Nielsen, 2005); how dried fish production in the Viking Age laid the foundations for a global trade (Perdikaris & McGovern, 2009); and how peripheral regions, such as Lusitania, came to be integrated into the Roman Empire through fish trade (Bombico, 2015). In the more recent colonial context, Reeves et al. (2014) describe how official Fish-Curing Yards came to be established in parts

of India in the 1870s, as a mechanism to exempt fish processors from the colonial Salt Tax, resulting in the emergence of bonded arrangements between consolidated fish curer/traders and their suppliers.

Specific dried and fermented fish production traditions can be understood as part of cultural adaptive strategies in particular environments. For example, Kenneth Ruddle (1987a) describes the complementary development of fermented fish and rice in South East Asia as a feature of highly seasonal floodplain river environments, suited to alternating production of fish and rice. Similarly, Vietnamese fermentation practices reflect a combination of distinct ecological features and biological rhythms, making use of small fish that can be fermented uniformly, that are of low monetary value (and thus protected from competing uses), and that can readily be harvested. Ruddle and Ishige's (2005) important cultural ecology of fermented fish convincingly proposes a direct link between environmental conditions and the choice of fish preservation technologies in South East Asia. From a cultural ecology perspective, fish drying may be taken as an adaptive requirement in environments that provide uneven access to fresh fish, either due to the seasonal availability of fish or to the need to balance use of fish with other inland resources. In this sense, cultural preference for dried fish can often be traced historically to specific environmental conditions in which fish preservation originally offered a means of avoiding food shortage (Dirar, 1994; Lee & Kim, 2013).

Dried fish may be approached as a subject within world food history, recognizing its role as a culturally important commodity within global trade systems. A particularly significant historical product is the fermented fish sauce *garum*, a central element of ancient Greco-Roman cuisine, which was celebrated for its flavour and supposed medicinal value and was a major trade commodity (Apicius, 2006; Curtis, 1991; Slim et al., 2007). In some settings, *garum* finds itself at the intersection of food history and gastronomy: taking an experiential approach to food history, a medieval Roman banquet reconstructed at the Ashmolean Museum in 2017, for example, featured a menu consisting largely of salt fish and *garum*-flavoured dishes (Mylona & Grainger, 2018), while a team of Danish food scientists has recently developed a series of modern, experimental *garums* (Mouritsen et al., 2017).

Other dried and fermented fish products are situated within cultural movements that are produced by, but also oppose, global flows. Thus, the Portuguese national dish *bacalhau* (salt cod [*Gadus* spp., *Gadidae*]) would be unthinkable without colonial connections to Newfoundland, which allowed cod—among other ingredients linked to conquest—to enter the Portuguese diet in the 16th century (Pires, 2015). Historical studies on Newfoundland and Labrador fishing communities (Kennedy, 1997; Keough, 2012), meanwhile, provide a clear indication of how global trade relations ultimately shaped both the establishment of isolated coastal communities and the emergence of a unique culture within them.

In Japan, *katsuo-bushi* (smoke-dried skipjack tuna [*Katsuwonus pelamis*, *Scombridae*]), whose name auspiciously signifies

“victory-bringing fish”, is entangled with commercial, military, and Imperial history—its early spread being attributed, for example, to 11th century Imperial policies that prohibited the consumption of meat as a means to promote Buddhism (Matsuda, 2001). Fermented fish has more recently become an important marker of localness and tradition in the Faroe Islands, drawing on associations with the Slow Food movement (Svanberg, 2015). Research exploring cultural heritage value has tended to focus primarily on European products, such as *surströmming* (Swedish fermented herring [*Clupea harengus*, *Clupeidae*]), whose consumption helps construct a traditional rural identity in opposition to modern, urban values (Nygaard, 2019); and the above-mentioned *bacalhau*, which is embedded in collective identity narratives and may be seen as a form of cultural capital (Arvela, 2013; Pires, 2015; Xie et al., 2013). A related approach takes dried fish as part of foodways, systems of culturally significant practices through which identity is negotiated through local foods, such as fermented fish in Thailand (Lefferts, 2005) or smoked tuna in Indonesia (Hayward & Mosse, 2012).

Taste for fish may be considered as a cultural attribute. Cultural acceptability is important in research on product development and consumer preference, as reflected in studies exploring topics such as the contrast in acceptability criteria for spice-cured sprats in Estonia and Thailand (Timberg et al., 2014), regionally distinct tastes for salted cod in different parts of Spain (Espinosa Seguí & Martínez Alba, 2015), local quality appreciation criteria for *lanhouin* (fish-based condiment) in Benin (Kindossi et al., 2012), or fermentation leading to improved acceptability of poor-tasting fish in Nigeria (Nwabueze & Nwabueze, 2010).

5 | DISCUSSION: STRENGTHS AND GAPS

In the preceding qualitative section, we framed analysis around three overarching sets of values that we identify as motivating the literature on dried fish. As *food*, dried fish is valued as meeting the biological needs of humans, which it does by providing safe nourishment, potentially at times of food scarcity. This food value can be undermined by contaminant and spoilage risks, or by anthropogenic pressures on aquatic ecosystems that reduce availability. *Economically*, dried fish is valued as a commodity that sustains the livelihoods of fishers, processors, traders, and retailers. But although dried fish provides economic opportunities to many, it is also associated with various disvalues. These include ecological impacts, technical problems in the value chain including losses during processing and storage, and social concerns such as gender inequalities and dangerous or exploitative working conditions. Third, dried fish is valued as a *cultural object*, the production, trade, gifting, and consumption of which is tied to shared histories, practices, tastes, and identities.

Nonetheless, as our quantitative analysis demonstrates, the dried fish literature is strongly oriented towards nutritional and economic improvement, with only peripheral attention to broader cultural, historical, ecological, social, political, and governance aspects

of food systems (HLPE, 2017). This observation indicates ample room for research on dried fish to grow and become more diverse. In the following sub-sections, we sketch out some critical gaps to be addressed, as well as important thematic intersections in the existing literature that suggest scope for further enquiry.

5.1 | Dried fish as food

The large body of food science research surveyed confirms that dried fish offers exceptional nutritional value, and provides critical micronutrients to many of the world's poor that can contribute to the alleviation of malnutrition (Kent, 2019; Siddhath et al., 2020). Nonetheless, published data on the nutritional properties of dried fish are dispersed across the literature and have yet to be correlated with studies of consumption practices and specific dietary needs.

Food science research also helps us to understand the forms of spoilage or contamination that are present in dried fish products. We recognize, from this research, that spoilage and insect infestation are widespread problems encountered by processors, but also that great harm can be done by the measures taken to counteract these problems, notably through the application of pesticides and preservatives. Food scientists have explored the effectiveness of treatments such as irradiation (Onyuka & Ofulla, 2013), salting (Singh et al., 2018), or safer insecticides (Golob et al., 1987); yet the poor uptake of such technologies suggests the need for better research into decision-making processes among dried fish processors, wholesalers, and retailers.

A small body of research on food and nutrition security builds on these findings, informing us how dried fish products, including food supplements, can be enhanced or disseminated to meet the nutritional needs of the world's poor (Abbey et al., 2017; Borg et al., 2019). While analyses highlighting the nutritional value of various processed fish products are available, we lack systematic research investigating the connection of dried fish consumption to positive health outcomes. Moreover, none of the research in our sample addresses changes in the nutritional value and nutrient concentration associated with dehydration or fermentation processes that may impact dietary nutrient intakes when fish is consumed in these forms, as opposed to fresh.

Research into the health risks of dried fish consumption, particularly the potential negative impacts of high smoked or salted fish intake, has been somewhat inconclusive. Multiple dietary studies from the 1980s and 1990s identified salted fish consumption as a risk factor contributing to the high incidence of nasopharyngeal carcinoma among Cantonese, Malaysian, and other South East Asian groups (Armstrong & Chan Siew Eng, 1983; Armstrong et al., 1998; Ning et al., 1990; Yu et al., 1986), but this correlation has more recently been challenged (Lau et al., 2013). Other research has suggested a connection between salted fish intake and hypertension (Begossi et al., 2013) and brain cancer risk (Hu et al., 1999), while fermented fish sauce has been linked to oesophageal cancer (Ke et al., 2002;

Li & Yu, 2003). This remains an area of importance for continuing research.

5.2 | The dried fish economy

Research on the economy of dried fish processing and trade shows that dried fish value chains are essential to the livelihoods of large numbers of people around the world. Studies in this area, particularly those that combine descriptive and quantitative data, help us to understand how dried fish value chains operate and how they are financed (e.g. Hossain et al., 2013; Sinh et al., 2014). Business-oriented studies tell us how transnational companies can optimize supply chains, particularly for salted fish (e.g. Hameri & Pálsson, 2003; Larsen et al., 2015). At the micro scale, some qualitative studies tell us about the impacts of changing markets on value chain actors' livelihoods, or how social inequalities affect participants in small-scale fisheries value chains (e.g. Abbott et al., 2015; Medard et al., 2019).

However, much research on dried fish value chains and labour is primarily descriptive and lacks substantial analytical or conceptual framing (for an important recent exception see Pradhan et al., 2022). Publications in this area may enumerate fish products and species, summarize the stages of fish processing technologies, or outline distribution channels, typically without addressing the political economy of value chains and labour relations. If adequate attention is given to social inclusion and rights, however, this thematic area offers strong potential to generate findings that can guide policy, governance, and development.

Current research that demonstrates this potential includes studies of labour exploitation, for example among child and migrant labourers in Bangladesh (Belton et al., 2018; Blanchet et al., 2006), or investigations of the challenges faced by women vendors and processors in places such as Cambodia or Kerala, India (Kusakabe, 2016; Rajan & Biju, 2014). These topics merit broader attention in other sites and value chains. We also note that research in this area has not systematically addressed how dried fish value chain actors are affected by regulatory regimes, such as the imposition of food safety standards or labelling requirements applied to fish packaged for sale in supermarkets or for export.

In contrast to the vast literature in fisheries on co-management and other forms of governance, references considering formal and informal governance of dried fish value chains are almost entirely absent. Governance is generally treated in the narrowest sense of economic interventions to enhance profitability or product quality. Exceptions that consider broader questions of governance include Fegan (1994) who implicitly discusses the political economy of state-led innovations in dried fish processing and Cole et al. (2018, 2020) and Kaminski et al. (2020) who demonstrate the importance of gender inclusion in value chain governance to reduce post-harvest losses. This latter work on Zambia is important because it links to a broader body of work on the political ecology of value chains in African inland fisheries (Gordon, 2005; Gordon, 2008; Jul-Larsen et al., 2003; Verelst, 2013). The impacts of environmental change (including climate change and depletion of

fish stocks) on the sustainability of the dried fish economy have also received little attention to date, let alone how dried fish value chain actors might respond to these threats. Here we flag as a crucial area for further research the diversion of fish from dried fish value chains to fishmeal production. As yet, evidence of the severity of this threat is inconclusive (Hapke et al., *In review*; Salagrama & Dasu, 2021).

5.3 | Dried fish as cultural heritage

Historical and archaeological research informs us that dried fish processing and trade activities have shaped settlement, migration, colonialism, and international trade. European colonialism in North America was deeply influenced by trade in salt cod (Kurlansky, 1998), while settlement patterns in Europe and elsewhere have mirrored sites favourable to fish preservation (Carusi, 2018; Slim et al., 2007; Yankowski et al., 2015).

Cultural ecological studies suggest that fish processing has historically grounded specific products and cultural practices in particular locations, with enduring presence in contemporary cultures (Ruddle & Ishige, 2005). We also know that fish products operate as symbolic markers of culture and identity, with taste preferences for dried fish marked by cultural upbringing and social relations (e.g. Lefferts, 2005; Timberg et al., 2014). However, with the notable exception of a few publications on the cultural importance of *bacalhau* as the Portuguese national dish (Arvela, 2013; Pires, 2015; Xie et al., 2013), our survey located only the occasional reference to dried fish as cultural heritage. Nonetheless, we observe that many food science studies, in seeking to establish the nutritional value of traditional dried fish products, appeared to be inspired by the cultural value of those products. We identify the need to address this cultural value explicitly, in particular from a humanities perspective, as a central gap in dried fish research.

We include the *social relations* of fish processing and trade within this thematic cluster, noting the particular importance of gender in the dried fish sector. Women are almost omnipresent in fish processing activities, irrespective of geography, and often run dried fish wholesale or retail businesses (Swathi Lekshmi, 2012). However, much of the literature on fisheries focuses on fishers rather than onshore processors, with the result that women's labour tends to be hidden (see Belton et al., 2019; Weeratunge et al., 2010). Moreover, with a few notable exceptions (e.g. Aswathy & Kalpana, 2018; Hapke, 2001), research on women's involvement in dried fish value chains has failed to engage deeply with critical perspectives on gender taken in social science, suggesting a fruitful avenue for further work.

5.4 | Thematic intersections

While most of the publications in our sample addressed more than one theme, we found few references with intersections that cut

across two or all three thematic clusters. The exploration of boundaries and intersections between key research questions and themes apparent in each cluster gives rise to sets of new questions that we contend can serve as a guide to future transdisciplinary research on dried fish (Figure 7).

At the intersection of *food and nutrition security and health* and *value chains, economy, and labour*, we see potential for research that further examines dried fish consumption patterns and assesses their importance for material well-being and health. A rich body of existing food safety research addresses the question of how economic and nutritional losses due to spoilage or contamination can be reduced. Food engineering studies have taken a converse approach by proposing new processing techniques and products that can add nutritional and economic value. Further research in this area can support policies to promote the health, safety, and well-being of dried fish producers and consumers.

At the intersection of *food and nutrition security and health* and *culture and social relations*, we see the potential for research that assesses how customary fish processing practices actively contribute to food and nutrition security, notably by providing an inexpensive and accessible food source. Several studies have addressed the local acceptability criteria for food supplements that incorporate dried fish powder. Further research in this area can support dried fish production and consumption as a culturally appropriate food that can meet the nutritional needs of consumers.

At the intersection of *culture and social relations* and *value chains, economy, and labour*, we observe the potential for further research that helps us to understand how cultural food preferences influence economic value, or how traditional processing technologies shape contemporary value chains. We also note the potential for studies of how diaspora communities are implicated in the emergence of new trade networks and value chains, as well as new consumption practices that foreground the role of dried fish as cultural heritage. Research in this domain can also inform us of the ways that historical patterns of economic development have shaped long-term cultural preferences for dried fish.

Very few publications in our sample address themes from all three clusters. Of these, notable publications that take a holistic view of dried fish economies include Kurlansky's *Cod: A Biography of the Fish that Changed the World* (1998), which explores the 600-year world history of cod fishing and salt cod trade with reference to culture and geopolitics; Mak Sithirith's (2016) political-economic study of fishing villages surrounding the Tonle Sap Lake in Cambodia; and *Slaves for a Season* (Blanchet et al., 2006), which reports on children's labour in the fish drying industry in Bangladesh, addressing themes of well-being, economy, gender, health, microeconomics, and labour relations. These studies are important for their attention to the human dimensions of dried fish economies, identifying the impacts of economic practices at scales ranging from the individual to the regional or global political economy. While we do not propose that such studies should serve as a universal model for research, their rarity underlines the need for more integrative, transdisciplinary research on the human aspects of dried fish value chains.

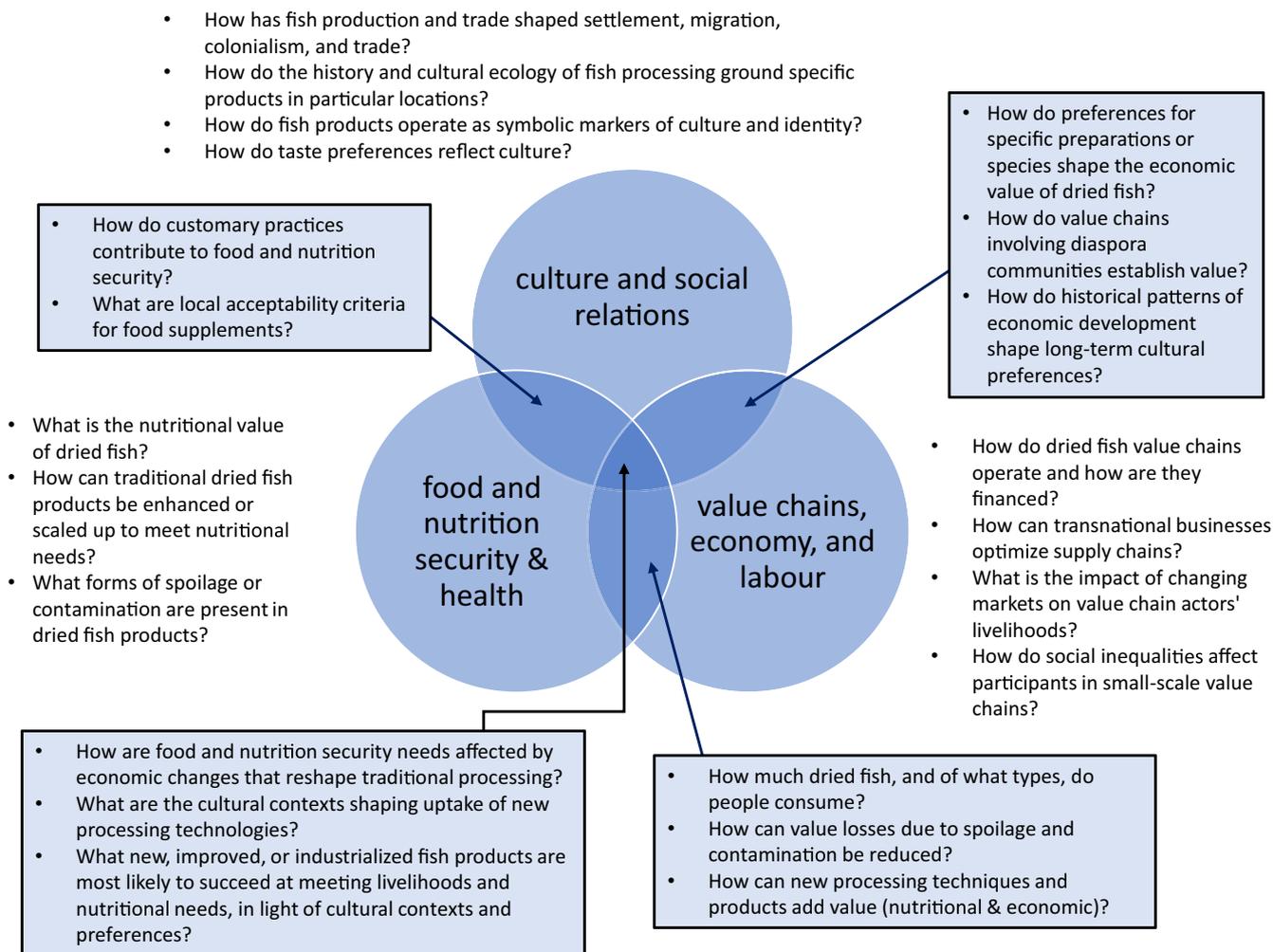


FIGURE 7 Thematic intersections in the literature on dried fish: Major themes and illustrative questions suggested by the literature survey

6 | CONCLUSION

This paper sets out a distinctive conceptual approach to the study of dried fish, and quantitatively and qualitatively maps the shape of the dried fish literature based on comprehensive survey of >1100 articles. Befitting its focus on fish as a processed food product, the orientation of the dried fish literature is markedly different from that of the general fisheries literature in its emphasis on processing, nutrition, health, and the inclusion of a greater diversity of value chain actors. The dried fish literature is also balanced towards the tropical majority world (Kurien, 2005), where most fish is consumed and where most people who are employed in fisheries reside.

A key recommendation of this paper is to bring the dried fish literature into much fuller and more explicit dialogue with the general fisheries literature. It is remarkable how little cross-fertilization currently exists between the two bodies of work. The dried fish literature is a resource on which to draw as the fisheries literature shifts towards viewing fisheries as food systems (e.g. Arthur et al., 2022; Campling & Havice, 2018; Foley & Mather, 2018; Simmance

et al., 2022), and in relation to the Small-scale Fisheries Guidelines (FAO, 2015) and the Sustainable Development Goals (HLPE, 2020). At the same time, the general fisheries literature provides tools and insights with which to address important blind spots in the literature on dried fish, particularly around governance (e.g. Kooiman et al., 2005), ecological dynamics (e.g. Kolding et al., 2019), and political economy (e.g. Campling et al., 2012). The work on Zambia that we highlighted earlier is one promising example of how the two literatures may be bridged in relation to these thematic areas. Much more work needs to be done to forensically examine the general fisheries literature for the hidden evidence it presents on the underemphasized aspects of dried fish food systems. Many of the fisheries that have been analysed by biologists or social scientists produce dried fish products, even if this information is not stated explicitly (e.g. Vezina et al., 2020). Trends such as climate change (Cheung et al., 2021), increasing substitution of culture fish for capture fish (Tezzo et al., 2021), and the complex effects of global efforts to control of illegal, unreported, and unregulated (IUU) fishing (Song et al., 2020) all have important consequences for the future of food systems that dried fish research must better address.

The integration of the dried fish and general fisheries literature raises major epistemological challenges given their very different disciplinary, normative, and substantive orientations. We do not seek to impose a single approach that can bring together all the analytical threads raised in this survey, but it seems clear that there is a need for systemic and transdisciplinary work. These integrative efforts should take a variety of forms and learn from prior efforts (e.g. Allison & Ellis, 2001; Arthur et al., 2022; Campling & Havice, 2018; Chuenpagdee & Jentoft, 2019; Foley & Mather, 2018; Kooiman et al., 2005; Ommer et al., 2011; Weeratunge et al., 2014). Figure 7 is presented as a starting point for this work. Highlighting topics that emerge from the combination of major themes and disciplinary perspectives within the dried fish literature, it suggests a range of questions that may help generate research initiatives linking food science, fisheries biology and ecology, governance, and the social sciences and humanities.

Our survey demonstrates the important and varied nature of the contributions that dried fish make to the food and nutrition security, health, livelihoods, and social and cultural well-being of people around the world. Among the three thematic categories of food, economic, and cultural values that we elaborate in this survey, we find the dried fish literature most heavily focused on food value, followed by economic value. The importance of social relational and aesthetic values of dried fish for consuming populations thus merit much greater attention. Other major lacunae are the ecological relations on which dried fish economies depend and attention to questions of political economy and governance that are required to assure the sector continues to supply adequate, nutritious, and safe foods, in ways that are sustainable and just. Without the sustainability of fisheries as a natural resource, all values of dried fish are undermined.

This systematic analysis of the dried fish literature reveals a surprising wealth of knowledge and insight, much of which has been overlooked by fisheries scholars. Our work also uncovers, however, significant limitations that offer scope for further research. Rigorous transdisciplinary efforts to address these gaps promise substantial returns in terms of the nutritional, economic, social, cultural, and ecological values that are interwoven in, and emerge from, the dried fish sector.

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DATA AVAILABILITY STATEMENT

The Dried Fish Sample tagged bibliographic dataset used in this survey is archived in the University of Manitoba Dataverse Repository,

<https://doi.org/10.34990/FK2/UEECMDM>. The active bibliographic database described in this paper is accessible at https://www.zotero.org/groups/2183860/dried_fish_matters/library. Given the limitations of the Zotero browser-based interface, readers who wish to analyse the dataset further are advised to work with an offline copy, which may be navigated using the open source Zotero desktop client. A basic listing of the publications included in this dataset and their accompanying analytic tags is provided in Appendix S6. Our original script used in interacting with the Zotero API for the purpose of tagging and querying library items is available at <https://github.com/DriedFishMatters/zotero-meta-analysis-toolkit>. A modified version of this code, used for interactively generating query graphs through a web form, is available at <https://github.com/DriedFishMatters/zoterotags/>.

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