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Rapid transformation in aquatic food value chains in three Nigerian states

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Introduction: Nigeria is Africa's most populous country, third largest fish producer, and second largest aquaculture producer. There have been numerous studies of aquaculture and fisheries in Nigeria, but no study to date has analyzed aquaculture and capture fisheries value chains together, while giving equal weight to all value chain segments and systematically capturing information on temporal trends in value chain structure, conduct, and performance. This paper does so.

Methods: We conducted a structured, qualitative, rapid reconnaissance survey of 180 actors from eight segments of the aquatic food value chain in three Nigerian states with contrasting geographies, Ebonyi, Kebbi, and Oyo.

Results: Results particularly important for future research and policy are as follows. (1) Partial vertical integration is a common feature of the organization of firms in all value chain segments, as a risk reduction strategy to overcome market imperfections and frictions. Scarcity and high cost of imported intermediate inputs is stimulating local innovation and import substitution manufacturing of feeds and fabricated items. (2) Inter-sectoral spillovers from the poultry industry have hastened the development of fish value chains, while improvements in power supply have enabled the expansion of cold storage capacity, facilitating the geographical lengthening of frozen fish value chains. (3) Rapid technological and/or institutional change is occurring in all value chain segments, including those usually viewed as traditional, such as processing and fishing. Logistics services are becoming more specialized and sophisticated, and digital communications technologies including social media play an increasingly important role in value chain coordination and marketing. (4) Increasing opportunity costs of time drive demand for convenience foods such as

smoked and fried fish, which require little further preparation and can be stored at room temperature. Demand for farmed catfish is linked to growing consumption of food away from home at bars and restaurants. (5) Significant opportunities exist to improve the performance of value chains in terms of gender equity, environmental impacts, and food safety.

KEYWORDS

Nigeria, value chain, aquaculture, capture fisheries, micro, small and medium enterprises (MSMEs)

1 Introduction

Literature on aquatic food value chains (supplying fish, crustaceans, and other aquatic organisms), has proliferated since the 2000s (e.g., [Bush et al., 2019](#); [Lang et al., 2022](#)), but capture fisheries and aquaculture value chains are nearly always analyzed separately. This tendency reflects disciplinary and productivist biases. Researchers studying fisheries and aquaculture are often from different epistemic communities, and the form of production (capture or culture) is often interpreted as the defining feature of a given chain ([Tezzo et al., 2021a](#)). However, fish sourced from capture fisheries and aquaculture often becomes intermingled in the mid-stream (wholesale and processing) and downstream (retail and food service) segments of the value chain, meaning that the two must be integrated from the value chain perspective. The pervasive division between research on fisheries and aquaculture development has given rise to recent calls for a more integrated approach that recognizes their interlinked and complementary nature with respect to food security and incorporates attention to entire value chain, as a basis for supporting formulation of more effective policy ([Tezzo et al., 2021a](#)).

Although capture fisheries and aquaculture have largely been treated separately in prior literature, research on capture fisheries and aquaculture value chains shares numerous similarities.

First, both literatures place a heavy emphasis on production. Studies of the upstream value chain segments (fishing or farming) are far more numerous than studies of midstream (processing, wholesale), lateral (production inputs, logistics, labor), and downstream (retail, food service) segments ([Belton et al., 2022](#)). Relatedly, many studies focus on a single value chain node and do not address multiple nodes simultaneously (e.g., [Ali et al., 2023](#)).

Second, aquatic food value chains studies often focus on individual issues such as profitability and efficiency (e.g., [Yildirim, 2023](#)), loss and waste ([Torell et al., 2020](#)), food safety ([Love et al., 2020](#)), or gender ([Kruijssen et al., 2018](#)), but do not address whole chain dynamics.

Third, many value chain analyses are normative diagnostic exercises that focus on identifying technical or institutional ‘bottlenecks’ as entry points for intervention (e.g., [Asiedu et al.,](#)

[2016](#)). Such analyses usually pay little attention to longer run transformations in value chain structure, conduct, or performance occurring over time.

Literature on aquatic food value chains in Africa, and Nigeria (the focus of this paper) reflects many of these tendencies. Nigeria is Africa’s most populous country (213 million), third largest fish producer (1.08 million t), and second largest aquaculture producer (276,000 t) ([FAO, 2023](#)). Nigeria’s aquaculture sector has grown ten-fold since 2000, but about three quarters of Nigeria’s aquatic food production originates from capture fisheries ([FAO, 2023](#)). Inland and marine capture fisheries account for 34% and 41% of Nigeria’s aquatic food production, respectively, a combined total of 75% ([Figure 1](#)). Ninety percent of the aquatic food produced in Nigeria is consumed domestically ([Issac et al., 2020](#)). The remaining 10% is traded overland into neighboring countries or exported overseas, mainly for consumption by the Nigerian diaspora. But despite recent growth in fish production, demand for fish far exceeds domestic supply, and imported frozen fish account for about 45% of the fish consumed in Nigeria ([Subasinghe et al., 2021](#)).

Studies of fish farming (e.g., [Iruo et al., 2019](#); [Olagunju et al., 2022](#); [Mukaila et al., 2023](#)) and fishing (e.g., [Moses et al., 2002](#); [Neiland et al., 2005](#)) in Nigeria are common. Some studies address fish processing – mainly smoking and drying – (e.g., [Akintola & Fakoya, 2017](#)) but literature on wholesaling and other lateral and downstream value chain nodes is more limited, as noted by [Adam & Njogu \(2023\)](#).

Moreover, rather few aquatic food value chain studies span multiple value chain nodes. Studies covering multiple nodes tend to be primarily descriptive (e.g., [Akintola & Fakoya, 2017](#); [Bradley et al., 2020](#); [Diyzee et al., 2022](#)), provide normative diagnostics predicated on the *a priori* assumption that value chains function inadequately (e.g., [Subasinghe et al., 2021](#)), or focus on a single dimension of the value chain such as marketing margins ([Osondu, 2015](#)) or gender ([Adam & Njogu, 2023](#)).

To our knowledge, only one study from Nigeria to date has attempted systematically to capture information on temporal changes in the structure of aquatic food value chains. [Gona et al. \(2018\)](#) identified rapid transformation in value chains in Kebbi State over the preceding decade, including large increases in numbers of fishers, rapid growth in numbers of farms and urban

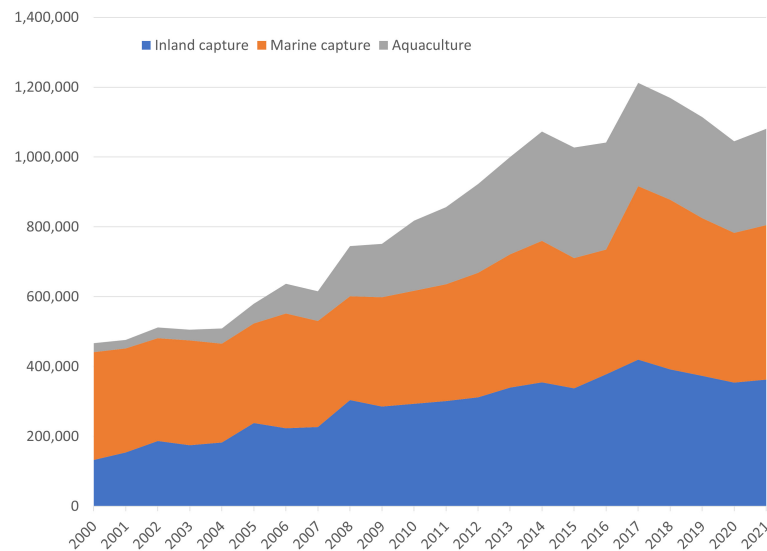


FIGURE 1
Quantity of fish produced in Nigeria by source & year (data from FAO, 2023).

fish retailers, and geographical lengthening of feed and seed value chains over long distances.

In this paper we extend Gona et al.'s approach via a qualitative scoping study of aquatic food value chains in three Nigerian states with contrasting characteristics; Kebbi, Oyo, and Ebonyi. We: (1) Analyze value chains of capture fisheries and aquaculture products together as linked components of the food system¹; (2) Give equal weight to all value chain segments; (3) Focus on whole chain dynamics, in terms of temporal and spatial variation in structure, conduct, and performance in relation to gender dynamics, environmental impacts, and food safety; (4) Focus analysis on what is happening, and on understanding the direction and drivers of change, rather than looking for examples of what isn't working and proposing solutions.

In doing so, this paper addresses the call by Tezzo et al. (2021a) for research to adopt an integrated food systems approach to fisheries and aquaculture development. Our attention to temporal dynamics of change throughout aquatic food value chains in three Nigerian states reveals characteristics and trends that might have remained invisible if the research had focused on a single form of production, node, or set of issues, and provides a basis for designing future quantitative research that can support robust evidence-based policymaking.

The remainder of the paper is organized as follows. First, we outline the data collection methodology deployed. Second, we present results and discussion, organized analytically with reference to the structure and conduct of upstream, midstream, downstream, and lateral value chain segments and their performance. The final section concludes by summarizing the paper's contributions to the literature on aquatic food value chains in Nigeria and beyond, and implications for future research.

¹ This includes domestically produced aquatic foods and imported (mainly frozen) products.

2 Methods

Our study focusses on three purposively selected states – Kebbi, Oyo, and Ebonyi (Figure 2). To select the three study sites, we first identified one key state from each of Nigeria's six geopolitical zones using data on aquatic food production and trade from the national 2020 Wet Season Agricultural Performance report (NAERLS, 2020). States with significant aquatic food production, trade, and/or consumption that were more-or-less representative of their respective agroecological zones were selected. Across the states, study sites were selected to be heterogeneous in terms of their agroecological, social, economic setting. Finally, all selected sites had to be safe for the study team to conduct research. The sample was restricted to three states due to resource constraints.

Kebbi state is in northwestern Nigeria, an area of the country with a lower level of economic development and higher incidence of insecurity than the South. Kebbi is well watered, traversed by the largest river in West Africa (the Niger) and a large reservoir (Kainji Lake) built on the river in the 1960s. These conditions are favorable to capture fishing and aquaculture. Kebbi is well connected to markets: it has two international borders (Benin and Niger) and major highways leading Southeast to the Nigerian capital Abuja and South to the huge urban markets of Ibadan and Lagos, nearby cities totaling 20 million people; by far the largest urban area in Africa. For comparison, this conurbation has a population equal to or greater than each of 40 other African countries.

Oyo state in the southwest is one of Nigeria's most prosperous zones. Oyo has good groundwater resources, is located amidst the largest concentration of urban markets in Africa, including Ibadan (population 3.5 million) and Lagos (population >15 million). Oyo has numerous fish and chicken feed mills and is supplied by maize for the feed mills from a north-south maize supply chain from Northern Nigeria (Liverpool-Tasie et al., 2017). Oyo is also a significant state for both capture fisheries and aquaculture production (NAERLS, 2020).

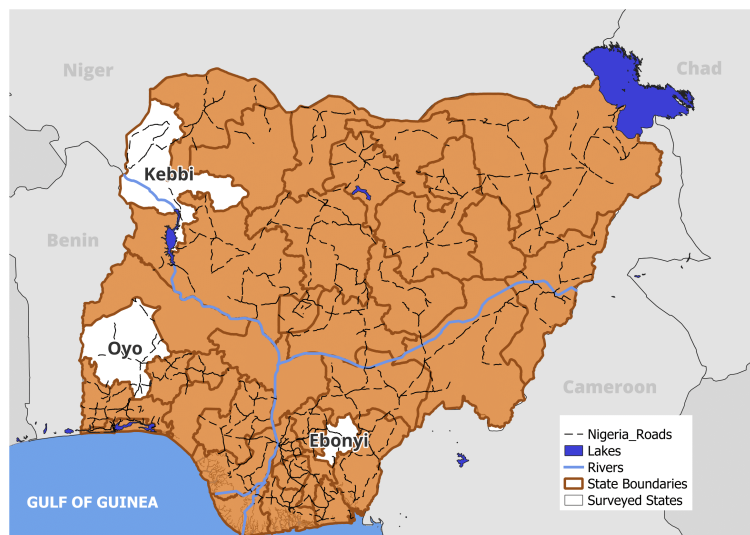


FIGURE 2
Map of study locations.

Ebonyi, a mainly rural state in the southeast, is also well-watered. Ebonyi is bordered to the east by the Cross River and is connected by a good highway the cities of Enugu and Port Harcourt, less than half a day's journey away. Ebonyi is a day's journey away from the Nigerian capital Abuja (population nearly 1 million) and Lagos, and close to the city of Onitsha, major trading port located on the Niger river with a population of 1.5 million.

This study was conducted as rapid reconnaissance (RR) in advance of a larger structured survey of multiple nodes of the fish value chain, planned for implementation in 2024. The purpose of the RR was to: (1) provide a contextual understanding of the microeconomic behavior of actors in the fish value chain in selected states; (2) facilitate the design of structured survey questionnaires capable of accurately capturing information on heterogeneity and temporal changes in value chain structure, conduct, and performance; (3) generate hypotheses to be tested using the survey instruments. That work will be the subject of future publications. The present paper summarizes initial findings arising from the qualitative RR exercise.

RR is a systematic qualitative data collection methodology based on interviews with actors at multiple value chain nodes. RR interviews followed a structured questionnaire with a mix of closed and open-ended questions. Interviewers were encouraged to explore in depth any issues of interest observed or arising during their conversations with respondents to gain deeper contextual understanding. Potential respondents were initially identified from existing databases compiled by the research team during previous research efforts (e.g., Liverpool-Tasie et al., 2021a). Subsequent respondents were identified by the snowball sampling technique, where initial participants in the research are asked to recommend other contacts who fit the research criteria and might be willing participate (Parker et al., 2020). Business owners or managers were interviewed by the research team at their places of work.

Businesses were categorized by scale according to four categories of enterprise scale recognized by the Government of Nigeria (Table 1). These are: nano (1–2 employees); micro (3–9); small (10–49); and medium (50–99). Very few, if any businesses in the aquatic food value chain in Nigeria have 100 or more employees, hence none of the enterprises were considered large scale, per this official definition.

Respondents were interviewed from each of the following value chain nodes, including (where applicable) informants from different parts of each state: (1) input suppliers (e.g., selling equipment, fish seed, feed and medicine); (2) producers (fish farmers and fishers); (3) third party logistics services providers (e.g., transport businesses); (4) processors (e.g., fish smokers and driers); (5) wholesalers of fish in fresh/frozen/smoked and dried forms; (6) retailers of fish in fresh/frozen/smoked and dried forms; and (7) 'one-stop shops' providing services spanning multiple value chain nodes including input supply, training, processing and marketing fish. Frozen fish import businesses were not encountered during the reconnaissance, and so were not interviewed.

The team interviewed around 50 respondents in each of the three states, respectively. Respondents in each state included women and men originating from a mixture of ethnic and religious communities. For respondents engaged in activities in multiple value chain nodes (e.g., a fish farmer also processing smoked fish), observations on enterprise scale were captured at the enterprise level, inclusive of all activities. Table 1 summarizes the number of respondents interviewed in each state by value chain node and scale of enterprise.

Data analysis proceeded iteratively. Interviews were initially analyzed thematically by research teams from each state, with reference to a conceptual framework (Noble and Smith, 2014) derived from the 'structure, conduct, performance, paradigm of industrial organization' (Porter, 1985), and compiled into summary reports. These reports were reviewed, and synthesized in a

TABLE 1 Distribution of respondents by scale in each state.

		Ebonyi	Kebbi	Oyo	Total	Share (%)
Scale	Nano	11	30	15	56	31
	Micro	30	28	26	84	47
	Small	13	8	17	38	21
	Medium	0	0	2	2	1
	Total	54	66	60	180	100
Nodes in the value chain	Input supplier	8	9	7	24	13
	Farmer/fisher	17	13	18	48	27
	Logistics provider	1	5	5	11	6
	Processor	8	11	9	28	16
	Wholesaler	9	13	8	30	17
	Retailer	9	15	8	32	18
	One-stop shop	2	0	4	6	3
	Others	0	0	1	1	1
	Total	54	66	60	180	100

presentation and report that was shared with all members of the wider research team for feedback and triangulation and modified further with information from a stakeholder validation event and the addition of secondary sources, to form the basis of this paper.

3 Results and discussion

In this section we present findings on the structure and conduct of the fish value chain in selected states in Nigeria and discuss their implications, by value chain segment and node. We distinguish findings by state where relevant. [Supplementary Table 1](#) presents a summary of key qualitative findings by value chain node and state, as reported by respondents.

3.1 Upstream

This sub-section addresses two nodes of the upstream (production) segment of the fish value chain: fish farming and fishing.

3.1.1 Farms

We observe the following key findings relating to the socioeconomic characteristics of farm operators, technological choice (species, production systems, and disease management), organization of production, and changes in value chain structure.

First, in Ebonyi, most new entrants into aquaculture were entrepreneurial people from varied backgrounds, rather than former fishers who had shifted from fishing to fish farming or people with formal education or training in aquaculture. Similar trends have also been reported for aquaculture in Asia (e.g., [Belton et al., 2012](#)), and for agriculture in Africa (e.g., [Neven et al., 2009](#);

[Jayne et al., 2019](#); [Omotilewa et al., 2021](#)), where many investments in commercially oriented farms are made by middleclass urbanites. This tendency has also been reported in Nigeria for peri-urban catfish farmers ([Miller and Atanda, 2011](#)).

Second, consistent with other studies from Nigeria (e.g., [Subasinghe et al., 2021](#)), by far the most common farmed species are *Clarias* and *Heterobranchus* catfishes and their hybrids, followed by tilapia. Fish are raised in production systems, including earthen ponds, concrete tanks, and tanks constructed of fiberglass or tarpaulins. The latter two tank designs, which are in use in Ebonyi and Oyo, are mobile and low cost and reported to be an adaptation to small landholdings, high land rental costs, and high pond construction costs. Significantly, some respondents reported that the small size and high mobility of these tanks have relaxed constraints on women's participation in aquaculture related to land ownership and property rights.

Third, catfish farming is highly intensive, even when practiced on a small scale, resulting in high risk of infectious diseases. Some farms follow bio-security measures to control the risk of disease (e.g., conducting water quality analyses, not using equipment from other farms, erecting fencing around the farm and limiting entry by outsiders). These practices were reported to be most common among larger farms. However, in Oyo, prophylactic use of antibiotics in fish feeds and the application of salt to treat infections and parasites were reported in farms of all scales. This finding is in common with Nigeria's poultry sector where high levels of antibiotic use are reported even on small farms ([Parkhi et al., 2023](#)).

Fourth, partial vertical integration (where an enterprise combines one or more functions that would otherwise be performed by firms upstream or downstream in the value chain, such as when a farm establishes its own hatchery or feed mill, or processes or trades fish) is a common strategy among farms in all

states, with the combination of functions integrated varying from farm to farm. Integrated functions include hatchery production, feed manufacturing, processing (smoking); and (for larger farms) establishment of own retail outlets. Similarly, there is a high degree of diversification in farm marketing channels in all states, where farms sell produce to a mix of wholesalers, retailers, and consumers. Given that specialization is often associated with greater economic efficiency, such pluriactivity by farms may reflect a need to overcome market failures such as poor or unreliable access to input or output markets.

Finally, farms are a dynamic accumulating value chain segment. Respondents on Kebbi reported that there has been rapid growth in farm numbers, output per farm, assets per farm, and size of workforce over the past ten years, though the respondents did not estimate the exact magnitude of these changes. Similar findings were reported by Gona et al. (2018), who found that numbers of farmers approximately doubled between 2008 and 2018 in Kebbi.

3.1.2 Fishers

In Ebonyi and Kebbi², fishers were reported to fish in and around major rivers using nets and traps, and (in Kebbi only) by dewatering temporarily enclosed sections of river channel. Fishers' main assets include nets, calabashes, canoes, baskets, basins, and sacks, which are mainly purchased using savings, or inherited. Commonly harvested species include African bonytongue (*Heterotis niloticus*), tilapia, and African carp (*Labeo coubie*).

Fishing enterprises are generally nano or micro-scale operations, though fishers often fish together in groups. Fishing activities are partially subsistence oriented in Ebonyi, with limited processing or market participation reported. Fishing in Eboni is highly seasonal, so fishers engage in other livelihood activities during the dry season from January–May. Fishing in Kebbi is more strongly commercially oriented and carried out year-round by some fishers. The dry season yields the highest catches, as fish are more concentrated in certain waterbodies. Monsoon season months (June–September) yield lower catches as fish are more disbursed with flood waters and many fishers engage in rice or vegetable farming during monsoon season. Similar patterns of seasonal livelihood diversification between fishing and farming are commonly reported elsewhere, in settings as diverse as Kenya (Geheb and Binns, 1997), and Laos (Martin et al., 2013).

In Ebonyi, fisher numbers and degree of market participation were both reported to be declining in response to diminishing fish stocks in inland rivers. Similar trends are reported elsewhere in Africa: e.g., Tanzania (Silas et al., 2020) and Ghana (Marquette et al., 2002). Respondents attributed stock declines to pollution from agricultural intensification and mining activities, although unsustainable levels of fishing pressure may also play a role. This reported decline in catches is at odds with official statistics, which suggest a gradual increase in inland fisheries landings in Nigeria over the past decade (Figure 1).

In contrast, an intensification of fishing effort appears to have taken place in Kebbi over the past 10 years, despite reportedly declining catches. The information gathered did not allow us to determine whether catch is declining per fisher (catch per unit effort), or in aggregate. Increasing fisher numbers might reflect a growing population. Similar trends are common elsewhere in Africa (e.g., Zeller et al., 2021), and are also consistent with results reported from Kebbi by Gona et al. (2018).

Notably, gender dynamics within Kebbi's inland fishery are reported to be changing, with women entering fishing in growing numbers in some locations. According to RR interviews, women now account for about 10% of fishers in Kebbi, compared to almost none in Oyo. Women's entry into fishing was ascribed by respondents to higher levels of income earned from fishing in recent years, perhaps reflecting increases in prices of wild fish as they become scarcer. Many of the women engaged in fishing do so by blocking off a portion of river with a temporary embankment and use calabashes to empty water from the area and catch the fish. Similar artisanal fishing techniques in Nigerian floodplain wetlands are reported by Thomas (1995). These fishing practices may be amenable with cultural norms that facilitate women's participation as they allow women to engage in fishing in a group with other family members.

3.2 Midstream and downstream

In this sub-section we consider two sets of mid-stream actors – processors and wholesalers – and one set of downstream actors – retailers.

3.2.1 Processors

Fish preservation (e.g., sun drying, smoking) is a traditional way to use gluts of wild fish that cannot be consumed immediately and is thus often thought of as a residual technology whose importance will eventually diminish with improvements in cold chains and transport that make it easier to distribute fish in fresh or frozen form (Belton et al., 2022). To the contrary, RR findings suggest that the fish processing sector in Nigeria is highly dynamic; evolving to make use of new sets of inputs and new technologies on the supply side, and pulled by growing consumer demand for convenience foods including smoked fish and fried fish. We identified the following key findings with respect to the structure and conduct this segment of the fish value chain.

First, the number of processors grew over the past ten years. In Kebbi, fish farmers are increasingly engaging in fish processing, particularly smoking. Similarly, in Ebonyi, catfish farmers are responsible for much of the smoke-drying processing, and most farms smoke catfish. This widespread form of vertical integration by catfish farmers suggests that farms face difficulty in marketing large quantities of catfish in live form. In Oyo, some fish smokers have diversified operations by offering custom processing services to others – a form of outsourcing.

Second, value chains for smoked fish are geographically long, linking sites of production in the south, northwest, and northeast to major cities throughout the south and center of Nigeria, and with

² No findings on fishers were reported in Oyo.

neighboring Niger and Benin. This finding points to widespread demand for processed fish products as well as the finite capacity of local markets to absorb supply.

Third, there is a high degree of differentiation among processed fish products and ongoing product innovation. Smoked catfish are produced mainly for consumption by higher income consumers. In Oyo, some processors use attractive packaging and/or branding for their products to obtain a price premium. Frozen imported marine fish are also processed by smoking. These are smaller, have shorter shelf lives, and are cheaper than catfish. There is also differentiation between smoked catfish originating from farms and capture fisheries. The latter, sourced from northeastern Nigeria and referred to as ‘mangala fish’, is preferred by some discerning consumers, but its availability is more seasonal compared to smoked farmed catfish. In Oyo, processors report increasing demand for new product variants such as spiced smoke-dried fish. Some processors in Oyo have diversified their operations beyond fish smoking to process animal products including chicken, turkey, pork, and mutton.

Fourth, convenience contributes to demand for processed fish products in a context where urban consumers face time constraints and high opportunity costs of time linked to their labor market participation. Fish sold in smoked or fried form is a convenience food; an almost-ready-to-eat product requiring less preparation time than fresh fish. These products meet the needs of buyers who find it inconvenient to handle or store fresh fish or who have limited time to prepare meals (e.g., government workers). This is an important observation, because fish is often framed as a relatively inconvenient type of food (Olsen et al., 2007).

Fifth, significant indigenous innovation and uptake of new processing technologies is taking place. Use of smoking kilns – locally manufactured box-shaped ovens, fabricated from iron-alloy bars and sheets – for oven-drying and smoking fish has increased over time. These kilns are an intermediate technology; an improvement over traditional methods, but cheaper to purchase and operate than electric ovens. Some processors own industrial smoking kilns powered by liquified gas or electricity, but often continue to use charcoal as their main fuel due to fuel costs, and customer preferences of the taste and appearance of fish dried using woodsmoke. In Oyo, processors have recently started using gas burners to fry fish, which is reported to be less polluting than the traditional practice of using firewood. Smoke inhalation by processors is a source of serious occupational health risks as it can cause asthma, other respiratory conditions, and exposure to carcinogens, as well as food safety risks to consumers due to carcinogenic compounds (Olaoye et al., 2015).

3.2.2 Wholesalers

Wholesalers source fish from a wide variety of suppliers, including farms, fishers, processors, frozen fish importers, and other traders, for distribution to buyers including retailers, processors, restaurants, bars, hotels, and other wholesalers. There is a high degree of specialization among wholesalers by product type. Different sets of wholesalers specialize in trading live, frozen,

and smoked fish. Most of the fish sold live is farmed catfish, which wholesalers keep alive for extended periods of time in drums or covered bowls. Marketing farmed live fish, especially hardy air breathing species such as clariid catfish, is also a common phenomenon in many Asian countries. Selling fish alive is a guarantee of freshness, and live fish fetch a premium over dead ones (c.f. Ali et al., forthcoming).

Frozen imported fish (mainly smaller, lower value marine species) provides alternatives for people not interested in live catfish or who cannot afford to purchase large fish. Some high-value species from inland capture fisheries (e.g., elephant fish, Nile perch) are frozen for transport to distant urban markets. Smoked fish are relatively shelf-stable, making them well-suited to long distance transport and trade, including to urban areas in southern and central Nigeria and neighboring countries, as also reported by King (2001).

The number of wholesalers specializing in sales of frozen fish and the volume of frozen fish traded has increased in Ebonyi and Kebbi in the past 10 years. Growth in frozen fish trade has been enabled by the establishment of public cold storage infrastructure, and improvements in power supply, which respondents noted has become more stable. These developments seem largely concentrated in urban areas. For example, in Ebonyi, this development has been concentrated in the state capital. In Kebbi, cold storages have been developed by the state government in three urban locations and the government provides stand-by generators to reduce losses from power outages. These investments have increased storage capacity and duration, with users paying fees to access these services. Similar patterns of public investment in cold storage development stimulating increases in the volume of agricultural commodities traded have been reported for potatoes in India (Minten et al., 2014).

Wholesalers in Oyo reported increasing use of social media for marketing and sales and coordination of deliveries using dispatch riders (motorbike couriers). This development has accelerated sales and product deliveries and improved the quality of service provided to clients. Wholesalers use established online platforms such as WhatsApp, rather than custom apps, for coordination. Adoption of social media for product marketing was hastened by the COVID-19 pandemic and associated restrictions on mobility and social interactions. Liverpool-Tasie et al. (2021a) found that fish and poultry retailers in Nigeria increased their use of information communications technology during the pandemic to solve these constraints. Similar trends have also been reported in Kenya (Naziri et al., 2023).

3.2.3 Retailers

There is a high degree of specialization among retailers by product type, whereby most retailers specialize in marketing either live, fresh, frozen, smoked, or dried fish, with each type of product obtained from different sources. Dried fish products include ‘stockfish’ (frames of salted demersal whitefish such as cod, imported from Europe), ‘crayfish’ (dried marine shrimp), and small dried marine fish. Stockfish and dried fish are often used to make soups, while crayfish is a common ingredient in many

Nigerian dishes. Fresh fish are often covered in crushed ice while on display, and unsold fish are stored in freezers overnight.

In all states, sales of live catfish have grown with rising consumption of food away from home at venues such as restaurants, barbecue grills, hotels, and bars. This pattern suggests that demand associated with the growth of food service and consumption of food away from home is contributing to the growth of aquaculture, and consumption of aquaculture products, mainly by better-off consumers. Similar trends have been reported in Ghana, where rapid growth in tilapia farms has been linked growing demand from food service (Kassam, 2014), and in Asian countries, including Myanmar (Tezzo et al., 2021b).

Larger frozen fish retailers have cold stores or chillers and sell a wide range of frozen fish, including high value species (e.g., croaker), as well as meat. They have weighing scales and sell fish measured in standard units at fixed unit prices. Smaller frozen fish retailers are mainly women who purchase individual cartons of mainly smaller, cheaper species of fish (e.g., mackerel) and sell non-standard quantities by haggling. Numbers of frozen fish retailers in Kebbi have increased in recent years, with nano-scale frozen fish retail businesses, most of which are operated by women, reported to be growing at a faster rate than larger frozen fish businesses. Frozen fish retailers who do not own refrigerators rent space in cold rooms to store unsold products for a fee. Frozen fish vendors who do not have access to cold rooms for storing unsold fish must run freezers using generators, which is costly. Inadequate cold storage facilities and erratic power supply have been reported as serious challenges for traders in previous studies of frozen fish marketing in Nigeria (Adebayo and Pitan, 2001; Bada and Rahji, 2010).

Retailers of live fish and frozen fish cut and clean purchased fish to order, for consumer convenience. Smoked fish retailers break up catfish into smaller pieces that are packaged and displayed in clear plastic bags to accommodate different buyer types. These practices point to the growing importance of marketing fish in forms that are more convenient, time-saving, and affordable for customers than purchasing large whole fish; important in a context where opportunity cost of time is increasing, and lower-income consumers and those in rural areas may lack refrigeration at home (c.f. Liverpool-Tasie et al., 2021b).

Social media use to advertise products and services, is reported to be driving sales for fish retailers in Oyo, similar to the trend reported by wholesalers in the previous subsection.

3.3 Lateral supply chains

In this sub-section we address changes in the structure and conduct of lateral supply chains for fish seed, feed and chemical inputs, and third-party logistics services.

3.3.1 Seed

Fish seed production is a highly specialized activity. Hatcheries are often clustered in locations where suitable environmental conditions and specialized technical knowledge exist. As a result, fish seed is often traded over long distances from hatchery clusters

to farm clusters (Belton, 2012). For example, most fish seed used by farms in Kebbi originates from Kainji in Niger state, and hatcheries in southern Nigeria and Abuja. Kainji's groundwater chemistry was reported by respondents to be better suited for breeding fish than that in Kebbi, and Kainji is the location of the Institute for Freshwater Fisheries Research; a first mover in fish seed production in Nigeria. Specialized fingerling traders from Kanji deliver seed over distances of several hundred kilometers to Kebbi and to other locations in Nigeria. This pattern is similar to that in many Asian countries. For instance, in Bangladesh initial hatchery clusters formed in locations with suitable groundwater chemistry for fish breeding (e.g., low dissolved iron content) and pioneering government hatcheries (Hernandez et al., 2018).

Smaller farms are especially dependent on seed traders to supply fingerlings. Larger farms sometimes collect fingerlings directly from distant hatcheries. However, as reported by respondents, transporting fingerlings over long distances can stress them, resulting in high post-stocking mortality and economic losses for farms. There is also scarcity of fish seed supply at times. As a result, some of the largest farms in Kebbi have vertically integrated hatchery operations to produce their own fingerlings to overcome scarcity and ensure adequate supplies of seed. Some of these large farms are reported to sell surplus fingerlings to smaller farms during peak season, creating local spillovers.

Scarcity of fish seed and high mortality rates for seed transported over long distances have prompted some farms in Ebonyi to learn fish breeding skills and produce their own fish seed. Broodstock are raised on-farm or purchased from input suppliers, who often sell catfish broodstock, indicating the emergence of another specialized upstream market for broodfish. Interestingly, in Kebbi, wild fingerlings harvested by fishers are traded for use in aquaculture, and the number of wild fingerling traders is thought to be increasing. This finding highlights the continued and, in this case growing, links between capture fisheries and aquaculture, as also observed in Asia (Tezzo et al., 2021a). Further work is needed to identify whether the wild seed supplied is of species not currently produced by hatcheries, or whether wild clariid catfish seed is traded, indicating that current hatchery production is insufficient to meet demand.

3.3.2 Feed and chemical inputs

Aquaculture input suppliers distribute feed and complementary inputs including veterinary medication, hormones (for breeding fish) and broodstock, to farms. Many input suppliers also offer advisory services to fish farmers, guiding them on matters such as stocking density and appropriate feed usage. This is consistent with the findings of Liverpool-Tasie et al. (2020) showing that SMEs in the midstream of agri-food value chains in the Global South often provide complementary services to their customers (such as training) which can be an important mechanism to support the growth and productivity of farms.

Intersectoral spillovers from the poultry industry to aquaculture were reported to have occurred, particularly within the past five years, as suppliers of poultry inputs diversified into selling

aquaculture inputs in response to growing demand. This sequence of sectoral development is also very common in Asia, where supply chains linked to intensive poultry farming often developed before those for aquaculture, creating subsequent spillovers in feed milling and distribution (e.g., [Hernandez et al., 2018](#)). There is complementarity across aquaculture and poultry inputs, many of which are manufactured by the same companies, making it possible for some distributors to avail bulk discounts when ordering both sets of inputs simultaneously. The proliferation of input suppliers has led to intense competition among them and smaller retailers reportedly face difficulties matching the prices offered by larger distributors.

Feed and medicine marketing are highly organized and closely linked. Feed manufacturers grant localized distributorship rights to dedicated sales representatives – usually existing input retailers with large customer bases – who assume responsibility for marketing and distributing feed to other retailers. This distribution model is very similar to that in Asia (e.g., [Ali et al., 2023](#)), and Africa's largest aquaculture producer, Egypt ([El-Sayed et al., 2015](#)). Similar arrangements govern the distribution of veterinary products, for which manufacturers appoint sales representatives to market products to retailers in a designated locality. Marketing activities include distribution of promotional materials and product samples, and manufacturers offer prizes and financial rewards to successful representatives to incentivize sales.

Formulated aquafeeds used in Nigeria were initially imported, but the high cost of imported feeds has spurred the growth of local feed manufacturing, including large mills supplying branded feeds, and smaller mills producing unbranded products, leading to a highly diversified feed supply sector. About half of farms were reported to use feed manufactured by larger mills during the initial stages of production, but switch to lower cost feeds manufactured using local ingredients later during the production cycle when larger quantities of feed are required. Scarcity of feeds occurs during the planting season when there are often shortages of locally cultivated grains from the previous season's harvest. Some of the largest farms produce their own feeds and sell surplus to smaller farms, particularly during peak crop harvesting season when raw materials are readily available. In addition, most 'one-stop-shops' (input suppliers vertically integrating multiple functions, including processing and trading fish) produce fish feed for sale and offer custom milling services to fish farmers who purchase feed ingredients and have them milled to their own specifications for a fee, although it should be noted there are relatively few one-stop-shops in operation.

The scarcity, high cost, and unstable price of imported feeds and imported equipment has driven input suppliers to engage in import substitution manufacturing of a range of items including feeds, feed milling machinery, farm implements, and nets. Input suppliers frequently attend trainings, seminars, and conferences to obtain information on new practices. Most input suppliers who produce fish feed do so using locally fabricated equipment rather than more expensive imported machines. The increasing self-sufficiency of input and equipment supply may have been accelerated by the COVID-19 pandemic, which temporarily disrupted international

supply chains, causing fish value chain actors to seek locally available alternatives ([Belton et al., 2021](#)).

3.3.3 Third party logistics

Third-party logistics services (3PLS) provide outsourced transport or storage services to other businesses to support their procurement or delivery activities. 3PLS for transporting aquatic foods and production inputs are diverse, growing in number and, in some cases, becoming increasingly specialized and sophisticated in their coordinating roles. Many 3PLS are individual vehicle owners who transport a variety of products and are not engaged full time in the aquatic food value chain. They are hired to make deliveries on an *ad hoc* basis and paid for their services immediately after delivery.

Wholesalers in Oyo use dispatch riders to deliver products quickly to retailers and consumers. The use of dispatch riders in fish marketing has become very common during the past five years and is said to have improved the quality of service offered by traders to their customers. Similar rapid growth of motorbike logistics services is occurring elsewhere in Africa, including Kenya and Rwanda ([Sitas et al., 2022](#)). As noted above, the use of dispatch riders is linked to the growing use of social media platforms in product marketing.

Buses are the most common form of transport used to deliver fresh catfish from farms to point of sale in Oyo, either by farmers themselves, or by logistics providers who employ staff to load and offload fish for clients. These products are tagged with delivery information and contacts and sent unaccompanied from one location to another. Similar findings have been reported in Myanmar, where the use of public buses to deliver fish around the country played an important role in the geographical lengthening of value chains for farmed fish ([Belton et al., 2018](#)).

A few 3PLS enterprises specialize in providing fish marketing services. For instance, in Ebonyi some enterprises focus on transporting stockfish from the major wholesale market in Abia state where imported stockfish is traded, and crayfish from the coastal states where is produced. These enterprises liaise with independent transporters, collating inventories of traders marketing these products, and organizing waybills and delivery to collection points. Stockfish and crayfish traders are informed when their goods arrive for collection. These dedicated 3PLS firms are mainly micro-scale enterprises, comprising 3–5 personnel working at an office for documentation, a store, and at vehicle onloading/offloading points. This type of specialization has become more common in the past five years but remains relatively rare.

3PLS service provision can be a pathway to accumulation. Most logistics providers reported starting their business by hiring vehicles to transport products before investing in their own vehicles using business profits and establishing more comprehensive logistics services companies. Many transporters remain reliant on hiring vehicles however. Common challenges reported by transporters include poor road infrastructure, high fuel costs, daily compulsory levies from transport unions, and bribery and harassment by corrupt police officers and thugs, as also found by [Kuteyi and Winkler \(2022\)](#).

4 Indicators of value chain performance

4.1 Gender

Gender inequality is evident in the distribution of ownership of enterprises and business assets in the fish value chain, confirming findings from previous studies in Nigeria (Velu et al., 2009; Adam and Njogu, 2023). Women are better represented in processing, trading, and retail segments than in production, and while businesses in upstream, lateral and some midstream segments tend to be controlled by men. Businesses owned by women in downstream, midstream, and some upstream value chain segments tend to be smaller than those operated by men, though with variations along the north/south axis that reflect regional religious and cultural differences. These disparities may reflect differential access to capital, gendered norms governing mobility and social interactions, and differences in time spent performing reproductive labor (e.g., childcare, cooking) (c.f., Murphy et al., 2020). There is also a strongly gendered division of labor among workers employed in aquatic food value chain enterprises, reflecting beliefs about of inherent biological differences between women and men and social norms that limit women's mobility and agency relative to men. However, we also found evidence of increasing women's participation in fishing in Kebbi, and indications from respondents that the small size and moveable nature of tanks used for fish culture had reduced barriers to women's entry into aquaculture.

4.2 Environment

The viability of capture fisheries is threatened by multiple anthropogenic pressures. In Ebonyi these were reported to include pollution from an industrial fertilizer and agrochemical plant located on the Onuebonyi River (Nwali et al., 2016), and unregulated mining activities that destroy waterbodies (Njoku et al., 2020) and pollute receiving waters with contaminants such as lead and zinc (Eyankware & Obasi, 2021). In Kebbi, conversion of riparian habitat to rice cultivation and agrochemical runoff from farmland was reported to be negatively impacting fisheries productivity. Expansion of rice cultivation on riverside land is linked to low water levels during dry season. The increasing intensity and erratic nature of drought and rainfall also impacts the breeding success and survival of wild fish populations. Similar types of anthropogenic impacts are reported to negatively impact inland fisheries productivity elsewhere in Africa, including Madagascar (Lammers et al., 2015). These effects are likely compounded by unsustainably high levels of fishing pressure. Discharge of eutrophic (nutrient rich) wastewater from intensively managed fishponds into the surrounding environment (e.g., agricultural land, public drains) is a common source of pollution. Use of charcoal as an energy source for fish smoking contributes to environmental degradation through deforestation and air pollution. Improper waste disposal at markets is also a source of pollution.

4.3 Food safety

Fish wholesale and retail markets and processing areas were widely observed to be unhygienic environments. Fish are often sold in the open, with no coverings to prevent contamination by dust or insects. Processors and market stall holders are observed to use unwashed and otherwise unhygienic utensils including bowls, cutting surfaces, and grills, and to handle fish with bare, unwashed hands. Fish friers often reuse cooking oil repeatedly, leading to rancidity and off-flavor. Some respondents reported the use of the insecticide 'Sniper' (2-2-dicholorovinyl dimethyl phosphate) as a preservative in for dried fish such as stockfish to prevent insect infestation. Use of pesticides in dried fish production and storage is thought to be widespread globally (Belton et al., 2022). Deposits of soot on fish smoked using charcoal are a source of potentially carcinogenic polycyclic aromatic hydrocarbons, as reported in Nigeria by Emoyoma et al. (2023). Use of antibiotics and other medications in aquaculture is widespread and poorly regulated, without observation of adequate withdrawal periods prior to harvesting, potentially resulting in the evolution of strains of antimicrobial resistant bacteria.

5 Conclusions

This paper presents findings from a rapid reconnaissance survey spanning all segments of the aquatic food value chain in three contrasting Nigerian states – Ebonyi, Kebbi, and Oyo. In all three states, aquatic food value chains have emerged spontaneously as clusters of economic activity in response to the pull of domestic demand and favorable conditions for fish production and distribution, in terms environment and geography (e.g., access to water and cities), and public investments in infrastructure (e.g., highways connecting major cities, wholesale markets, electricity, cold storage, communications) that have created an enabling environment. We find that Nigeria's aquatic food value chains are comprised predominantly of micro, small and medium enterprises (MSMEs), and highly dynamic in terms of structure and conduct, even in segments commonly thought of as traditional. Though often dynamic, adaptable, and capable of innovation, MSMEs face considerable challenges linked to the uneven or inadequate provision of enabling infrastructure, and economic and political instability. MSME performance also often remains suboptimal.

In this concluding section we elaborate further on five sets of observations emerging from the analysis that are particularly important areas for future research and policy. These concluding observations are organized in line with the structure-conduct-performance paradigm that underpins this paper's conceptualization of value chains. The first two sets of conclusions relate to value chain structure, with respect to the vertical integration of individual enterprises and geographical lengthening of value chains, and the ways in which these structural characteristics of value chains have been shaped by public investments in infrastructure, market imperfections, and intersectoral spillovers. Our third and fourth sets of conclusions pertain to the conduct of value chain actors, with respect to technological choice and institutional arrangements, and in

response to consumer behavior. Our final set of conclusions relates to value chain performance with respect to gender, the environment, and food safety.

First, partial vertical integration is a common feature of the organization of firms in all value chain segments, including micro and small-scale enterprises. This form of value chain structure is unlike that found in most of Asia, where clusters of aquaculture and capture fisheries activity are typically characterized by a high degree of horizontal integration among SME firms with highly specialized functions, and rather limited vertical integration other than in the largest agri-businesses (e.g., [Hu et al., 2019](#); [Belton et al., 2018](#)), following the classic pattern of ‘gains to specialization’.

In Nigeria, the supply of production inputs (e.g., fingerlings, medicines, formulated feed, feed ingredients, feed milling equipment) is often unreliable, and subject to high costs and price instability due to factors including seasonality, macroeconomic conditions, transport infrastructure, and insecurity. In this setting, widespread vertical integration, including among very small enterprises, may be understood as a risk reduction strategy to overcome market imperfections and frictions. Scarcity and high cost of imported inputs also appears to be driving local innovation in the form of import substitution manufacturing of feeds using domestically produced raw materials, and the fabrication of items such as feed milling machinery, nets, and farm implements – another form of vertical integration. Policies aimed at sectoral development should be two pronged, seeking support indigenous innovation as it emerges, and to establish the necessary enabling environment for specialization to occur so that firms have greater choice in the matter of whether to vertically integrate.

Second, inter-sectoral spillovers from poultry to fish have hastened the development of fish value chains, as poultry feed millers and input suppliers have diversified existing product lines to meet emerging demand from fish farms. A similar sequence of development has been widely observed in Asia ([Hernandez et al., 2018](#)). Improvements in power infrastructure and reliability of power supply have also created spillovers by permitting the expansion of cold storage capacity, including in relatively peripheral zones such as Kebbi. The expansion of access to cold storage services has facilitated the growth of markets and geographical lengthening of value chains for frozen fish, increasing flows of relatively affordable imported frozen fish from ports in the South to the interior, and some reverse flows of high value frozen riverine fish in the opposite direction. Improvements in access to power and cold storage will be important for the rapid transformation observed to extend to rural areas.

Third, rapid technological and/or institutional change is occurring in all value chain segments, including those usually viewed as traditional, such as processing and fishing. Numbers of actors are increasing over time in most value chain nodes and locations, including capture fisheries in Kebbi, where women are entering the fishery in growing numbers. Indigenous technological innovation is occurring throughout the fish value chain to modify traditional or imported technologies to changing local conditions. For example, the use of mobile tanks and tarpaulins for raising fish, transport of fingerlings and live harvested fish over long distances, improved kiln designs for fish processing, and new forms of

packaging and presentation of retail products. Logistics services are becoming more specialized and sophisticated, and digital communications technologies including social media play an increasingly important role in value chain coordination and marketing, supporting the geographical lengthening of value chains and accelerating the rate of circulation of goods. Additional research on these innovations to identify their impacts on profitability and their scalability could significantly guide the development of government and donor programs to support the fish subsector in Nigeria.

Fourth, the behavior of actors in upstream and midstream value chain segments is shaped by consumer demand and corresponding changes in the food environment downstream. Poor electricity access and increasing opportunity costs of time are driving demand for convenience foods such as smoked and fried fish, which require little further preparation, and retailer practices such as cleaning and cutting fish in reduce preparation time at home. Demand for farmed catfish is closely linked to the consumption of food away from home at bars and restaurants. This pattern suggests that farmed fish may not serve as a direct substitute for fish originating from capture fisheries, but as a complement occupying a different niche. This observation may have broader gender and class implications, depending on which types of consumers are able to consume foods in such settings. This question requires further research. These observations also underline the highly differentiated market for aquatic foods in Nigeria, where fish originating from varied sources are consumed in diverse product forms and dishes.

Fifth, although transformation in the structure and conduct of aquatic food value chains in Nigeria is impressive in its scope and pace, the performance of value chains in terms of gender equity, environmental impacts, and food safety suggest opportunities for improvement. Women are engaged at various nodes of the fish value chain in Nigeria, with participation growing in some instances, but they often occupy less remunerative roles as enterprise owners and workers. Further research is needed on how women’s businesses perform relative to men’s and identify any systemic differences in the challenges they face. All value chain nodes generate environmental impacts. These include biodiversity loss through overfishing, wastewater discharge and excessive use of antibiotics by farms, use of unsustainably produced charcoal and air pollution in fish processing, and disposal of plastics and food waste at markets. Food safety is also poor at all value chain nodes due to unhygienic practices and contamination with toxic substances. These issues all highlight potential for interventions to improve value chain performance.

Together, our findings suggest that government and donor efforts to support increased access to fish among Nigerian consumers require a holistic consideration of the fish value chain. This is particularly timely as the Fishery and Aquaculture Policy for Nigeria (2024–2028) is being developed. Adequate consideration of activities of MSMEs in the midstream and downstream of the input and output supply chains for fish as well as lateral supply chains is critical. The operations of these MSMEs directly and indirectly affect the cost and productivity of fish production as well as the cost and quality of fish available to consumers. Further research on and

with existing MSMEs in aquatic food value chains in Nigeria can provide insights on the nature of interventions that are most likely to be sustainable and scalable.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Michigan State University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LL-T: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. AW: Investigation, Methodology, Writing – review & editing. MA: Formal analysis, Investigation, Writing – original draft. AG: Formal analysis, Investigation, Writing – review & editing. CE: Formal analysis, Investigation, Writing – original draft. MF: Formal analysis, Writing – original draft. OO: Formal analysis, Investigation, Writing – original draft. RO: Formal analysis, Investigation, Writing – original draft. SN: Formal analysis, Investigation, Writing – original draft. TA: Formal analysis, Investigation, Writing – original draft. TR: Conceptualization, Methodology, Writing – review & editing. BB: Conceptualization, Methodology, Writing – original draft.

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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.frontiersin.org/articles/10.3389/faquc.2024.1302100/full#supplementary-material>

SUPPLEMENTARY TABLE 1

Summary of key findings reported by respondents, by value chain node and state. "X" denotes an observation reported by one or more respondents interviewed during rapid reconnaissance in each state.

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