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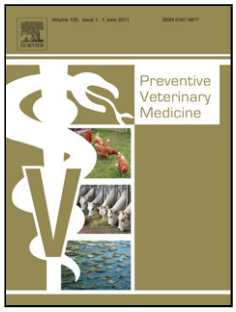

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Understanding Fish Production and Marketing Systems in North-western Nigeria and Identification of Potential Food safety Risks Using Value Chain Framework

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Abstract.

Fish production systems in North-western Nigeria has a significant role in food, nutrition and income generations to families, yet an important setup for zoonotic disease transmission. The aim of this study was to provide a broad knowledge of the structure, activities and food safety risks of the fish value chains operating in North-western Nigeria using the value chain framework. A total of 16 focus groups and 8 key informant interviews were conducted to gather data from fish producers, fish sellers and fish processors in selected peri-urban and rural settlements in Kaduna State. In addition, 129 semi-structured questionnaires and observation checklists were used in this study to gather evidence-based data, such as demography of value chain actors, product characterization, and food safety risks.
The fish value-chain in North-western Nigeria is characterized by four main stakeholders, namely, fish producers, transporters, as well as raw- and processed-fish-sellers (wholesalers, retailers). Two major sources were identified supplying farmed fish to North-western Nigeria: the distributors from the central and southern part of the country and the fish farmers within the North-western and North-eastern regions of Nigeria. Raw-fish-wholesalers within the two major markets sold most of their high-value products to raw-fish-retailers, while low-value products were routed to raw-fish-retailers in the rural communities, processed-fish-retailers and household consumers in rural settlements. There were no large companies operating and no differentiation of chains between aquaculture and wild fishery. Raw fishes not sold and began to rot were sold to street vendors at a cheaper price and household consumers.
Fish production and supply chains were characterised by poor structural and sanitary support for food safety and hygiene measures. Food safety risks identified were related to lack of biosecurity measures in fish farms, lack of cold chain and access to running water, poor hygiene practices by all handlers, lack of fish inspection at all levels, lack of use of protective clothing and limited health inspection of handlers.
In overall, government control of activities in fish value chains was relatively poor leading to the absence of food safety regulatory enforcement characterised by lack of institutional goals on improving food safety measures in a chain-wide distribution. Hence, this study points the significant structural, sanitary and hygiene limitations along with fish value chain components. It provides a baseline for microbial food safety risk assessments, and information required for policy-making for implementation of disease control programmes, as the sector is fast-evolving in Sub-Saharan Africa.

Keywords: Fish production system; Fish marketing system; Value chain mapping; Food safety risk identification; North-western Nigeria

1.0 Introduction

Fisheries sector has a significant impact on the daily activities of most households in low to middle income countries, by provision of nutritional diet, job opportunities and income generation. Nearly 8% of the world population, approximately 540 million people, mostly from developing countries, rely either directly or indirectly on fisheries and aquaculture sector for their livelihoods. In Nigeria, agriculture contributes 24.4% of the gross domestic product (GDP), with 0.5% contributed by the fishery sector in 2015 (NBS, 2017; FAO, 2017). The trend of production from both capture fisheries and aquaculture in Nigeria increased from 441, 377 tonnes in 2000 to 759, 828 tonnes in 2014. In that same period, aquaculture had a 12 fold increase from 25,718 tonnes to 313,231 tonnes (FAO, 2017). By implication, the increase was significantly due to rise in commercial fish farming in and around rural and urban cities of Nigeria, and the corresponding establishment of fish markets that are accessible to these farmers. In North-western Nigeria, aquaculture production has been found to be rapidly developing across the region to complement the decreased output from the wild resources such as the Lake Chad Basin and increased demand of fish for consumption (Béné *et al*., 2003).

The consumption of fish in Nigeria has increased from 7.6 kg per capita in 2000 to about 13.9kg in 2014 (Belton and Thilsted, 2014). The increase is attributed to urbanisation, population growth, and increase in middle income households, increase awareness on health implication of red meat and the continuous viability of the aquaculture production systems in Nigeria (HLPE, 2017). In response to meet the increased fish demand, aquaculture production in sub-Sahara African countries is expected to double the annual growth rate recorded in 2020 (World Bank Report, 2013). Presently, the production of fish in Nigeria is only 0.78 million metric tonnes (MT) while demand is compensated through importation of 750,000 MT of fish worth USD 600 billion (Oota, 2012). The projected demand of at least

2.66 million MT of fish per annum is required in order to maintain the annual per capita consumption level of at least 13.9 kg in Nigeria (Belton and Thilsted, 2014). There is a considerable gap of demand-supply of at least 1 million metric tons of fish, which needs to be closed not by importation, but enhancing a more market-driven fish value chains of aquaculture and wild catch that supplies high quality fish and fish products for consumption.

Nigeria, being the most populous country in Africa, is experiencing rapid human population growth since the last two decades, from a total of 95, 269, 988 in 1990 to 195, 875, 237 in 2018 (Worldometers, 2018), and 51% living in urban cities. Other changes related to urbanization is proliferation of markets, street vendors, shops and restaurants to better satisfy the growing class of food requirements in the middle income households and institutions (Opoko and Oluwatayo, 2014). These socioeconomic changes in relation to urbanization and infrastructural development have affected the land utility in and around the cities by reducing access to land for fish farming (Ekanem, 2008; Opoko and Oluwatayo, 2014; Lasisi *et al*., 2017; FAO, 2017). In line with the global trend of fish supply, the fisheries sector of Nigeria is changing from the wild catch to an increase in fish supply from aquaculture practices (Rabo *et al*., 2014; Ndimele, 2018). The unit size of production has increased from subsistence to commercial production and the level of processing has gone towards large scale processing and distribution within the country. While the production is still restricted to traditional methods of fish rearing, the value addition process and distribution represent processes that can supply affordable and accessible animal proteins within and outside the country (Gomna, 2006; Gomna and Rana, 2007; FDF, 2008; Ipinjolu *et al*., 2014). Aquaculture production has been reported to be a sustainable enterprise, adaptable to the urban environment, even in the face of competing factor such as land use for livelihoods like crop farming (Adedeji and Ademiluyi, 2009; FAO, 2011b; Chang *et al*., 2016).

With the transition of fish supply from wild catches to farming, there is less information on the level of functional and organizational structure of the fish production and value addition systems. Value chain analyses is a framework used for the description of the livestock production systems, its components, stakeholders and potential hotspots for disease transmission within a sector (Rushton, 2009; FAO, 2011a). These include the initial mapping and description of the value chains including people and product characterisation and flow as well as the behavioural practices along the chain. It also involves institutional and power characterization, assessment of gender distribution, and critical control point's identification for policy implementation (Kaplinsky and Morris, 2000). There are very few studies on the value chain of the fisheries sector in Nigeria, and available ones solely focused on socio-economic and microbiological factors only. Veliu *et al.* (2009) conducted gender-based value chain analysis of the aquaculture sector in North-eastern Nigeria. Akanbi *et al*. (2016) and Adebayo *et al*. (2016) investigated the fish value chains at state level, the thrust of the study was to analyse the financial viability of small scale fish farmers in the respective regions. Fregene *et al*. (2016) used value chain approach to analyse various conflict activities within the fisheries livelihoods in Nigeria. Odebiyi *et al*. (2013) sampled fish farmers, fish processors and marketers to determine the economic variability amongst the stakeholders within the value chains. Several studies have identified food-borne microbes such as *Salmonella* spp, *Campylobacter, Staphylococcus aureus*, *Escherichia coli* and *Listeria monocytogenes* contaminating the production systems or products from the systems (Udeze *et al*, 2012; Wendlandt *et al*., 2013; Nyenje and Njip, 2013; Ekundayo *et al*., 2014; Nurudeen *et al*., 2014; Ibrahim *et al*., 2014, Grema *et al*., 2015a,b). Other pressing problems like antimicrobial use in aquaculture production and residues along value chains were also reported (FAO/OIE/WHO, 2006; Romero *et al*., 2012; Santos and Ramos, 2018; Manage, 2018). Hence, the need to identify microbial risk of food contamination, specific hot spots

along the chains and sources of environmental contamination has become vital. This could be attained by understanding the structure, product flow cues, food safety and hygiene practices and sanitary activities along the whole fish production and marketing systems.

To the authors' knowledge, no fish value chain study has been published investigating the market structure, stakeholder identification and linkages, and characterization of hygienic and sanitary risks along the production systems with focus on North-western Nigeria. As such, information from this value chain characterisation is essential to serve as framework for research activities as well as for sectorial planning, identification of possible growth opportunities, tackling of development challenges and support of national public health policies and disease control programmes. The aim of the study was to provide broad knowledge of the structure, activities and food safety risks of the fish value chains operating in North-western Nigeria using the value chain framework.

2.0 Materials and Methods

A cross-sectional study of each of the fish value chain component was conducted between April 2016 and March 2017 to answer the following research questions (RQ) as adopted from Alarcon *et al*. (2017):

- RQ1 –What are the key components of the fish value chains and the linkages of input supplies within the components?
- RQ2 - What is the structure of the components of the fish value chains in terms of product characterisation, product flow and various products' value addition activities within the chains in the study area?
- RQ3 – Who are the actors directly involved in the flow of products and their demographic characteristics along the value chains?

- RQ4- What percentage of the fish and fish products supplied from the upward streams supplied to different downward components?
- RQ5 - What are the geographical routes for the supply of fish and fish products to the different markets and processing units?
- RQ6 - What is the seasonal variation of fish and fish products along the value chains?
- RQ7 - What are the major challenges that may pose risk of microbial hazards from the current structure of the chains?

2.1. Study area and selection of participants

The study was conducted in North-western geopolitical zone of Nigeria, which is purposefully selected for its importance regarding livestock and fisheries production and the newly developing aquaculture industry including several local fish markets supplying fish to Kaduna and Kano states. These two states have relatively larger population and higher middle income households in the region (National Survey for Agricultural Commodities, 2005; Suleiman *et al.*, 2018). Kaduna State, known to be endowed with favourable climatic conditions, and abundant water bodies as well as several agricultural related institutions, aquaculture and other livestock productions are recorded as the main livelihood sources of many communities in the State (FAOSTAT, 2015; Suleiman *et al*., 2018). Most importantly, due to a decade of violent conflicts spread across North-eastern Nigeria, which has severely weakened the already fragile fisheries livelihood of the region, and the banning of fisheries and aquaculture activities in the region, the fish market within the North-western region including Kaduna State, has taken the largest share in the Northern region of Nigeria (USAID, 2015; World Food Program, 2017).

A pilot survey was conducted to ascertain entry points and value chain components and their tributaries for better understanding. The research team initiated the study by contacting both

fish farmers (via cooperatives and farmers associations) and fishermen (at sale points along water bodies). In addition to recruitment at meeting points, snowballing was used to recruit fish farmers that were unregistered and absentees, reflected in the poor record keeping observed from outdated list of registered members. Similarly, due to diverse nature of the fish processors (restaurant, hawkers, street fish vendors, bars etc) and lack of business associations, snow balling method was used for recruitment of fish processors. Fish sellers had a well-organized business association, thus, Chairmen of the four major fish markets confirmed from pilot study in Kaduna State were visited at market premises: Sabon Gari Market, Gaula Market, Gamji Market, and Murtala Square Market for introduction.

The leaders in the fish farmer- and seller-components were visited and discussions were held prior to the fieldwork to introduce the research team, explain the objectives and benefits of the study and seek for cooperation and mobilization of fellow colleagues. These introduced the research team to most of the workers, and recruitment of participants were conducted to obtain consent for participation in the research. An initial interview with the leaders in the respective markets and associations was followed by identification and classification of people in each components by their operational functions (RQ1). For each operational type, 5 to 10 people were selected in collaboration with the group members and a focus group discussion was held. Diversity in groups on the basis of demographic and operational characteristics such as age, gender, stock size, fish species handled and sources of fish was encouraged. Where not feasible, discussions were conducted in homogenous groups of farmers, several marketers and processors including women specific groups. The translator recruited in the team helped to facilitate the discussions, mostly speaking Hausa language (a native language widely spoken by people in North-western Nigeria). To minimize bias and withholding of information, the presence of leaders and elders were discouraged, and

discussion was held away from place of work to create conducive environment for opening up and discourage reluctance to share information.

Focus group discussions were complemented with semi-structured interviews to the participants and the key informants. Additional questions were administered to other workers with good knowledge of the structure and functionality of the market as well as supply chains. For the questionnaire administration, 45 fish farmers, 64 sellers and 20 processors were interviewed in order to further explore individual demographic and operational activities, and various sources of fish supply, distribution and destination. Eight key informants were identified and interviewed in the study, these included the suppliers known as middlemen and major fish transporters in the State (Table 1). To facilitate interviewer observation of hygiene, sanitary risks and infrastructural challenges, business premises, farm environments and vending areas were visited during the study. A whole working day was spent in the various work locations along with the participants, and check listed various hygiene, sanitary and structural challenges faced by value chain actors in course of business. Information on checklists were categorised based on value chain components into infrastructural condition, hygiene status of workers, slaughter slab and storage conditions, and environmental sanitation (RQ7).

2.2. Data collection

In the focus group discussions, participants were asked to:

1) Explain briefly the various fish-related businesses and their operations in the study area. (RQ1 and RQ2)
2) Explain how business components interact with one another, and discussions were centred on understanding the diversity of suppliers, buyers and transporters of fish or fish products. (RQ1 and RQ2)

3) Identify and describe the people, different types of fish they handle, fish products and value adding practices associated to each business component in the chain (RQ3 and RQ4)
4) Describe the supply areas, destinations and seasonal differences among the different stakeholders. (RQ5 and RQ6)
5) Describe the seasonal and temporal: inputs of fish supply, pattern of fish supply within the various components and estimation on the proportion of people according to gender as well as flow of products within a particular component. (RQ4-6)

The key informants' interview participants were requested to:

1) Describe the type of products produced by the component, their distribution channels and proportion of supplies associated to each component. (RQ4, RQ5 and RQ6)
2) Provide yearly production estimates and the associated percentages of product flow to various components in the different chains. (RQ4)
3) Describe seasonal, temporal and geographical route of fish supply from various sources to the value chains. (RQ5)
4) Describe the various hygiene and sanitary practices conducted within the components of the fish value chains in the study area. (RQ7)

Researcher observation checklist (ROC) was used to identify food safety risks (structural challenges and potential hygiene and sanitary risks) in 45 fish farms, 4 fish markets and 20 fish processing sites (RQ7). Using the risk profiling criteria in the food safety risk analysis guide for national food safety authorities published jointly by FAO/WHO (2006), the following hygiene and sanitary risks contextualized to the study area were used:

1) Presence of well-developed and permanent structure

2) Whether the structure was well ventilated, lightened and away from pollution prone area
3) Good source of clean water (pipe borne water), electricity and cold chain
4) Presence of washing area and specific rubbish bin
5) Presence of toilet facility in working area
6) Use of personal protection equipment (PPE) by personnel
7) Eating and drinking practices at place of work
8) Presence of domestic animals in working area
9) Mixing of dead and live fishes
10) Regular cleaning of fish dressing slabs
11) Washing hands and fish after evisceration

Data collection was facilitated by using a combination methods such as open ended questions, flow charts and matrix ranking and scoring. Open ended questions on the different types of fish handled in the value chain components and the construction of flow charts with participants for deliberation to reach proportions of people, products, supply locations, patterns and flows, and quantities within chains. Probing on open ended questions and matrix ranking were further used to decide on several opinions generated by participants. Key informants' interviews with individuals were focused on generating data on proportional estimates, seasonal variations in relation to geographical locations and gender distribution of participants by ranking from low (1) to high (3). In addition to note taking, some qualitative data from focus group discussions and key informants interviews were audio recorded after research introduction and consent approval.

2.3 Data analysis

Repetitive listening to the recordings and cross reference with the notes resulted in collation of data into Word document. Using thematic analysis of the audio data, themes describing patterns, specific activity in a chain and linkages between components were identified. Templates from themes were then used to develop structural segments such as type of fish handled, type of suppliers, interaction within stakeholders, geographical location of suppliers, seasonal variation within supply chains etc. These information were then backed up by the flowcharts obtained. An initial chain that allowed major operational activities between the fish production and marketing systems (‘artisanal suppliers’, ‘local distributors from other states’, ‘fishermen’ and the ‘wholesale and retail marketers’) were developed for subsequent data analysis and results presentation.

Data analysis of the different value chain components was conducted on three levels similar to the approach of Alarcon *et al*. (2017): (1) people, gender and product profiling, (2) geographical flow pattern and (3) seasonal variation and annual production estimates. Flowcharts of the various fish types handled, product types, people and locations in each market and processing units, and the flow between the types of people and components were developed. These flowcharts were used to develop system maps that indicate the chain flows, characteristics of people and products operating in a specific component and proportional estimates indicated when available. In case of conflicting information, the most reliable datum was used. To enhance diagrammatic clarity, groups of people working in the system but not directly linked to fish handling (such as middlemen and transporters) were excluded in the chart but included in the result narration.

Geographical mapping (RQ5) identified the main locations and routes through which fish reached different markets through analysis of focus group discussions or key informant

interview data. Different origins and destinations were linked together as one route following similar network of roads to reach the market. Movement of products within the study area was illustrated by pointing out the main destination areas as reported by fish traders, fish transporters or middlemen in each market.

Seasonal and proportional mappings (RQ4 and RQ6) were done by examining the contribution of fish suppliers to the primary markets in dry (January, February, March, April, May) and rainy (June, July, August, September) seasons. Available data on fish traded in markets were converted to monthly units for comparison. Data from raw-fish-sellers were used to plot and compare seasonality variations of trade volume. The sanitary and structural challenges (RQ7) were identified through analysis of the interviewer observation results obtained from the various components of the value chains.

2.4 Data validation

Initial results were presented for validation to people knowledgeable of the fish production and marketing systems, such as experienced fish farmers, fishermen, fish transporters, traders and academic and field fisheries experts. As such, information inconsistencies or lack of data were rectified by further data retrieving from key informants and group leaders to update data profiling and mapping.

3.0 Results

The fish value-chains in North-western Nigeria is relatively simple, with four main actors directly involved in fish handling, namely:

1. Fish farmers; which consisted of fish farmers and fishermen were found to supply fish to the markets around Kaduna State.

2. Fish transporters; these segments of the value chain consist of actors who are strictly responsible for transporting live (raw) fish from neighbouring states to fish traders in Kaduna State.
3. Raw-fish-sellers (raw-fish-wholesalers and -retailers); which by definition in this study, refers to fish handlers, who sell live or dead (raw) fish and/or fish products that were unprocessed either for further sale or to customers. They included raw-fish-wholesalers and raw-fish-retailers, who usually buy from markets outside Kaduna State and transport it for onward distribution in Kaduna State or from markets within Kaduna State to fish processors/household consumers, respectively.
4. Processed-fish-sellers (processed-fish-wholesalers and -retailers); all fish handlers selling fish in its processed/preserved forms were defined as processed-fish-wholesaler or retailer, depending on customer. These segment of the value chain actors buy raw fish from fish traders, process it via grilling, roasting, frying or cooking and sell to the consumers, often in restaurants or at street sides.

3.1 General demographic and operational characteristics along the fish value chains in Kaduna State (RQ2, RQ3, and RQ7)

Table 2 presents the demographic and operational characteristics of fish farmers (aquaculture) interviewed in the study. Almost 80% of the respondent interviewed were owners of the farms aged around 41years with approximately 7 years of fish farming experience. Men were the predominant gender (71.1%) in the fish farming business and mostly qualified with tertiary education (53.3%). When asked if they had ever attended food safety training, 88.9% reported never attended food safety training even once. More than 90% of the fish farmers said they had to purchase fish feed from vendors supplying imported aquafeed. These feeds were mostly reported to be stored for short period of time between 2 to 30 days, and common feeding practices was manual feeding without wearing of gloves by the

farmers (100%). The primary species cultured by about 97.7% of fish farmers was African catfish, predominantly in earthen ponds (57.8%) and concrete ponds (33.3%) (Table 2).

Table 3 presents the demography of raw-fish-retailers and -wholesalers as well as their corresponding operational characteristics. A total of 64 raw-fish-sellers were interviewed in this study. Around 87.5% of these sellers were engaged in retail businesses, and henceforth referred to as raw-fish-retailers. While the remaining 13% sold raw fish at wholesale level and thus referred to as raw-fish-wholesalers. Generally, about 59.4% of all raw-fish-sellers handled fish sourced from farms (cultured fish) while 3% reported selling wild caught fishes only. All raw-fish-sellers in this study were men (100%) and had secondary school education (40.6%). Around 13% of them attended formal food safety and hygiene training. Major factors considered by them in purchase of raw fish included cost of fish (65.6%), and fish qualities such as stomach fullness, thickness of muscles and lack of rotten smell before buying (21.9%). Fish products were usually carried alive in water-filled plastic boxes (100%), usually cleaned daily (79%), but few (9%) used disinfectants.

Table 4 shows the demographic characteristics of processed-fish-sellers interviewed in this study area, and henceforth referred to as processed-fish-retailers and -wholesalers. Their average age was 35 years, with fish processing experience of 9 years. Majority of them were females (55%) that owned the business. The type of fish mostly handled by them was cultured fish (75%) and prepared mostly by grilling (35%) and smoking (45%).

3.2 Fish marketing segments and their contributions to Kaduna State fish value chains (RQ1 and RQ2)

Three fish segment categories were created: the ‘local fish farms’ (LFFs), the ‘Raw fish markets’ (RFMs) and ‘fish processing units’ (FPUs). The Raw fish markets (RFMs) namely

Sabon Gari Market (SGM), Gaula Market (GLM), Gamji Market (GJM), and Murtala Square Market (MSM) were where:

- Raw fish (live & dead) were sold, and mostly killed and gutted prior to collection by customers.
- Trading involved largely independent people with heterogeneous purchasing patterns, fish proportions and processing methods.
- Most activities in the markets were not documented and usually dictated by the experienced and elderly traders as well as collective rules created by the operators and their leaders.
- Fish and fish products were sold and traded upon individual perception of weight and quality with apparently little differentiation between different fish types.
- There were limited operations involving value addition to products, and traders and customers generally focus on raw products with no brand name.

Gamji market was considered the major fish market in the study area (trading approximately 100,000–150,000 kg of fish per week). These products were mostly supplied from outside the study area. For wild fish species captured from surrounding water bodies, fish captured were sold in Gamji, Gaula and Sabon Gari markets daily (trading around 55,000 kg per week), accounting for almost one quarter of fish supply per week in the study area. Estimates during high catch periods (particularly in rainy season) indicates that wild fish catch supply may be as high as around 150,000 kg per week due to catches characterized by huge sizes and body weights.

3.3 Sources of fish supply into Kaduna State fish value chains. Three major sources supply raw fish into Gamji markets in Kaduna State. Approximately 20% of supply was from fish farms around the state. Retailers described that fishes were bought most frequently through

the middlemen who usually connect the retailers to the farmers, thus having some percentage share of price. Retailers in such businesses complain mostly of increase in unit price due to the share price increased by the middlemen. Occasionally, some retailers reported a well-organized agreement with the farmers to directly bring stock to the markets because of higher price returns. Most retailers reported sourcing their fish from wholesalers that sourced fish from external sources, especially common during times of shortages. Fish sellers (wholesalers) stated supplies from urban cities where fish farming is highly practiced namely Abuja, Niger, Ibadan, Jigawa, Taraba and Kano States. In addition to handling farmed fish, about 20% sourced wild fish species from water bodies within or outside the state such as Wara and Kawuri rivers (Kebbi State), Kainji Dam (Niger State), and water bodies in Sokoto and Kano States. Fish traders selling wild fish species reported supplies from river Kaduna; a river within the State that spanned through Kaduna North and South, Zaria and Sabon Gari towns.

3.4 Transport of fish from various external sources to Kaduna State. Transport of live fish from sources external into the study area were described to be organised collectively by live fish traders (mostly raw-fish-wholesalers) within the study area. In Gamji and Sabon Gari markets, fish stocks sourced from nearby markets within the study areas, the distant markets within the study area were reported to be transported in motorcycles, tricycles and cars. But those transporting from distant markets, outside the study areas such as Abuja and Ibadan, mainly use buses, improvised to contain space. Transportation of live fish may take from a single day to maximum of 2 days, the most frequent was a day. Transporters estimated transportation of about 250kg to 500kg of live fish depending on the capacity of the vehicle. Two to three fish traders usually hire a transporter and pay for a combined transportation fee. A bus was estimated to transport about 10 containers weighing each approximately 25kg while mini-trucks could carry up to 30 of the 25kg containers for 3 to 5 different traders twice

a week, depending on the distance of origin. These trucks were, most of the time, owned by the transporters or an independent person who could possess several of it. Transporters usually use the trucks to transport from the fish markets either passengers or foodstuff after delivering the fish.

Smoked fish were described as transported to and from the study areas but in paper packages. Retailers handling smoked fish detailed that fish that stayed for long and loose its weight and quality were usually used for smoking. The smoked fish were transported to neighbouring cities and rural areas. Different set of transporters, which were classified as occasionally hired were responsible for transporting fish to and from the study area. The practice of fish smoking was found to be reported by both traders in Gamji and Sabon Gari markets, which were the two largest fish markets in the study area (Fig. 1).

3.5 Transactions of live fish within and to the markets in Kaduna State. In Sabon Gari and Gamji markets, it was described that once the fish were delivered to the markets, they would be weighed using weighing machine and then transferred into tanks by each seller. It is in the 'tank' that some would be collected and displayed for sale. In some instances, customers that buy large quantity usually do transactions at the tank site. Raw-fish-sellers estimated that 80% of the fish bought from outside the study area were bought by traders in Gamji market while the remaining were sold to traders in Murtala square markets and other traders within the communities. In turn wholesalers in Gamji market sell out to traders in Sabon Gari markets. Fish farmers usually sell their stock at the farm gate to the raw-fish-sellers or middlemen and price negotiation was enhanced by visual estimation of weight. So weak and debilitated stock were said to be bought by traders that smoke fish product for onward transportation to the Southern part of Nigeria.

Fish farmers described that product transactions were frequently done through middlemen, who operate in two folds. Either they purchase fish on credits and sell them at a higher price to the traders in the markets, or fish farmers offer the middlemen some price percentage for finding customer capable of buying fish at a certain price. Farmers also reported to operate less often by contacting fish retailers directing and negotiate price without the middlemen, albeit, a less common phenomenon. The frequency of purchasing fish from suppliers was reported to be twice per week, although most retailers in small markets said they sometimes request for supplies only once in a week. The pattern of supply was reported to be mainly regulated by the demand of fish in the area. During this period when fish are kept in markets in tanks, fish were not fed which result in loss of weight and quality which mostly result in low price and subsequent poor return to raw-fish-sellers.

3.6 Degutting and transaction of fish products. The fish traders were identified as the main persons who organised the degutting and cutting into pieces of the fishes to the customers satisfaction. In all the fish markets, the fish traders usually recruit young boys responsible for degutting and cutting of fishes into small pieces post price negotiation with customers. The minimum price paid for such service was ₦50 (US$ 0.2) and maximum of ₦100 (US$ 0.3) per fish depending on size (1US$ = N305.5 in 2018). Raw-fish-wholesalers, who were said to be the minority, have the capacity to buy more than 1000 kg of fish per day, while retailers usually buy in containers of 25 kg (between 50 and 100 kg of fish) per day. During the KII, specifically informants for Sabon Gari and Galma markets, reported the presence of fish safety inspectors during the colonial period, however, presently, all markets reported lack of fish inspection by either the government or any private institution. Hence, the fish dressing slabs (concrete slabs used for degutting, skinning, filleting and removal of fins) were operated mainly without order, and no inspection of sanitary and hygiene measures as well.

3.7 Common fish types and grading systems used in fish production and marketing systems

Raw-fish-sellers in all the markets visited, reported marketing of locally farmed fish species predominantly. Among the locally farmed fish species, they unanimously listed African catfish and tilapia. Others that reported handling wild fish species, mostly listed Carp fish and some wild species of tilapia and catfish. Most farmed catfishes were described by the middlemen and transporters to arrive mainly to SGM, GJM and MSM from Abuja and its peri-urban cities. The price of raw fish sold in the markets were almost similar. In Sabon Gari market, a table sized catfish (approximately 1kg) was reported to be sold at an average of ₦700 (US$ 2.29). Galma market, characteristically known as the wild fish market, were known in selling large fishes caught from water bodies. Raw-fish-sellers in this market reported selling wild carp fish as big as a 10kg and can cost as high as ₦3000-5000 (US$ 9.82-16.37). In all the fish markets, there was no reports of any formal grading systems for both live, smoked or processed fish, but key informants and other participants explained that fish valuation was based on visual assessment of live weight, absence of rotten smell and palpation of the flesh, with big and fleshy fish having better prices. Similarly, there was no any formal or standard grading system of fish was reported to be done in all the fish markets. Hence, traders indicated that fish quality is subjectively evaluated by both traders and customers based on the perceived fish size, weight and smell.

3.8 General fish value chains in Kaduna State. Generally, there was no formal differentiation among aquaculture, fisheries and imported frozen fish value chains. Only two markets controlled the market share of farmed and wild fishes in the State. Raw-fish-sellers mostly handled both the farmed and wild fishes, and hence, both products were found to flow along same value chains. Raw-fish-wholesalers, in both large fish markets, reported to have their ‘standard quality fish’ freshly brought from sources sold to “high class” customers that buy in bulk such as the hospitals, hotels, institutions. Higher quality fishes have been perceived to be more demanded by retailers located within the metropolis in Kaduna State, while low quality

fishes were usually demanded by raw-fish-retailers in the outskirt of the city or rural areas. Some raw-fish-retailers were found to have direct contact with farmers for supply and likewise direct contact with institutions, schools and restaurants for onward delivery. Raw fishes that were not sold, and began to rot, would be sold to processed-fish-retailers and household consumers, at a very cheaper price. In addition, selected processed-fish-wholesalers specialized in smoking fishes, were reported to smoke and export to other countries' (in Niger, Cameroon and Ghana) (Fig. 1).

3.9 Spatial maps (RQ5 and RQ6)

3.9.1 Geographical descriptions of fish sources within Nigeria

Geographical analysis of supply chains resulted in the two regions having a distinctive geographical pattern based on the combination of main routes and proximity. Sabon Gari Market largely reported getting most of their supply from the Northwest of Nigeria (Kano, Kebbi, Jigawa, Katsina; Gamji market, having proximity to North-central and Southern geopolitical regions such as Abuja, Nasarawa, Jos, Niger, Lagos and Ibadan; Gaula market, a market with predominance for wild caught fish get supplies from Kaduna rivers, Kainji Dam, Challawa Gorge dam, Shiroro Dam, Tiga Dam. Murtala square market, highly specialized with sale of frozen fish reported supply from Lagos and Ibadan. Sabon Gari market also depended on Gamji market for supplies particularly in dry season when the fish farming activities are usually not practiced (Fig. 1).

3.9.2 Temporal descriptions of fish supply to major fish markets in Kaduna State

Fish supply in the study area was reported to be largely dependent on seasonality, particularly the rainy and dry seasons and not considering festive seasons. In the dry season, most farmers quit farming due to lack of ground water, and shrinkage of small rivers within towns. Hence, during the season, the dominant markets (Gamji and Sabon Gari) were the main markets

where supply do not seize but the unit price per fish would be doubled. Further analysis on seasonality of fish supply to the markets indicated that their supply from within the study area seizes in the months between November-April while it poor supply peaks around March. Markets during these periods reported to depend on distant supplies such as fish farms in Abuja, Ibadan, Lagos and Nasarawa. Temporal fluctuation was reported to be a very common phenomenon for both farmed fish and wild catch supplies. Analysis of records collected from researcher's observation in Gamji market revealed highest supply of 6,698.50 ± 1802.7 kg in the month of August and 6,426.77± 1663.01kg in the month of September. Whereas the supply dropped to 1,626.41± 804.16kg in March, the peak of dry season (Fig. 2).

3.10 Food safety Risks identified (RQ7)

Structural and Non-structural challenges: Hygiene and sanitation practices regarding farm biosecurity measures, personnel and equipment hygiene statuses were summarized in Figure 3. Risks identified in fish farms included use of untreated animal manure to fertilize the ponds (71.1%), practice of integrated livestock farming (51.1%), with domestic animals such as poultry, sheep, goat and cattle and use of not prescribed antibiotics during health problems (76%). All farms visited had rodents around and no human traffic control (100%). Most farms had no designated foot mat (11.1%), and farm PPE (15.6%).

Figure 4 presents interviewer's observation of structural challenges regarding fish markets and processing units visited, which revealed no permanent structure (72.6%) and pest control (90.5%), no toilet facilities (96.4%), no running water (82.1%) and electricity (75%) and markets were located close to open drainages (56%) and refuse dumping areas (22.6%).

Raw-fish-sellers and processed-fish-sellers had no designated apron (71.4%), head cover (75%) and hand gloves (97.6%). Around 16.7% showed signs of cough and flu and some had uncovered wounds (15.5%). Almost all sellers eat and drink at selling points (96.4%),

displayed fish uncovered (23.8%), at room temperature (23.8%) and mixed with other food stuffs (27.4%) and/or wild aquatic animals (39.3%). Both raw- and processed-fish-sellers commonly practiced less washing of fish dressing slabs before (21.4%) and after (17.9%) use (Fig. 5).

4.0 Discussion

The information for the mapping of fish value chain presented in this study is distinctive, as it provides some level of detail on the people, product and their flows in the fastest-growing industry not documented previously. Data from fish farms, fish markets and fish processing units in this study has helped in understanding the complexity of the product flows and identify challenges associated to its structure and food safety. Several potential uses of these results from mapping analysis would be elaborated all through this discussion.

The simplicity of the chains and people operating in the value chains and the proportion of product flows, provide an understanding on the importance of developing the fish value chain and people involved in the control of flows. An important example is the different categories of operators characterised by rudimentary chains, small scale entrepreneurs having poor to lack of basic services. These results were consistent with Eltholth *et al*. (2015) and ILRI report (2011), where fish value chains in Egypt and Uganda were characterised. The mapping similarly provided an understanding of the dependency of different stakeholders to specific sources, products or other stakeholders.

The results indicated that middlemen and retailers particularly those in Murtala square and Sabon Gari markets relied mostly on fish supply from Gamji market for 80% and 50% of their supply, respectively, and that these depended on markets outside the study area. In the literature, major sources of fish supply to the study area were reported to be the aquaculture, artisan fishermen and importation (Ita, 1993). The market structure of farmed fish was found

to consist of several sources of suppliers, each contributes substantially to the existence of the fish markets but have limited price control (Scott, 1995). In this study, the market share was dominated by sellers with supply from neighboring states and those purchasing from fish farmers within Kaduna State, yet the prices for both occupied by the fish suppliers from other states competing for fish farmers in the state. As such, policies for developing the value chain and implementation of food safety and hygiene measures may require involvement of almost all the fish suppliers such as the fish farmers, fishermen, middlemen and main fish distributors within and from other states. This type of market structure has more channels of product flow, poor institutional and functional structure which affects success of policies for market development (Smith, 1981). In terms of product valuation in farmed fish value chains, fish were usually processed as whole, without undergoing several processing stages, which serves as nutrient retention. However, due to lack of temperature control at fish processing units to inhibit bacterial growth and multiplication, higher risk for food borne disease (FBD) could occur (Eltholth *et al.*, 2014). Moreover, lack of traceability of fish source, absence of inspectors, and diverse traders not having any knowledge or control on initial fish source and production management, do make the product vulnerable to food borne disease outbreaks. Middlemen were found to exist in the major fish markets, providing linkage with fish farmers and retailers and between fish sellers. As such, they influence the price setting of fish and products in the markets. This is a scenario common in other livestock studies, describing them as 'the cartels' (Aklilu, 2002; Alarcon *et al*., 2017). Several economic studies reported that the activities of middlemen otherwise known as brokers, is of benefits via inflating of product price while farmers suffer disadvantage by deprivation of the profit and being challenged to improve production (Surtida, 2000; Brewer, 2011; Makokha *et al*., 2013). Hence, to improve food systems in Nigeria, policy makers need to consider all the diverse chains, product flows in the markets, and implementation of stakeholder analyses.

The characteristics in the market components regarding product differentiation and governance was investigated in this study. Almost all the chains could be classified as relational value chains according to Gereffi *et al*. (2005). These chains are characterised by lack of standard fish grading system, and corresponding lack of product value addition. Products are therefore marketed as raw, simply classified as either high or low quality based on subjective perceptions and specifications of sellers and consumers. Farmers, sellers and processors in these markets were capable of producing fish and its products with little or no contribution from consumers. As such, there are independent stakeholders like the middlemen involved in the flow of products present in both up and down streams of the value chains, and contracted based on social ties. The mapping of the value chains, thus showed main product sources, flows and destinations in the markets. The general production and marketing cost of fish could be considered low, and the market for fish in the whole region was also reported by the stakeholders interviewed to depend on the Kaduna markets. The lack of development of the value chain might be an important barrier to export opportunities in the region. Factors such as lack of value addition, low economies of scale, low demand for value added products by consumers, poor marketing strategies, poor use of technology, challenges of institutional management and poor quality and high contamination rates were reported as cues for under development in several fish value chain analyses (Mwirigi and Theuri, 2012; Eltholth *et al*., 2014, 2015; Asiedu *et al*., 2017).

Despite demonstration of these characteristics in this study, the dominant markets such as Gamji and Sabon Gari markets were reported as contributing a large share of the market for fish due to presence of some level of product differentiation and low cost of products. This may not be unconnected to the fact that the two markets had a semi-formal system of governance (by the leaders in associations) playing vital roles in setting of product prices. However, these markets, characterised with large share, requires more government attention

to combat moral hazards, illegal activities and food safety risks (Omojokun, 2012; Edun, 2013). Absence of basic food safety measures and food product inspection by public health workers still remains a problem, not only in fish markets located in Nigeria, but abattoirs as well (Ilu *et al*., 2016). This study has provided evidence required by policy makers to aim at developing future interventions and policies that would improve system efficiency, food security and food safety needed for economic and social development in the food animal systems.

Several potential food safety risks have been identified from the system structures. The lack of organization of the whole system from 'farm to fork' was a source of social, economic and health concerns. As a consequence, some farmers reported use of animal dung for feeding or practiced integrated farming methods which represented possible sources of environmental contamination and disease transmission. The holding of fish in tanks for long periods in Gamji and Sabon Gari markets and lack of cold chains associated to all the markets represented another potential source of poor fish quality and food borne disease transmission. In addition, the fact that traders and processors operated without licence in an untidy environment create potential sources for fish contamination. These were identified to represent sources of low quality fish to processing units such as restaurants, street fish vendors, and poor households. This problem was seen as a significant contributing factor in street fish vending where hygiene and sanitary measures were poor (Delia, 2015). The fish processors in this type of value chains were reported to have poor food safety attitude and practices (Grema *et al*., 2019). Coupled with harsh ambient temperature in tropical Sub-Saharan countries, fish and fish products from these sources could be the potential sources of pathogens to humans and the consequent occurrence of food borne diseases. This is due to the prolonged exposure of fish to germs that favours multiplication and release of toxins at ambient temperature. It also contributes to an important food security factor called food

wastage derived from the poor preservation and spoilage of fish in the food system (FAO, 2017). In the case of Gamji market, characterised by sourcing of fish from long distances without cold chain, this could result in wastage and food security problems. For those that sourced fish from farms, lack of control of fish diseases on farms and poor bio-security measures, represented an important gap for disease control. Even though, farmers interviewed reported use of antibiotics for both prophylactic and therapeutic measures, this practice similarly is a potential public health hazards due to issues of antibiotic residues in fish tissues as well as problems of antibiotic resistance in human isolates (Cabello *et al*., 2006; Okocha *et al*., 2018).

Lack of policies targeted at improving market facilities, business transactions and control of food safety risks at farm and market levels is a direct translation of the neglect of agricultural sector by the Nigerian government for long (Weldeghaber *et al.*, 2006). Poor returns from taxation of agricultural livelihoods as well as huge dependence on importation resulted in disregard for agriculture, reduce system efficiency and improve disease hazards (Weldeghaber *et al.,* 2006). Improvement in infrastructure and institutional policies such as standardisation of fish grading systems in all the markets, access to basic physical facilities for hygiene and laws directed towards meat inspection prior to sale would definitely translate into improve efficiency, promote flow of fish to stakeholders while generating market opportunities and improve safety to the populace (Bello-Schünemann and Porter, 2017). Various value chain actors in forms of associations could draw government attention to improve infrastructural and institutional policy development in the sector. Besides, interventions aimed at formulation of policies towards that stimulates economic growth, safety and better preservation of fish and its products through, for instance, improving technology, while sustaining its availability and safety to poor households should be explored (FAO, 2001). The development of the aquaculture sector to complement the out sourcing and

poor catch during dry season, and standardization of street fish vendors regarding technology and safety measures could be realistic in combatting food and nutrition insecurities, only when policies are adopted by the value chain actors. However, nutrition- sensitive interventions in these systems should consider diversification of products and further valuation to 'low class retailers' and low income consumers. The findings in this study regarding mapping of the fish value chains has provided the foundation for research areas towards investigation of pathogen flows along the chain, identification of the hot spots for risk analyses and HACCP and finally understand and estimate the population at risks. Public health policy makers could use this framework to provide food safety control measures or to asses microbial risk exposures in different fish value chains.

The findings from geographical and temporal mappings of the fish value chains provided key information on sources and seasonal effects of fish availability in the system. The results showed how fish is moved from all over the neighbouring states, entire North-western region and southern states to supply markets in Kaduna State. The major cities described in the study were in accordance to previous studies regarding trend of fish farming and water resources (Ita, 1993; AIFP, 2004). There are several influence of different production regions in the country to the supply of fish to various markets in Kaduna State. The type of production systems such as aquaculture and artisanal fishing was shown to have clear contribution and supply to the State (Kudi *et al*., 2008). This shows that any shock in the production of fish in those areas would create a substantial impact in fish availability in the State. Similarly, due to huge dependence on these sources, shocks in a specific market within the State may have significant impact on demand share in the region. Hence, there is need for governments in Nigeria to provide policies that focus efforts on regional fisheries development rather than local development. Furthermore, interventions aiming at improving production and household nutrition in Nigeria should consider the market proximity and seasonal

fluctuations associated with fish supply. Thus, the mapping analysis offers policy makers with the tool to recognise target points and best strategy in times of interventions. For instance, the analysis of temporal mapping for fish supply, showed how the supply contribution from different sources changes by season. Fish farming and fishing were reported to be less practiced during the dry season due to absence of ground water and low level or complete drying of water bodies, respectively. Intervention regarding enhancement of water reservoir or source of water supplies could complement fish availability in dry season. Generally, there is need for Nigerian government to invest in the agricultural value chain to promote, not only availability but food safety and preservation.

Finally, there are several shortcomings of this study that should be put into consideration when interpreting the results. Bulk of the information regarding fish value chain mapping in this study were derived from qualitative data and the estimation of proportions were also obtained through focus group discussion and key informant interviews. Estimations were mainly obtained from key positions and individuals appointed to have good knowledge of the pattern of product flow, and common activities in the value chains such as leaders of the various associations. The number of participants in this study were very few compared to the representative in each chain, due mainly to lack of financial capacity and logistics of the research team. Similarly, most of the quantitative data weren't sampled using random approaches, hence, descriptive analysis used with fairly no representativeness. Another problem encountered during the study was lack of documentation of activities and records of product flow by traders or associated stakeholders as well as lack of information from fishermen at the time of the study, because there activities were offshore and individualistic. Therefore, estimations were based on perceptions and experiences of the stakeholders and the records from participant observations. However, researchers in the study minimized bias by interviewing different categories of people in the chains for effective triangulation of

information and to minimize errors. In addition, information between and within markets were compared with that of other groups to check for validity. Results collected after transcription were presented to various key informants in the system to assess for errors and validation of results. Information regarding production output from various farms were concluded to be incorrect as most producers did not have records during the study time, thus the information was not considered. Lastly, geographical routes were not mapped using ArcGIS due to lack of coordinates in some locations of the study area as well as unavailability of the ArcGIS application by the researcher at the time of manuscript write up.

5.0 Conclusion

The study was able to identify three important components of the fish production and marketing system; the fish suppliers, fish sellers and fish processors. From these, suppliers consisted of the fish farmers, fishermen and the wholesalers to the major markets in the city which operated as a 'fish market value chain'. Two markets (Gamji and Sabon Gari markets) were the chief markets controlling most of the supply. People and product analysis revealed large diversity of product flows, different stakeholders, and importance of each in the supply of fish to the consumers. Retailers solely depended of wholesalers and middlemen for the supply of fish which invariably affect the price and quality of fish at the retailer level. The key structural deficiencies at the market levels included lack of value addition, disorganised system functions, promotion of middlemen activity. Poor infrastructure, lack of toilet facilities, poor use of personal protection equipment, lack of waste management systems and several others, which represent potential disease transmission hazards and limitations to inaccessibility to export market. Results of geographical and temporal analyses provided an understanding of sources of fish supply and their potential impact on regional and local fish markets in the country. This study provides a framework for intervention studies and policies towards improvement of the system efficiency and can be used as a core foundation for

economic analysis and other researches regarding governance, entry barriers, assessment of food safety risks and practices and pathogen transmission. Further quantitative studies is required for further understanding of system's functionality.

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References

Adebayo, E; Polycarp M. and Anyanwu, S., 2016. Analysis of Fish Value Chain in Yola Area of Adamawa State, IIFET 2016 Scotland Conference Proceedings, Challenging New Frontiers in the Global Seafood Sector: Proceedings of the Eighteenth Biennial Conference of the International Institute of Fisheries Economics and Trade, July 11-15, 2016. Compiled by Stefani J. Evers and Ann L. Shriver. International Institute of Fisheries Economics and Trade (IIFET), Corvallis, 2016, https://ir.library.oregonstate.edu/concern/conference_proceedings_or_journals/6h440v49t (accessed on 3 January 2019)

Adedeji, O. H. and Ademiluyi, I. A., 2009. Urban Agriculture and Urban Land use Planning: Need for a synthesis in metropolitan Lagos, Nigeria, J. Geogr. Reg. Plann., 2(3): 043-050

Akanbi, S., Ismaila, M.Y., Akinsanya, D.O., 2016. Value Chain Analysis and the Performance of Small Scale Agri-business: Evidence from Cultured Fish Farmers Kwara State, J. Mark. Dev., 1(2): 85-105

Aklilu, Y., 2002. An audit of the livestock marketing status in Kenya, Ethiopia and Sudan. Volume 2 - Issues and Proposed Measures. Organization of African Unity/Interafrican Bureau for Animal Resources. http://www.eldis.org/fulltext/cape_new/Aklilu_Marketing_vol_1.pdf (accessed 14 February 2019).

Alarcon P., Fèvre E. M., Murungi, M. K., Muinde, P., Akoko, J., Dominguez-Salas, P., Kiambi, S., Ahmed, S., Häsler, B., Rushton, J., 2017. Mapping of beef, sheep and goat food systems in Nairobi—A framework for policy making and the identification of structural vulnerabilities and deficiencies, Agr. Syst., 152:1–17

Aquaculture and Inland fishery project (AIFP), 2004. Inventory of Fish Farms in Nigeria-FAO and Federal Government of Nigeria Joint Project on National Special Programme on Food Security, Pp. 148.

Asiedu, B., Nunoo, F.K.E. and Seidu I., 2017. Prospects and sustainability of aquaculture development in Ghana, West Africa, Cogent Food and Agriculture, 3: 1349531

Bello-Schünemann, J. and Porter, A. (2017). Building the future Infrastructure in Nigeria until 2040, Institute for Security Studies, WEST AFRICA REPORT 21, https://issafrica.s3.amazonaws.com/site/uploads/war-21.pdf (Accessed 2 December 2019)

Belton, B. and Thilsted, S.H., 2014. Fisheries in transition: Food and nutrition security implications for the global South. Glob. Food Sec., 3 (1): 59–66

Béné, C., Neiland, A., Jolley, T., Ovie, S., Sule, O., Ladu, B., Mindjimba, K., Belal, E., Tiotsop, F., Baba, M., Dara, L., Zakara, A., and Quensiere, J., 2003. Inland fisheries, poverty, and rural livelihoods in the Lake Chad basin, J Asian Afr Stud., 38 (1): 17-51, https://doi.org/10.1177/002190960303800102

Brewer, T., 2011. Coral reef fish value chains in Solomon Islands: Market opportunities and market effects on fish stocks. Report to Solomon Islands Government Ministry of Fisheries and Marine Resources in collaboration with the Secretariat of the Pacific Community,https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/58/581b4f2314a4ebc894154e58e4ae5258.pdf?sv=2015-12-11&sr=b&sig=0rB077qHOtAMlbOtw5y7PaIXEP1O1QE6uA9zjzlMI4w%3D&se=2019-10-11T10%3A39%3A47Z&sp=r&rscc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22Brewer_11_FishValue_SolomonIs.pdf%22 (Accessed 14 April 2019)

Cabello, F.C., 2006. Heavy use of prophylactic antibiotics in aquaculture: a growing problem for human and animal health and for the environment, Environ. Microbiol., 8 (7): 1137 – 1144

Chang, C., Zimmermann, A., Heckelei, T., 2016. The Expansion of Aquaculture and Its Effects on Global Land Use and Sustainability, 56th Annual Conference, Bonn, Germany, September 28-30, 244765, German Association of Agricultural Economists (GEWISOLA).

Delia, G., 2015. Food Safety in Low and Middle Income Countries. "Int J Environ Res Public Health, 12(9): 10490–10507.

Edun, O.M., 2013. Safety and Quality Concerns Associated with Fish Production. J Fish Aquat Sci., 8: 21-25.

Ekanem, E.O., 1998. The street food trade in Africa: safety and socio-environmental issues, Food Control 9: 211–215. https://doi.org/10.1016/S0956-7135(97)00085-6

Ekundayo, F.O, Diyaolu, D.O. and Fasakin, E.A., 2014. Composition, Distribution and Antibiotic Sensitivities of Bacteria associated with Cultured *Clarias gariepinus* (Burchell 1822). Malays J Microbiol, 10(2): 72-79.

Eltholth, M., Fornace, K., Grace, D., Rushton, J. and Hasler, B., 2015. Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. Food Policy, 51: 131–143.

Eltholth, M., Fornace, K., Häsler, B. and Rushton, J., 2014. Rapid Integrated Assessment of Nutrition and Health Risks Associated with Tilapia Value Chains in Egypt, For the International Livestock Research Institute, Pp. 1-60

FAO (2001) Production, Accessibility, Marketing and Consumption Patterns of Freshwater Aquaculture Products in Asia: A Cross-Country Comparison, FAO Fisheries Circular No. 973, http://www.fao.org/3/Y2876E/y2876e00.htm#Contents (Accessed 2 December 2019)

FAO, 2011a. A Value Chain Approach to Animal Diseases Risk Management – Technical Foundations and Practical Framework for Field Application. Animal Pro. Rome. http://www.fao.org/docrep/014/i2198e/i2198e00.pdf.

FAO, 2017. Losses in fisheries and aquaculture tackled at Global Fishery Forum, http://www.fao.org/europe/news/detail-news/en/c/1037271/, (Accessed 27 March, 2019)

FAO, 2011b. The Place of Urban and Peri-Urban Agriculture (UPA) in National Food Security Programmes. Rome. http://www.fao.org/docrep/014/i2177e/i2177e00.pdf. (Accessed 27 March 2019)

FAO/OIE/WHO 2006. Antimicrobial Use in Aquaculture and Antimicrobial Resistance, Report of a Joint FAO/OIE/WHO Expert Consultation on Antimicrobial Use in

Aquaculture and Antimicrobial Resistance, Seoul, Republic of Korea, 13–16 June 2006,https://www.who.int/topics/foodborne_diseases/aquaculture_rep_13_16june2006%20.pdf, (Accessed 29 March, 2019)

Food and Agricultural Organization of the United Nations and World Health Organization (FAO/WHO) (2006). Food Safety Risk Analysis: A practical guidelines for national food authorities, FAO Food and Nutrition Paper No. 87, http://www.fao.org/3/a-a0822e.pdf, (Accessed 19 October, 2019)

Federal Department of Fisheries, (FDF). 2008. Fishery Statistics of Nigeria. 4th Edition, Federal Department of Fisheries, Abuja, Nigeria, pp: 49.

Fregene, B., Idogun, J., Bello, M., 2016. Assessment of conflicts activities on livelihood of fishing and fish farming households in Nigeria, PROCEEDINGS ICAS VII Seventh International Conference on Agricultural Statistics I Rome 24-26 October 2016, 310-314, DOI: 10.1481/icasVII.2016.a06c, (Accessed 28 March 2019)

Gereffi, G., Humphrey, J., Sturgeon, T., 2005. The governance of global value chains. Rev. Int. Polit. Econ. 12, 78–104.

Gomna, A., 2006. The role of traditional aquaculture systems and fish in food security and livelihoods of fishing communities in two states in Nigeria, A thesis submitted for the degree of Doctor of Philosophy, Institute of Aquaculture, University of Stirling, Stirling, Scotland, November, 2006.

Gomna, A. and Rana, K., 2007. Inter-household and intra-household patterns of fish and meat consumption in fishing communities in two states in Nigeria. Br. J. Nutr., 97(1), 145 - 152.

Grema, H.A, Kwaga, J., Bello, M., Onimisi, H.U., 2019. Assessment of Food Hygiene Knowledge, Attitudes and Practices of Fish Handlers in Kaduna State, Nigeria, nigeria. Adv. Anim. Vet. Sci. 7(3): 131-137.

Grema, H.A., Geidam Y.A., Gadzama G.B., Ameh J.A. and Suleiman A., 2015a. Multi-drug Resistant Bacteria isolated from fish and fish handlers in Maiduguri, Nigeria. Int. J. Anim. Vet. Adv., 7 (3): 49-54.

Grema, H.A., Geidam, Y.A., Gadzama, G.B., Ameh, J.A. and Suleiman, A., 2015b. Methicillin Resistant Staphylococcus aureus and Methicillin Resistant Coagulase Negative Staphylococci isolated from fish and fish handlers in Maiduguri, Nigeria. AJAFS, 9 (7): 76-81.

HLPE, 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome. http://www.gainhealth.org/wp-content/uploads/2017/09/HLPE-12-Nutrition-and-food-systems.pdf, (Accessed 14 April 2019)

Ibrahim B. U., Baba J., Sheshi M. S., 2014. Isolation and Identification of Bacteria Associated with Fresh and Smoked Fish (Clarias gariepinus) In Minna Metropolis, Niger State. Nigeria. J Appl Environ Microbiol, 2 (3): 81-85

Ilu, I. Y., Frank, A. and Annatte, I., 2016. Review of the Livestock/Meat and Milk Value Chains and Policy influencing them in Nigeria, Olanrewaju B. Smith, Abdou Salla and Berhanu Bedane (Eds), Published by the Food and Agriculture Organization of the United Nations and the Economic Community of West African States, http://www.fao.org/3/a-i5259e.pdf (Accessed 23 February 2019)

International Livestock Research Institute (ILRI), 2011. Fish value chains in Uganda and Egypt: Background proposals for the CGIAR Research Program on Livestock and

Fish,https://cgspace.cgiar.org/bitstream/handle/10568/16958/LivestockFish_FishVCUgaEgypt.pdf?sequence=1 (Accessed 23 February 2019)

Ipinjolu, J. K., Magawata, I. and Shinkafi, B.A., 2014. Potential Impact of Climate Change on Fisheries and Aquaculture in Nigeria. JFAS, 9: 338-344.

Ita, E.O., 1993. Inland Fishery Resources of Nigeria. CIFA Occasional Paper No 20. Rome, FAO. Pp. 120, http://www.fao.org/3/T1230E/T1230E00.htm#TOC, (Accessed 14 April 2019)

Kaplinsky, R. and Morris, M., 2000. A Handbook for Value Chain Research first ed., IDRC. PP 1-89

Kudi, T.M., Bako, F.P. and Atala, T.K., 2008. Economics of Fish Production in Kaduna State. Asian Research Publishing Network (ARPN). J. agric. biol. sci., 3(5-6): 17-21.

Lasisi, M., Popoola, A., Adediji, A., Oluwatola, A., Babalola, K., 2017. City Expansion and Agricultural Land Loss within the Peri-Urban Area of Osun State, Nigeria. 9.

Makokha, S., Witwer, M., Monroy, L., 2013. Analysis of incentives and disincentives for cattle in Kenya. Technical Notes Series. FAO report, Rome.

Manage, P.H., 2018. Heavy use of antibiotics in aquaculture: Emerging human and animal health problems- A review, Sri Lanka J Aqua Sci. 23(1): 13-27

Mwirigi, M. F. and Theuri, F. S., 2019. The challenge of value addition in the seafood value chain along the Kenyan north coast. International Journal of Business and Public Administration, 2(2), 51-56.

National Survey for Agricultural Export Commodity in Nigeria (2005). A project organized by Consultative Committee on Agricultural Export Commodity Statistics (CCAECS),

Sponsored by Central Bank of Nigeria. Pp 19, file:///C:/Users/hp/Downloads/Report%20agricexport-2005-.pdf (Accessed 2 December 2019)

Ndimele, P.E., 2018. The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem, Academic press, https://doi.org/10.1016/C2015-0-05649-0

Nigeria Bureau of Statistics, 2017. Nigeria Gross Domestic Products 2017, quarterly Gross Domestic Product (GDP) estimates for 2016, and the annual figure for 2016 and estimates for the first, second and third quarters of 2017.

Nurudeen, A. A., Lawal, A. O. and Ajayi S. A., 2014. A survey of hygiene and sanitary practices of street food vendors in the Central State of North-western Nigeria. J. Public Health Epidemiol., 6(5):174-181.

Nyenje M. E. and Ndip, R. N., 2013. The challenges of food borne pathogens and antimicrobial chemotherapy: A global perspective. Afr. J. Microbiol. Res., 7(14): 1158-1172.

Odebiyi O.C, George F.O.A, Odulate D.O., Agbonlahor M.U. and Olaoye O.J., 2013. Value-Chain Analysis for Coastal Fisheries Development in Nigeria. GJSFRAV, 13 (11):1-10

Okocha, R.C., Olatoye, I.O. and Adedeji, O.B., 2018. Food safety impacts of antimicrobial use and their residues in aquaculture, Public Health Rev., 39: 21.

Omojokun, J., 2013. Regulation and Enforcement of Legislation on Food Safety in Nigeria, Mycotoxin and Food Safety in Developing Countries, Hussaini Anthony Makun, IntechOpen, DOI: 10.5772/54423. https://www.intechopen.com/books/mycotoxin-

and-food-safety-in-developing-countries/regulation-and-enforcement-of-legislation-on-food-safety-in-nigeria (Accessed 4 March 2019)

Oota, L., 2012. Is Nigeria committed to fish production? https://www.degruyter.com/downloadpdf/j/ats.2016.49.issue-1.../ats-2016-0006.xml, (Accessed 20 October 2012)

Opoko, A. P. and Oluwatayo, A., 2014.Trends in Urbanisation: Implication for Planning and Low-Income Housing Delivery in Lagos, Nigeria, Architecture Research, 4(1A): 15-26

Rabo, P. D., Zarmai, D. U., Jwanya, B. A. and Dikwahal, S. H., 2014. The role of fisheries resources in national development: a review International Letters of Natural Sciences, 18: 20-28

Romero, J., Carmen G.F. and Paola N., 2012. Antibiotics in Aquaculture – Use, Abuse and Alternatives, repositorio.uchile.cl/.../InTech-antibiotics_in_aquaculture_use_abuse_and_alternative... (Accessed 23 March 2019)

Rushton, J., 2009. The Economics of Animal Health and Production. CABI Publishing, Wallingford, UK.

Santos, L., Ramos, M., 2018. Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem, Int J Antimicrob Agents, 52(2):135-143.

Scott, G. J., 1995. Prices, products and people: Analyzing agricultural markets in developing countries, Pomeroy R. S. and Trinidad A. C. (Eds), International potato Center, Lynne Rienner, London, 2 (9): 217-238

Smith, I. R., 1981. The economics of the milkfish fry and fingerling industry of the Philippines. ICLARM Technical reports 1. International Center for Living Aquatic Resources Management, Manila and Aquaculture Department (ICLARM), Southeast Asian Fisheries Development Center, Iloilo, Phillipines.

Suleiman, A., Jackson, E., and Rushton, J. (2018). Perceptions, circumstances and motivators affecting the implementation of contagious bovine pleuropneumonia control programmes in Nigerian Fulani pastoral herds, Preventive Veterinary Medicine, 149: 67–74

Surtida, A. P., 2000. Middlemen: the most maligned players in the fish distribution channel. SEAFDEC Asian Aquaculture, 22 (5):21-26

Udeze, A.O., Sowoolu, G.A., Ezediokpu, M.N., Nwanze, J.C., Onoh, C., Okonko, I.O., 2012. The Effect of Escherichia coli on Catfish (Clarias gariepinus). Report and Opinion, 4(4):36-42

Veliu, A., Gessese, N., Ragasa, C., Okali, C., 2009. Gender Analysis of Aquaculture Value Chain in Northeast Vietnam and Nigeria. World Bank Agriculture and Rural Development Discussion Paper, 44.

Weldeghaber, K., Materne, M., and Philippe, D. (2006). Food security and agricultural development in sub-Saharan Africa: Building a case for more public support, Food and Agriculture Organization of the United Nations. Policy Assistance Series N. 2: (4-5): 38-79

Wendlandt, S., Schwarz, S., and Silley, P., 2013. Methicillin Resistant *Staphylococcus aureus*: A food borne pathogen? Annu Rev Food Sci Technol, 4:117–39.

World Bank Report, 2013. Fish to 2030, Prospects for Fisheries and Aquaculture, Agriculture and Environmental Services Discussion Paper 03 , World Bank Report Number 3177-Glb , http://www.fao.org/3/i3640e/i3640e.pdf, Accessed 30 April, 2019

Worldometers, 2019. http://www.worldometers.info/world-population/nigeria-population/

Table 1: Various focus group discussions (FGDs), key informant interviews (KIIs) and structured questionnaire interviews conducted in this study.

Segments	FGD (participants number)	KII (participants number)
Gaula Market	3 FGD: with fishermen (6); middlemen (4); raw-fish-retailers (10), processed-fish-retailer (10)	2: Leaders of fish sellers association (1),
Sabon Gari Market	4 FGD: with middlemen (5); raw-fish-retailers (8); fish transporter (7); raw-fish-wholesalers (10)	3: Leaders of fish sellers association (1), fish transporter (1), middleman (1)
Gamji Market	5 FGD: with raw-fish-wholesalers (10); raw-fish-retailers (10); fish transporters (4); processed-fish-wholesalers (6); processed-fish-retailers (3)	3: Leaders of fish sellers association (1), fish transporter (1), Middlemen (1), processed-fish-wholesalers (1)
Murtala Square Market	4 FGD: with raw fish wholesalers (5); raw fish retailers (6); fish transporters (4); processed fish vendors (3); Smoked fish retailers (4)	1: Leaders of fish sellers association (1),

Table 2: Demographic analyses of fish farmers and operational characteristics of farms visited in Kaduna State, Nigeria (n=45) using semi-structured questionnaires

Variables	Description	No. of respondents (%)
Role of respondent	Manager	2 (4.4)
	Owner	36 (80)
	Worker	(15.6)
Age	Mean±SD	41±11.24
Years of business experience	Mean±SD	6.4±4.7
Gender	Male	32 (71.1)
	Female	13 (28.9)
Educational level	No formal education	6 (13.3)
	Primary school	1 (2.2)
	Secondary school	14 (31.1)
	Tertiary school	24 (53.3)
Food safety training	Yes	5 (11.1)
	No	40 (88.9)
Type of Production system	Concrete ponds only	15 (33.3)
	Earthen ponds only	26 (57.8)
	Multi culture system	4 (8.9)
What time of the day do you buy fish?	Early morning	32 (56.1)

	Afternoon	10 (17.5)
	Evening	1 (1.8)
Type of fish species cultured	Clariid	44 (97.7)
	Tilapia	1 (2.27)
Type of fertilizer used	Organic	24 (53.3)
	Inorganic	2 (4.4)
	Both	6 (13.3)
	None	13 (53.3)
Sources of water	Ground water	24 (53.3)
	Well water	1 (2.2)
	Bore hole	18 (40)
	Stream/River	2 (4.4)
Product form sold	Live fish	42 (93.3)
	Dead Fresh	0
	Smoked	3 (6.7)

Table 3: Demographic analyses and operational characteristics of raw-fish-sellers in Kaduna State, Nigeria (n=64) using semi-structured questionnaires

Variables	Descriptions	No. of respondents (%)
Gender	Male	64 (100)
	Female	0
Location	Kaduna	43 (67.2)
	Zaria	21 (32.8)
Type of business	Wholesale	8 (12.5)
	Retail	56 (87.5)
Educational level	No formal education	17 (26.6)
	Primary	15 (23.4)
	Secondary	26 (40.6)
	Tertiary	6 (9.4)
Formal Food safety Training	Yes	8 (12.5)
	No	56 (87.5)
Years of business experience	Mean±SD	39.8±10.9
Age of Respondents	Mean±SD	15.3± 9.9

Role of respondent in fish trade	Managers	6 (9.4)
	Owners	50 (78.1)
	Workers	8 (12.5)
Fish forms purchased	Live farmed fish	38 (59.4)
	Fresh wild caught fish	2 (3.1)
	Both wild and farmed fish	24 (37.5)
Factors for choice of fish forms	Availability	8 (12.5)
	Cost	42 (65.6)
	Freshness and quality	14 (21.9)

Table 4: Demographic analyses and operational characteristics of processed-fish-sellers in Kaduna State, Nigeria (n=20) using semi-structured questionnaires

Variables	Description	No. of respondents (%)
Gender	Men	9 (45)
	Women	11 (55)
Educational level	No formal education	3 (15)
	Primary	3 (15)
	Secondary	11 (55)
	Tertiary	3 (15)
Formal food safety training	Yes	1 (5)
	No	19 (95)
Age of respondents (years)	Mean±SD	34.5±8.5
Years of business experience	Mean±SD	8.8±4.5
Role of respondents	Owner	10 (50)
	Worker	10 (50)
Type of fish handled	Cultured fish only	15 (75)
	Wild caught fish only	5 (25)
Fish forms sold	Fried fish	4 (20)
	Smoked fish	9 (45)
	Grilled fish	7 (35)

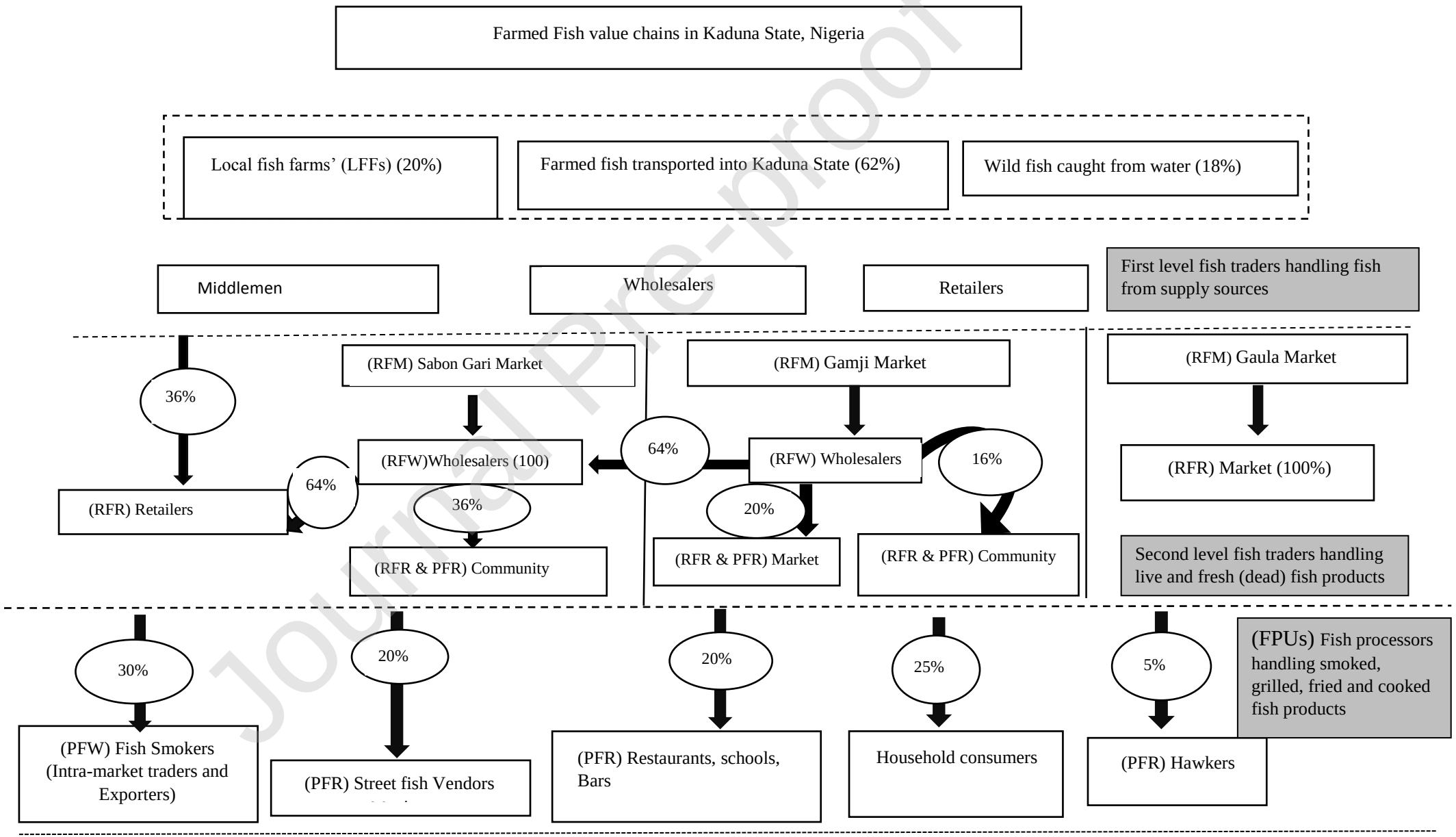

Fig. 1. Contribution of each fish supply component to the Gamji, Sabon Gari and Gaula fish market, and their interactions including percentage supply. Fish were transported into the city from neighbouring towns which contributes over 60% of supply to the markets, and the 50% of the fish ends with the wholesalers within the market. Almost all fish supply from neighbouring states ends with the wholesalers, which were distributed to fish retailers within the markets, other markets and communities. Abbreviations: RFM-Raw Fish Market; FPU-Fish Processing Units; LFF-Local Fish Farms; RFW-Raw Fish Wholesalers, RFR-Raw Fish Retailers; PFR-Processed Fish Retailers; PFW-Processed Fish Wholesalers.

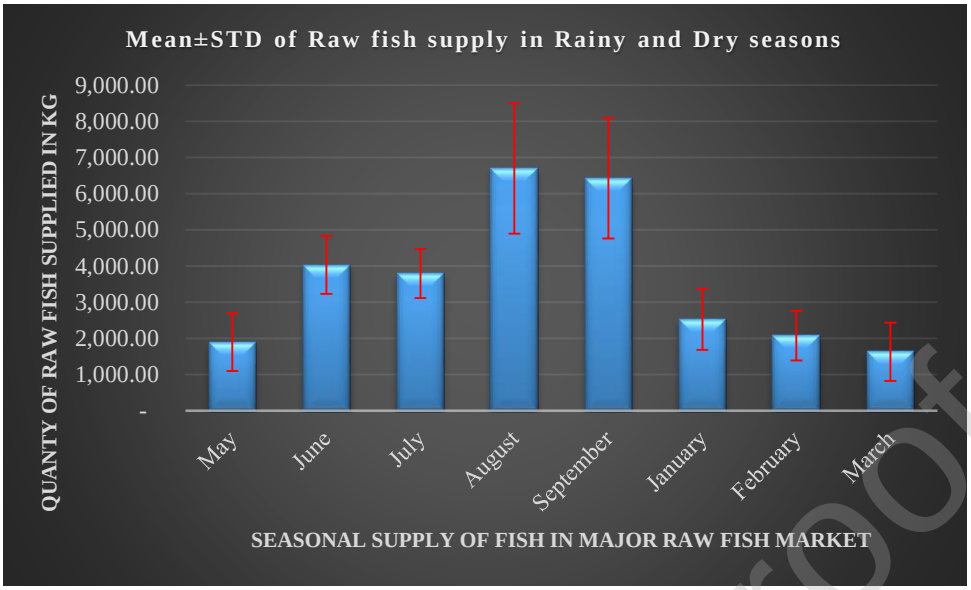

Figure 2: Seasonal trend of raw fish supply in major fish market (Gamji market) in in North-western Nigeria showing the mean± Standard deviation of supply at the peaks of rainy (June, July, August and September) and dry seasons (January-May).

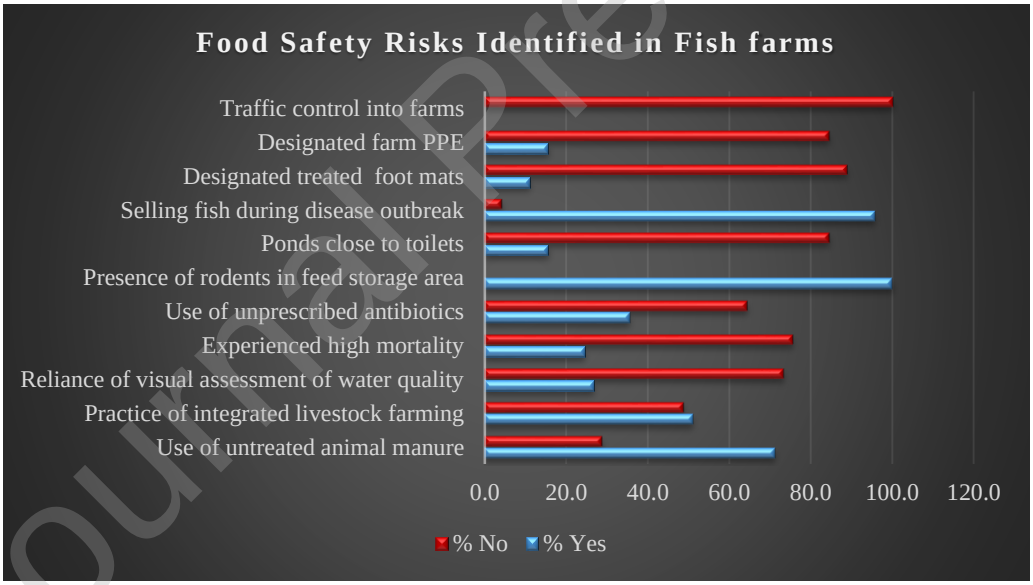

Figure 3: Researcher observation checklist results on fish farm biosecurity measures, personnel and equipment hygiene.

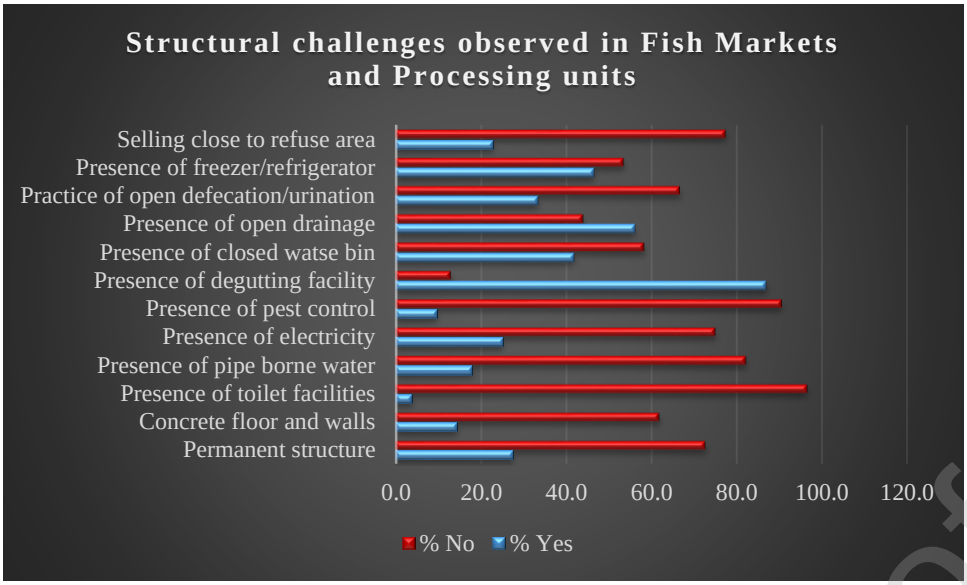

Figure 4: Checklist results for Structural challenges identified in raw-fish- market and fish processing units visited in Kaduna State, Nigeria

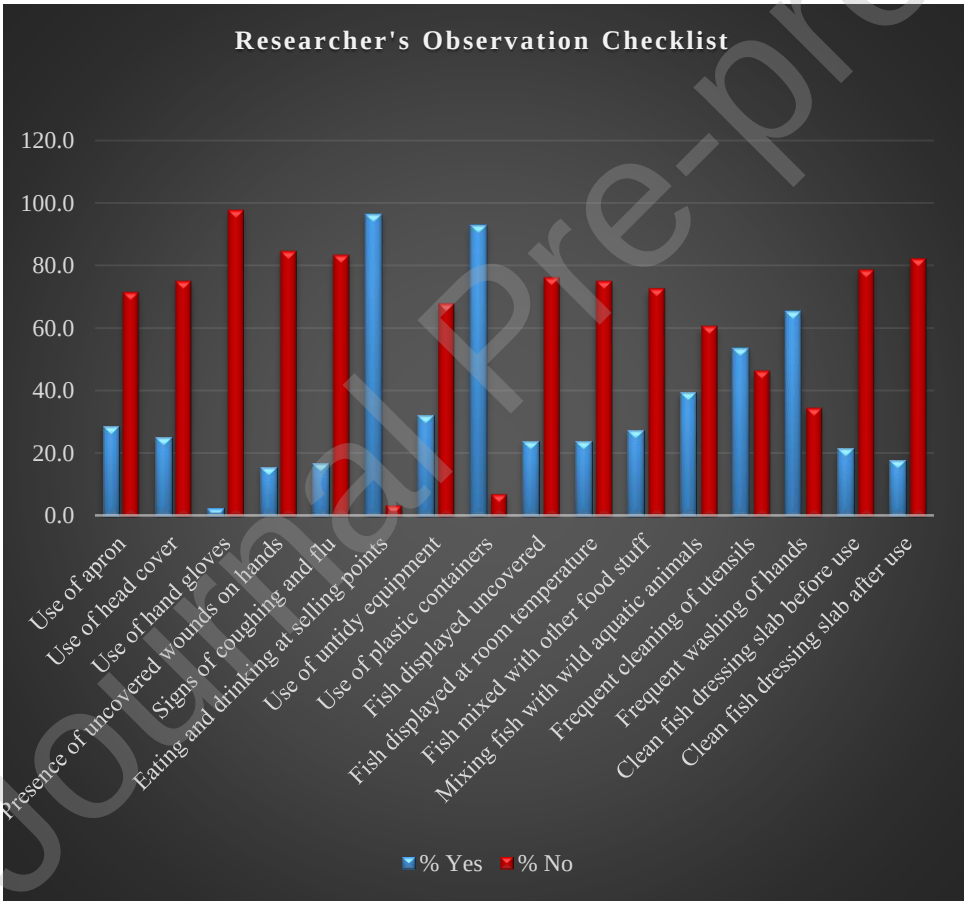

Figure 5: Checklist results for identified food safety risks at raw-fish market sites and fish processing units visited in Kaduna State, Nigeria

Appendix

Researcher Observation checklist

Facilities: Record the following for the sale location	**YES**	**NO**
a. Is there a permanent structure?		
b. Is it well ventilated and lightened?		
c. Is there pest control (Screen)?		
d. Is it a pollution prone area (close to industrial/Agricultural facility)?		
e. Is there a source of electricity?		
f. Is there a refrigerator or freezer present?		
g. Does the retailer have access to running water?		
h. Does the retailer have access to a hand-washing area with soap?		
i. Is the flooring and wall material concrete or tile?		
j. Is the area where fish are kept protected from the environment?		
k. Is the area where fish are kept clean (no obvious dirt or flies)?		
l. Are there any rotten fish or food around sale area?		
m. Is there a separate rubbish bin?		
Fish Farm Facilities: Record the sanitary and hygienic practices of the farm		
a. Use of untreated manure		
b. Use of ground water		
c. Practice of integrated livestock farming		
d. Reliance of visual assessment of water quality		
e. Experienced high mortality		
f. Use of not prescribed antibiotics		
g. Presence of rodents in feed storage area		
h. Ponds close to toilets		
i. Use of untreated manure		
j. Presence of dead fish in ponds		
Worker/ retailer conditions: Record the following for people selling the fish		
a. Do workers have clean designated clothing and shoes?		
b. Do workers have uncovered wounds?		
c. Do workers have any visible signs of communicable diseases?		
d. Are latrines present in the area?		

e. Are workers eating or drinking while selling fish?		
Fish marketing conditions: ask to see where the fish are stored and record the following		
a. Are crates or storage equipment clean?		
b. Are plastic storage containers used (not baskets, etc.)?		
c. Is the fish on display?		
d. Is the displayed fish covered?		
d. Is the displayed fish in contact with other food products?		
e. Is the processed fish in refrigerator?		
Slaughter Slab Sanitation	**Yes**	**No**
a. Washing fish after evisceration		
b. Washing hands after evisceration		
c. Cleaning of slaughter slabs		
d. Cleaning of equipment		
Waste Management		
a. Presence of fish tissue left over on slaughter slabs		
b. Presence of waste bin (Covered/uncovered)		
c. Presence of drainage (Covered/uncovered)		