Nigeria fish futures

Aquaculture in Nigeria: Increasing Income, Diversifying Diets and Empowering Women

Report of the scoping study

WorldFish

Funded by

Bill & Melinda Gates foundation

USAID
FROM THE AMERICAN PEOPLE

CGIAR

RESEARCH PROGRAM ON Fish

Led by WorldFish

Nigeria fish futures

Authors

Rohana Subasinghe, Sunil Siriwardena, Kendra Byrd, Chin Yee Chan, Kanar Dizyee, Kelvin Shikuku, Nhuong Tran, Agbabiaka Adegoke, Lydia Adeleke, Kim Anastasiou, Malcolm Beveridge, Jessica Bogard, Long Chu, Bernadette Tosan Fregene, Henrietta Ene-Obong, Kai Ching Cheong, Julius Nukpezah, Olanrevaju Olagunju, Andrea Powell, Joseph Steensma, Gemma Williams, Colin Shelley and Michael Phillips.

Citation

This publication should be cited as: Subasinghe R, Siriwardena SN, Byrd K, Chan CY, Dizyee K, Shikuku K, Tran N, Adegoke A, Adeleke M, Anastasiou K, Beveridge M, Bogard J, Chu L, Fregene BT, Ene-Obong H, Cheong KC, Nukpezah J, Olagunju O, Powell A, Steensma J, Williams G, Shelley C and Phillips M. 2021. Nigeria fish futures. Aquaculture in Nigeria: Increasing Income, Diversifying Diets and Empowering Women. Report of the scoping study. Penang, Malaysia: WorldFish. Program Report: 2021-16.

Acknowledgments

Ahmed Ogunlaja, Abdullahi Muhammad Orire, Abiodun Oritsejemine Cheke, Ajibola Olaniyi, Bolarin Titus Omonona, Brianna Bradley, Gabriel Gana Bake, Govinda Raju, Isaiah Oladipo Opadokun, Oludolapo Abraham, Paul Ibukun-Olu Bolorunduro and Suryaprakash Rao are acknowledged for their contribution to the scoping study and various technical inputs to this document.

This work was undertaken as part of the CGIAR Research Program on Fish Agri-Food Systems (FISH) led by WorldFish. The program is supported by contributors to the CGIAR Trust Fund.

Funding support for this work was provided by the Bill & Melinda Gates Foundation in the framework of the Aquaculture: Increasing Income, Diversifying Diets and Empowering Women in Bangladesh and Nigeria project [ID: OPP1198810] and the USAID-funded Feed the Future Innovation Lab for Fish.

Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: worldfishcenter@cgiar.org

Creative Commons License

Content in this publication is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0), which permits non-commercial use, including reproduction, adaptation and distribution of the publication provided the original work is properly cited.

© 2021 WorldFish.

Photo credits

Front cover, Olaniyi Ajibola/WorldFish; page 8, Sunil Siriwardena/WorldFish; page 18, Rohana Subasinghe/WorldFish; pages 46, 52, Brianna Bradley/WorldFish.

Table of contents

Foreword

It is my great pleasure to write this message introducing this important work, "Nigeria Fish Futures", The comprehensive study comes at an important time as the Nigerian Government looks to develop aquatic food systems to nourish our growing nation and provide economic opportunities while respecting environmental health.

Fish and other aquatic foods are an essential part of sustainable healthy diets in Nigeria. Despite large increases in demand for aquatic foods, Nigeria's per capita consumption of fish is comparatively low in global comparisons. This means there is a significant opportunity to increase the supply and consumption of aquatic foods to better nourish our growing population and achieve food nutrition security. This is why the Nigerian Government is prioritizing the sustainable, inclusive development of our national aquaculture sector.

Current fish supplies in Nigeria do not meet the national demand and we are left with an annual deficit of 2.5 million metric tons of fish, which has been bridged through fish imports. With Nigeria's aquatic food systems' contribution to the gross domestic product having risen from 0.5 percent in 2013 to 4.5 percent currently, the federal government is committed towards improving the aquaculture sub-sector, increasing domestic production of fish to reduce importation of frozen fish into the country. This resource will serve to inform the government, private sector and international development partners to ensure the sustainable and inclusive development of the aquaculture sector to achieve our goal.

The federal government appreciates and value the collaborative work between WorldFish, Bill & Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID), in partnership with the Federal Department of Fisheries and Aquaculture, assessing the contribution of fish and other aquatic foods to the people of Nigeria, identifying the bottlenecks, challenges and opportunities for investment which resulted in this comprehensive knowledge account. We will address the challenges identified and the recommendations provided in this publication as the basis for our new national aquaculture development plan and strategy. We look forward to our continued collaboration and partnership with WorldFish, FBGF and USAID, in this regard.

I thank everyone's contribution towards comprehensive assessment of the role of aquatic foods in Nigerian lives, which lead to producing the "Nigeria Fish Futures".

Dr. Mohammad Mahmood Abubakar
Honourable Minister,
Federal Ministry of Agriculture & Rural Development
Republic of Nigeria

Fish and other aquatic foods offer unmatched potential to nourish Nigeria's growing population. As an essential source of micronutrients and animal protein, the increased availability and consumption of safe, nutritious aquatic foods can improve food and nutrition security, especially among vulnerable populations. Developing sustainable and inclusive aquatic food systems will increase the country's food sovereignty and create economic opportunities for Nigerians while respecting the natural environment. A thriving aquaculture sector promises to complement marine and inland fisheries to achieve multiple wins across the sustainable development agenda.

This report explores the emerging aquaculture industry through a culmination of surveys, studies and analyses carried out by a team of researchers from WorldFish, the Fish Innovation Lab of the United States Agency for International Development (FIL-USAID) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), in partnership with the Federal Department of Fisheries and Aquaculture of the Government of Nigeria. Primary financial support for this work was provided by the Bill & Melinda Gates Foundation, with assistance from the CGIAR Research Program on Fish Agri-Food Systems (FISH CRP) and FIL-USAID.

This seminal work builds a knowledge base on the opportunities and challenges to building a thriving and prosperous aquaculture sector that works for all people and the planet. A significant investment in skills, knowledge and inputs is needed for the growing sector to endure lasting success. This resource identifies research, policy and investment actions to guide sustainable and inclusive growth. Public and private stakeholders and international development funders can use this evidence base when developing initiatives in the sector that ensure commitments to the UN Sustainable Development Goals.

WorldFish's 2030 Research and Innovation Strategy, Aquatic Foods for Healthy People and Planet, is positioned to support the Nigerian government's goals to make aquatic foods a central part of a food systems transformation toward sustainable healthy diets for all. WorldFish looks forward to furthering its partnerships with the Nigerian government, entrepreneurs and the private sector, NGOs, and educational and research organizations to develop aquaculture and fisheries that are climate-resilient and environmentally sustainable while ensuring social and economic inclusion as well as nutrition and public health of all Nigerians.

I recommend this publication to you and to share it with your colleagues and affiliates.

Gareth Johnstone, Ph.D.
WorldFish Director General
CGIAR Senior Director of Aquatic Food Systems

Preface

Nigeria is the second-largest aquaculture producer in Africa, with a high demand and preference for fish among consumers. However, the role and potential of aquaculture to achieve goals for improving smallholder income, dietary diversification and women's empowerment have yet to be realized. In partnership with the Bill & Melinda Gates Foundation (BMGF), WorldFish launched a comprehensive study in January 2019 to fill critical knowledge gaps and provide an evidence base to inform future investment decisions that would facilitate inclusive growth of the sector. The 18-month study focused on identifying aquaculture sector bottlenecks for inclusive growth, based on fish production, consumption and value chain models that have high potential to positively impact smallholder income, nutrition, youth employment and women's empowerment at scale.

This document provides an analysis of the data and information gathered during the WorldFish/BMGF 2019 scoping study of the Nigerian aquaculture sector, outlining the evidence-based opportunities toward increasing the contribution of fish to people in Nigeria, especially the rural poor and smallholders, in the coming decades. Results of the four field surveys conducted during the scoping study are separately detailed in the following publications:

Byrd KA, Ene-Obong H, Tran N, Dizyee K, Chan CY, Shikuku KM, Steensma J, Nukpezah J, Subasinghe R and Siriwardena SN. 2021. Fish consumption patterns and diets of rural and urban Nigerians. Working Paper. Penang, Malaysia: WorldFish. (in press).

Chan CY, Chu L, Cheong KC, Tran N, Olagunju O and Phillips, MJ. 2021. Future fish supply demand and market trends in Nigeria. Working Paper. Penang, Malaysia: WorldFish. (in press).

Chan CY, Chu L, Tran N, Cheong KC, Shikuku KM, Olagunju O, Byrd K, Dizyee K, Subasinghe R and Siriwardena S. Foresight scenarios on policy implications in Nigerian fish food systems. (in preparation for submission to *Food Security*).

Dizyee K, Williams G, Anastasiou K, Powell A, Shikuku KM, Tran N, Byrd K, Chan CY, Bogard J, Steensma J, Nukpezah JA, Adegoke AL, Subasinghe R and Siriwardena SN. 2021. Performance analysis of existing catfish and tilapia value chains and market systems in Nigeria: Post-farmgate value chain scoping study. Working Paper. Penang, Malaysia: WorldFish. (in press).

Tran N, Shikuku KM, Cheong KC, Chan CY, Nukpezah JA, Siriwardena SN and Subasinghe R. 2021. A performance assessment of aquaculture production systems in Nigeria. Working Paper. Penang, Malaysia: WorldFish. (in press).

It is important to indicate, from the outset, that the current COVID-19 pandemic is affecting the global economy, and its impacts on private sector-led business and smallholder productivity and income will remain a question for some time (Belton et al. 2021; Liverpool-Tasie et al. 2021; Love et al. 2021). Considering the Nigerian economy will continue to grow, as anticipated before the COVID-19 pandemic, albeit at a slower rate (World Bank 2019 and 2020), new government policy interventions and improvements to national agricultural productivity will be needed more than ever to nourish the increasing population.

List of abbreviations

ABP	Anchor Borrowers' Programme
ADP	agriculture development program
APP	Agriculture Promotion Policy
BAU	business as usual
BMGF	Bill & Melinda Gates Foundation
CBN	Central Bank of Nigeria
FAO	Food and Agriculture Organization of the United Nations
FCR	feed conversion ratio
FDAE	Federal Department of Agricultural Extension
FDFA	Federal Department of Fisheries and Aquaculture
FMARD	Federal Ministry of Agriculture and Rural Development
FGD	focus group discussion
FISON	Fisheries Society of Nigeria
FTE	full time equivalent
GEF	Graduate Entrepreneurship Fund
GNI	gross national income
KII	key informant interview
NAERLS	National Agricultural Extension and Research Liaison Services
NADP	national aquaculture development plan
NIFFR	National Institute for Freshwater Fisheries Research
NWRP	National Water Resources Policy
NIOMR	Nigeria Institute of Oceanography and Marine Research
NAQS	Nigerian Agricultural Quarantine Service
PFRS	Policy Framework and Reform Strategy
PPP	public-private partnership
SME	small or medium-sized enterprise
WIA	Women in Agriculture

Summary

Recognizing the present and potential importance of fish to the people of Nigeria, WorldFish, partners and stakeholders carried out a series of value chain studies and reviews to better understand the country's fish food system and assess the potential for fisheries and aquaculture to improve food and nutrition security, youth employment, and livelihoods and income (WorldFish 2018). A subsequent field-based study set out to address knowledge gaps with regard to fish consumption and production technologies. It identified high potential aquaculture value chains for future interventions and investments to address barriers to increasing the contribution of fish for sustainable and equitable social and economic empowerment of the people, especially poor smallholders, women, youths and children. A set of concepts for developing business investment strategies for achieving those recommendations was produced (WorldFish 2021).

WorldFish Foresight Model projections indicate that the fish supply-demand gap in Nigeria will widen over the coming decades. Fish supplies from marine capture fisheries will remain stable, so future growth in fish supplies will have to come from aquaculture, artisanal fisheries and imports. The annual rate of growth of aquaculture is expected to decrease from 11 percent (2010–2015) to 7 percent (2015–2025) and then to 5 percent (2025–2035) and to 2 percent (2035–2050). Fish imports can play an important role in bridging the fish supply-demand gap. Average annual per capita fish consumption would increase from 11.2 kg in 2015 to 14.8 kg in 2050. This is more optimistic than the World Bank's projection that fish consumption in sub-Saharan Africa will decline at an annual rate of 1 percent to 5.6 kg from 2010 to 2030. However, it does accord with projections in some sub-Saharan African scenarios found in other studies, such as Bjorndal and Tusvik (2020).

Fish imports currently cost the Nigerian government USD 1 billion a year of valuable foreign exchange. Pursuing a strategy to control fish imports while increasing fish supplies through facilitating inclusive aquaculture growth and increasing inland artisanal catch is far more likely to meet future fish supply-demand gap and improve the national economic outlook.

Nigerian aquaculture, at all levels along the value chain, is profitable. Smallholders practice fish farming for profit. Smallholder catfish farmers have higher per hectare net incomes than agriculture farmers. Our studies indicate that smallholder fish farming could be promoted as primary employment, while catfish farming could increase household income by 26 percent, if practiced as secondary employment.

However, sustainable and profitable business requires investment, inputs and knowledge. Availability and accessibility to better farming practices and inputs are inadequate and, in some instances (e.g. quality seed and feed), largely unavailable. Increasing smallholder access to finance, quality inputs, technical services and modern technology will improve productivity and incomes.

Aquaculture production (pre-farmgate value chain) is male dominated. Eighty-five percent of the survey respondents were male, 66 percent of whom had attained tertiary education. Eighty percent of survey respondents owned their farm. This indicates that smallholder aquaculture is a an attractive but knowledge-intensive business.

Because Nigerian fish value chains, in general, are economically viable and inclusive of women and youths, especially in post-harvest activities, investment to enhance fish value chains is likely to both empower and confer additional economic benefit to all value chain actors and the wider economy, as well as bringing nutritional benefits to households, including those during the first 1000 days of life. However, greater awareness of the importance of fish in the nutrition of children and pregnant women is needed. Increasing access to nutrient-rich fish and fish products presents investment opportunities. Promoting the use of products such as fish powder would improve access to fish among young children. There are also

opportunities to improve transportation and distribution of fish. Unmet market demand, especially in the dry, rural north, offers investment potential to improve transportation and develop cold chains that extend fish availability and access to households far from production sites.

Strategies are required to involve more women in both pre-harvest and post-harvest value chains and to empower those women already employed in the fish value chains through improved access to capital, technical, entrepreneurial and financial management skills.

Nigerian aquaculture is still technologically immature and based on two species: tilapia and catfish. Almost all catfish production originates from smallholder farming; by contrast, there is little or no tilapia production among smallholders. Farm production of tilapia and catfish alone is unlikely to be sufficient to bridge the demand-supply gap for fish or satisfy consumer demand for aquatic food over the coming decade. As a result, it is vital to explore opportunities for species diversification in Nigerian aquaculture with indigenous and/or introduced species. Although smallholder catfish farming is profitable, greenhouse gas emissions and environmental sustainability of tilapia farming appears to be better than that of catfish. More than 60 percent of farmers surveyed were interested in growing tilapia. Smallholder tilapia production could be increased by increasing availability and access to quality seed and affordable quality feed.

There is little or no scientific broodstock management and no genetic improvement programs in Nigeria. There are insufficient operational hatcheries and multiplication centers to supply the demand for quality seed, especially of tilapia. A genetic improvement and broodstock management program that increases the supply of quality seed is essential to expand smallholder-based tilapia farming. The bulk of catfish seed originates from small- to medium-scale hatcheries, and the genetic quality of the bulk of catfish seed currently produced is assessed by farmers as poor and performance sub-optimal.

Locally produced and imported fish feed is available. The bulk of the catfish feed is locally produced by small- to medium-scale producers. The quality of imported or commercially produced feed is superior but costlier than that produced by cooperatives and small- to medium-scale producers. Little or no tilapia feed is produced by cooperatives and small-to-medium scale producers. The lack of affordable feed also constrains smallholders from entering tilapia farming. Most commercial feed manufacturers do not operate at optimal production capacity due to a lack of demand for their products, a result of the devaluation of the Naira in 2015, when such feeds, dependent on imported feedstuffs, became unaffordable. Even if demand for commercial feed supplies increases, it is likely to be from larger, commercial farms. Use of food-grade fish, especially nutrient-rich freshwater and marine pelagic fish, as a fishmeal replacement must be stopped, as it represents an affordable, nutritious food for rural and urban poor.

Ninety-two percent of households in the nine survey states had consumed fish during the previous week, a clear indication of the affinity of Nigerian people for fish. Despite this, average per capita fish consumption in Nigeria is about half the global average. Cultured fish (catfish and tilapia) were consumed relatively more frequently in the north. However, access to fresh fish from inland capture fisheries in the north is more limited, and the diversity of fish consumed there is lower than in southern states. Interventions to increase availability and accessibility of fish for the rural poor and vulnerable must pay attention to communities in the northern states of Nigeria.

Fish plays an important role in the diets of women and children (and households) in Nigeria. Nevertheless, access to fish by children in rural poor households should be improved. Incorporating more fish and fish-based products into school feeding programs—especially via linking aquaculture to school meals—should be considered. To implement a fish-based nutrition approach to improve health and welfare, it is necessary to increase both fish consumption and diet diversity. The dietary diversity score among children and women in Nigeria is high. Many women and children reported consuming fish, the most frequently consumed animal-source food, in the preceding 24 hours. Fish supplies therefore must be protected, maintained and increased at a pace that matches increases in population.

Sun-drying small pelagic fish, ensuring their availability in local and remote markets and that they are consumed whole, is the most high-yielding, eco-friendly, low carbon-emission and nourishing way of using the high productive potential of inland waters. However, a range of social, technical, economic, legal and policy barriers inhibit the full potential of using small fish to improve nutrition in Nigeria. These include a lack of enabling fisheries management and legislation and food safety challenges in fish processing and marketing.

Although our survey was conducted outside the harvest season, 3 percent of fish reported in northern state households and 4 percent in southern state households were clupeids, consumed in fresh, fried and dried form. Like bonga (shad), clupeids in Nigeria could play an important role in ensuring food and nutrition security if supplies could be improved through better inland fisheries management. Stock enhancement should be considered. Dried crayfish is a staple aquatic food product in southern states and wealthier households but is not accessed by northern households. Given that it is a nutrient-dense, shelf-stable and readily transportable product, promotion in northern states should be explored.

Behavioral change interventions may be needed to increase awareness of the nutritional quality of fish and consumption. Rural households, particularly in the north, do not consume adequate quantities of fish, and some family members (likely women and children) might not receive an appropriate share in their diets. Fish supplies should be increased and supply chains aligned to make fish affordable and accessible to the rural poor, with special emphasis on northern states. Designing and implementing social and behavior change communication programs, including fish recipes, encouraging caregivers to begin feeding fish in small quantities or in powdered form, beginning at 6 months of age, would improve fish consumption during the first 1000 days window. A digital data portal could be developed to collect, collate and disseminate market and price data/information.

Health management and disease control in Nigerian aquaculture, especially among smallholders and small- to medium-scale farming practices, is minimal. Disease-related production losses are widely reported, but economic impacts are unknown. Aquatic animal health management capacity within the national veterinary system is minimal. Limited private sector engagement in aquaculture health management needs improvement and strengthening. It is important to assess national aquatic animal health management capacity and embark on a technology and capacity development program.

Information and access to technical knowledge on efficient production, processing and marketing is lacking. Information and data on pricing and marketing does not exist. Awareness on the importance of fish in diet and nutrition is inadequate, so an organized awareness program, especially addressing first 1000 days in the states where consumption is low, should be considered.

Although gaps exist, current government policy toward aquaculture development is comprehensive and in alignment with economic priorities. However, transaction costs are high and policy implementation is poor. Considering the current and projected demography, behavior and global economics, some policy reform is necessary. Increased communication, discussion and engagement with policymakers are recommended.

The national aquaculture strategy is comprehensive and broadly sufficient to stimulate aquaculture growth in the country. However, implementation issues, including technical assistance, the high cost of inputs and services, difficulties in accessing capital investment and finance, are major challenges, especially for smallholders to continue/expand their operations and/or engage in aquaculture business. Policies on land rights for agriculture/aquaculture are unclear, and land rights are not clearly defined. About 95 percent of agricultural land is not titled, effectively nullifying their capacity use as collateral for financial transactions. Clear policies to access land and land rights for aquaculture are needed to enable farmers to access finance. Government run extension services for the aquaculture sector suffer from inadequate financial resources for mobility and equipment. Partnerships between government and the private sector (feed manufacturers and hatcheries) might be able to provide a more effective extension system.

Although our study suggests that the organizational arrangements at both federal and state levels for fisheries and aquaculture sector are adequate, services rendered to the aquaculture sector, especially to smallholders along the value chain (production and processing), are inadequate to stimulate sector growth. While current economic policy is meant to assist smallholders, it is not conducive to smallholder development. High interest rates, bureaucratic and stringent loan procedures and high collaterals bar smallholder access to finance. Development partners and the private sector can encourage policymakers to improve the situation for the aquatic food sector.

Roadside fish seller, Nigeria.

Introduction[1]

Nigeria has one of the most dynamic economies in Africa. It is also going through a demographic revolution. By 2023, and by a considerable margin, it is poised to become sub-Saharan Africa's largest economy in GDP terms (Frontier Strategy Group 2018). Nigeria accounts for a significant share of regional government revenues and spending and will remain a major oil exporter. By 2050, it will be the third-most populous country in the world.

Pre-COVID-19, the Nigerian economy was expected to grow 60 percent over a 5-year period to reach USD 599.3 billion by 2023 (Frontier Strategy Group 2018). Nigeria was also expected to continue to have higher rates of poverty and income inequality, weaker governance, more difficult private sector operating conditions and a smaller public spending budget than economies of comparable size in other parts of the world (Frontier Strategy Group 2018). These demographic and economic changes place tremendous pressures on natural resources and the food systems. Understanding the implications of these trends on food and nutrition security in the country is important and timely.

Malnutrition remains a major public health and development concern: 49 percent of children under 5 years of age are either stunted, wasted or overweight. This is partly because 34 percent of children between 6 months and 2 years old are fed food that is not rich and diversified enough to ensure optimal growth (CGD Nigeria 2018). Rates of overweight and obesity among children and youths are rising, and the market-based economy and economic development are shifting consumption patterns away from healthy diets (Toriola et al. 2017).

Although Nigeria is one of the largest oil producers in the world, agriculture remains the foundation of the economy, providing the main source of livelihood for most Nigerians. The sector faces many challenges that constrain agricultural productivity (average of 1.2 t of cereals/ha), with high post-harvest losses and waste (FAO 2016). Livestock is an important component of Nigerian agriculture. However, domestic production of livestock products, except for eggs, is far below demand, resulting in large imports of livestock and livestock products. The livestock sector has the potential to create new opportunities for farmers and provide more affordable and healthier diets for future generations (FAO 2016).

Fisheries and aquaculture make up 3–4 percent of Nigeria's annual GDP. The sector is also a key contributor to fulfilling the population's nutritional requirements, accounting for about 50 percent of the supply of animal-source food, and it is an important source of essential dietary nutrients. In addition, fisheries, aquaculture and associated value chains generate employment and income for a significant number of fishers, fish farmers and fish traders. Yet despite the potential for fish production through aquaculture, artisanal and inland fisheries, domestic fish production still falls far below demand. As a result, the country imports half of the fish it consumes. To reduce the level of fish imports and decrease the drain on foreign exchange, the Government of Nigeria has selected aquaculture as one of the priority food value chains targeted for expansion and development (The Guardian 2019).

Initial assessment (2017)

Recognizing the present and potential importance of fish to the people of Nigeria, WorldFish partnered with a range of stakeholders in 2017, including state agencies, civil society, communities and the private sector to conduct a preliminary scoping study, which included a value chain analysis and reviews. The purpose of the study was to better understand the country's fish food system and the potential for fisheries and aquaculture to improve food and nutrition security, youth employment and the livelihoods and income of the poor (WorldFish 2018). Preliminary studies identified a strong market demand for fish and opportunities to increase fish supplies from aquaculture.

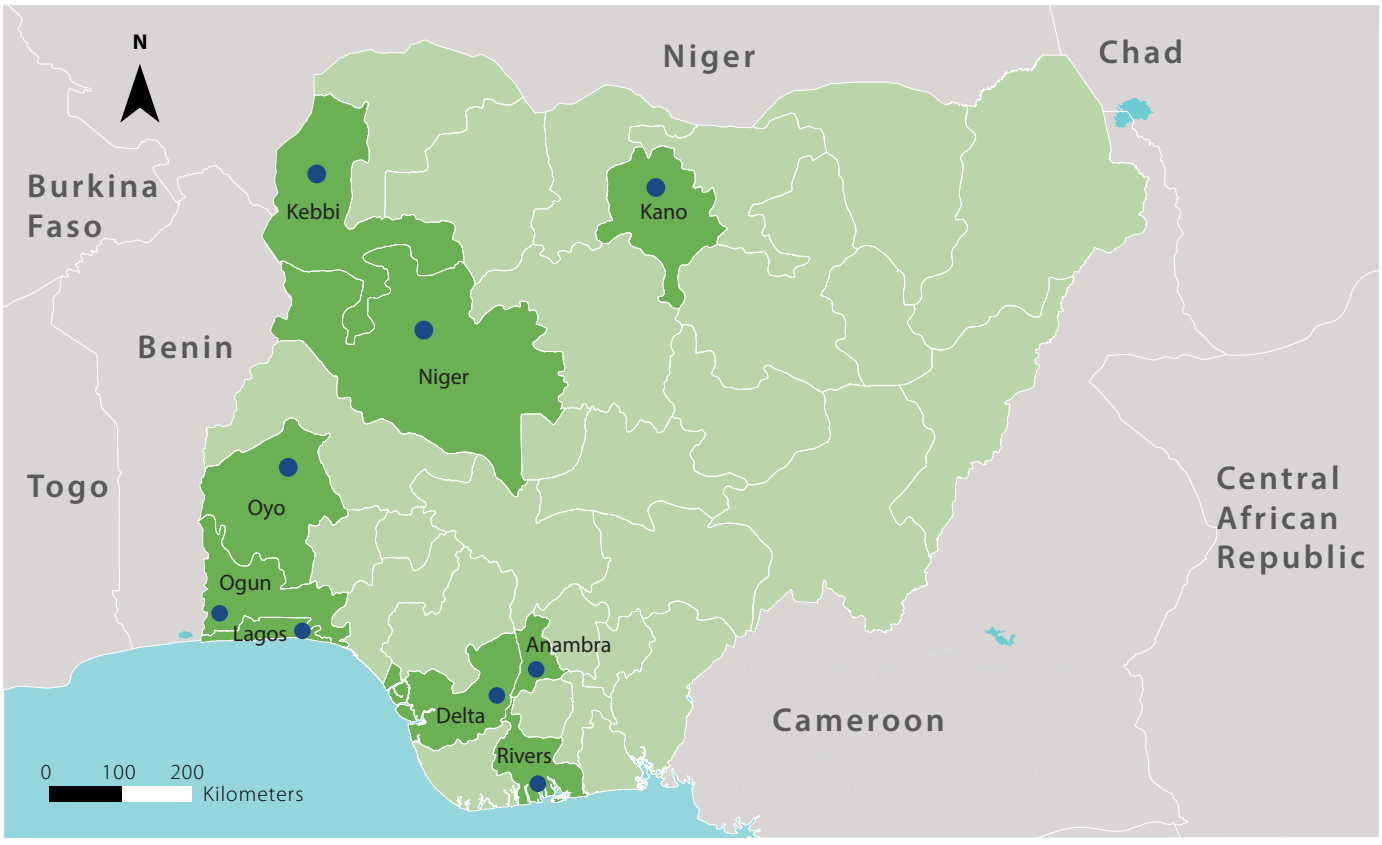
However, the study also revealed a lack of robust data and analysis on many aspects of fish within Nigerian food systems related to the following:

- fish production and productivity
- inputs and services
- processing, marketing and consumption
- gender and policy
- fish value chain efficiencies, including gender- and age-disaggregated data on value chain actors
- future fish market trends
- household fish consumption data
- the roles of women in aquaculture and fish trade
- the nutritional contribution of fish to rural diets.

It is essential to bridge knowledge gaps in order to provide private and public sector investment guidance and to identify opportunities and policy direction to increase the contribution of aquaculture and fish to rural development, in line with government policies.

WorldFish/BMGF scoping study (2019)

A scoping study was designed to plug key gaps in the aquaculture knowledge base to help identify high potential aquaculture value chains and guide future interventions and investments. These would harness opportunities and remove barriers and bottlenecks for increasing the contribution of fish to sustainable and equitable social and economic empowerment of the people, especially poor smallholders, women and children. A detailed study protocol is given in Annex 1 (Nigeria Scoping Protocol). While literature reviews and desk studies covered all of Nigeria, methods such as the field research, surveys, focus group discussions (FGDs), value chain assessments and key informant interviews (KIIs) focused on eight states (Figure 1). Household surveys targeting fish consumption and diet were conducted in nine states, including those eight states where the other surveys were conducted, following the criteria provided in the Nigeria scoping protocol (Annex 1).



Source: WorldFish/BMGF study 2019.

Figure 1. Survey geographies, including the nine study states (Kebbi, Niger, Kano, Oyo, Ogun, Lagos, Delta, Anambra and Rivers).

1. Nigeria 2020[2]

The Federal Republic of Nigeria is a lower middle-income West African country with a coastline along the Atlantic Ocean that forms the country's southern border. It has a total surface area of 923,768 km^2 and is comprised of 36 states and its Federal Capital Territory, Abuja. It shares land borders with the Republic of Niger to the north, the Republic of Benin to the west, and Chad and Cameroon to the east, while its southern coast lies on the Gulf of Guinea in the Atlantic Ocean. With a population of 209 million and a high fertility rate of 5.38 children per woman, it is estimated that Nigeria's population will reach 394 million by 2045, nearly a 90 percent increase (NBS 2018). By 2050, at 2.6 percent annual population growth, Nigeria's population is expected to reach 440 million, which will make it the third-most populous country in the world, after India and China (United Nations 2019). A scarcity of resources and land in rural areas has resulted in Nigeria having one of the highest urban growth rates in the world, at 4.1 percent (USAID 2018).

1.1. Economy

Nigeria has an abundance of natural resources, including extensive oil reserves and the largest natural gas reserves on the continent. Despite being Africa's biggest oil exporter, only 10% of Nigeria's GDP comes from oil (World Bank 2020), while over 70 percent comes from services, agriculture and industry (NBS 2018). Before the 2016 recession, Nigeria had the biggest economy in sub-Saharan Africa.

Although Nigeria is positioned to be a leading economy in the world (World Bank 2017), poverty has remained significant, with increasing inequity and regional disparities. Forty percent of the population, or almost 83 million people, live below the country's poverty line of NGN 137,430 (USD 381.75) per year (NBS 2020). Over 60 percent of the population is under 25 years old and over 40 percent is under 15 years old. Nigeria's young population faces challenging economic circumstances. According to the most recent (2018) demographic and health survey, the lifetime risk of maternal death related to pregnancy or childbearing is 1 in 30 women; one in every 15 Nigerian children will die before reaching 1 year old, and 1 in every 8 will not survive to their fifth birthday (NFC Nigeria and ICF International 2019). Nigeria currently ranks 160 out of 166 countries with regard to progress toward meeting the UN Sustainable Development Goals (Sachs et al. 2020).

The pandemic, which hit Nigeria in early 2020, has exacerbated poverty and inequality. The country's economy contracted and entered its worst recession in four decades (World Bank 2020). Five million more Nigerians now live in poverty, relative to the pre-COVID-19 economic forecast (World Bank 2020). The growth outlook remains highly uncertain, as it depends on how the world economy and oil prices recover. Policy areas essential to mitigating the impacts of COVID-19 in Nigeria and promote economic recovery must aim to

- contain the COVID-19 outbreak;
- enhance macroeconomic management to boost investor confidence;
- safeguard and mobilize revenues;
- reprioritize public spending to protect critical development expenditures;
- support economic activity and provide relief for poor and vulnerable communities (World Bank 2020).

There are many inherent differences between the north and south of Nigeria, not least a significant poverty gap between the two regions (NBS 2020). The challenge for policymakers is to increase federal allocations and infrastructure funding to the north to attract the necessary flow of foreign investments without raising the poverty rate in the south (Dapel, Zuhumnan. 2018). The economic impact of recent discoveries of oil in commercial quantities in northern Nigeria will depend on a number of factors, both internal and external, including global oil prices.

1.2. Food system

In 2019, agriculture made up about 22 percent of Nigeria's GDP, while 27 percent came from industry and 50 percent from the services sector

(World Bank 2019[3]). The agriculture sector employs about 70 percent of the labor force, including women and youths, and comprises four subsectors: crops, livestock, forestry, fisheries and aquaculture. Crop production has remained the major driver of the agricultural sector, making up 90 percent of the agricultural GDP, livestock 6.88 percent of the sector, with fishery and forestry at 2 percent and 1 percent respectively (Chatham House 2019). Maize, millet, cassava and rice are some of the major food crops produced in Nigeria, and there are a handful of forest reserves scattered across various parts of the country.

More than 37 percent of Nigeria's total land area is currently arable land, 77 percent of which has the potential to become agricultural land, while 7 percent is forest areas. The country also has a vast expanse of inland freshwater and brackish waters for fishing and aquaculture activities distributed throughout the country, from the coastal region to the arid zone of the Lake Chad Basin. The major rivers, estimated at about 10,812,400 ha, make up about 12 percent of the total surface area of Nigeria, while lakes and reservoirs represent about 1 percent of the total area of Nigeria (Ita et al. 1985).

Nigeria's agriculture sector is projected to grow by a little over 2 percent during 2020–2021 (World Bank 2019), well below the agreed-upon levels in the Malabo Declaration, which aims for a 6 percent growth rate in the agricultural sector (AU-NEPAD 2016). The Nigerian government has several initiatives and policies that relate to food production, safety and accessibility. However, the bulk of the government's historical policy focus has been on increasing the quantity and quality of crop production; only recently have livestock, fish and other products been targeted.

Based on Nigeria's official definition of smallholders, meaning those owning less than 5 ha of land as defined by the Federal Ministry of Agriculture and Rural Development (FMARD) (2016), 88 percent of farmers are considered smallholders. Smallholders produce 99 percent of Nigeria's agricultural output, yet their productivity is constrained by the lack and high cost of labor and agricultural inputs in rural areas, limited access to information, modern agricultural technology and adequate financial services, a land tenure system that prevents the acquisition of new land, and inconsistent support from local government (FMARD 2016). On average, 55 percent of a Nigerian farmer's annual gross income of USD 9,815 is earned from agricultural activities, among which crop production accounts for 49 percent and livestock about 6 percent (Anderson et al. 2017). Consequently, despite their importance for the domestic economy and due to the sector's productivity limitations, more than 72 percent of Nigeria's smallholders live below the poverty line of USD 1.90 per day (Anderson et al. 2017).

1.3. Fisheries and livestock

The fisheries and livestock sectors are integral to the country's agricultural economy, contributing 2.09 percent and 9 percent respectively. They play key roles in socioeconomic development, poverty reduction and nutrition security. Products from livestock and fisheries contribute significantly to the high-quality protein and micronutrient intake among poor rural and urban households. They are also a major capital and collateral reserve for most crop farming households. Cattle, small ruminants (sheep and goats), pigs and poultry dominate livestock production, while catfish and tilapia are the major fish species farmed. Artisanal marine and inland fisheries are a major contributor to fish supplies. Livestock are raised throughout Nigeria in traditional mixed crop-livestock systems; mobile pastoral/agro-pastoral systems are mainly found in the north, where about 90 percent of cattle and 70 percent of sheep and goat populations are kept, while commercial semi-intensive peri-urban poultry and pig production occurs in the south (Chatham House 2019).

The livestock sector in Nigeria has significant social and economic potential. About 60 percent of the ruminant livestock population is in the country's semi-arid zone and mostly managed by pastoralists. Annual per capita meat consumption is 9.2 kg, while that of milk is 8.1 liters (FAO 2019). Except for eggs, domestic production of animal products meets less than half the demand for beef, mutton and goat meat, and less than quarter for milk and pork products (FAO 2016). Livestock industry development is constrained by low productive breeds, inadequate access to feeds and grazing lands, frequent farmer–pastoralist conflicts, lack of processing facilities and low technical inputs into the management of the animals, including diseases (FAO 2016 and 2019).

2. Fish in Nigerian lives

Fish is a nutrient-dense, affordable, available and much appreciated animal-source food commonly consumed across all income strata in Nigeria. On average, fish accounts for about 50 percent of total protein intake in Nigeria (NBS Nigeria 2018). Nigeria's aquaculture industry is active in almost all regions; however, there are hubs of activity in the South West, South South, South East and the North Central geopolitical zones.

2.1. Supply and demand

Fish supplies in Nigeria originate from both local production and imports. Local production derives from three main sectors: (1) artisanal fisheries from coastal and brackish waters and inland lakes, dams and rivers, (2) aquaculture and (3) industrial marine fishing. In 2018, total fish production (capture + culture) in Nigeria was 1.17 million metric tons, up from 1.04 million metric tons in 2016, largely due to artisanal fisheries (FAO website). It is widely believed that the current potential of artisanal fisheries in freshwater reservoirs, dams and lakes has not been realized. By contrast, catches from marine trawling and industrial fishing have declined in recent years, possibly due to overfishing.

More than 70 percent of Nigeria's total domestic fish supply originates from artisanal small-scale fishers from coastal areas (Figure 2), creeks and lagoons, inland rivers and lakes of the Niger Delta. Nigeria is a net importer of fishery products, with an average annual trade deficit (2014–2018) of USD 970 million. Fishing is a significant source of livelihood. In 2016, 653,000 people were reported as engaged in inland fisheries (FAO website), an estimated 21 percent of whom are women (Nigerian Fisheries Statistics 2015).

FAO figures indicate a reduction in aquaculture production between 2016 and 2018 (Table 1). One possible explanation is the cost of feed.[4] Prior to the devaluation of the Naira in 2014, a 15 kg bag of both locally produced and imported catfish feed sold for NGN 6,000. Thereafter, the same products cost NGN 6500 for locally produced and NGN 11,000 for imported feed (PIND 2018). Consequently, many smallholders and cooperative farmers who used high quality imported and/or high-quality corporate feeds reportedly switched to inferior cooperative and smallholder feeds, resulting in a decrease in aquaculture productivity and production.

Nigeria imports about 45 percent of its net domestic fish supply (Table 1).[5] Imported fish include pelagic fish—mackerel, horse mackerel, hake, herring, blue-whiting, stockfish (dried cod)—and stockfish heads from various exporting countries, such as Japan, Holland, Denmark, Norway and China. Due to the high foreign exchange expenditure on fish imports, Nigeria initiated measures (quotas and tariffs) to control the escalating foreign exchange demand for fish imports into Nigeria, starting in 2013. Despite restrictions, the volume of fish imports has continued to increase (Table 1). If the government does not make a concerted effort to improve domestic fish production, fish imports will continue to fill in the gap between domestic supply and demand, draining significant amounts of foreign exchange.

2.2. Consumption, diet and nutrition[6]

Nigeria is a fish-eating country. Between 1980 and 2013, the proportion of fish in animal-source food consumption increased from 36 percent to 42 percent (Liverpool-Tasie et al. 2018). Over the same period, annual fish supplies increased from 984,000 t to 1.84 million metric tons—an 87 percent increase in national fish supplies. However, the population grew from 73 million in 1980 to 172 million in 2013, with the result that per capita fish consumption remained the same over time (13.4 in 1980 to 13.5 in 2013).[7]

Although fish prices are lower in the northern states than the southern states, average expenditure and consumption in the north is significantly lower than in the south (Table 2). Malnutrition rates in the north are higher than the south (Amare et al. 2018), and this needs urgent attention.

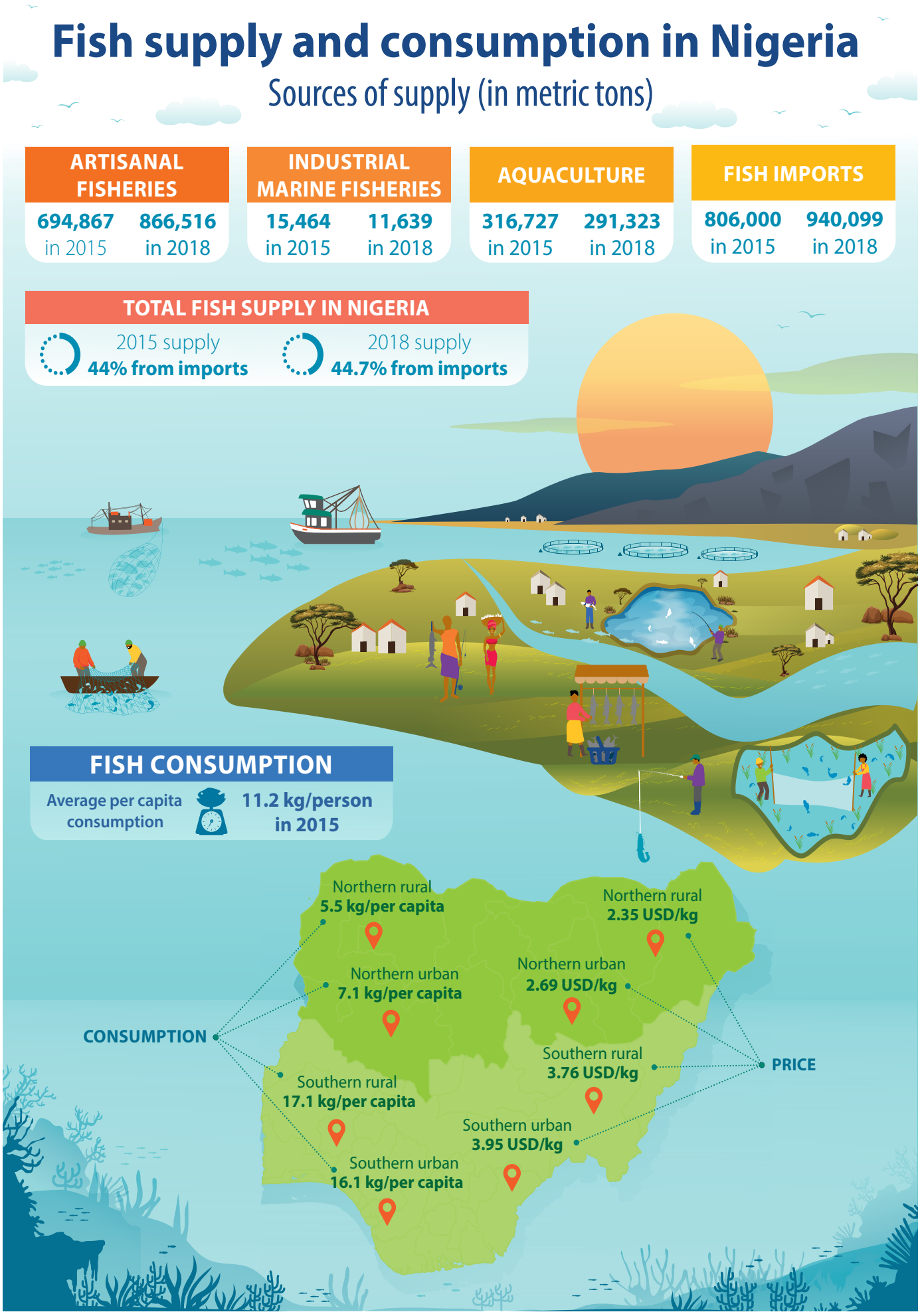


Figure 2. Fish supply and consumption in Nigeria.

Sector	2014 (t)	2016 (t)	2018 (t)
Artisanal fisheries	759,828	NA	866,516
Coastal and brackish water	435,384	684,359	474,328
Inland water	324,444	327,320	392,188
Aquaculture	313,231	306,767	291,323
Industrial fishing	49,952	NA	11,639
Total production	**1,123,011**	**1,041,498**	**1,169,478**
Imports	776,552	806,000	940,099
Total supply	**1,899,563**	**1,833,058**	**2,109,577**

Source: Federal Department of Fisheries and Aquaculture published statistics and personal communications; FAO Fishstat and WorldFish/BMGF scoping study estimates.

Table 1. Fish supplies in Nigeria, 2014–2018.

Region	Fish consumption kg/person/year (2015)	Average fish price USD/kg (2019)	Wealth quintile	Fish type and form	Observations (N)	Percentage of fish type and form
Urban south	16.1	3.95	Urban south poor (n=102)	Fresh mackerel	29	28.4
				Fresh catfish	27	26.5
				Dried crayfish	25	24.5
				Frozen mackerel	16	15.7
Rural south	17.1	3.76	Rural south poor (n=98)	Dried crayfish	30	30.6
				Fresh catfish	24	24.5
				Fresh mackerel	21	21.4
				Frozen mackerel	19	19.4
Urban north	7.1	2.69	Urban north poor (n=37)	Fresh catfish	10	27.0
				Fresh tilapia	8	21.6
				Dried catfish	4	10.8
				Dried tilapia	4	10.8
Rural north	5.5	2.35	Rural north poor (n=41)	Fresh catfish	10	24.4
				Smoked catfish	7	17.1
				Dried catfish	5	12.2
				Fresh tilapia	5	12.2

Source: WorldFish/BMGF household survey and foresight model projections (2019).

Table 2. Per capita fish consumption, fish price and the top-four most reported fish and fish forms by the poorest quintile of households.

2.2.1. Household consumption

Our household survey recorded that 92 percent of households had consumed fish during the previous week, a clear indication of the affinity of Nigerian people for fish. The average annual per capita fish consumption is 11.2 kg (2019), which is well below that of the global average of 20.5 kg (2018) (FAO 2020), though higher than the average of 9.9 kg for Africa (2017) (FAO 2020).

Our survey showed that 55 percent of the households in all surveyed states purchased fresh catfish, indicating availability of locally produced catfish nearly all around the country. Imported frozen fish (mackerel) were more commonly consumed in the south, with apparent limited availability in the north, possibly due to a lack of cold chain facilities. Crayfish was also more commonly consumed in the south but appeared to be rare in the diets of households in the north. Cultured fish (catfish and tilapia) were consumed relatively more frequently in the north. However, fresh fish from inland capture fisheries is less available in the north (Byrd et al. 2021).

Fifty percent of households in the rural north reported that they were unable to access fish/seafood in the markets as often as they would like, implying a large unmet demand. Any interventions to increase availability and accessibility of fish to rural poor should therefore pay particular attention to communities in the northern states.

Nutrient databases tend to provide the nutrient content of fish flesh only (FAO 2016a), but in many settings, including Nigeria, many households eat more than just the fish flesh (fillet). Bones and eyes provide high levels of calcium and vitamin A (Roos et al. 2002). Furthermore, Isaacs (2016) says "calcium in fish, digested when the bones and organs are eaten, is even slightly more effective than milk as a source of calcium." Our survey showed that nearly all households left bones behind during consumption. Behavioral change interventions could help raise awareness among rural households of the nutritional value of fish consumption.

While a handful of species (catfish, mackerel, tilapia, crayfish) dominate consumption, many Nigerian households consume a diversity of fish species (freshwater and saltwater sardines, croakers, bonga, codfish) in various dried, fresh and smoked forms. This is important, as a diversity of species of a given food group in diets is associated with greater micronutrient adequacy (Akintola et al. 2018). While a diversity of species of fish was reported across Nigeria, the types of fish consumed in the previous week in the south were slightly higher than in the north (Table 3).

Aside from large, high market-value farmed fish, small fish (especially small fish that can be eaten whole) play an important role in food and nutrition security for the poor (Thilsted et al. 2016; O'Meara et al. 2021). In Nigeria, these include bonga (*Ethmalosa fimbriata*) and the freshwater sardines, locally referred to as clupeids (*Pelonula* spp. and *Sierrathrissa leonenses*), that are caught in northern states, particularly in the Kainji Lake fishery (Akintola et al. 2018; Kolding et al. 2020). Bonga and small clupeids are harvested in large quantities between November and May, leading to a seasonal glut. Though our survey was conducted outside the harvest season, 3 percent of all fish consumed in the north and 4 percent in the south were small clupeids, in fresh, fried and dried form. Consumption was even detected in the highest wealth quintile at 1.5 percent of fish reported. Both bonga and clupeids are culturally highly acceptable and could play an important role in ensuring food and nutrition security in Nigeria, if supplies could be improved through better inland fisheries management (Byrd et al. 2021).

Crayfish is an important fishery in estuarine villages, and a significant fishery extends from the eastern part of the Niger Delta. Crayfish are mainly eaten as a sundried product or incorporated into the traditional Nigerian food called *ogi*, especially during the dry season, which corresponds to the peak period for this fishery. Consequently, our survey found that dried crayfish is a staple fish product in southern states, and in wealthier households, but is largely absent from households in the north. It is unclear why northern households do not access it, as it is a readily transportable, shelf-stable product. This is an area that warrants further research, as dried crayfish is a nutrient-dense food worth promoting in northern states.

Although marine fisheries play an important role in food and nutrition security in Nigeria, they could be enhanced. There is a high prevalence of both overnutrition and micronutrient deficiencies

in West African coastal countries, even though children's dietary nutrient requirements could be met with less than 20 percent of current fish catches (Hicks et al. 2019). As recently as 2018, Nigeria was ranked third in the world in terms of dependency on coastal ecosystems for nutrition (Selig et al. 2018). However, it is clear from our survey that Nigerian households consume mainly freshwater fish, including those from inland artisanal fisheries. Further research should identify how to increase the availability of these highly nutrient-dense marine fish.

The major factors that influence food and nutrition security are household income, region and seasonality. From 2010 to 2015, according to data from the Living Standard Measurements Survey – Integrated Surveys on Agriculture, the percentage of Nigerian households in the south consuming fish increased 20 percent. The percentage of household food budget allocated to fish also steadily increased. Meanwhile, the percentage of households in the north consuming fish remained steady during that period, even as the household budget allocated to fish decreased in 2015 (Liverpool-Tasi et al. 2018). These trends suggest that there is strong demand for fish throughout the country, despite apparent household budget constraints in the northern region.

There appear to be clear cultural perceptions of fish affecting the diets of women and children. Food taboos around pregnant women and children may decrease their fish consumption (Mayer-Frank 2017), risking nutritional deficiencies and developmental setbacks. There is also a perceived medicinal value of fish among some communities. However, in our qualitative survey of urban and rural men and women, few taboos concerning fish consumption were listed; on the contrary, nearly all participants reported that fish is an important food for women and children. This indicates that the taboos might only be regionally and socioeconomically specific. Furthermore, in FGDs, many consumers reported a willingness to eat cultured fish, though only about half see cultured fish as of superior quality. Some expressed concerns about cultured fish, mainly regarding the use of chemicals in ponds, what the fish were fed, and that they might not be as nutritious as captured fish. However, all reported eating cultured fish (Byrd et al. 2021).

2.2.2. Fish in the first 1000 days

Fish is an important nutrient-rich animal-source food for all, but particularly during pregnancy, lactation, and for children aged 6–23 months (the first 1000 days of critical growth) (Thilsted et al. 2016; O'Meara et al. 2021). Our survey confirmed that fish was the most consumed animal-source food among women and children in poorer households. Nearly 80 percent of women had consumed fish in the day prior to the survey; the figure was 73 percent for children. Although the frequency of fish consumption is high, expenditure data indicates that the serving size of fish per household member is small. Additionally, some families indicated that they cannot access fish in the market when they want it. These low consumption figures, overlaid with the high rates of malnutrition in Nigeria, particularly in the north, imply that fish could play a bigger role in diets, and thus in addressing malnutrition.

Despite a high average frequency of fish consumption, there could be room to increase both the frequency and amount of fish to improve further the diets in some regions. For example, women in the northern states consumed fish less frequently than their southern counterparts, indicating that increasing fish availability and accessibility to that population is imperative for the health of pregnant and lactating women. The convenience of accessing fish could play a role in whether or not fish land on a woman's plate, as we found that living farther from a market was associated with a decreased likelihood that a woman of reproductive age would consume any type of fish. In short, fish supplies should be increased and supply chains should be developed to make fish affordable and accessible to rural poor, with special emphasis on women in northern states (Byrd et al. 2021).

Additionally, greater attention may need to be paid to fish in the diets of infants. The ages of 6–12 months are especially critical. The nutrient to calorie ratio is relatively high, given the small calorie requirement and stomach capacity (Dewey 2013). Increasing the proportion of children consuming animal-source foods during this period is a key intervention for reducing the burden of malnutrition. Sixty percent of children between 6 and 12 months of age consumed fish the day before our survey, which is encouraging but

leaves room for improvement given the ubiquity of fish in Nigerian diets. As children grow older, caregivers appear more willing to provide fish in the diet, as we found that an increase in child age was associated with greater fish consumption. Increasing fish consumption in infants thus could be a key intervention in addressing the impaired growth (stunting) that we see in this age group, given that fish is a highly nutrient-dense food (O'Meara et al. 2021). Designing and implementing social behavior change communication programs, including fish recipes, and encouraging caregivers to begin feeding fish in small quantities or in powdered form, beginning at 6 months of age, has the potential to improve fish consumption during the first 1000 days window.

Furthermore, the contribution of fish to micronutrient intakes could be underestimated, as nutrient tables and modeling are largely based on consuming fish flesh, even though many people around the world consumed almost all parts of the fish. Our survey confirmed that in Nigeria, most households leave only the bones of fish behind, though bones are sometimes consumed as well. Indeed, children are also reported to be given parts of the fish other than the flesh.

As part of a high-quality diet, fish can address many of the multiple burdens of malnutrition, such as undernutrition and overweight/obesity, both of which are problems in Nigeria. The prevalence of undernutrition is 11 percent, and overweight/obesity is 25 percent (National Population Commission and ICF International 2014). While national rates of micronutrient deficiencies in women are unknown, anemia afflicts more than 12 percent of pregnant women (Ajepe et al. 2020) and one-third of children (Mainasara et al. 2017), in large part due to low intakes of iron. Fish, especially small fish consumed whole, are a rich source of bioavailable iron (Thilsted et al. 2016) and increasing fish consumption could also increase women's and children's iron reserves. Furthermore, in our survey, we found high rates of the consumption of processed snacks and sugary beverages among both women and children, which are known to contribute to increased rates of overweight and obesity. Encouraging more fish on the plate, as part of an overall healthy diet, can help crowd out the processed, nutrient-poor foods commonly consumed across all geographies and wealth groups (Byrd et al. 2021).

As a result, fish are an important animal food source, especially among populations where the rates of malnutrition (both undernutrition and overnutrition) are high. Developing fish as a food source, via increasing production through aquaculture and implementation of better small-scale fisheries practices, is imperative in the fight against malnutrition (Byrd et al. 2021).

Juvenile tilapia from a nursery pond in Nigeria.

3. Fish value chains[8]

To bridge key data gaps related to fish value chain efficiencies in Nigeria, it is critical to understand the dynamics of fish markets and prices and their impacts on both the performance of value chain actors and also food and nutrition security at the national level. The WorldFish/BMGF 2019 study included a comprehensive Nigeria fish value chain assessment that addressed key research questions, such as the following:

- What are the key aquaculture value chains in Nigeria?
- Who are the key actors in aquaculture value chains?
- What are the key leverage points along the fish value chain to enhance the contribution of the aquaculture sector to the livelihoods of smallholder producers, nutrition, and women and youth empowerment?
- Where are the key intervention points to better engage the private sector toward improving the contribution of fish to the Nigerian people?

Due to time and resource constraints, this study had a number of limitations. First, our data is static—what we have is a snapshot of Nigerian fish value chains. While static datasets give an overview of the aquaculture value chains at a specific time (e.g. last week), they lack information on, for example, production seasonality and its impact on the performance and behavior of value chain actors. Second, our analysis is mostly descriptive—describing the value chain and its performance indicators. Descriptive statistics provide data-driven evidence of the current situation of aquaculture value chains and investment opportunities that forms the basis of policy analysis. However, it lacks the ability to provide dynamic results, whereas simulation models can inform policymakers of different policy scenarios and their likely financial gains and losses over different points in time (e.g. 1 year, 5 years, 10 years from now).

This section provides the evidence gathered during our 2019 study and identifies the key aquaculture value chains, products, people's involvement, as well as employment and post-harvest activities up to sales at markets. The survey and study geographies, design and methodologies are outlined in the Nigeria scoping protocol (Annex 1).

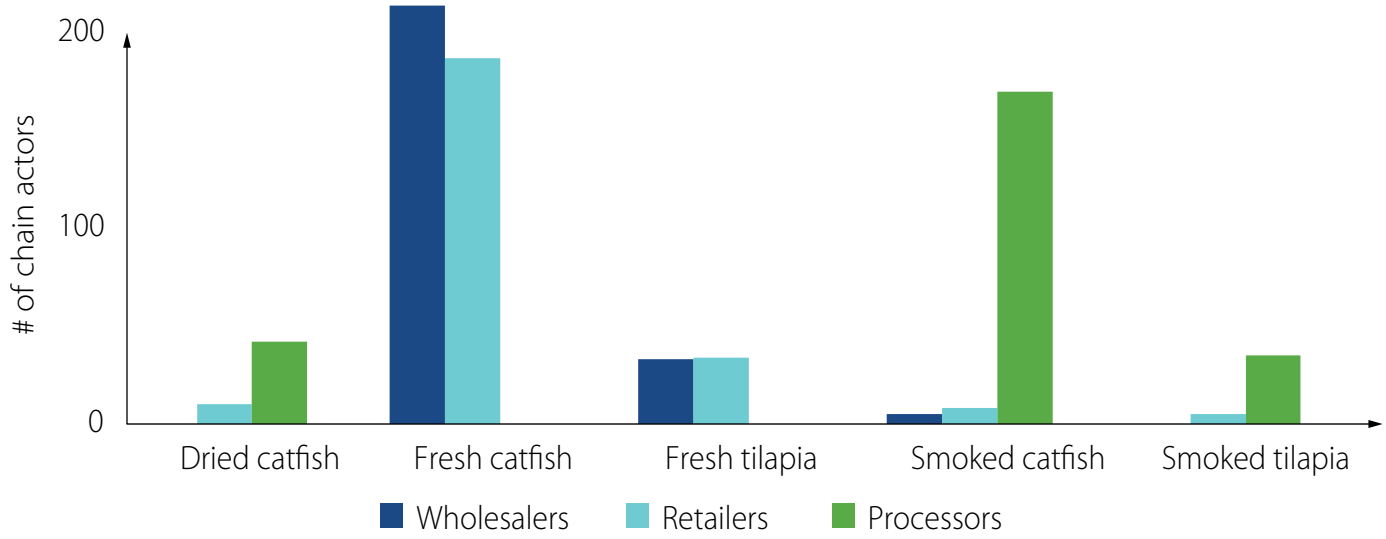
Five key aquaculture value chains were identified. The fresh catfish value chain dominates, followed by smoked catfish, dry catfish, fresh tilapia and smoked tilapia (Figure 3). In general, fish is preferably sold fresh. Value chain actors process (smoke and/or dry) unsold fresh fish, both small (less than 300 g) and large (greater than 300 g). Access to the cold chain is limited (Dizyee et al. 2021).

Fish wholesalers, retailers and processors are key post-farmgate actors in Nigerian fish value chains. Figure 3 shows the number of businesses—value chain actors—(based on our survey sample) engaged in each segment of the value chain (wholesaler, retailers and processors) per fish product. Different gender and age groups participate in fish value chains. Figures 4 and 5 show ownership of post-farmgate aquaculture businesses by gender and age group, respectively. Nigerian fish value chains are diverse with respect to gender and age groups. About 50 percent of post-farmgate value chain activities are owned by women and 35 percent by youths (under 35 years old) (Dizyee et al. 2021).

Investment in Nigerian fish value chains is likely to benefit a wide range of actors of different gender and age groups.

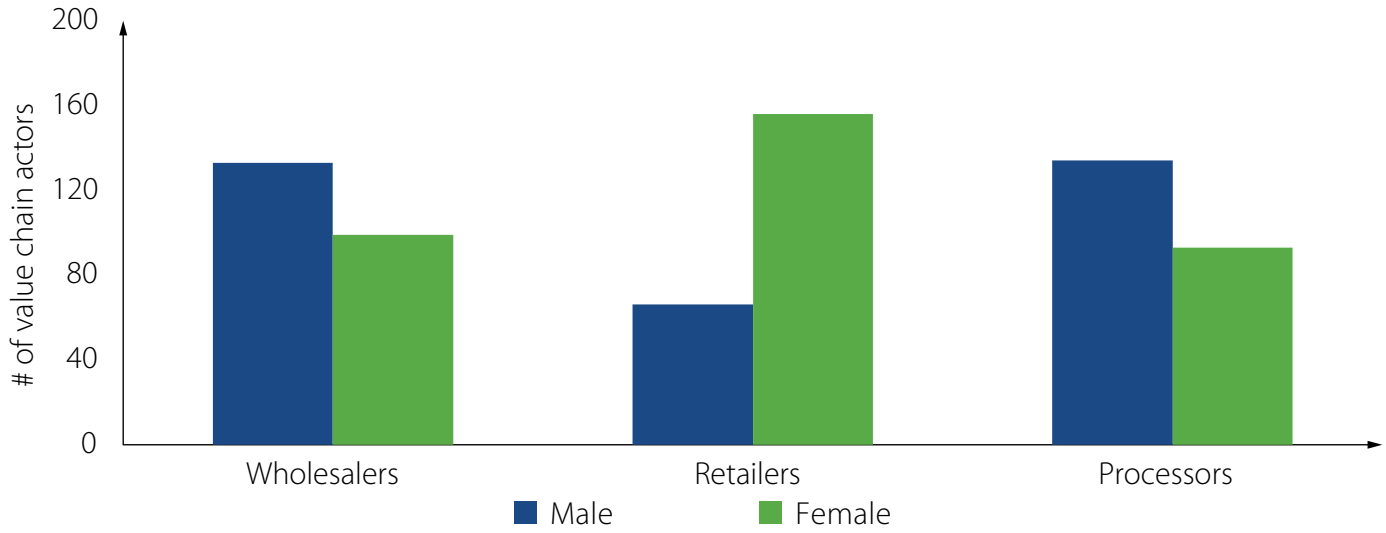
3.1. Value chain structure

Fish value chains in Nigeria consist of a variety of actors, including input providers, producers, capture fisheries, frozen fish importers, wholesalers, processors, retailers/marketers and consumers (Figure 6). Pre-farmgate value chain actors include broodstock suppliers, catfish and tilapia hatchery operators, feed producers and farmers. Post-farmgate value chain actors include wholesalers, processors and retailers. Figure 6 maps the Nigerian fish value chains, based on information and data from the 2019 WorldFish/BMGF study (Dizyee et al. 2021).



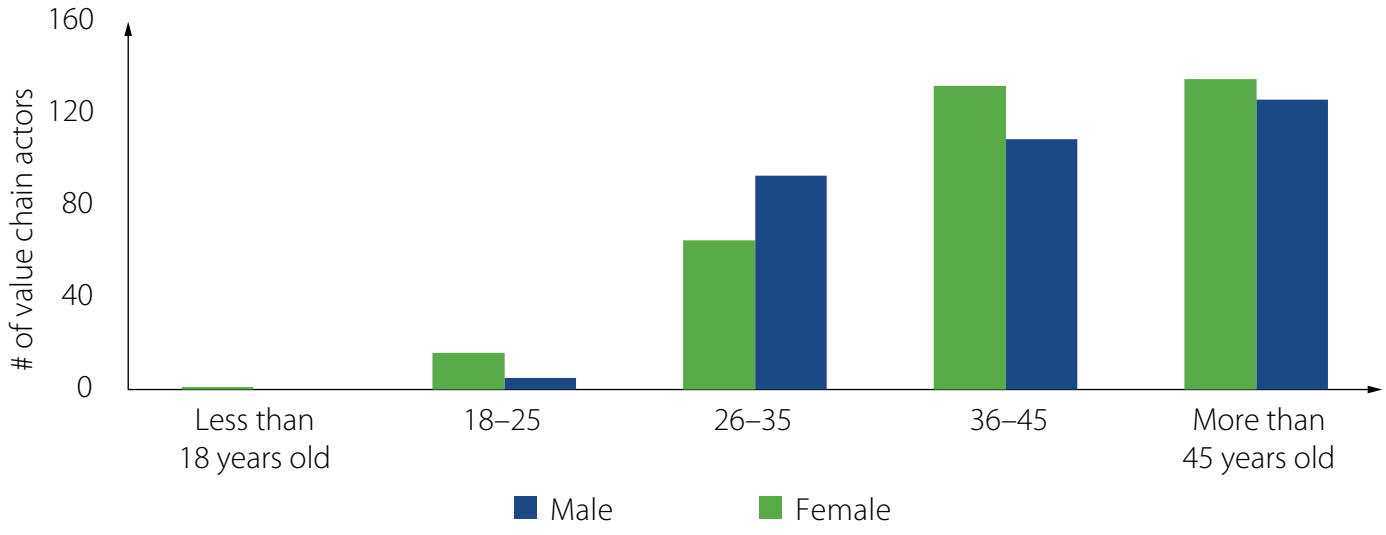
Source: WorldFish/BMGF value chain assessment 2019 (Dizyee et al. 2021).

Figure 3. Type of aquaculture value chains in Nigeria.



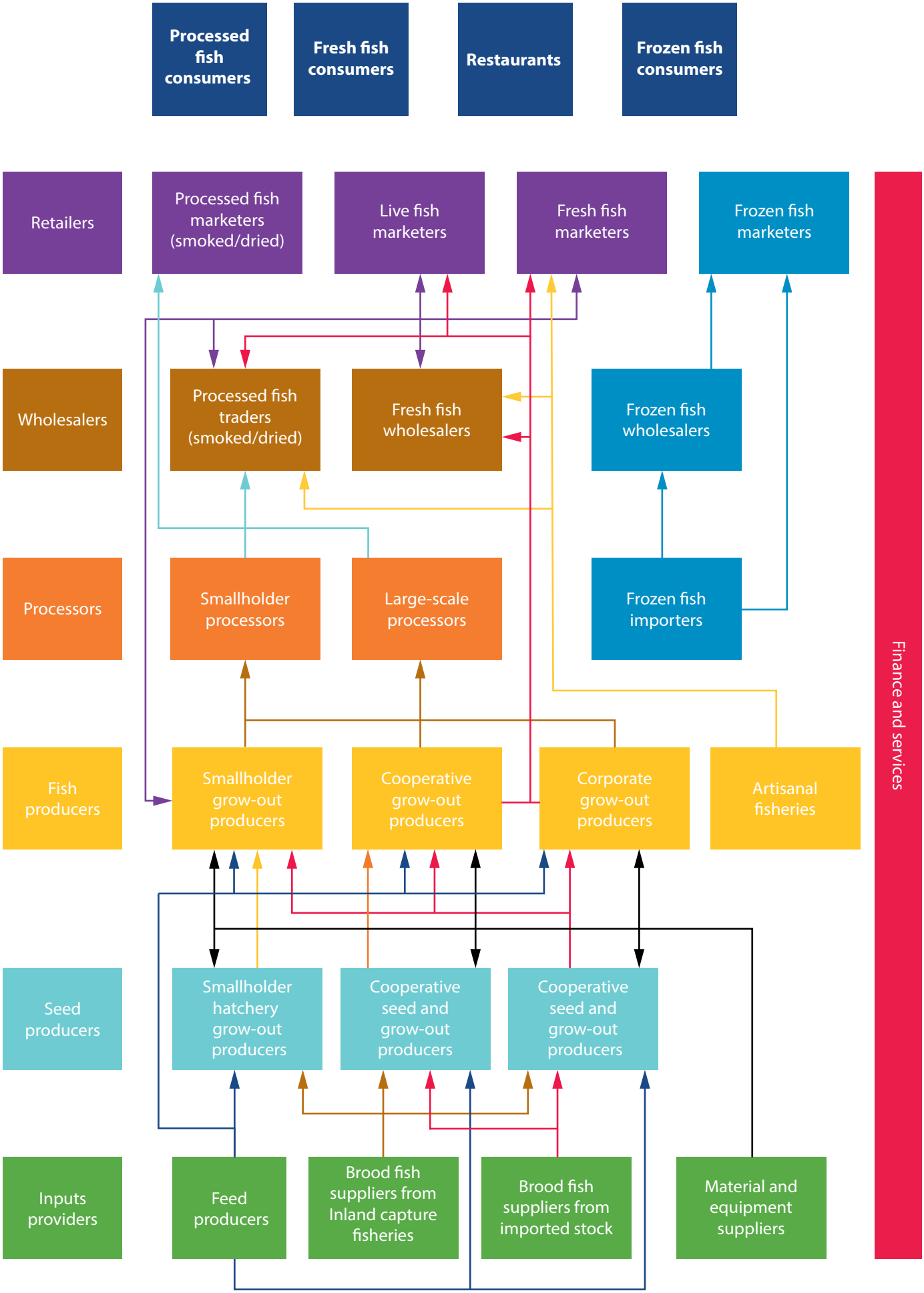
Source: WorldFish/BMGF value chain assessment 2019 (Dizyee et al. 2021).

Figure 4. Gender disaggregated value chains actors.



Source: WorldFish/BMGF value chain assessment 2019 (Dizyee et al. 2021).

Figure 5. Age disaggregated value chain actors.



Source: 2019 WorldFish/BMGF study.

Figure 6. Structure of the fish value chains in Nigeria.

3.2. Roles and responsibilities of the value chain actors

Private sector	Roles and responsibilities	Status and proposed improvements
Seed suppliers	Supply adequate quality catfish and tilapia seed.	Neither the quantities nor quality of seed produced are sufficient to support aquaculture growth. Genetic improvement and broodstock management are needed.
Feed suppliers	Supply different types of feed of different quality.	While the quality of feed produced by major corporate companies is good, the overall quality of feed produced by cooperatives and smallholder producers is poor and does not support sustainable aquaculture growth. Improve supplies of affordable quality feeds for smallholders.
Health managers	Few private veterinary companies provide fish health management services to farms.	The service is not widespread and quality is questionable and needs improvement. Invest more to provide accessible aquatic health management services.
Technical assistance	Technical assistance to fish farmers is provided by private feed suppliers and a few individual aquaculture consultants.	Technical assistance provided through government extension services is inadequate due to lack of resources. Build partnerships between the government extension services and the corporate sector to provide extension for smallholders.
Out-growers	Smallholder out-growers often organize into clusters and cooperatives to access loans through the Anchor Borrowers' Programme (ABP) and pool their produce to access better markets. Out-growers supply table-size tilapia and catfish to markets. Some out-growers also act as fish processors.	Cluster farms need transformation into smallholder enterprises with developed entrepreneurial skills.
Importers	Some production inputs such as tilapia and catfish broodstock, commercially manufactured feeds, equipment and feed ingredients are imported by private companies (importers). Frozen fish importers are important value chain actors, filling nearly 50 percent of the current supply-demand gap.	Broodstock importers do not maintain/manage pure lines of broodstock or multiply them to sell to other breeders. Smallholder breeders do not have access to quality broodstock. Invest in genetic improvement and broodstock management programs that improve access smallholders to quality broodstock.
Processors	These workers process fish into products such as smoked fish, dried fish and small quantities of fish powder and fish snacks. Processors sell these products directly to consumers or to retailers and marketers.	The quality of the products is variable. Opportunities exist to improve efficiency of processing methods and develop and implement quality and safety standards.
Marketers	Marketers facilitate consumer access to fish and fish products and sell fish to consumers.	Lack of cold chain makes access to fish and fish products difficult in some areas, particularly in the north. Invest to improve cold chain supply and/or invest in the development of the aquaculture value chain in the north to enhance access to fish and fish products.
Farmer cooperatives	These bring smallholder farmers together into organized and manageable groups or clusters. Cooperatives are supported and promoted by state administration. Operational constraints faced by cooperative societies include insufficient capital accumulation and mismanagement.	Invest in technological improvements in cooperative farm feeds and breeding programs. Expand fish farm cooperatives to include potential rice farmers in floodplains areas as rice-fish farmers. Improve management capacity and strengthen community capital.
Transporters	Transporters transport live catfish to markets and fresh fish and fish products to distant areas from the source of production.	Develop a mechanism to transport live catfish with increased survival. Invest in cold storage facilities in transportation vehicles to preserve the fish and fish product quality.

Private sector	Roles and responsibilities	Status and proposed improvements
Wholesalers	Wholesalers buy fish in bulk from producers and sell to retailers, traders and processors.	Invest in expanding the distribution network of retailers, traders and processors to access markets in distant states.
Small to medium buyers/traders	This important segment of the value chain, which is controlled by both men, women and youths, directly trades with consumers in the market.	Improve networking of small to medium traders to improve fish supply to the north.
Cold chain operators and marketers	These actors are limited and mainly operate along the imported frozen fish value chain. New cold chain for locally produced tilapia is developing.	Cold chain supply is weak in bringing fish products to the north. Invest in improvements to the cold chain supply to the north.
Professional societies	These societies liaise with public and research institutes to promote certification services and traceability systems, processing infrastructure, production standards and niche product development. They collaborate with academic institutions and research institutes and other NGOs to improve fish health services, use of waste in production chains and entrepreneurship training.	Lobby federal and state governments for implementation of policies conducive to implementation of inclusive growth. Facilitate institute-industry partnership research.
Small-scale fishers	These fishers observe fishery management regulations and self-management measures based on the principles of fisheries co-management.	Organizations of small-scale fishers in inland waters are weak. Form community-based organizations or cooperatives to promote collective actions.
Federal Ministry Department	This department promulgates policies, laws and legislation. It develops the overall national fisheries and aquaculture policy to align with the overall political vision of national development.	Adhere to the Maputo declaration. Back the policy of the Women in Agriculture (WIA) component of agricultural development programs (ADPs) with appropriate legislation. Increase the supply of credit to cooperatives and cluster farmers and embark on an enlightenment campaign to increase participation of rural farmers in cooperatives and cluster farm activities. Provide incentives to the private sector to enter and expand aquaculture value chains.
State Department	This department implements state-level policies and programs, including fisheries and aquaculture.	Address the issues of access to land and water at the state level. Implement inclusive business model-based policies to include smallholder farmers in commercial aquaculture. Strengthen state-level administration of the aquaculture sector, including licensing, extension, legal framework and law enforcement. State extension officers build partnerships with private sector value chain actors for extension delivery.
Academia/ universities	Produce qualified personnel for the fisheries and aquaculture sectors and for research.	Include industry needs in the curriculum and research to produce graduates with more problem-solving skills. Increase aquaculture components in vocational institutes to produce middle-level technical personnel for the aquaculture sector.
Government research institutions	These institutions are mandated to handle all marine, brackish water aquatic resources, inland water fisheries and aquaculture research and oceanographic research, training and development.	In consultation with stakeholders, formulate an aquaculture and small-scale fisheries research program. Enter institute-industry research partnerships.
Donor and development agencies	These agencies support implementation of government policy through technical and financial assistance, including private sector engagement.	Both technical and financial assistance from donor and development partners are necessary to make Nigerian aquaculture growth inclusive and effectively help in bridging the future supply-demand gap.

Table 3. Roles and responsibilities of the aquaculture value chain actors and other stakeholders (private and public).

3.3. Pre-farmgate value chain

Pre-farmgate value chain actors comprise suppliers of inputs and services. They include broodstock suppliers, catfish and tilapia hatchery operators, feed producers, various service providers (mainly health management and technical advice to cooperatives and smallholders) and farmers.[9]

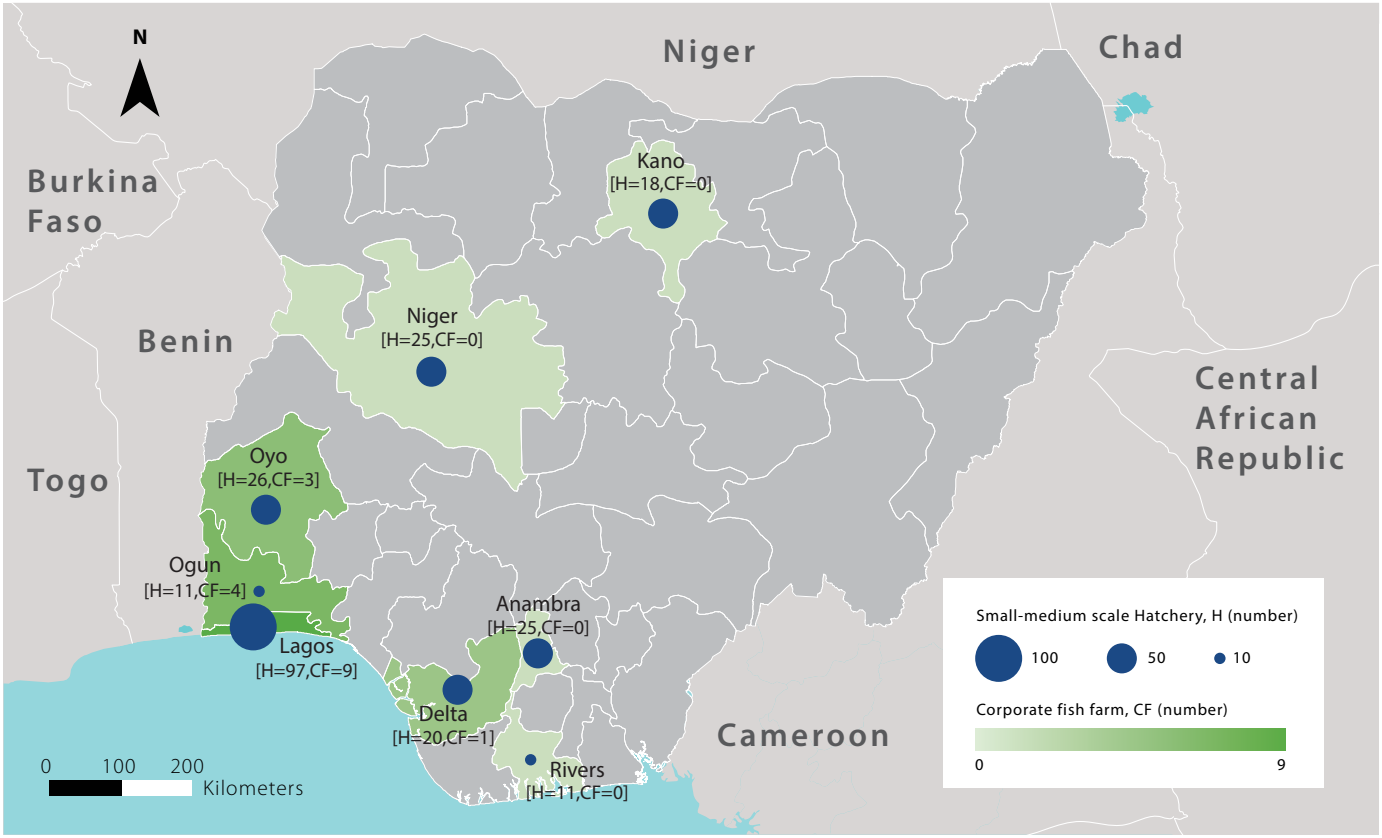
Four fish farming companies import catfish broodstock from the Netherlands, and six companies import tilapia broodstock from Thailand and the Netherlands. Since imported stocks are limited, many small- to medium-scale catfish breeders depend on broodstock from fish farmers or through a special arrangement with fishers engaged in capture fisheries in dams, reservoirs or rivers. The two most important inputs in the Nigerian pre-harvest aquaculture value chain are seed and feed.

3.3.1. Catfish seed supply

Both corporate hatcheries and small- to medium-scale hatcheries produce catfish seed in Nigeria, the former selling fry and fingerlings to catfish farmers. Availability of genetically improved[10] broodstocks is limited, and no farm maintains breeding lines. There has been no setting of breeding objectives incorporating, for example, disease resistance (there is no organized veterinary service providing technically sound disease control and health management services to the Nigerian aquaculture sector), faster phenotypic growth, higher fecundity or improved feed conversion ratio (FCR) because of a lack of technical know-how and facilities.

The pedigree of such fish and their fecundity is variable. Those using exclusively local broodstock can also have good results, depending on water source, hatchery facilities, on-farm water quality and staff expertise.

In 2019, the six largest corporate catfish hatcheries in Nigeria produced about 7.4 million catfish fry. To produce an estimated 264,000 t of catfish in 2019 required an estimated 346 million fry, indicating that the bulk of catfish seed production originates from small- to medium-scale hatcheries (Figure 1). We recorded 233 small- to medium-scale hatcheries in the eight states surveyed. If the bulk of catfish seed



Source: WorldFish/BMGF study 2019.

Figure 7. Distribution of small- to medium-scale hatcheries in surveyed states.

originates from small- to medium-scale hatcheries, presumably without organized broodstock and seed quality management programs, the genetic quality of the bulk of catfish seed produced in Nigeria (98 percent) is likely to be low.

Our estimates indicate that catfish fry and fingerling demand is likely to almost double, from 346 million in 2019 to 683 million by 2030. To meet demand will require an increase in the numbers of small- to medium-scale hatcheries or an expansion of existing large-scale hatcheries, or both.

3.3.2. Tilapia seed supply

The six corporate hatcheries have sourced Nile tilapia (*Oreochromis niloticus*) broodstock from Thailand and the Netherlands. None of these farms/hatcheries maintain broodstock, nor do they sell broodstock to others. According to our research, commercial tilapia hatcheries produced about 6.9 million fry/fingerlings in 2019, equating to just over 50 percent of production capacity (12.4 million). Tilapia hatcheries sell only monosex fry or fingerlings to farmers. In contrast to catfish, small-scale tilapia breeders and/or fry/fingerling producers do not exist because of a lack of access to quality broodstock. Production of tilapia seed in Nigeria is thus limited, as is access to fry and fingerlings by farmers. This is likely a main contributing factor to the low production of tilapia and the small number of farmers involved in tilapia farming.

In 2019, the ratio of production volume of catfish to tilapia was 6.5:1. Interviews with corporate sector hatcheries revealed that tilapia and catfish hatcheries are profitable business ventures. Tilapia and catfish hatcheries with a fry production capacity of 2.5–3 million generate revenue of NGN 47,500,000–54,000,000 and incur an annual expenditure of NGN 24,792,000–30,044,000.[11] The selling price of individual 2 g tilapia fry is about NGN 17–20, while 3–5 g catfish fry is NGN 18–20. No broodstock management program was found to be operating in any tilapia hatchery. The general opinion is that the fry and fingerlings produced in Nigeria are of poor quality and that a scientific broodstock management and/or breeding program or the introduction of a better performing tilapia strain is timely.

3.3.3. Feed supplies

Fish feed is produced by three main commercial sectors in Nigeria: corporate feed millers, fish farm co-operative feed millers and farm-made feed producers. A considerable volume of fish feed is also imported. The eight leading corporate sector commercial feed manufacturers in Nigeria produce on average 140,000 t of commercial pelleted feed annually. A further 70,000 t of feed was imported during 2019. Cooperative feed millers and farm-made feed producers make pelleted sinking pellets and compound feeds using their own formulations based on the availability of raw materials. Some farmers use slaughterhouse waste as feed to grow their fish to table size. Fish feed supplies and prices from 2015 to 2019 are presented in Tables 4 and 5.

Most raw materials for fish feed are available locally. Availability (including seasonality), quality, price and consistency of supplies are challenges for the Nigerian aquafeed industry. Fish feed manufacturers must compete for ingredients with the well-established and much larger poultry feed industry. Nigerian soybean meal production, for example, was about 519,000 t in 2019, 80 percent of which was used for poultry feed and 20 percent for fish feed. Cassava peels, vegetable oil and fish oil are locally produced and available in Nigeria, while most fishmeal, mineral pre-mixes and soybean meal are imported. Dried fish that is unfit for human consumption is also available locally and used by smaller feed millers. However, it is widely claimed that food-grade freshwater pelagic fish, both fresh and dried, are increasingly used by the aquafeed industry, reducing availability and accessibility to the rural poor. While our research did not confirm this, presumably because our household survey was conducted during the pelagic fish off-peak season, the claim warrants investigation.

Corporate feed producers use science-based formulas to prepare their products, which are generally considered of good quality. However, feed formulas and some ingredients used by cooperatives and small- to medium-scale feed producers do not appear to be as good as those by the corporate commercial sector. A significant disparity was found between the quality and price of commercial and cooperative/small-scale manufactured feed,

Year	Feed production (t)			FCR	Estimated aquaculture production based on volume of feed (t)	Percent age of contribution to the total aquaculture production based on volume of feed
	Commercial	Imported	Small- to medium-scale			
2019	140,000	70,000		1.2	175,000	56.5
			221,000	1.7	130,000	43.5
2019*	199,000	70,000		1.2	224,166	71.0
			221,000	1.7	130,000	29.0
2015	214,740			1.2	178,950	56.5
			234,221	1.7	137.777	43.5

Source: BMGF/WorldFish study 2019.
**If all commercial feed manufacturers operate to full capacity*

Table 4. Fish feed supply in 2015 and 2019.

Feed type	Price/kg (NGN)		Crude protein (%)		Crude fat (%)	
	Catfish	Tilapia	Catfish	Tilapia	Catfish	Tilapia
2 mm floating feed	397–595	326	43–45	32	10–14	8
3 mm floating feed	359–410	301	42–45	30	10–12	6
4.5 mm floating feed	350–460	301	42–45	28	10–12	6
6 mm floating feed	335–447		40–45		9–14	
8–9 mm floating feed	321–440		30–45		9–14	

Source: BMGF/WorldFish study 2019.

Table 5. Fish feed prices in 2019.

NGN 200–250/kg versus NGN 300–600 Naira/kg (Table 5), which acts as a barrier to smallholders adopting tilapia aquaculture production.

Annual commercial feed supplies are currently about 210,000 t. Based on an average FCR of 1.2 for catfish farming, this volume would only support about 175,000 t of fish production (56.5 percent), out of an estimated total aquaculture production of 305,000 t (2019). This indicates that about 130,000 t of cultured catfish production (43.5 percent) is supported by feed produced by the fish farm cooperatives and smallholder farming sector. Based on an average feed conversion of 1.7 in cooperative and smallholder farms, it is estimated that they produced about 221,000 t of feed in 2019. This suggests that the two sectors (cooperatives and smallholder farmers) make a significant contribution to overall fish feed supply in Nigeria. It should be noted that the contribution is mainly toward catfish farming, which accounts for more than 90 percent of current national aquaculture production.

If all commercial feed manufacturers operated at full production capacity, and current import levels remain at 70,000 t, the commercial manufactured feed supply could reach 269,000 t to support an aquaculture production of 224,166 t. Adding the cooperative and smallholder sectors to the corporate total, the potential total national feed production would support an aquaculture

production of about 354,166 t, which is greater than the total estimated average production during from 2015 to 2019.

Our research suggests that most commercial feed manufacturers do not operate at optimal production capacity due to lack of demand. One explanation is that smallholder farmers who used to purchase commercial feeds prior to the devaluation of the Naira in 2015 switched from using commercial pelleted feed to cooperative and smallholder feeds, because feed prices had become unaffordable. Thus, even if corporate feed supplies could be increased, sales are unlikely to increase while commercial feed prices remain unaffordable to smallholders. Smallholder feed prices ranged from NGN 200 to 250/kg.

3.4. Service provision

The transportation and distribution sectors are important service providers to the Nigerian aquaculture sector. Gender, age composition, profits and income of these important value chain actors are provided under the value chain discussion (pages 22–23). Unfortunately, we were not able to get a good estimate of the number of people involved in this service provision sector, at state or national levels.

There are a few companies providing health management advice to fish farmers. Many veterinarians provide some technical advice to smallholders, medium-size production facilities and hatcheries. However, the quality of their advice and the technology employed is, in general, not as good as that accessed by leading aquaculture producers. There is no organized and established health management and biosecurity program in the Nigerian aquaculture sector. There are no estimates of mortalities and related production losses in hatcheries and grow-out facilities. Provision of better aquatic health services and national organization of such is urgently required.

3.5. Production systems, practices and performance[12]

Nigerian aquaculture is still technologically undeveloped. Only a limited number of different aquaculture systems and practices are employed in tilapia and catfish production in the country (Table 6). Our results also showed that aquaculture production is catfish dominated, as 98–100 percent of surveyed households across the nine study states reported growing catfish (Table 7). Tilapia farming was practiced by 5.6 percent of surveyed farms. While catfish are mainly farmed by smallholders in earthen ponds, borrow pits and tanks, most tilapia production originates from cage culture practiced by large corporate companies, with insignificant production by smallholders (Table 6). A small number of flow-through systems and recirculatory systems are also used. However, these systems do not appear to be popular among smallholders. Monoculture is the most popular farming system, with a little polyculture involving catfish, tilapia and carp. Although these polyculture systems yield some tilapia at the end of the production cycle, they are mainly used to feed catfish (Table 7).

Our research and the existing literature indicate there are some 6200 smallholder fish farms in the eight states surveyed. Our survey of approximately 10 percent of farming households suggests that lack of seed and the price of commercial feeds are the main reason for smallholders not engaging in tilapia farming. Few respondents mentioned farming tilapia, African bonytongue (*Heterotis niloticus)* or common carp, either.

The majority of the aquaculture producer survey respondents were male (85 percent) with 66 percent attaining tertiary education, indicating that aquaculture in Nigeria, even at the household level, is mostly practiced by males with a good education. Eighty percent of sample respondents owned their farm, showing that aquaculture is a business that requires greater knowledge than basic agriculture and livestock production and its attractiveness as a business for Nigerian farming households.

Although promotion of aquaculture in Nigeria began more than three decades ago, the industry has only shown significant growth since 2000. Most respondents in our survey stated that they started their aquaculture operation after 2000 (Figure 8). The number of farmers converting to aquaculture has increased significantly since then, suggesting a growing demand for fish over the past two decades, the profitability of small-scale aquaculture businesses and the opportunities they offer (Nhuong Tran et al. 2021).

Production facilities	N	Prevalence (%)	Mean facility size (ha)	Median size (ha)	Min (ha)	Max (ha)
Earthen ponds	648	57.94	0.1269 (0.2765)	0.0464	0.0002	3.0000
Concrete tanks	648	38.43	0.0199 (0.0428)	0.0088	0.0010	0.0480
Fiber-plastic tanks	648	12.35	0.0025 (0.0098)	0.0005	0.0001	0.0864
Tarpaulin	648	15.28	0.0104 (0.0270)	0.0020	0.0001	0.2500
Collapsible ponds	648	2.17	0.0033 (0.0033)	0.0020	0.0008	0.0120
Cage	648	0.77	0.2321 (0.3367)	0.0600	0.0013	0.8094
Flow-through raceway	648	0.31	0.0005 (0.0004)	0.0005	0.0002	0.0008
Recirculating aquaculture system	648	0.31	0.0050 (0.0064)	0.0050	0.0005	0.0096
Burrow pit	648	1.23	1.0907 (0.4984)	1.0000	0.4047	2.0000

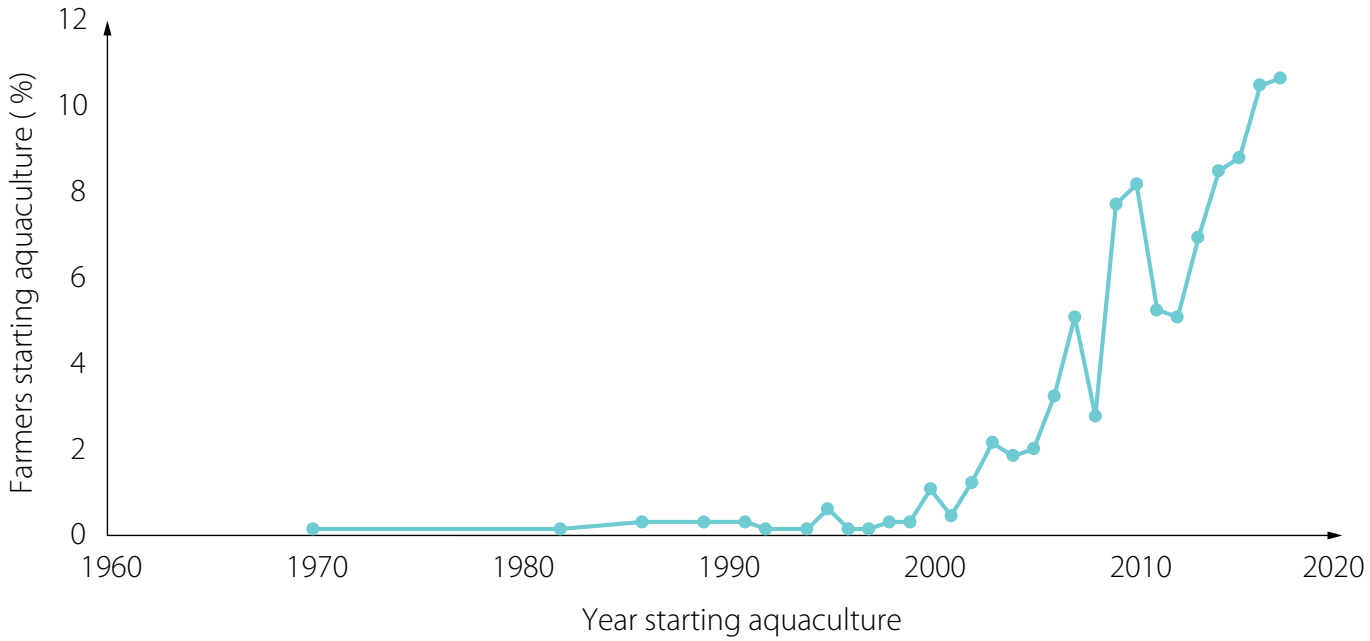
Source: WorldFish/BMGF farm performance survey 2019 (Nhuong Tran et al. 2021).

Table 6. Aquaculture production systems, prevalence of use by smallholders (percent age) and size (hectares).

Farmed species	Whole sample	Lagos	Ogun	Oyo	Delta	Rivers	Anambra	Kano	Niger
Catfish (%)	99.38	100.00	98.78	100.00	100.00	98.48	100.00	98.04	98.04
Tilapia (%)	5.60	2.67	2.44	4.26	1.38	3.03	4.00	35.29	7.84
African bonytongue (%)	1.90	0.67	0.00	2.13	0.69	0.00	4.00	11.76	1.96
Common carp (%)	0.30	0.00	0.00	0.00	0.69	0.00	0.00	1.96	0.00
Polyculture practice (%)	5.30	0.67	1.22	8.51	2.07	4.55	10.00	27.45	5.88
Integrated agriculture/livestock and aquaculture practice (%)	17.91	14.67	20.73	23.40	0.00	19.70	58.00	33.33	11.76
Observations	642	150	82	47	145	66	50	51	51

Source: WorldFish/BMGF study 2019 (Nhuong Tran et al. 2021).

Table 7. Aquaculture production in Nigeria by cultured species and techniques.



Source: WorldFish/BMGF farm performance survey 2019 (Nhuong Tran et al. 2021).

Figure 8. Trends in aquaculture start-ups by smallholders.

Most farmers had more than seven years of experience, showing that household aquaculture can be a sustainable business. Most farmers have been living in the village for more than 15 years. A single family farm (average five members) is on average 0.3 ha (aquaculture farm size of surveyed farms ranges from 0.02 to 2.02 ha), confirming that our survey was mainly of smallholders (based on the Nigerian government's definition). Farmer age ranged from 21 to 81 years, including the involvement of youths (25 percent) in household aquaculture.

Since almost all surveyed smallholders farmed catfish, our analysis and assessment of smallholder fish farms focuses on this species. The most commonly used production systems for catfish culture are earthen ponds (57.94 percent) and concrete tanks (38.43 percent). About 12.35 percent of the households use plastic and fiberglass tanks, and some smallholders use more than one type of system. Of the two most popular systems, the average size of earthen ponds was estimated at 0.126 ha (0.046 ha median) (Table 6). The size of concrete tanks ranged from 10 m^2 to 480 m^2, with an average size of 199 m^2 and a median size of 88 m^2 (Table 6). On average, a smallholder farmer operates three or four tanks or ponds. Tank-based production systems provide options for those with no or limited access to land for pond construction to engage in tank-based aquaculture (Nhuong Tran et al. 2021).

Different stocking densities are used in different production systems for catfish. For grow-out production, catfish were stocked at two or three individuals per square meter, varying by production facilities. Stocking density in concrete tank aquaculture systems was reportedly higher than in earthen ponds and other production facilities. The surveyed farmers preferred juveniles with an average weight of 6 g at stocking. The high reported survival rates (79–84 percent) suggest that tank productivity is considerably higher than that of ponds. This may explain the preference for tank-based catfish production systems by smallholders, though higher capital costs limit access of some smallholders to using such systems. The government's program of providing tanks (free or at subsidised prices) during the 1990s increased smallholder catfish farming. Nonetheless, expansion of tank-based catfish culture among smallholders might have been constrained by high capital requirements (Nhuong Tran et al. 2021).

The length of the crop cycle differs between earthen ponds (162 days) and tanks (133 days), an indication of higher productivity in tank than in pond systems. Catfish is commonly harvested at weights above 1 kg per piece, which is the preferred market size.

Some smallholders (18 percent) practice integrated agriculture/livestock/aquaculture production. Integrated aquaculture can reduce

production costs, as by-products from agriculture and livestock could be used as inputs for feed. Furthermore, from a food and nutrition perspective, integrated systems produce a more diverse range of foods for local markets to nourish families. Popularization of integrated aquaculture could be a strategy to improve smallholder income, in areas where the necessary resources are available (Nhuong Tran et al. 2021).

Catfish farming requires a high protein feed. Considering the volume of commercial feed production in Nigeria, it is evident that the majority of catfish farmers use feeds produced by small and medium feed producers or prepare their own feed. Our surveys confirmed that the nutritional quality of these types of feed is inferior compared to commercial pellets produced or imported by the large companies. Our calculations indicate an average FCR of 1.7 of catfish fed on feed from small and medium feed producers, which is relatively high.

The average productivity of catfish (tanks and ponds) farming is equivalent to 16 t/ha across the whole surveyed sample (20.24 t/ha for concrete tanks; 14.27 t/ha for earthen ponds). At the farmgate, harvested catfish were sold at USD 2.3/kg.

According to our cost-benefit analysis, average revenues from 1 ha of catfish farming per production cycle is about USD 36,600. Revenues varied according to the system used: USD 32,600 from earthen ponds and USD 46,300 from concrete tanks. Feed is the highest production cost element, accounting for more than 80 percent of total costs. Seed costs accounted for 5 to 6 percent of total costs and varies little among production systems. Other cost items, such as hired labor, equipment depreciation, interest rates and other expenses, each account for 1–2 percent of total costs. Total production costs per hectare of catfish per cycle, excluding family labor and original construction costs, was estimated at USD 22,200. Operational costs of tank systems were the highest.

Energy use, both electricity and fossil fuel (diesel), is lower in pond- than in tank-based catfish systems, indicating that the former is environmentally better than tank-based framing. In terms of cost-benefit ratio, all aquaculture production systems are profitable, with an average cost-benefit ratio of 1:1.64—for every dollar invested in catfish monoculture, farmers get back 1.64 dollars.

Smallholder catfish farmers thus have an average gross income of about USD 14,400/ha per crop cycle or USD 4320 per farm (median farm size is 0.3 ha) (Nhuong Tran et al. 2021).

Earthen pond systems had higher cost-benefit ratios than concrete tanks or other production facilities. Catfish is a hardy species and poses a low economic risk to smallholders. Affordable family and local labor (average hired labor cost was estimated at USD 255.14/ha per cycle) in rural areas allows smallholders to substitute labor for costly equipment in production facilities, which helps increase profits. Catfish farming in earthen ponds requires more labor. While low labor requirements may be economically advantageous, catfish farming in earthen ponds could be more strategically beneficial, especially in rural communities where land is available, offering greater employment opportunities in a country with high unemployment. Table 8 provides further detailed data on the economics of production and the costs and benefits of aquaculture systems and operations (Nhuong Tran et al. 2021).

Although our survey indicated little to no tilapia monoculture, the cost-benefit analysis of the few tilapia polyculture systems surveyed shows production ranged from 2.5 to 5.7 t/ha per cycle. Average farmgate prices for tilapia were USD 2.53/kg, higher than for catfish. Cost-benefit analysis of catfish versus mixed production of catfish and tilapia is provided in Table 9. However, the primary motivation for stocking tilapia in catfish ponds appears to be as a source of live feed. Any additional revenues came from any fish that remained at the end of the production cycle.

Aquaculture provides more than 50 percent of household income in more than 75 percent of the 642 smallholders who participated in the survey. Fifty-five percent of those surveyed did not engage in any other income generating activity. From our analysis, it is evident that small-scale aquaculture can increase smallholder income. This confirms that smallholder aquaculture is a profitable business. Improvement and expansion of small-scale aquaculture would bring wider economic, social and nutritional benefits to rural smallholders.

Variable	Whole sample	Earthen ponds	Concrete tanks	Other production facilities
Yield				
Catfish yield (t/ha per cycle)	15.98	14.27	20.24	16.39
Prices of fish				
Catfish price (USD/kg)	2.29	2.29	2.29	2.29
Costs				
Seed (USD/ha per cycle)	1250.96	1168.15	1538.59	1216.56
Feed (USD/ha per cycle)	19,022.95	16,669.88	23,658.30	20,497.48
Fertilizer (USD/ha per cycle)	1.44	2.19	0.46	0.71
Chemicals (USD/ha per cycle)	10.43	10.97	13.30	5.85
Hired labor (USD/ha per cycle)	255.14	287.90	235.91	202.55
Depreciation (USD/ha per cycle)	822.71	537.03	1405.95	941.37
Interest (USD/ha per cycle)	126.47	69.67	191.94	188.55
Other expenses (USD/ha per cycle)	879.47	543.09	1554.09	1019.43
Total cost	**22,369.57**	**19,288.88**	**28,598.54**	**24,072.50**
Profitability				
Gross benefit	14,224.63	14,488.62	17,751.06	13,460.60
Benefit–Cost ratio	1.64	1.75	1.62	1.56

Source: WorldFish/BMGF farm performance survey 2019 (Nhuong Tran et al. 2021).

Table 8. Profitability of catfish aquaculture systems (monoculture).

A comparative analysis of different catfish aquaculture production systems currently practiced in Nigeria is presented in Table 10. FCRs were compiled from the literature, and all other socioeconomic and environmental performance indicators were computed from the survey sample. It is clear that earthen pond systems use less electricity and fossil fuel but are more labor intensive than concrete tanks and other production facilities. Earthen pond systems also generated higher profit per unit product produced due to lower production costs than for concrete tank systems. Expansion of earthen pond aquaculture is, however, constrained by land tenure and access arrangements, which vary substantially from state to state and community to community in Nigeria. Concrete tank systems offer an innovative solution to catfish aquaculture that can be further developed if farmers can have better access to financial capital and services.

3.6. Employment and labor

Nigerian aquaculture production practices can be put into three categorized: (1) smallholder operations, (2) cooperative and cluster farm operations and (3) large commercial operations. Accurate numbers are scarce, and our assessment is based on government (DOF Fisheries Statistics 2015) and FAO estimates. The total number of fishers (full time, part time and occasional) amounted to 1.45 million in 2015, a reduction of about half a million from the 1,921,651 reported in 2014. According to FAO, this number further

Variable	Whole sample	Earthen ponds	Other production facilities
Yield			
Tilapia yield (t/ha per cycle)	6.89	5.67	2.49
Prices of fish			
Tilapia price (USD)	2.53	2.53	2.53
Costs			
Seed (USD/ha per cycle)	880.44	688.44	986.27
Feed (USD/ha per cycle)	12,934.15	11,762.59	9337.35
Fertilizer (USD/ha per cycle)	1.76	2.52	1.19
Chemicals (USD/ha per cycle)	11.16	7.64	8.33
Hired labor (USD/ha per cycle)	155.75	116.84	195.42
Depreciation (USD/ha per cycle)	436.62	217.54	409.07
Interest (USD/ha per cycle)	43.36	0.79	103.13
Other expenses (USD/ha per cycle)	413.21	358.71	474.77
Total cost	14,876.45	13,155.07	11,515.53
Profitability			
Gross benefit	2555.25	1190.03	-5215.83
Benefit–Cost ratio	1.17	1.09	0.55

Source: WorldFish/BMGF study 2019 (Nhuong Tran et al. 2021).

Table 9. Profitability of tilapia aquaculture systems (polyculture).

Criteria	Earthen ponds	Concrete tanks	Other tanks
FCR	1.2–1.7	1.2–1.7	1.2–1.7
Electricity (USD/ha/cycle)	873	1234	1016
Fossil fuel (USD/ha/cycle)	347	3005	1826
Productivity (t/ha)	14.28	20.24	16.57
Revenue (USD/ha)	32,666	46,278	37,899
Profit (USD/t)	937	873	836
Family labor (*FTE/t)	1.47	0.73	1.12
Total employment (FTE/t)	3.85	1.52	2.63

Source: WorldFish/BMGF study 2019 (Nhuong Tran et al. 2021).
**FTE = Full Time Equivalent (hours worked by one employee on a full-time basis; 8 hours).*

Table 10. Socioeconomic and environmental performance of aquaculture systems.

decreased to 1,190,000 in 2016. The decline could be attributed to the policy shifts and unsustainable exploitation that have led to a long-term decline in fishery resources, leaving the target rural economies more vulnerable than ever. FAO (2017) estimated that women account for 21 percent of the total employment in inland capture fisheries and 15 percent in marine capture fisheries. The numbers of fishers involved at fish landing sites in different states are also available from national statistics, which suggest some 128,000 fishers are involved.

The industrial fisheries sector that involves the use of trawlers for fishing and shrimping, currently employs about 9000 Nigerians. It is widely accepted that employment numbers in the industrial fisheries sector have declined in recent years because of falling numbers of fishing vessels operating in Nigeria's territorial waters. In 1995, 315 trawling vessels operated in Nigeria; by 2012, the number had dropped to 191 (Effiong et al. 2016).

Estimating the numbers of fish farmers accurately is impossible. Most smallholder fish farmers are not registered with the government or farmer cooperatives or societies, because the size and nature of their operations exempt them from mandatory registration or licencing.

Our study estimates that a small catfish pond of about 150–200 m^2, producing about 3.5 t per crop of catfish, directly and indirectly (smallholder household labor, feed and seed value chains) helps support approximately 18 people. Extrapolating from the estimated total aquaculture production of 305,000 t in 2019, the sector supports about 1.57 million people. A cage farm with 10 cages, each 160 m^3, producing about 35 t per crop of tilapia, supports a further 18–20 people, directly and indirectly. Extrapolating to the estimated total tilapia production of 41,000 t in 2019, the sector potentially supports about 21,100 to 23,430 people.

3.7. Processing and value adding

Generally, fish are marketed fresh in Nigeria. While Nigerians prefer eating fresh fish, a lack of cold chain facilities, inadequate refrigeration facilities and a lack of or interrupted electricity supply results in people consuming a lot of processed fish. Fish processing in Nigeria is very basic: the main means is by smoking, though some fish are also dried.

Smoked fish is generally a profitable business. The product is popular because of its special taste and because no cold storage is required. The widespread disruption of electricity is a disincentive to households to refrigerate fresh fish and other seafood products. Smoked fish has proven to be a good alternative to securing the freshness and safety of catfish.

Producers (mostly men) usually sell their live fish to women at the farm gate, who then either sell them directly to consumers at local markets (some supply to hotels and restaurants) or bring the fish to their processing facility to be smoked. After smoking, the fish are then taken to markets to be sold directly to consumers, with some also being supplied to hotels and restaurants. Women, often with the help of youths (mostly female), also sell smoked fish door-to-door and street-by-street, all day long. The practice is common throughout Nigeria.

Fish marketing and distribution in Nigeria varies from zone to zone as a result of different market structures. Fish prices in various markets—farmgate, roadside sales, structured markets—depend on fish type and size as well as the volume of fish in the markets. Price fluctuations and availability affect the marketing and distribution of fish, as the volume of fish for sale at a particular period determines the overall sales price in a market. If there is a glut (high volumes; few buyers) prices will be very low, whereas sales prices will be very high in times of low volume of fish in the markets. The 5th Edition (2008–2015) of the Fishery Statistics of Nigeria includes the state-by-state average fish price per kilogram. There is no reliable state level data on volumes of processed fish sold.

Trading and marketing aquaculture products is mostly done by women who are in the middle-income bracket, expending NGN 25,000–50,000 per day to buy fish from producers. Approximately 80 percent of aquaculture fish processors involved in smoking catfish in Nigeria are small-scale processors, processing 20–30/kg per day. Only about 20 percent are considered large-scale processors, capable of smoking 50 kg of fish or more per day.

Many Nigerian customers prefer live catfish to other types of farmed fish, like tilapia and African bonytongue (*Heterotis)*. It is commonly used by

patrons of "pepper soup joints," where customers choose the live catfish they want to eat. However, there is no market for farmed catfish in the South South geopolitical zone of Nigeria (e.g. Warri), where people do not buy scaleless fish because of local traditions. Smoked catfish is preferred mostly in the South West geopolitical zone while smoked African bonytongue is preferred in the northern parts of the country.

There are few constraints on the purchase of fish for lower-income or urban consumers, as they can usually find some sort of affordable fish. Many people in this group often buy imported herring, in either frozen or smoked form. Sixty-one percent of Nigerians are categorized as low-income (NBS 2010). As a result, less than 40 percent of Nigerians buy and consume fresh or smoked cultured fish.

While catfish are sold fresh or (mainly) smoked, tilapia is sold mainly fresh. Tilapia are generally not smoked, however, as vendors dry unsold fish before selling it in the market. Large corporate producers of tilapia freeze them either at the production facility or in a nearby cold storage facility. Frozen fish are transported to many parts of the country and are marketed alongside imported frozen fish. This is only possible and practiced by a few corporate fish farmers and importers who have the capacity and facilities to do so. The frozen fish trade is almost entirely operated as a separate value chain to that for live and smoked fish.

There are no government standards for processed fish. To date, Nigerian smoked fish has not penetrated European markets due to the industry's inability to comply with the required food safety and quality standards. Smoked and dried catfish imports to the US from Nigeria have been banned since 2018 due to substandard quality and improper documentation. At present, food safety of processed fish is a significant issue for the aquaculture sector. Only a few businesses make niche products such as fish powder, fish crackers and fish noodles. These are at an early stage of development.

3.8. Markets and trade

The Nigerian fish market can be divided into several commodity-based operations: (a) traditional smoked fish, (b) fresh fish, (c) live catfish, (d) imported fish and (e) industrial fish.

3.8.1. Traditional smoked fish market

The smoked fish market includes smoked farmed products such as catfish, tilapia and African bonytongue and marine fish like croaker, barracuda and shiny nose (Peter's elephant-nose fish (*Gnathonemus petersii*)). The fish in traditional smoked fish markets are packed in reused cartons, which typically contain 10–25 kg of smoked product. The packaging is so poor, however, that the oil from the smoked fish stains the carton, making it unattractive to many health-conscious buyers. There are no fixed prices in this market. They are based on fish species and on buyers' abilities to negotiate prices with sellers. Prices varied between NGN 1000/kg and 2000/kg in 2019.

3.8.2. Fresh fish market

The fresh fish market is for fish caught by the artisanal fishers using canoes and set nets. Fish are packed in ice when they are caught and landed at various jetties at fishing villages along the coast. Catches are bought from the fishers by women, who often pay the fishers in advance, thereby acting as provider of informal credit to the fishers. Artisanal catches are usually relatively small (less than 20 kg). The women who buy directly from the fishers often sell the fish directly to consumers.

Fresh fish market prices are determined by negotiation and depend on the size and type of fish. Prices range from NGN 1000/kg for small fish (three to five pieces per kilogram) to NGN 3000/kg for larger fish (one to two pieces per kilogram). There is often a strong interdependence between women fish sellers and fishers, which influences market decisions by the women fish sellers. Marketing arrangements are thus often long lasting, providing an assured market outlet to fishers and steady supplies and incomes to fish sellers.

3.8.3. Live catfish markets

Catfish is the only farmed fish sold live in Nigeria. Live catfish markets can be found throughout the country. Live catfish wholesalers buy from farmers and then sell to small traders and distributors. Small traders store live fish in basins (bowls) for transportation to retailers in various markets. Most of the retailers sell the live catfish at roadsides and at the periphery of general markets. Live catfish are kept in containers at markets run by cooperative

societies, while those selling at roadsides keep the fish in smaller bowls.

Catfish mortality is high along the value chain due to poor transportation technology and equipment. Keeping large numbers of live fish in small enclosures with no aeration leads to oxygen depletion and mortality. In markets run by trade cooperatives, prices of live catfish are largely controlled. The prices of live and smoked catfish sold during the second half of 2019 in the survey areas are given in Table 11. There appear to be considerable state-level price differences, ranging from NGN 550/kg to 820/kg for fresh catfish and NGN 2500/kg to 5000/kg for smoked catfish.

3.8.4. Imported frozen fish markets

Nigeria is a net fish importer, importing 770,802 t of fish in 2013. Other than for fish species farmed in the country, which are now strictly regulated and under prohibition from being imported without control, other fish species are free to enter within the set quota. In October 2013, as a measure to save foreign exchange, the government introduced an import quota policy aimed at reducing Nigeria's frozen fish imports by 25 percent. It was also intended to stop the import of species such as catfish, tilapia and croaker that are produced in Nigeria through local aquaculture and capture fisheries. The government decided to approach the quota administration through control of the use of foreign exchange. In late 2013, the government and importers settled on an annual baseline fish import figure of 700,000 t and set the quota for 2014 at 500,000 t, a 25 percent reduction against the baseline figure.

A few large international companies and some local companies import frozen fish into Nigeria. Imported fish include mackerel, horse mackerel, herring, blue-whiting, hake, stockfish and stockfish heads from Japan, Netherlands, Holland, Denmark, Norway, China and the UK, as well as other countries. Importers sell these fish to distributers, who sell to retailers. Compared with farmed fish, imported fish is cheap and affordable for many people, depending on type and size. On average, imported fish such as herring is sold at NGN 300/kg, while mackerel (two pieces per kilogram) is about NGN 600/kg compared to cultured catfish (one piece per kilogram) which cost NGN 700/kg in late 2019. Because of the relatively low price of imported fish, the majority of Nigerians purchase it rather than the more expensive farmed fish. Importing frozen fish is a capital-intensive business as it requires significant foreign exchange transactions, good infrastructure, power generators, refrigerated trucks and cold storage.

State	Live catfish price/kg (NGN)			Smoked catfish price/kg (NGN)
	1 piece 1–3 kg	2 or more pieces Per kg	Mixed sizes Per kg	Per kg
Abuja FCT	700	600		5000
Adamawa	560	550		3000
Anambra	800–900	650		3000
Kaduna			820	4000
Kwara	800	600		3500
Lagos	650	600		3500
Ogun	850	600–650		2500
Oyo	800	650		3500

Source: WorldFish/BMGF study 2019.

Table 11. Live and smoked catfish prices in October to December 2019.

3.8.5. Industrial fish market

This market is operated by trawler owners, mostly owned by multinationals, as the operations are too capital intensive for many local businesses. Their priority is access to trawl for shrimp and fish in Nigeria's inshore waters. Catches are processed in their own factories for export. Unlike farmed fish, marine fish have gained access to international markets, including the EU, US, Canada and Japan.

3.8.6. Informal cross-border trade

Informal trade is an integral but unrecognized component of Africa's economy (Jawando et al. 2012). The trade is mainly conducted by individual traders (a large proportion of whom are women), micro-, small- and medium-sized enterprises, and it often consists of small consignments (Ojo 2016). Nigeria's informal imports of fish products are almost exclusively smoked or dried, contrasting with officially recorded imports of low-value frozen pelagic fish from Mauritania, Namibia and non-African suppliers, though there are imports of (dried and/or salted) stockfish from a number of European countries (Rondon and Nzeka 2010). FAO data attests to Nigerian imports of dried and smoked products from Mali, Niger and Senegal; imports that enter via inland borders are, in particular, likely to be higher than those officially reported (Gordon et al. 2013). Some traders operate entirely outside the formal economy; others are registered domestically yet fully or partially escape trade-related regulations and duties (Ojo 2016). Informal cross-border trade as a form of employment plays a vital role in alleviating poverty. It is a vital source of livelihood for the poor and an important component of Africa's economy, contributing immensely to the economy of Africa, especially in terms of economic upliftment of women, food security, regional economic trade and social integration (Matsuyama 2011).

3.9. Post-farmgate value chain[13]

Our primary data shows that post-farmgate value chain actors source fish from both farmed and capture fisheries. The catfish value chain relies largely on farmed fish while the tilapia value chain depends more on capture fisheries, both of which in value terms contribute a substantial proportion of fish to the market. The catfish aquaculture sector is better established than tilapia, as it sources more fish from farms than capture fisheries. Investment in farmed catfish could thus generate positive livelihood impact for larger numbers of producers and post-farmgate value chain actors relative to farmed tilapia. However, there is investment potential in expanding farmed tilapia capacity to supply more fish to Nigerian markets, which in return could create new opportunities to promote and expand farmed tilapia value chains and generate more value throughout the economy (Dizyee et al. 2021).

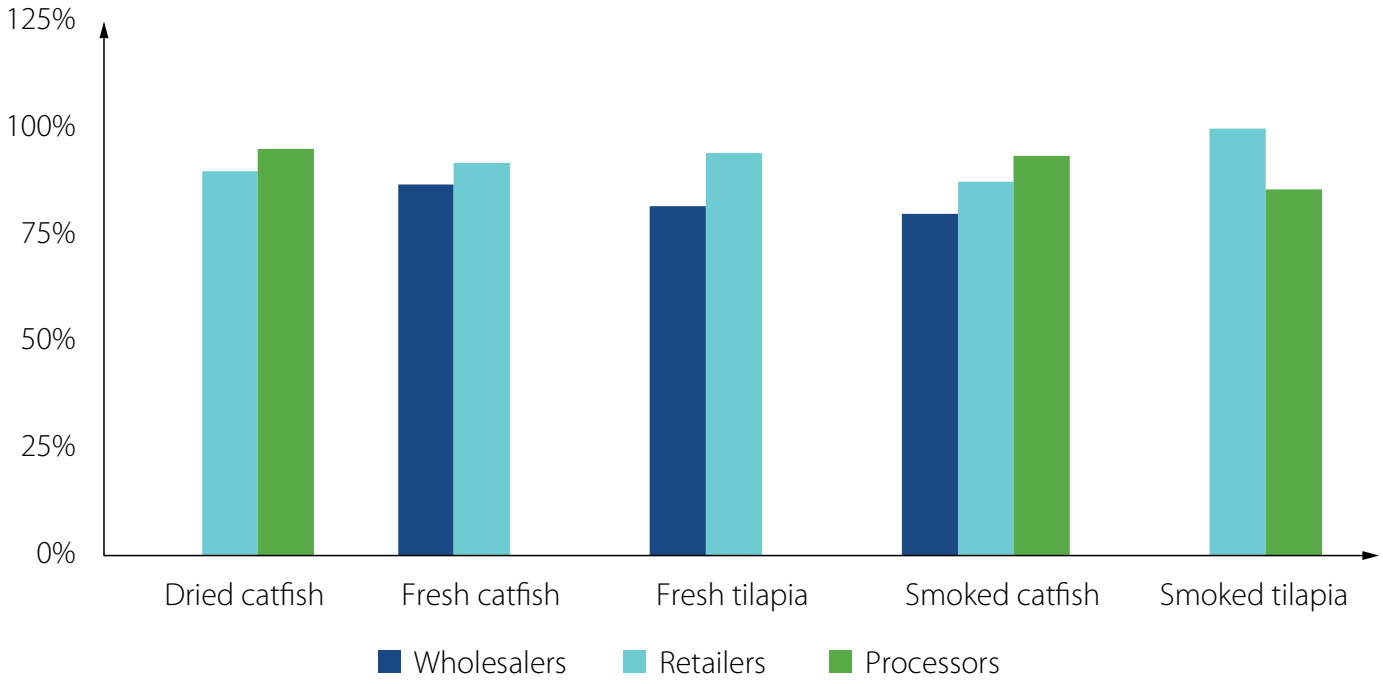
Post-farmgate value chain actors source fish directly from producers as well as intermediaries and fishers (Figure 6). Wholesalers and processors source most of their fish from farmers and fishers (capture fisheries), while retailers also rely also on wholesalers. Fish sales channels are more complex than fish purchase channels. Wholesalers and processors sell most of their fish to retailers and urban consumers directly, while retailers sell the vast majority of their fish to urban consumers. Between 32 and 50 percent of catfish and 48 and 62 percent of tilapia go from production (farmed and captured fish) through a single intermediary (e.g. wholesaler, processor or retailer) before reaching urban or rural consumers. The rest of the fish go through multiple chain actors until they reach consumers.

Cold chains are almost nonexistent in Nigeria, forcing value chain actors to sell fish fresh or process unsold fish to avoid spoilage. The chain actors play multiple roles (i.e. wholesaling, retailing and processing) rather than primarily focusing on a single activity. Nigerian farmed fish value chains are market driven and no single chain actor (or small group of actors) has a monopoly over post-farmgate activities. Fish purchase and sales channels for value chain actors are diverse, with post-farmgate chain actors buying fish directly from producers or intermediaries and selling to a variety of end-market actors (Figure 6). This suggests that investment in fish value chains in Nigeria not only serves producers, key post-farmgate value chains actors and consumers, but also a variety of other market actors, such as restaurants, hotels and school feeding programs.

3.9.1. Financial performance

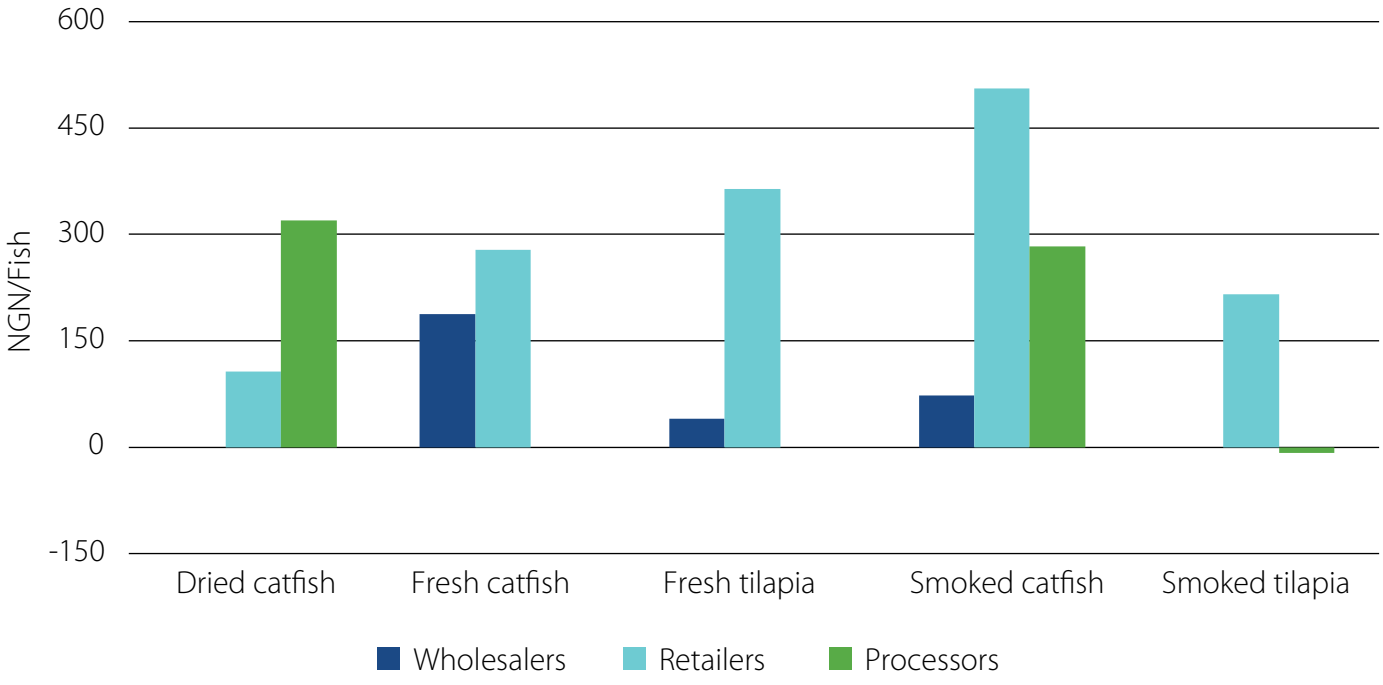
Over 80 percent of value chain actors who engaged in post-farmgate fish value chain activities realized a profit (our data represents a

snapshot of the 7 days prior to the survey date) (Figure 9). However, profit generated per fish per value chain actor varies based on type of value chain (e.g. fresh catfish, smoked catfish, fresh tilapia) and segment (e.g. retailer, wholesaler and processor) of the value chain. Trading both fresh and processed catfish and tilapia is profitable, except for smoked tilapia at the wholesale level, which generated a loss of about NGN 9 per fish. The loss might be linked to the lack of a cold chain to preserve the freshness of tilapia. For the rest of the fish products, profits per fish for value chain actors varied from NGN 40 (fresh tilapia at wholesaler level) to NGN 506 (smoked catfish at retailer level) (Figure 10).



Source: WorldFish/BMGF Nigeria fish value chain assessment 2019 (Dizyee et al. 2021).

Figure 9. Percentage of value chain actors realizing a profit.



Source: WorldFish/BMGF Nigeria fish value chain assessment 2019 (Dizyee et al. 2021).

Figure 10. Profit per fish per value chain.

Table 12 shows average and median profit generated per value chain actor across different fish products during a week.

Mean and median values show that 80 percent of post-farmgate actors who engaged in fish value chains made a profit (Table 12). The data distribution is skewed, however, because a few observations (value chain actors made extreme positive or negative profit) substantially impacted average (mean) values, so median profit is considered the better indicator of chain actors' profit.

Value (NGN) is not only created through direct fish trading through value chains but also through service provision, such as labor and transportation. Value chain actors use labor and transportation as part of their business operation. Although labor (opportunity cost in case of family labor), transportation and other operational activities are costs associated with producing and transforming fish products for chain actors, they are considered value for service providers, such as labor and transporters. We captured value created through labor and transportation per fish for key aquaculture value chains in Nigeria. Labor value created throughout the value chains ranges from NGN 0.4 per fish (fresh catfish at wholesaler level) to NGN 21.5 per fish (dried catfish at retailer level). In a similar vein, transporters, value addition ranges from NGN 0.8 (fresh tilapia at retailer level) to NGN 9.5 per fish (dried catfish at retailer level). Tables 13 and 14 present the labor and transporter profit at different value chain actor levels (wholesalers, retailers and processors) (Dizyee et al. 2021).

Fish type	Number of wholesalers	Average profit NGN/week	Median profit NGN/week	Standard deviation
A. Wholesalers				
Dried catfish				
Fresh catfish	214	2,065,723	158,528	13,330,631
Fresh tilapia	33	277,917	91,777	5,759,713
Smoked catfish	5	125,133	46,349	172,545
Smoked tilapia				
B. Retailers				
Dried catfish	10	46,675	25,832	69,320
Fresh catfish	187	591,479	64,060	1,519,496
Fresh tilapia	34	827,572	168,290	1,795,406
Smoked catfish	8	699,310	38,772	1,748,036
Smoked tilapia	5	72,410	33,127	89,461
C. Processors				
Dried catfish	42	220,136	58,009	593,183
Smoked catfish	170	1,175,234	185,224	2,997,357
Smoked tilapia	35	-33,366	613,000	7,317,978

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).
Note: USD 1 = NGN 362 (2019).

Table 12. Value chain actor's profit per week.

Fish/VC type	Wholesalers		Retailers		Processors	
	NGN	USD[1]	NGN	USD[1]	NGN	USD[1]
Dried catfish	5373	14.84	9398	25.96	2978	8.23
Fresh catfish	4854	13.41	5651	15.61	N/A	N/A
Fresh tilapia	7039	19.44	2974	8.22	N/A	N/A
Smoked catfish	3874	10.70	719	1.98	9.492	26.22
Smoked tilapia	2498	6.90	998	2.76	2069	5.72

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 13. Labor profit at different value chain actor levels.

Fish/VC Type	Wholesalers		Retailers		Processors	
	NGN	USD[1]	NGN	USD[1]	NGN	USD[1]
Dried catfish	5001	13.81	4139	11.43	4945	13.66
Fresh catfish	61,559	170.10	19,057	52.64	N/A	N/A
Fresh tilapia	56,036	154.80	1703	4.70	N/A	N/A
Smoked catfish	1251	3.46	7766	21.45	23,045	63.66
Smoked tilapia	998	2.76	437	1.21	20,685	57.14

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 14. Transporter profit at different value chain actor levels.

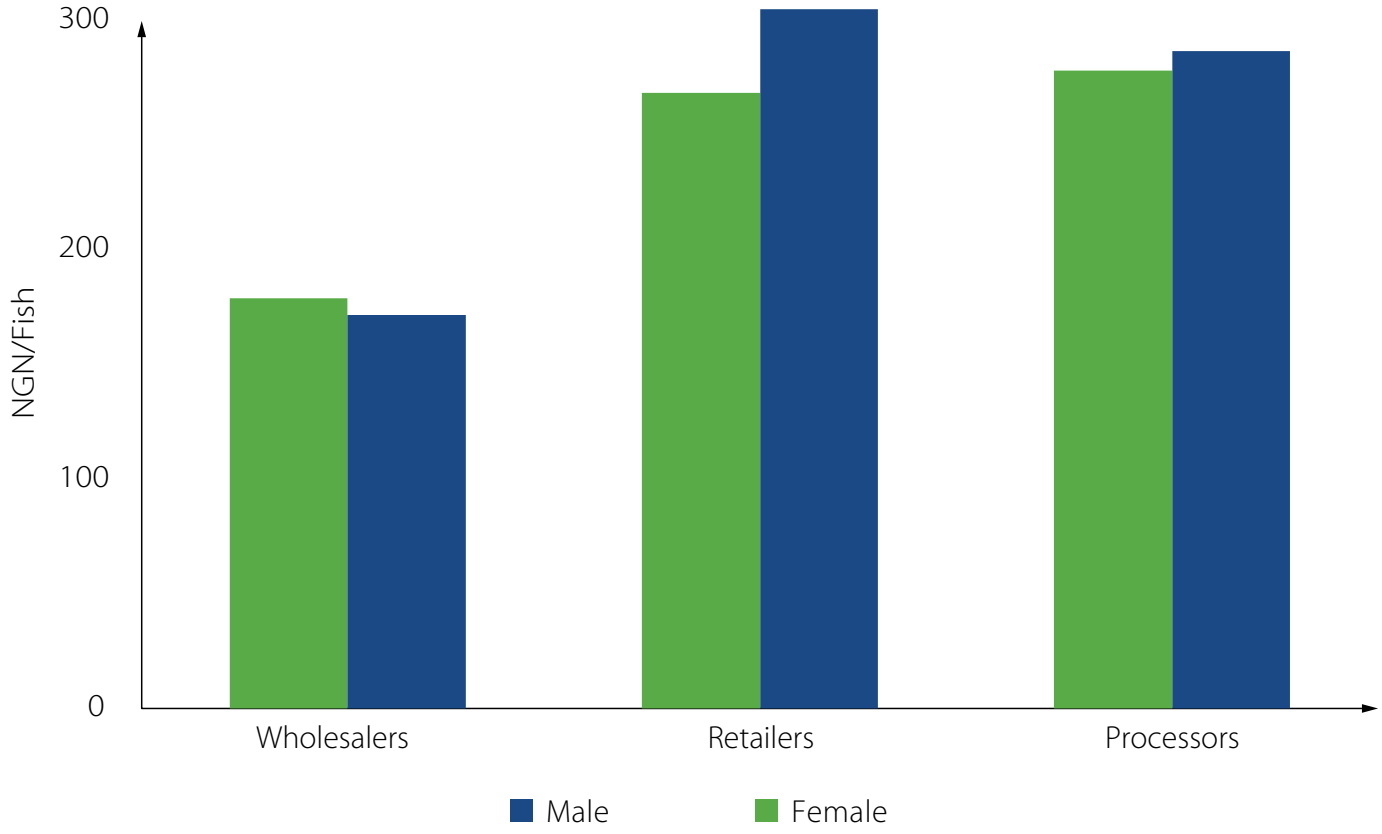
3.9.2. Gender and inclusiveness

In general, fish processors, followed by retailers and wholesalers, generate the highest value per fish traded throughout the value chains. Male value chain actors make a higher profit per fish at the processor (NGN 287) and retailer (NGN 305) levels than their female counterparts (NGN 278 for processors and NGN 269 for retailers). In contrast, female wholesalers make more profit per fish (NGN 179) than male wholesalers (NGN 172) (Figure 11).

The age of chain actors engaged in fish value chain activities in Nigeria ranged from less than 18 to more than 45 years old. The performance of age disaggregated value chain actors shows that almost all value chain actors (regardless of gender and age) make positive profit, except value chain actors aged 18 to 25 at the wholesaler level (Figure 12).

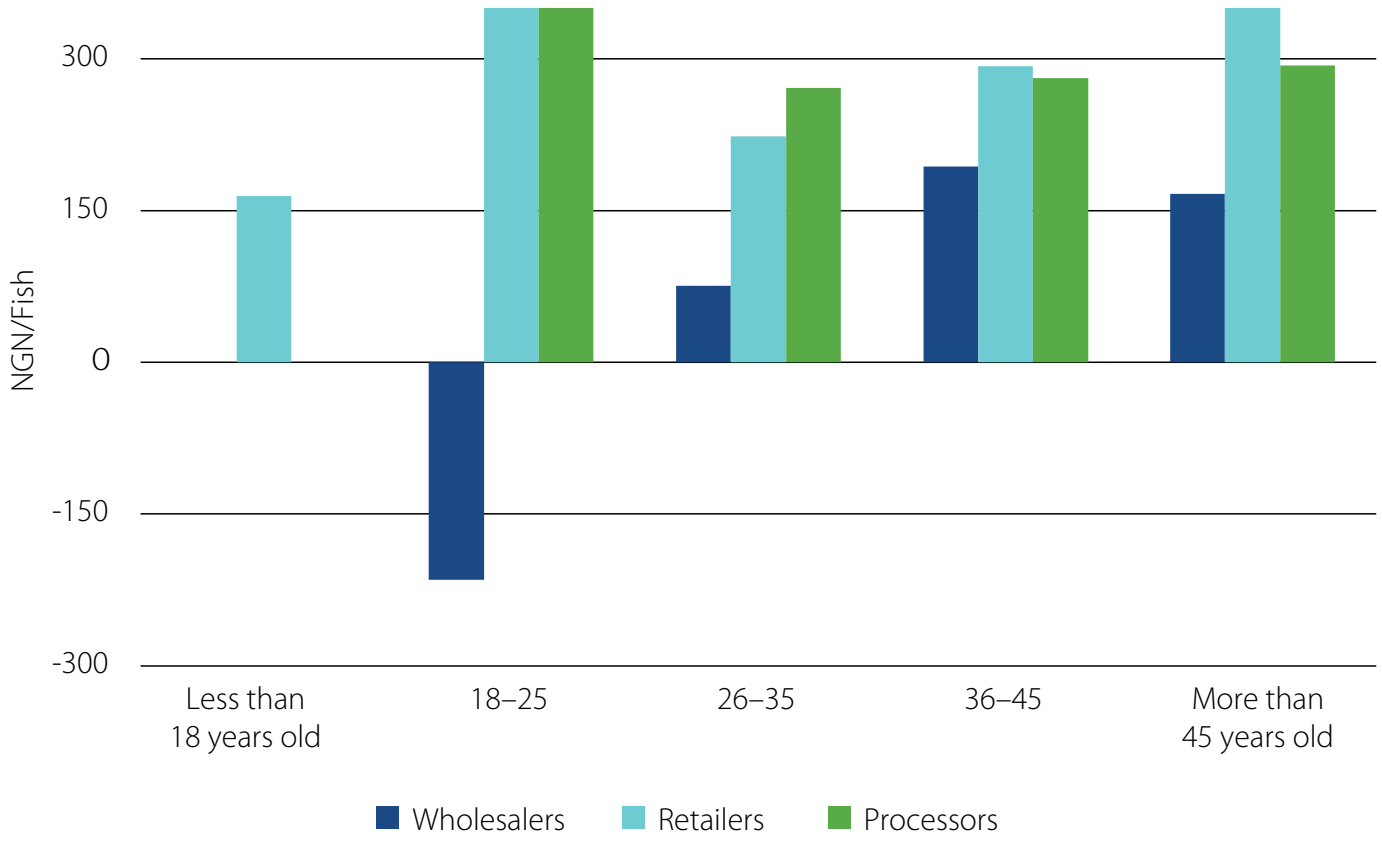
Tables 15 and 16 show gender and age disaggregated average and median profit generated per value chain actor across different fish products. On average (both means and median), most chain actors, regardless of gender and age group, who engaged in fish value chains made a profit, except for the age group 18–25 at the wholesaler level. Our data distribution is once again skewed, because a few value chain actors made very high positive or negative profits, radically affecting mean values. Median profits are thus considered the more appropriate indicator of average profits (Tables 15 and 16).

Although women are actively engaged in different value chain segments, businesses owned by women are smaller in size (based on profit) than those of their male counterparts, especially at the processor and retailer levels. This could be because of a lack of access to capital and business



Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Figure 11. Gender disaggregated profit per fish per value chain actor.



Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Figure 12. Age disaggregated profit per fish per value chain actor.

Sex	N	Average profit (NGN)	Median profit (NGN)	SD profit (NGN)
A. Wholesalers				
Female	105	336,180	160,955	540,629
Male	152	2,713,876	115,095	16,005,546
B. Retailers				
Female	169	210,743	46,696	582,486
Male	75	1,460,689	496,500	2,397,717
C. Processors				
Female	99	126,709	84,900	4,315,886
Male	149	1,310,934	184,798	3,191,341

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 15. Profit for gender disaggregated value chain actors.

Age category	N	Average profit (NGN)	Median profit (NGN)	SD profit (NGN)
A. Wholesalers				
18–25	3	-329,401	-17,967	765,673
26–35	38	379,808	61,105	2,569,256
36–45	100	2,437,780	190,603	15,822,908
More than 45 years old	116	1,642,979	116,539	10,994,017
B. Retailers				
18–25	11	380,389	179,896	712,859
26–35	63	719,549	91,688	1,219,460
36–45	93	514,181	73,205	1,565,986
More than 45 years old	76	628,835	49,497	1,782,175
C. Processors				
18–25	8	1,528,405	541,845	2,836,005
26–35	58	898,348	89,478	3,126,884
36–45	62	1,491,486	188,565	3,434,341
More than 45 years old	85	614,560	102,813	1,546,783

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 16. Profit for age disaggregated value chain actors.

development and technical knowledge. In general, women played important roles across the value chain in all surveyed states, except Kano, where men dominate almost all value chain activities, possibly because of cultural and religious differences. Youths are actively engaged across all segments of aquaculture value chains.

3.9.3. Environmental performance

We use fish transportation mode and transportation time to measure post-farmgate environmental performance. Modes of transportation are given in Table 17. The results seem to indicate that post-farmgate value chain actors prefer non-motorized means to reduce operational costs and/or that the majority transport fish for short distances across the value chain. It also indicates that most trading and marketing are local in nature because of a lack of cold storage transportation.

The average times taken for different fish products moving between value chain actors or to consumers are given in Table 18. The low average transportation times are consistent with the fact that fish are sold fresh. However, examples

Mode of transportation	Wholesalers (%)	Retailers (%)	Processors (%)
Headload	1.1	3.1	1.7
Bicycle	0	0.4	0.4
Motorcycle	17	21.1	15.2
Ox-cart	0	0	0
Boat	1.9	0.8	0
Car/truck	37.1	17.6	23.2
Public transportation	0	1.2	0
Wheelbarrow	34.5	40.2	48.5
Rickshaw/three-wheeler (not motorized)	0.4	0	0.4
Auto rickshaw/three-wheeler (motorized)	8	15.6	10.1
Other	0	0	0.4

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 17. Mode of fish transportation post-farmgate.

Type of fish	Wholesalers	Retailers	Processors
Fresh tilapia	1.63	1.23	1.38
Frozen tilapia	1	0.16	1.5
Smoked tilapia	0.75	1.31	1.33
Fresh catfish	2.08	1.58	1.89
Dried catfish	3	1.62	1.58
Smoked catfish	1.19	0.84	1.39

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 18. Transportation time (hours) per value chain actor.

of transportation times of up to 24 hours were also noted on occasion, potentially making food unsafe for human consumption because of a lack of appropriate storage (including cold storage) facilities (Dizyee et al. 2021).

3.9.4. Fish transportation, processing and food safety

Storage and transportation times varied with fish product type. The lack of a cold chain forces chain actors to buy and sell fish in a short time frame to minimize losses. In Nigeria, fish is preferably traded fresh. However, small fish (less than 300 g) or unsold fresh fish (larger than 300 g) are processed to preserve them and avoid spoilage losses.

Catfish are mostly transported alive along the value chain (99 percent), as consumers prefer to buy it live. Tilapia are moved along the value chain either on ice (38 percent) or using other means (43 percent), and they are predominately (84 percent) transported after having been killed. Value chain actors transported less than a sixth (15 percent) of catfish using other storage modes. Processed fish is mainly transported in bags without water or ice. Transportation times vary greatly, but the vast majority of fish products takes less than 4 hours to move along the value chain. Food safety measures are not consistently practiced.

Basic storage, long transportation times and the fact that most value chain actors (65 percent) did not use closed or sealed containers to transport fish potentially exposes fish to environmental contaminants and food safety issues. Over half (56 percent) of the value chain actors monitored water and fish temperature at some point during fish transportation and storage. However, temperature checks are done by hand rather than with a thermometer. Although chain actors use simple transportation and storage techniques, fish losses are minimal. Household wastes too are minimal, as all parts of fish are consumed or otherwise used (Dizyee et al. 2021).

Some post-harvest fish handling practices are also non-hygienic, a further source of possible contamination. About 12 percent of value chain actors did not have access to toilets, and 6 percent had no access to clean water (Table 19). The majority of value chain actors (76 percent) did not use gloves while handling fish, and some 34 percent of them did not clean their hands prior to handling fish. There are thus risks that unhygienic post-farmgate fish handling practices compromise the nutritional benefits of consuming fish. Investment strategies to improve post-farmgate fish handling practices are likely to generate substantial food safety and hygiene benefits.

3.10. Key messages

- Five key value chains operate in Nigeria to supply fish to consumers: fresh catfish, fresh tilapia, smoked catfish, dried catfish and smoked tilapia. In the post-farmgate value chain, fish move through up to three main value chain actors (wholesalers, retailers and processors) before reaching consumers.

	Are there toilets available at your worksite?		Is there access to clean water at your worksite?		Do you practice hand washing?		Does you use gloves?	
	N	%	N	%	N	%	N	%
Yes	547	78	615	88	422	60	111	16
No	81	12	43	6	239	34	534	76
Sometimes	76	11	43	6	42	6	58	8
Don't know	-	-	1	0	1	0	1	0
Total	**704**	**100**	**702**	**100**	**704**	**100**	**704**	**100**

Source: WorldFish/BMGF fish value chain assessment 2019 (Dizyee et al. 2021).

Table 19. Post-harvest fish handling sanitation practices.

- In general, fish value chains are economically profitable and inclusive, as women and youths own over 50 percent of post-farmgate value chain activities. Investments to enhance fish value chains are likely to generate not only additional profit to value chain actors and the wider economy but also benefits to different chain actor groups (men, women, youths).
- Fish in Nigeria is mostly sold fresh due to a lack of cold chains. Nevertheless, no substantial fish spoilage or losses occur, as value chain actors smoke or dry unsold fresh fish. Although fish is preferably traded fresh, processed fish products are common and highly profitable. Cold chains would improve fish value chains in Nigeria, increasing access to fish among rural poor communities.
- Fish value chains in Nigeria are generally short and localized. Fresh fish is often transported by unmotorized modes of transportation, moving along value chains within hours of harvest. If fish cannot be sold within the day of harvest, it is generally smoked to avoid spoilage.
- Fish value chains in Nigeria are economically viable, with over 80 percent of post-farmgate value chain actors making a profit. The weakest point in the value chain is at the wholesale level, where profit margins are lowest. Overall, most value chain actors regardless of gender and age group reported healthy profit margins.
- Women and youths (less than 35 years old) are actively engaged in fish value chains. About 50 percent of post-farmgate value chain activities (processing, wholesaling and retailing) are controlled (owned) by women, of which 35 percent are youths. Women chain actors, like their male counterparts, derived profit from their aquaculture businesses. In general, women dominate fish retailing, while men are more engaged in wholesaling. An exception is Kano State in northern Nigeria, where women play a marginal role along fish value chains, possibly for cultural and religious reasons.
- Although short value chains help keep fish fresh and reduce transaction costs, they limit availability in inland areas. A cost-benefit assessment should be carried out regarding the development of long chains (e.g. cold chains) to facilitate fish reaching regions remote from coastal and aquaculture production zones.
- Inadequate post-farmgate handling practices (e.g. not washing hands and/or wearing gloves prior to handling fish), use of inappropriate packaging, unsealed transportation containers and a lack of refrigerated transportation, especially when combined with adverse environment conditions (e.g. high heat and humidity) along the value chain, are likely to compromise the nutrition benefits of consuming fish.
- Policy strategies that aim to develop, promote and impose food safety standards (e.g. using gloves, washing hands, using sealed containers to transport fish) would improve food safety and consumer well-being.
- Fish processing is mostly ad hoc. Chain actors use rudimentary, unstandardized techniques with regard to fish smoking or drying times, which can compromise fish quality. Investment plans targeted at improving fish processing and transportation technologies would enhance fish quality and food safety standards along the value chain.
- Access to capital is limited, which inhibits chain actors from investing in technologies to improve post-farmgate fish handling standards. Access to capital through credit and/or grant systems to invest in fish production, processing and transportation technologies is seen as key to unlocking the potential of aquaculture value chains in Nigeria.

4. Gender, women, youths and children

Gender is a concept that deals with the roles and relationships between women and men that are determined by social, political and economic contexts—not by biology. Unequal power relations between women and men in many cultures mean that women are disadvantaged in terms of their control over resources and their access to services as well as in their ability to take advantage of new opportunities and deal with ongoing changes affecting their lives (FAO 2008). Gender policies are needed to address these issues.

4.1. Gender in agriculture policy in Nigeria

Nigerian women play important roles in food and agriculture. It is reported that smallholder women farmers constitute 70–80 percent of the agriculture labor force. They produce the bulk of food for domestic consumption, and they are the drivers of food processing, marketing and preservation. Women also make a significant contribution to the nutritional needs of the family. Despite their significant contribution to national food security, however, women received no formal recognition by way of a policy announcement to encourage, protect and facilitate their access to inputs and services until 1986. That was when the government developed a policy directive to establish the Women in Agriculture (WIA) component of ADPs, which were responsible for grassroots extension and advisory services in all states of Nigeria (FAO and ECOWAS 2018). As stated in FAO and ECOWAS (2018), the overall goal of the WIA policy was the integration of women into the nation's total agricultural development (by mainstreaming them into the ADP system) to enable them to have equal access to agricultural inputs, credit, loans and extension services. The premise of this policy was that the successful integration of women into the ADP system would significantly increase their productivity, raise their incomes, improve their quality of life and make a significant contribution to the nation's overall agricultural development. However, the political will to back the policy with appropriate legislation was not realized (FAO and ECOWAS 2018).

Despite the contributions women make to the agriculture sector, in most communities they have limited access to land, credit facilities, farm inputs, training and advice, and technology and crop insurance, among other things. The limited access to credit facilities hinders them from purchasing inputs and hiring labor, forcing women instead to depend on family labor. There is no policy to provide for women's access to land and production inputs, which are major determinants of successful agricultural production and poverty alleviation (FAO and ECOWAS 2018).

4.2. Women's participation in aquaculture in Nigeria

Participation of women in aquaculture in Nigeria is increasing, which contributes to household food security (Olufayo 2012). The gender roles of women in fisheries and aquaculture production are recognized in three stages of production: fishing, processing and marketing (FAO and ECOWAS 2018). In coastal wetland communities, women are closely involved in artisanal fishing activities, including unloading fish from canoes as well as fish processing and marketing. Processing is the most common activity for women engaged in fisheries in the Lake Kainji area, which involves about 60 percent of all women (Nwabeze et al. 2013). Women also contribute significantly to the artisanal fisheries sector, especially through small-scale village-based commercial activities, and their increased participation is attributable to the growing commercialization of non-finfish species, especially shellfish (Olufayo 2012). Despite the important role that they play, women have received little recognition, and the social, economic and political indicators all show that women's status is very low in this sector (FAO and ECOWAS 2018). As a result, there is a strong need to provide incentives to women in Nigerian fish production if their contribution to producing this valuable source of quality animal protein is to be optimized (Olufayo 2012).

Women also have poor access to finance, which must be addressed if their potential is to be realized. Men predominate in fish seed production, artisanal fishing, processing and storage and marketing, in that order (FAO and

ECOWAS 2018). For women, the major activities are processing and marketing. Their role in fishing is limited to loading and offloading fish from canoes. Traditional practices, beliefs and laws, including male dominance and forbidding women from fishing at night, hinder women's participation in some value chain activities. Local laws perceived to be harmful to women are also in force in some states. The roles of women are somewhat unconnected with socioeconomic characteristics, as can be seen from their greater participation in post-harvest value chain nodes (Benson 2018). Nevertheless, the gender division of labor has dichotomized the benefits of women and men in the subsector, with women generally being disadvantaged (FAO and ECOWAS 2018).

Although men dominate the pre-harvest fish value chain, women play an important role in the post-harvest value chain, especially in processing and retailing. Our survey found that 38 percent of women decide for themselves what to do with their own earnings, while 47 percent decide together with their spouses. Of their partner's earnings, 43 percent decide what to do with the money together. These findings are largely in agreement with national level surveys, which also report an improvement in women's decision-making power. While these findings are encouraging, women in Nigeria still have a long way to go to achieve equity, as evidenced in part by lower employment levels and beliefs around women's rights. However, the government has made it a priority to increase gender equity in Nigeria. As it continues to grow, the growth of the aquaculture sector must be inclusive to assist the government with this goal. Women are less organized into societies/clusters along the fish value chain than men. Access to finance is a significant issue for both men and women. Considering all the positive indicators, developing and implementing strategies to expand women's involvement in Nigerian fish value chain seems promising.

Photo credit: Brianna Bradley/WorldFish

Retailer selling smoke-dried catfish and freshwater small pelagic fish in Ilora Town, Oyo State, Nigeria.

5. Policy and governance

The Nigerian aquaculture sector has experienced significant growth in the past 20 years. As a result, the country has become the second-largest producer of farmed fish in Africa, second only to Egypt, which exports much of its fish to Nigeria. Despite this, numerous challenges exist to aquaculture development, requiring a strategic approach to realize the sector's potential. A review of current policies, regulations, legislation and institutional arrangements for the aquaculture sector was undertaken to determine where changes could be made to support future aquaculture development consistent with national priorities.

A number policies in Nigeria refer to working with the private sector to create an enabling environment for the development of aquaculture in order to close the fish demand-supply gap. The most recent policy and development strategies include the Nigerian Vision 2020, the Agricultural Transformation Agenda (ATA) 2011, the Agriculture Promotion Policy (APP) 2016 and the National Aquaculture Development Plan (NADP) 2011. Nigeria Vision 2020 envisaged increasing domestic agricultural productivity, reducing current levels of food imports, reducing post-harvest losses of agricultural produce and adopting improved varieties/species of seed and broodstock for livestock and fisheries. As laudable as the ATA was, there were notable constraints to the full realization of targets in the Fish Transformation Plan. Nevertheless, there were also some notable achievements: moderate increases in aquaculture productions (from 21,700 t in 1999 to 316,700 t in 2015), development of value-added products and marketing of products through value chain development.

The NADP identified high potential aquaculture zones to guide investors and also identified an appropriate framework for aquaculture outreach to enhance adoption through awareness creation. Unfortunately, the plan for monitoring and evaluation of the NADP was not implemented, which would have allowed for assessment of the plan's performance.

Under the current APP, aquaculture is one of the industry sectors prioritized for domestic and export markets. The APP focuses on solving the core issues at the heart of both limited food production and delivery of food with good quality standards. It has three themes: productivity enhancements, attracting private sector investment and institutional realignment. Constraints were highlighted and policy initiatives were elaborated to tackle each theme. Emerging issues from each theme were prioritized, with costing and implementation schedules for 2016–2020. APP policy instruments were focused on the key principles that promote private sector business inclusiveness.

The Inland Fisheries Act brought to focus the procedures that must be complied with to scale up fisheries and aquaculture through good aquaculture practices and better fisheries management. Detailed requirements and explanations are given in the act of what the aquaculture sector is required to do to conform to international standards for traceability and certification.

It is recognized at the government level, both nationally and in all six geopolitical zones, that fish is a commodity of primary focus and that aquaculture is the best means of bridging the wide gap between latent demand and local production. One of the government's inclusive business development initiatives that has impacted agriculture, including fisheries and aquaculture, is the ABP, established by the Central Bank of Nigeria (CBN) in 2015, to create links between anchor companies involved in processing and smallholder farmers producing key agricultural commodities.

Multisector initiatives from various sectors have produced policies and strategies that touch on agriculture and fisheries perspectives within their mandates: industry, trade, economy, science and technology, health, education and nutrition.

On the impacts of the current policy, frameworks and control mechanisms on inclusive business development, the analysis shows that the

principles of the current ABP effectively accommodate the five pillars of inclusive business and are applicable to aquaculture development. (See also Kaminski et al. 2020.)

5.1. Relevant public policies

Some sections of the National Water Resources Policy (NWRP) 2016 are of direct relevance to fisheries and aquaculture. Comparative water demand estimates for 2010 and 2030 by sector show that annual demand by aquaculture is expected to increase from 728 million m^3 to 1.166 billion m^3. The NWRP postulated strategies to improve the benefits to fisheries through better water management, as well as addressing issues associated with transboundary water resources, dams and reservoirs.

The Land Use Act makes it difficult for investors to acquire land for aquaculture. The bureaucratic processes involved in land allocation are reportedly cumbersome, though several states are trying to simplify the process of land allocation and the issuance of Certificates of Occupancy.

The Revised National Policy on the Environment (2016) addresses environmental protection and the conservation of natural resources for sustainable development. Sections of the policy relevant to fisheries and aquaculture include freshwater and wetland ecosystems, coastal and marine ecosystems, fisheries and transboundary water resources.

The Nigeria Public Private Partnership Policy (2016) sets out the steps that government will take to ensure that private investment is used, where appropriate, to address infrastructure deficits and improve public services in a sustainable way. In line with government commitment to transparency and accountability, the transfer of responsibility to the private sector will follow best international practice and will be achieved through open competition. By implication, a sound operational public-private partnership (PPP) policy should provide a conducive business environment for investors in all sections of the economy, including aquaculture.

5.2. Regulatory framework

The acts specifically governing the aquaculture sector are the Fisheries Act of the Federal Republic of Nigeria (2014) and the Inland Fisheries-Aquaculture Regulations (2017). Regulations governing establishment and operation of aquaculture farms are detailed in the former. The Inland Fisheries (Aquaculture) Regulations empowered the Federal Department of Fisheries and Aquaculture (FDFA) as the competent authority to implement the regulation. Detailed requirements and explanations are given in the Inland Fisheries Act on the official control programs (for value chain activities) to conform to good aquaculture practices and international standards for traceability and certification.

None of the regulations mentions the issue of land acquisition for aquaculture. Indeed, some aspects of land law hinder its development. It is remarkable that aquaculture has reached its present state of development in an almost complete legal vacuum, in which even basic land law offers little security. Access to water was not mentioned in any fisheries legislation except for restrictions placed on cage and pen installations in bodies of water used for domestic water supply. However, the water use policy that is contained in the National Water Resource Policy (2016) mandates that water resource management respects the water requirements of self-sufficiency in fish production.

The registration and approval process for fish farming is clearly elaborated in Part II of the Inland Fisheries (Aquaculture) Regulations, as well as environmental guidelines and assessments, aquatic animal health regulations, waste disposal, pollution control, environmental standards, food safety, sanitary and phytosanitary controls (Table 20).

5.3. Organizational arrangement for fisheries and aquaculture

Organizational arrangements at both federal and state levels for the fisheries and aquaculture sector were reviewed. Broadly speaking, they provide an enabling environment for the growth of the aquaculture industry, despite challenges. Administrative, planning and regulatory duties are within the purview of the FDFA and Departments of Fisheries in the states (including the Federal Capital Territory) on all matters of fisheries policies, regulation and administration. The Nigerian Agricultural Quarantine Service (NAQS) supervises, regulates and controls the import and export of aquatic resources by quality assessment and certification through the Aquatic Resources Quarantine Department.

Policy	Purpose	Direction/Influence on aquaculture
National policies		
Nigerian Vision 2020 (2009–2020)	Achieve a three-fold increase in domestic agricultural productivity by 2015 and a six-fold increase by 2020; reduce present levels of food imports 50 percent by 2015 and 90 percent in 2020; reduce post-harvest losses of agricultural produce 50 percent by 2015 and 90 percent by 2020; increase adoption of improved varieties/ species of seed and broodstock (livestock and fisheries) to 50 percent of farmers by 2015 and 75 percent by 2020.	Emphasis is on species diversification, broodstock management and genetic improvement; improved quality seed supply in aquaculture has been identified in the vision.
Agriculture Promotion Policy 2016	Solve the core issues at the heart of limited food production and delivery of quality standards. Focus policy instruments on the key principles that promote private sector business inclusiveness.	The policy thrust is to (a) enhance fish breeding, (b) enhance traceability, (c) increase the availability of fishery/ aquaculture inputs by promoting hatchery development, and standardization of hatchery and fish breeding processes, and (d) reduce insecurity in fisheries areas.
Agricultural Transformation Agenda 2011	Create a hunger-free Nigeria through an agricultural sector that drives income growth, accelerates achievements in food and nutrition security, generates employment, and transforms the country into a leading player in global food markets to grow wealth for millions of farmers.	Create an enabling environment for the increased and sustainable production of over 1.25 billion fish seed, 400,000 t of fish feeds and 1 million metric tons of aquaculture fish, and generate 500,000 jobs within 5 years.
National Agricultural Extension and Advisory Services Policy (AEAS) for Nigeria 2017	A legislated, knowledge-based, pluralistic, participatory demand-driven, market-oriented, ICT-enabled agricultural extension and advisory service system, catering to a variety of actors along targeted value chains of priority interest to the government (value chain approach).	Ensure a well-coordinated institutional and organizational framework at federal, state and local government levels for effective and efficient extension services delivery for all smallholder producers and value chain actors.
National Water Policy (2016)	Improve management and control of water resources to optimize the use of Nigeria's water resources at all times and for present generations to live in harmony with environmental requirements without compromising the existence of future generations.	Ensure that water resource management respects the requirements of self-sufficiency in fish production; ensure that newly planned dams guarantee and respect the requirements of self-sufficiency in fish production; ensure that self-sufficiency in fish production is possible through appropriate water resource development.
Land Resource Policy 2004	Rehabilitate areas affected by drought, desert encroachment, soil erosion and flooding, and prevent the spread of natural disasters to other areas through effective protection measures.	The federal and state governments are to produce regional land use maps to help provide land to individuals, commercial farmers and other entrepreneurs in such a way that peasant farmers will be catered for.
Land Use Policy 2013	Harmonize the various land tenure regimes for ease of control and administration.	It aims to address difficulties investors face in acquiring land for aquaculture investment.
Nigeria National Policy on Public Private Partnerships, 2016	Ensure that private investment is used, where appropriate, to address the infrastructure deficit and improve public services in a sustainable way.	In line with the government's commitment to transparency and accountability, transfer responsibility to the private sector and provide a conducive business environment for investors in all sections of the economy, including aquaculture.

Policy	Purpose	Direction/Influence on aquaculture
Regional policies		
Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (PFRS) 2014	Catalyze the transformation of Africa's fisheries and aquaculture for food, livelihoods and wealth.	Make explicit essential guiding principles for good governance of Africa's fisheries and aquaculture for increased coherence and coordination of the sector.
Union Guide for Developing and Implementing Public-Private Partnership (PPP) Models for Sustainable Fisheries and Aquaculture Development in Africa, 2019	Provide guidance for the development and implementation of PPP projects in fisheries and aquaculture by African Union member states within the context of the PFRS, with a view to enhancing increased and sustainable returns from the sector.	PPPs have been identified as an effective strategy for development of fisheries and aquaculture in Africa.
National Aquaculture Development Plan (NADP) 2011–2014	Develop sustainable aquaculture that achieves the overall objectives of sustainable and profitable aquaculture businesses through the growth of small and medium enterprises, as well as creating opportunities for large-scale investors.	High potential aquaculture zones will guide investors; the development and implementation of an appropriate framework for aquaculture outreach will enhance adoption through awareness creation.
Regulatory framework		
Fisheries Act of the Federal Republic of Nigeria 2014	It focuses on conservation, management and development of sea fisheries, inland fisheries and aquaculture, as well as related matters.	Delegate the relevant aquaculture authority to specify conditions relating to the establishment or operation of aquaculture, including conditions or requirements.
Inland Fisheries Act of 2017	Official control programs must be adopted for conforming with good aquaculture practices and international standards for traceability and certification.	Regulate registration and development of aquaculture and processing facilities and operation; enforce aquatic animal health and waste disposal and pollution control regulations; implement sanitary and phytosanitary program for aquaculture.
Land Use Act of 1978 & 2004	Place the ownership, management and control of land in each state of the federation under control of state governors.	Land for commercial, agricultural and other purposes is allocated by state governors.
Water Resources Act 2004	Develop and improve the quantity and quality of water resources.	Provide authority to make pollution prevention plans and regulations for the protection of fisheries, flora and fauna.
Environmental Impact Assessment Act 2004	Consider the environmental impacts of public and private sector projects.	It requires an assessment of public or private sector projects likely to have a significant (negative) impact on the environment.

Source: WorldFish/BMGF study 2019.

Table 20. The main policies, plans and regulations relevant to aquaculture.

Two research institutes have responsibilities for fisheries and aquaculture research and development in Nigeria: the Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos, and the National Institute for Freshwater Fisheries Research (NIFFR). The former covers all research on marine and brackish water aquatic resources and oceanographic research, training and development, while the latter has the national mandate for inland water fisheries and aquaculture research, training and development.

Nigerian educational institutions produce professionals of all levels. Fifty-six (34 percent) of the 164 universities (federal, state and private) offer degree programs in fisheries and aquaculture. Diploma programs in fisheries technology are offered by 9 (11 percent) of the 79 polytechnics in the country. With 29 federal universities, 24 state universities and 3 private universities, Nigeria has good higher education capacity across all 36 states. Thirteen (46 percent) of the 28 government-owned agricultural monotechnics in the country offer diploma and vocational programs in fisheries technology, three of which are specialized fisheries colleges, executing the training mandates of their respective institutes.

Institutional arrangements for fisheries extension include the Federal Department of Agricultural Extension (FDAE), which formulates policy and oversees, monitors and provides the leadership for efficient and effective agricultural extension and advisory service delivery. The FDFA has the responsibility of working with relevant federal- and state-based extension agencies to accelerate adoption of research findings in all aspects of fisheries to attain the national goal of self-sufficiency in fish production. The National Agricultural Extension and Research Liaison Services (NAERLS) disseminate proven and relevant agricultural research findings from research institutions through print and electronic media to the whole country to boost food production. The extension and socioeconomic departments of fisheries research institutes, the departments of fisheries and agricultural extension in universities, and the multistate ADPs (with the responsibility for grassroots extension delivery) all contribute to extension services in fisheries and aquaculture.

Availability and access to credit by value chain actors and stakeholders is important for the development of the nation's aquaculture sector. The CBN through the ABP creates economic links between smallholder farmers and reputable large-scale processors with a view to increasing agricultural output and significantly improving capacity use of processors. Fisheries and aquaculture is among the prioritized agricultural commodities of the ABP.

The Bank of Agriculture provides agricultural credit support to all agricultural value chain activities, while the Bank of Industry provides financial assistance for the establishment of large, medium and small projects, as well as the expansion, diversification and modernization of existing enterprises, especially through the Food and Agro-Commodity Processing Scheme and the Graduate Entrepreneurship Fund (GEF). Other key players in the financial sector financing fisheries projects include other commercial and microfinance banks.

Non-state actors in fisheries in Nigeria are well established with legal backing. Some have strong participation of women and youths, who play important roles in developing and scaling-up best practices in aquaculture. Major non-state actors in fisheries and aquaculture in Nigeria include the Fisheries Society of Nigeria, the Catfish and Allied Farmers Association of Nigeria, the Tilapia Aquaculture Developers Association of Nigeria, the Nigerian Association of Fisheries Scientists and the recently formed National Fisheries Association of Nigeria. Numerous associations, cooperatives and farmer-based organizations are also active at local levels.

Provision of professional, technical and artisanal personnel needs in the fisheries and aquaculture industry in Nigeria are largely skewed toward public institutions. Only five (4 percent) of the 116 private institutions offer a certificate, diploma or degree in fisheries technology. However, some entrepreneurial centers are registered with the National Board for Technical Education to offer short training on aspects of agriculture in the country.

The Nigerian fish market is competitive, with no restriction to entry, especially in trading small-scale fish catches. However, the capital requirement in frozen fish marketing limits smallholder engagement in the value chain. With the growth of the aquaculture industry in

recent years, marketing is becoming increasingly important. Key issues in marketing aquaculture produce include price instability, lack of a price information system, intermediaries, limited product variety, a weak cold chain structure and dispersed rather than clustered operations.

The current organizational structures at federal and state level are judged to effectively help foster an enabling environment for the growth of aquaculture, despite ongoing challenges.

The purpose of the regulatory institutions and their influencing areas are summarized in Table 21.

5.4. Human resource capacity in fisheries and aquaculture

Nigeria has the largest array of seasoned fisheries professionals, experts, industrialists and entrepreneurs in sub-Saharan Africa. It has two federal research institutes, the NIOMR and NIFFR, with clearly defined national mandates in fisheries and aquaculture. Personnel development is taken care of strategically in all universities of agriculture, universities of technology and faculties of agriculture in non-specialized universities at the federal and state levels (including private universities), offering fisheries courses at undergraduate and post-graduate levels. Nigerian education institutions have produced an abundance of trained personnel that can serve the aquaculture industry. However, economic factors have led to non-engagement of this pool of qualified technical staff in public institutions, despite the poor staffing situation in most of the establishments.

Fisheries and aquaculture extension services in Nigeria are largely moribund, as in the other agriculture sectors. Fisheries extension specialists, subject matter specialists and fisheries technical officers are inadequate in NAERLS, the AERLS of research institutes and the ADPs. Due to aging and staff retirement, especially at the state ADPs, the average ratio of extension staff to farm families in Nigeria is 1:4000 compared with FAO's recommendation of 1:800.

Education in Nigeria's fisheries subsector requires a thorough needs assessment survey to determine where the demand for skilled human resources lies and which skills are required by the different components, especially aquaculture. Without such a study, the institutions currently involved will likely continue to run courses for the sake of training, with little regard to future employment. The capacity strengthening needs of research and education institutions need to be thoroughly assessed. Like the universities, the research institutes suffer from inadequate funding to execute research, a lack of infrastructure and equipment and insufficient personnel to cover research programs in the entire country due to restrictions on public service employment.

Education and training institutions need to become more practical and professional in their work and programs. There is a danger of further decline due to inadequate funding of research and training programs and because of institutions becoming irrelevant, impractical "ivory towers."

Dried crayfish being sold in a market in Ibadan, Oyo State, Nigeria.

Public sector	Institution	Function
Federal institutions		
Federal Ministry Agriculture & Rural Development	Federal Department of Fisheries & Aquaculture (FDFA)	Implement fisheries policies and regulations, and administer and work with state-based extension agencies to adopt research findings in fisheries to attain the national goal of self-sufficiency in fish production.
	Federal Department of Agricultural Extension (FDAE)	Formulate policy, and oversee, monitor and provide the leadership needed for an efficient and effective agricultural extension and advisory service.
	National Agricultural Extension and Research Liaison Services (NAERLS)	
	National Institute for Freshwater Fisheries Research (NIFFR)	Conduct inland water fisheries and aquaculture research, training and development.
	National Institute for Oceanography and Marine Research (NIOMR)	Manage marine and brackish water aquatic resources, and conduct oceanographic research, training and development.
	National Agricultural Quarantine Service (NAQS)	Disseminate proven agricultural research findings through print and electronic media to the whole country to boost food production.
Federal Ministry of Environment	National Environmental Standards and Regulation Enforcement Agency (NESREA)	Handle environmental protection, planning, pollution prevention and control, and set standards for effluent discharge.
Federal Ministry of Education	Universities	Produce professional high-level personnel required for the fisheries and aquaculture industry. A total of 56 out of 164 universities offer degrees in fisheries and aquaculture.
	Polytechnics and monotechnics	Produce mid-level personnel required for the fisheries and aquaculture industry.
Federal Ministry of Land, Housing and Urban Development		Delegate the ownership, management and control of land in each state of the federation with the governor. Land is allocated with the governor's authority for commercial, agricultural and other purposes.
State institutions		
State agencies	State Department of Agriculture	Manage ADP for grassroots extension delivery, which includes WIA.
	State Department of Fisheries	Manage fisheries policies, regulations and administration at the state level.
	State Environment Protection Agency	Deal with the considerations of environmental impact of public and private projects.
	State Ministry of Land and Surveys	The governor has the right to grant statutory rights of occupancy to land to any person for all purposes. If the applicant is content with acquiring customary rights of occupancy to the land, they can be acquired from local government.

Public sector	Institution	Function
Independent institutions		
Central Bank of Nigeria (CBN)	Bank of Agriculture	Provide agricultural credit support to all agricultural value chain activities. Create economic links between smallholder farmers and reputable large-scale processors under the ABP.
	Bank of Industries	Offer financial assistance for the establishment of large, medium and small projects, as well as the expansion, diversification and modernization of existing enterprises under the GEF.
	Commercial banks	Provide commercial loans for entrepreneurs and enterprises.
	Microfinance institutions	Provide microfinance for farmers and entrepreneurs.
Fisheries and fish farmers associations & professional societies		
	Fisheries Society of Nigeria (FISON)	It is Nigeria's apex non-governmental organization responsible for promoting and coordinating activities in the nation's fisheries research and development.
	Catfish and Allied Farmers Association of Nigeria (CAFFAN)	Increase fish farming production profitability, credit worthiness and scalability through competitive management and a cooperative approach.
	Tilapia Aquaculture Developers Association of Nigeria (TADAN)	Promote profitable tilapia farming business in Nigeria across the value chain.
	Association of Nigerian Fisheries Scientists (ANIFS)	Contribute to sustainable fish production, improved human nutrition, enhanced livelihoods and food security through research and development in the conservation, use and management of aquatic resources.
	National Fisheries Association of Nigeria (NFAN)	Facilitate the coming together of all stakeholders in the fish value chain, and work in synergy with a common interest to boost fisheries production in Nigeria.
	Cooperative farms	Reduce poverty and improve livelihoods and nutrition of the poor through increased aquaculture fish production in a sustainable manner.

Source: WorldFish/BMGF study 2019.

Table 21. Summary of the regulatory institutions and their mandate.

6. Nigeria beyond 2020

With a sizable and rapidly growing population, by 2023 Nigeria will have the second-largest public spending budget in sub-Saharan Africa, totaling USD 33 billion. The country's consumer class will grow from 36 million people in 2018 to 44.4 million in 2023. The scale of the market means the country will be crucially important for consumer-facing companies looking to grow their business in sub-Saharan Africa. State spending on infrastructure, property construction and procurement also provides opportunity (FSG 2020).

Without significant structural policy reforms, Nigeria's medium-term growth, pre-COVID-19, was projected to remain at about 2 percent per annum. Given that the economy is expected to grow more slowly than the population, living standards can only worsen. Growth is constrained by a weak macroeconomic framework with high persistent inflation, multiple exchange rate windows and forex restrictions, distortionary activities by the central bank, and a lack of revenue-driven fiscal consolidation results. Rising public debt and increasingly complex policy interventions by the central bank constrain private sector credit growth. External balances are fragile to hot money movements and fiscal buffers are exhausted, making Nigeria's economy vulnerable to external risks (World Bank 2019).

Although policymakers are encouraging diversification of the economy, the country is still heavily reliant on oil export earnings. Its fragile economic growth can be halted if oil prices drop significantly, which happened during 2020–2021 as a result of the COVID-19 outbreak.

With Nigeria's population growing at more than 3 percent per year, it is predicted that there will be 402 million people in Nigeria in 2050. Nigeria will continue to have weak governance, higher rates of poverty and income inequality—which will challenge more operating conditions—and a smaller public spending budget than economies of comparable size in other parts of the world.

Pre-COVID-19 projections by the United States Department of Agriculture are that Nigeria's economy will more than double by 2030, making it the first African country to reach USD 1 trillion GDP. In 2019, with an annual GDP of about USD 448 billion, Africa's largest economy is 27th in the world. By 2030, it is expected to climb to 19th, just ahead of the Netherlands.

The Nigerian government promotes agriculture and agri-business through schemes and platforms established for farmers. Many young people are taking advantage of the opportunities in the agriculture value chain, as can be seen in the success of youth employment in agriculture. Many innovations are being carried out in the agriculture sector, such as the use of drones, food processing, packaging, transportation and logistics, and marketing, especially by youths. Agriculture universities have an important role to play in linking research, innovations and technologies to farmers and the food and agriculture sector.

The COVID-19 pandemic is affecting the global economy and is impacting private sector-led businesses and smallholder productivity. Incomes will remain a question for some time. Prior to the pandemic, the Nigerian economy was predicted to continue to grow, albeit at a slower rate, and new government policy interventions and improvements to national agricultural productivity will be needed to feed the increasing population.

6.1. Future fish supply[14]

The WorldFish foresight model generated future fish supply and demand projections based on five scenarios, including a business-as-usual (BAU) scenario as well as the following four alternative scenarios: (1) Hicks-neutral technological progress, (2) a tax increase on imported fish, (3) climate change, and (4) an increase in capture fishery management. The BAU scenario is characterized by a set of model parameters to reflect a continuation of past trends into the future with adjustment to align projections with country capacities and endowments. The trends consider knowledge from published sources and feedback from country stakeholder consultations. Alternative scenarios were developed during a stakeholder consultation workshop to investigate the key prospects and challenges of Nigeria's

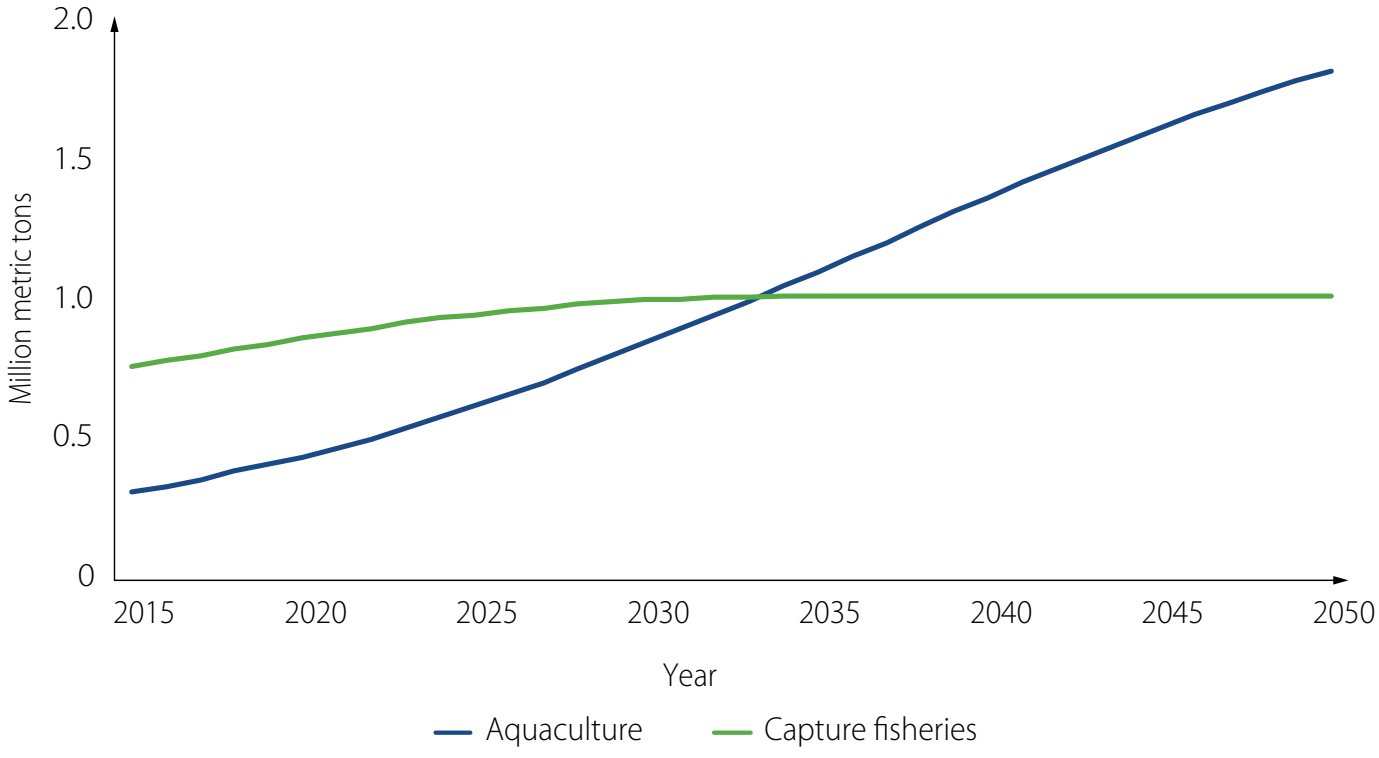
fish sector. The first scenario (Hicks-neutral technological progress) focuses on the overall improvement in aquaculture technology that could increase aquaculture production by 25 percent from 2020 to 2050. The second scenario (a tax increase on imported fish) investigates the impact of an increase in imported fish prices of 10 percent though an import tariff. The third scenario (climate change) assumes a 20 percent reduction of capture fisheries output by 2050 compared to 2015. The final scenario (an increase in capture fishery management) analyzes an increase of 1.5 percent per year from 2015 to 2050 because of stock enhancement and effective fisheries management.

If fish production in Nigeria continues under the same previous trends (BAU), total fish production (aquaculture and capture fisheries) is expected to increase up to 2.8 million metric tons by 2050. Aquaculture output is projected to increase by a factor of 4.5 between 2020 and 2050, from 330,000 t to 1.8 million metric tons. Since aquaculture will grow much faster than capture fisheries (6.3 percent vs. 1.1 percent during 2020–2035), aquaculture production will exceed total capture fisheries production (inland and marine) by the mid-2030s (Figure 13).

The production of all fish groups (catfish, tilapia, carps, Nile perch, snakeheads, clupeids,[15] shrimps and other fish) will increase over time, though at different growth rates (Figure 14). Since the growth of marine capture fisheries has been globally stagnant for several decades, growth in catches of species such as clupeids and shrimps in Nigeria would not be significant (Figure 14).

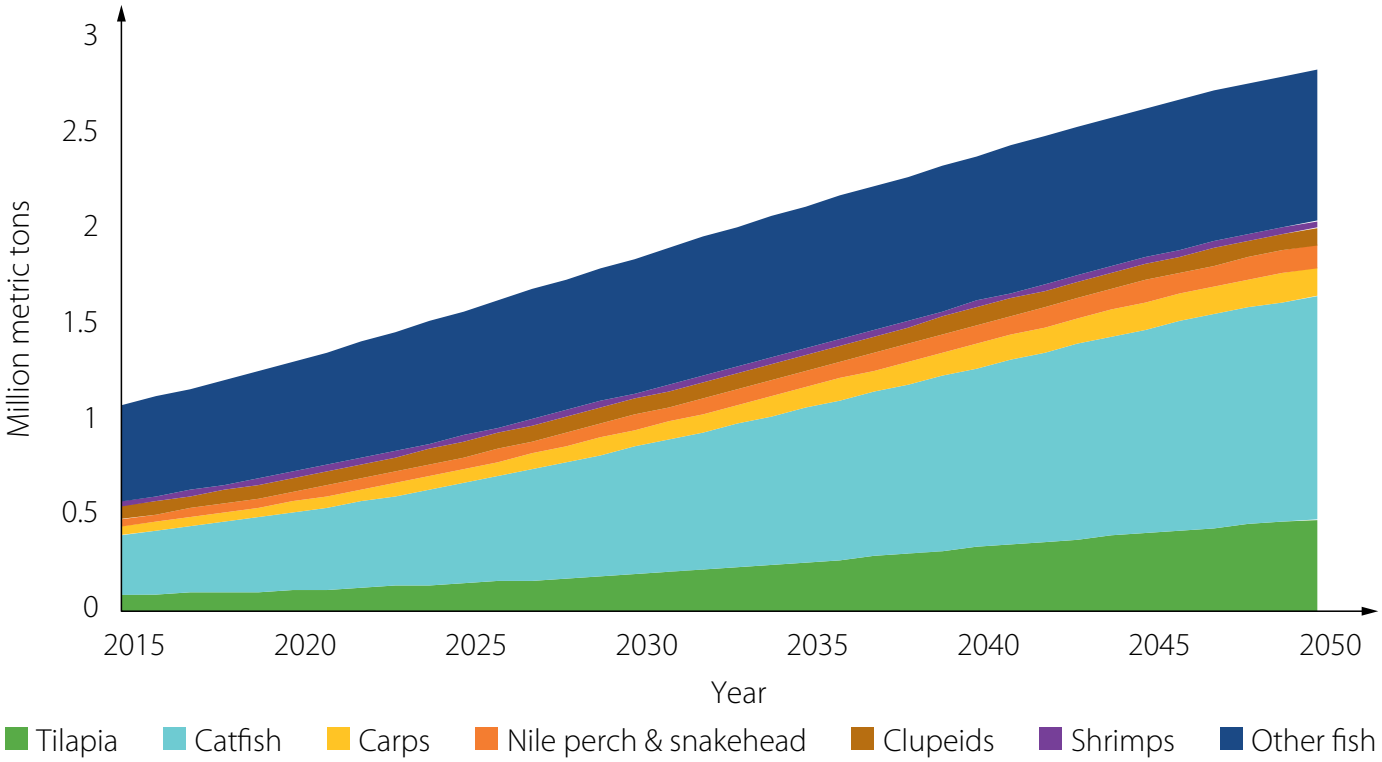
Economic and population growth (Frontier Strategy Group 2018) will increase fish consumption in Nigeria over time. Supply to bridge this demand gap should come from domestic production and imports. Changing the foreign exchange situation and depreciation of the Naira, together with government efforts toward reducing foreign exchange drain through food commodity imports, will have a negative impact on fish supplies and consumption. Past and future trends indicate that, even with government restrictions on fish imports (tax increase, etc.), including rising demand, fish imports (both legal and illegal) would continue in Nigeria, bridging the supply-demand gap.

Imports account for nearly half of Nigeria's domestic fish supply (Table 22). In 2018, Nigeria spent USD 1.2 billion on fish imports



Source: WorldFish foresight model projections 2019 (Chan et al. 2021).

Figure 13. Future fish production in quantity.



Source: WorldFish foresight model projections 2019 (Chan et al. 2021).

Figure 14. Future fish production by species and quantity.

Category	2015	2030					2050				
		BAU	HN	IIT	CH	IFM	BAU	HN	IIT	CH	IFM
Fish supply (million metric tons)	1989	3394	3466	3256	3164	3411	5900	6300	5600	5700	6200
Aquaculture (thousand metric tons)	317	850	921	848	934	844	1800	2200	1800	2000	1700
Capture fisheries (thousand metric tons)	766	1003	1003	1003	696	1026	1000	1000	1000	600	1400
Imports (thousand metric tons)	906	1541	1542	1405	1534	1541	3100	3100	2800	3100	3100
Consumption (kg/person/year)	11.2	12.8	13	12.2	12	12.8	14.8	15.7	14.1	14.1	15.4
Fish supply (without imports) (million metric tons)		1853	1924	1851	1630	1870	2800	3200	2800	2600	3100
Consumption (without imports) (kg/person/year)		7.09	7.37	7.09	6.14	7.16	6.98	7.98	6.98	6.48	7.73
Aquaculture annual growth rate (percent)	11					5					2
Population (million)*	181					261					401

BAU = Business as usual; HN = Hicks-neutral technological progress; IIT = import tax increase; CH = climate change; IFM = inland fisheries management.

Source: WorldFish foresight model 2019 (Chan et al. 2021).

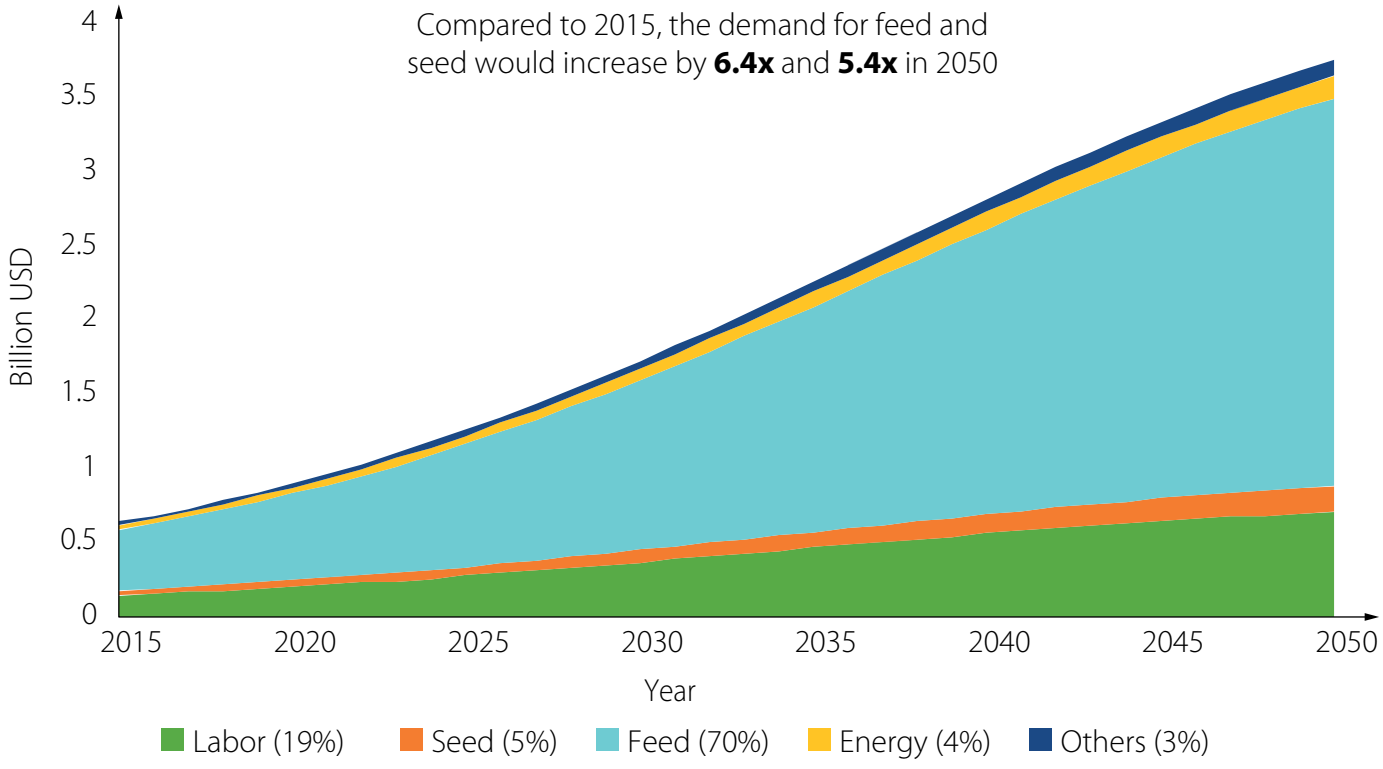
Table 22. Fish production (supply) and consumption (demand) forecast for Nigeria.

(The Guardian 2019). In 2013, Nigeria initiated measures to control the escalating foreign exchange demand for fish importation. The federal government's effort to control fish imports led to a reduction in fish imports in 2014 (Table 22). However, despite government import restrictions, fish imports increased gradually from 2014 to 2018, surpassing 2014 figures over the 5-year period. If fish import restrictions are not stringently implemented, imports will continue to fill in the gap between domestic supply and demand, draining significant amounts of foreign exchange in the coming decades (Chan et al. 2021).

The WorldFish foresight model predicts the annual rate of growth of aquaculture will gradually decrease from 6.3 percent during 2020–2035 to 3.4 percent during 2035–2050. Marine capture fisheries production will remain stable. Fish imports would play a more important role in bridging the fish supply-demand gap. Average annual fish per capita consumption would increase from 11.2 kg in 2015 to 14.8 kg in 2050 (Figure 15). This is more optimistic than that of the World Bank, which projects that fish consumption in sub-Saharan Africa will decline at an annual rate of 1 percent to 5.6 kg during 2010–2030 (World Bank 2013). However, it is consistent with trends modeled in several scenarios by Bjorndal and Tusvik (2020).

In 2015, the total food fish supply in Nigeria was 1.83 million metric tons. The average annual per capita fish consumption in Nigeria in 2015 is estimated as 10.8 kg. Considering the future growth of its population and national income (World Bank World Development Indicator Database (2008–2017); United Nations 2019),[16] Nigeria would need an additional 3.4 million metric tons to achieve an average annual per capita consumption of 12.8 kg by 2030, and would need 5.9 million metric tons to reach 14.8 kg by 2050. As per the WorldFish foresight model, if growth in fish supplies continues in a BAU manner, there will be a supply-demand gap of 3.1 million metric tons of food fish in Nigeria. It would only be possible to bridge the gap by increasing fish imports, which will not be economically viable and/or practically possible due to current government food import restrictions. Despite the restrictions based on the 2013 policy to ban imports of several food products, including some species of fish, the food and drink import bill of Nigeria increased from USD 2.9 billion in 2015 to USD 4.1 billion in 2017 (National Bureau of Statistics 2019).

There exist opportunities to increase fish supply from domestic production, and there are several possible scenarios. By increasing the rate of



Source: WorldFish Foresight Model projections 2019 (Chan et al. 2021).

Figure 15. Future aquaculture input costs.

growth of aquaculture (i.e. increased production and productivity), not only will the supply increase and the contribution of fish to Nigerian lives be improved, but also a significant amount of foreign currency that could be used for fish imports could be saved and diverted to improve smallholder-based aquaculture production. Although fish prices appear to be lower in the northern states compared to the southern states, fish consumption in the north is significantly lower than in the south, as discussed earlier in this document, where malnutrition rates are higher (Amare et al. 2018). The disparity needs urgent attention (Chan et al. 2021).

Under the foresight model BAU scenario, by 2030 Nigerian aquaculture production will be 850,000 t, a 2.7-fold increase from 2015 (Table 22). In 2050, aquaculture production would be 1.8 million metric tons, a 5.8-fold increase from 2015. Under the BAU scenario, however, only 50 percent of the 2030 fish supply-demand gap in Nigeria will be bridged. The evidence suggests that unless a strong concerted effort is initiated to significantly increase the rate of growth of aquaculture and significantly increase inland fisheries productivity and production, average annual per capita consumption of fish among Nigerians will not increase beyond 13 kg, which is well below the global average and requirement for a healthy lifestyle. It is also clear that increased production through better management of inland fisheries will increase dietary diversity among rural poor.

Chan et al. 2021 showed that the bulk of future aquaculture production will originate from smallholders (about 70%) while large-scale aquaculture will contribute about 30% to the national total by 2050, and that inputs costs will be dominated by feed (Figure 15).

According to our foresight model fish import tax scenario analysis, if the current fish import tax is increased by 10 percent, fish imports will decrease 5 percent in 2030. The lower fish supply will increase domestic fish price by about 10 percent and annual per capita consumption would drop 0.4 kg by 2030 (Chan et al. 2021). This indicates the importance of increasing local fish supplies. According to the Hicks-neutral technological improvements scenario, aquaculture production by 2030 would stand at 900,000 t while fish imports will be 1.5 million metric tons (Table 22).

It is also clear that if legal fish imports are banned and illegal imports controlled (i.e. the national fish supply will be based on aquaculture and capture fisheries production), average per capita fish consumption will decrease significantly in the coming decades, under all foresight model scenarios predicted, with possible significant health implications nationwide. In 2018, in importing 940,000 t of fish, the Nigerian government spent USD 1.2 billion. If fish imports are to be regulated at their 2018 level (940,000 t) and still reach the projected 13 kg of consumption by 2030, Nigeria must increase aquaculture production by an additional 560,000 t. Maintaining imports at their 2018 level will save the government USD 720 million in foreign currency in 2030. We therefore propose a policy of "increasing local production while reducing imports," where savings from lower fish imports will be directly diverted to aquaculture sector.

The current cost of catfish production is USD 1398/t, while the cost of importing a metric ton of frozen fish is USD 1277 (Table 23). Although importing fish is marginally cheaper than producing locally, the socioeconomic benefits of local production significantly outweigh the cost of imports. For example, based on a 3.85 FTE labor requirement to produce a metric ton of catfish (Table 24), increasing aquaculture production by an additional 560,000 t would create 2.2 million jobs. Moreover, locally produced fresh fish have further advantages in terms of nutritional value and fewer food miles. Therefore, we strongly advocate taking stringent policy measures to reduce legal fish imports, control illegal fish imports and to divert foreign currency savings, with necessary additional funds, to increase local fish production by creating a conducive business environment for smallholders to enter fish farming.

Climate change could have negative impacts on the wild-catch sector of Nigeria (Ipinjulo et al. 2014), potentially reducing catches. The size of the output reduction varies across assumptions about possible climate realizations, mitigation strategies and estimation approaches, ranging from 10 to 34 percent by 2050 (Frost et al. 2012).[17] Given these estimates, we calculate a projection outcome if climate change causes a 20 percent reduction in catch output, i.e. catch output in 2050 is 20 percent lower than in the base year, 2015. The reduction in catch output would decrease the fish

Fish imports and costs	
Amount imported in 2018*	941,000 t
Amount spent*	USD 1.2 billion
Amount spent/metric ton*	USD 1275
Projected imports by 2030**	1.5 million metric tons
Projected increase of imports by 2030**	559,000 t
Amount required to import the increase***	USD 713 million
Aquaculture fish production and costs* **	
Catfish yield	16 t/ha
Cost of production	USD 22,370/16 t
Unit cost of production	USD 1398/t
Difference in fish production and import costs	USD 123/t

** National statistics*
*** WorldFish foresight model*
**** WorldFish calculations*

Source: WorldFish scoping study 2019 (Chan et al. 2021).

Table 23. Costs and benefits of indigenous fish production vs. fish imports.

Variable	Whole sample	Earthen ponds	Concrete tanks	Other production facilities
Yield				
Catfish yield (t/ha per cycle)	15.98	14.27	20.24	16.39
Prices of fish				
Catfish price (USD/kg)	2.29	2.29	2.29	2.29
Costs				
Seed (USD/ha per cycle)	1250.96	1168.15	1538.59	1216.56
Feed (USD/ha per cycle)	19,022.95	16,669.88	23,658.30	20,497.48
Fertilizer (USD/ha per cycle)	1.44	2.19	0.46	0.71
Chemicals (USD/ha per cycle)	10.43	10.97	13.30	5.85
Hired labor (USD/ha per cycle)	255.14	287.90	235.91	202.55
Depreciation (USD/ha per cycle)	822.71	537.03	1405.95	941.37
Interest (USD/ha per cycle)	126.47	69.67	191.94	188.55
Other expenses (USD/ha per cycle)	879.47	543.09	1554.09	1019.43
Total cost	**22,369.57**	**19,288.88**	**28,598.54**	**24,072.50**
Profitability				
Net Income (USD/ha/per cycle)	14,224.63	14,488.62	17,751.06	13,460.60
Net Income (USD/ha/per year)**	21,337.50	21,733.50	26,626.50	21,191.5
Net Income (USD/farm/year)***	6401.25	6520.05	7987.98	7063.83
Benefit–Cost ratio	1.64	1.75	1.62	1.56

** According to the Nigerian government's definition, farmers with fewer than 5 ha of land are considered smallholders.*
*** Based on an estimated 1.5 cycles per year according to WorldFish survey 2019.*
**** Estimated average smallholder farm size is 0.3 ha.*

Source: BMGF/WorldFish farm performance survey and 2019 (Nhuong Tran et al. 2021).

Table 24. Profitability of smallholder* catfish aquaculture systems (monoculture).

supply, causing an overall increase in fish price, which increases fish farmers' profits. As a result, aquaculture would grow faster than in the BAU scenario, partially offsetting the reduction in the wild-catch sector. Feed and seed quantities used in aquaculture would increase faster, while labor input would decline because of the contraction of the labor-intensive catch sector. Fish consumption would be lower than in the BAU scenario, and the impact on fish imports is not significant.

The foresight model also analyzed the stock management (fisheries management) scenario, where capture fisheries output would increase over time until 2050. We calculate the projection figure assuming capture fisheries output would increase at 1.5 percent per year until 2050 instead of the BAU scenario where the capture fisheries output would grow only until 2025, then slow down and level off. The expansion of the fisheries sector would increase fish production and consumption. The increase in fish supply would reduce fish farmer profits compared to the BAU scenario. As a result, aquaculture sector output would be lower, with less feed and seed inputs. Labor inputs would be higher than in the BAU scenario due to the expansion of labor-intensive capture fisheries (Chan et al. 2021).

Fish consumption in Nigeria differs between states, with clear disparities between the north and south of the country. However, what is clear from our forecast is that unless strong concerted action is taken to (a) significantly increase the rate of growth of aquaculture and (b) significantly increase inland fisheries productivity and production, then average annual per capita consumption of fish among Nigerians will not increase beyond 12.8 kg by 2030, which is well below the global average and what is required for a healthy lifestyle.

Our conclusions are that fish demand will increase over the coming decades and that supply should be increased through sustainable means to bridge the supply-demand gap. Supplies from marine capture fisheries will be minimal or negligible. Considering the long-term economic outlook, we do not see importing large quantities of fish as a viable mechanism to bridge the widening demand-supply gap. We strongly recommend increasing production through sustainable and inclusive growth of the aquaculture sector and increasing artisanal fisheries productivity and production through enhancement and better management (Chan et al. 2021).

6.2. Future markets

Despite the relatively positive enabling environment for the rapid growth of aquaculture in Nigeria, there are a number of market failures that are preventing the rapid growth of private sector enterprises in the sector. They include the following:

- high input costs, especially commercial and semi-commercial feed, owing to the weakening exchange rate of the Naira
- poor feed quality, resulting from low quality ingredients and low technology and related lost smallholder revenues
- an inadequate reliable market information network, where WorldFish/BMGF could invest
- high loan interest rates, a macroeconomic challenge with no ready solution
- poor food safety standards stemming from lack of appropriate policy, legislation and law enforcement that limits international fish trade.

Other challenges related to fish trade in Nigeria, especially for aquaculture products, include the following:

- lack of adequate quality technical capacity for improving trading and food safety standards, including traceability
- impact of fish imports on domestic fisheries and aquaculture production
- impact of escalating input (feeds, seed, broodstock, equipment, energy) costs due to high and fluctuating foreign exchange
- food quality, safety and international market access requirements
- access to modern fish markets
- fish marketing information systems and network, including an efficient price information mechanism
- lack of modern infrastructure and modern equipment, like refrigerated trucks
- certified processing facilities
- efficient live fish transportation equipment and vehicles.

Although up for debate, we think the following market-based interventions are necessary to reduce the five market failures listed in section 6.4:

- Dialogue between the private sector and federal government: Initiate a dialogue on incentives for importing locally non-available feed ingredients, equipment and other materials to address high input costs, owing to the declining exchange rate of the Naira. Provide incentives to increase local commercial and semi-commercial feeds to reduce dependency on imported feeds.
- Adopt feed manufacturing and storage standards: Include feed ingredient quality standards and technology standards to improve smallholder feed quality, and certify smallholder feed. Provide skills development for smallholders so that they can develop their businesses.
- Build reliable market databases: Build a database to address inadequacy in reliable market information. Establish a reliable marketing information network and mechanism to gather and share information of market prices and market opportunities among market actors so that they can strengthen or develop their businesses.
- Discuss financing options: To address high loan interest rates, extend the ABP to smallholder post-farmgate actors and input providers, and discuss with other financial institutions implementation of such programs with the participation of external agents for risk sharing.
- Improve food safety standards: Assist the federal Department of Fisheries and Aquaculture to review and revise appropriate policy and legislation to improve and implement food safety standards to enable international fish trade. Provide skills development to improve the quality of fish processing toward accessing foreign markets.

Most of the above interventions could only be implemented through creating a conducive business environment, unlocking the potential of the corporate sector to include smallholders in their business models. Creating a conducive business environment requires an organized client community, supporting policies, efficient institutions, adequate investment and improved private sector engagement. Smallholder fish farmers should be organized into formal, legal entities, allowing the corporate business community to expand its business model to include them. Provision of quality and affordable inputs (seed, feed, technology) and services (including financial) will promote scaling up aquaculture among smallholders. Servicing a large smallholder client community will become attractive and profitable to the corporate sector, potentially increasing business investment in the smallholder-based aquaculture value chain.

Measuring the effectiveness of interventions and investments requires appraisals. Rapid market appraisals (RMAs) could be conducted to collect, process and analyze information on the measures adopted to prevent market failures. Such an initial assessment of the aquaculture sector or selected value chain within the sector would help determine the likely relevance and feasibility of proposed interventions. The RMA could be complemented by value chain analysis of selected value chain(s) in order to determine the underlying reasons why interventions had been unsuccessful at solving market failures and help design novel interventions to create systemic and sustainable change in the sector. A further essential element would be to develop and implement indicator-based monitoring of the effectiveness of new measures to address market failures, based on "benefits for market actors" or "benefits for value chain actors."

7. Inclusive growth of aquaculture

In this section, based on our survey results and research, we present major issues and bottlenecks that impede the sustainable and inclusive growth of the Nigerian aquaculture sector. We propose a series of opportunities and actions to address them. Analysis suggests that most actions should be directed toward increasing the contribution of smallholders and the poor to produce fish by unlocking the potential of the private sector to create profitable business opportunities. There are also a number of actions that state agencies, academia and research institutions, donor and development agents and the general public should consider.

Our assessment focused on two aquaculture species: tilapia and catfish. Evidence suggests that little or no tilapia production came from smallholders, while almost all catfish production originates from smallholders. Although we were interested in comparing the performance of different production systems used in tilapia and catfish farming, systems performance focused on three systems practiced by smallholder catfish farmers, as no tilapia is farmed by smallholders. We analyzed the socioeconomic and environmental performance of tilapia aquaculture systems using cages in lakes, dams, reservoirs and in some cases earthen ponds.

Our survey demonstrated that the bulk of catfish production originates from smallholder farming. It indicates that smallholders practice fish farming, not as a way of life as it is for many who are involved in agriculture, but as a business requiring investment, inputs and knowledge. However, credit institutions consider smallholder farmers non-creditworthy because of inadequate prerequisites (collateral). As a result, smallholders have no access to loan facilities from conventional banks. Availability and accessibility to better farming practices and inputs are inadequate and, in some instances (e.g. quality seed and feed), are essentially unavailable. Increasing smallholder access to finance, quality inputs, services and technology will improve productivity and incomes.

Analysis of the current demand for fish in Nigeria indicates that it is unlikely that farm production of just two species, tilapia and catfish, will be sufficient to bridge the demand-supply gap for fish, or will satisfy consumer demand for aquatic food over the coming decade. Exploring science-based species diversification is recommended.

While some corporate sector farming operations import catfish and tilapia broodstock, there is no genetic improvement, proper maintenance of broodstock lines or well-run multiplication processes to scale up quality seed supplies to smallholder farmers. A genetic improvement and broodstock management program with scaling up of seed supply is needed.

As the bulk of catfish seed originates from small- to medium-scale hatcheries, presumably without organized broodstock and seed quality management programs, the genetic quality of the bulk of catfish seed currently produced in Nigeria (98 percent) is most likely to be low. Tilapia seed quality is also questionable and appears to be poor, and the quantity is far from adequate to reach/stimulate smallholders.

There is a need to improve the quality and composition of fish feed produced by small- to medium-scale manufacturers. This will also help reduce the use of food-grade fish (especially food-grade nutrient-rich pelagic fish from both freshwater and marine environments) as a fishmeal replacement, allowing their use as affordable, nutritious food for rural and urban poor.

Value chain activities, including the transportation of fish and fish products, should be expanded and improved to increase availability of nutrient-rich fish to households, especially in the northern states.

An organized awareness program on the importance of fish in diet and nutrition, especially addressing the first 1000 days (i.e. from conception until the child has reached 2 years of age) in states where consumption is low, should be considered. Interventions to increase fish consumption could include promotion of the use of products such as fish powder so that young children also have access to fish. It is important to create business opportunities to achieve this goal. Incorporating

more fish into school feeding programs—especially linking aquaculture to school meals in selected states—should also be considered.

Involvement of women along aquaculture value chain, especially in post-harvest activities, is evident. Empowering women with the necessary technical, entrepreneurial and financial management skills is essential.

Smallholder aquaculture in Nigeria currently uses very little technology. Considering the substantial increases in fish supplies needed to bridge the demand-supply gap in coming decades, there is an opportunity to use better technology and improved farming practices to support intensification and sustainability of production.

Until the pandemic struck, government policy toward aquaculture development was judged comprehensive and appropriate. Transaction costs, however, remained high and policy implementation was poor. Considered together with demographic change, the impact of COVID-19 and the global economic situation, policy reform is needed.

The current policy on land rights for agriculture/aquaculture is unclear, and land rights are not clearly defined. About 95 percent of agricultural land is not titled, effectively nullifying its capacity to be used as collateral for financial transactions. Clear policies for inclusive (including women) access to land and land rights for aquaculture would help farmers access finance.

Government-run extension services for the aquaculture sector suffer from inadequate financial resources for mobility and equipment. In partnership with the private sector (feed manufacturers and hatcheries), the government may be able to support a more effective extension system.

While current economic policy is meant to assist smallholders in Nigeria, it does not appear to be conducive to smallholder development. High interest rates, bureaucratic and stringent loan procedures and high collaterals prevent smallholder access to finance. Development partners and the private sector can encourage policymakers to improve the situation for the aquatic food sector.

Thirty-five percent of post-farmgate value chain (processing, wholesaling and retailing) and farming activities are controlled (owned) by youths. Current and future financial schemes such as the ABP should target youth smallholder farmers, who lack collateral to receive loans from financial institutions.

Catching small pelagic fish, which are then sun-dried and consumed whole, increases economic and geographic access in local, often remote markets. It is the most high-yielding, eco-friendly, low carbon-emission way of using the high productive potential of inland waters to produce nutritious food. However, a range of social, technical, economic, legal and policy barriers inhibit the full potential of using small fish to improve nutrition in Nigeria. These include a lack of enabling fisheries management and legislation and food safety challenges in fish processing and marketing. In addition, their local use as fishmeal in animal feeds, including for aquaculture, is increasingly competing for these resources.

Health management and disease control in Nigerian aquaculture, especially among smallholders and small- to medium-scale farming practices, is minimal. Disease-related production losses are widely reported, but economic impacts are not known. Aquatic animal health management capacity within the national veterinary system is minimal. Limited private sector engagement in aquaculture health management needs improvement and strengthening. It is important to assess national aquatic animal health management capacity and embark on a technology and capacity development program.

Information and access to technical knowledge on efficient production, processing and marketing are lacking. Information and data on pricing and marketing do not exist. A digital data portal could be developed to collect, collate and disseminate market and price data/information.

Based on the past few years of research and a 2029 scoping study, we identified a series of opportunities where the private sector could contribute to removing bottlenecks. Issues, bottlenecks and private sector opportunities are presented in Table 25.

Issue	Bottlenecks	Private sector opportunities
The supply-demand gap is widening for aquatic food (seafood–fish) in Nigeria	• Illegal and legal fish imports drain foreign exchange and flood markets with relatively cheap, low-quality fish, constraining increases in local production through smallholder aquaculture. • Sub-optimal artisanal fishery production does not contribute adequately to bridging the supply-demand gap.	• Fisheries and farmer associations and professional societies should lobby government to impose stringent fish import controls. • Partnership management of artisanal fisheries should play its triple role of a food supplier, employment provider and income earner, involving artisanal fisher communities, state fisheries authorities, state ADP, farming communities, and women groups for post-harvest value addition.
Average per capita fish consumption in Nigeria is around half of the global average.	• Although many Nigerians consume fish regularly, the quantities consumed are sub-optimal due to low accessibility and affordability.	• Invest in increasing smallholder aquaculture production, processing and fish-based products, especially in the northern region. • Conduct scientific research into diversification of cultured species, including indigenous and introduced species.
The potential of aquatic production (tilapia and catfish) has not been realized due to the insufficient quantities of quality seed.	• No science-based broodstock genetic improvement or management programs are in place for the main cultured species, such as tilapia and catfish. • The existing hatchery production system is not capable of supplying seed (tilapia, mainly) to smallholders prepared to enter aquaculture production.	• Invest in a corporate sector-led catfish genetic improvement program and a tilapia broodstock management program. • Introduce/transfer genetically improved farmed tilapia to Nigeria and establish a private sector-based quality seed production and networking program with smallholder farmers for dissemination. • Invest in development of decentralized brooder units within cluster and cooperative farms in aquaculture concentrated areas, linking with corporate broodstock producer hatcheries. • Improve and expand private hatcheries to increase availability and affordability of seed reaching smallholder farmers. Implement a voluntary seed quality assurance program. • Increase and diversify seed supply by bringing locally available species into production to offer opportunities for potential smallholder farmers to enter aquaculture.
Feed quality is a constraint to smallholder aquaculture production and profitability.	• Nutritional quality of semi-commercial fish feeds (produced by cooperatives and small- to medium-scale feed producers) is inadequate for cost-effective production of catfish and tilapia. • Feed formulation is sub-optimal. • Cheap and low nutrient ingredients are used.	• Corporate sector feed manufacturers should invest in better feed formulation and manufacturing of quality feeds, using locally available nutrient-dense ingredients where possible to reduce costs. • Cluster farms and cooperative farms should seek/explore opportunities to improve smallholder feed production and feed management.

Issue	Bottlenecks	Private sector opportunities
Feed price is recognized as a constraint for smallholders entering tilapia farming.	• Price of high-quality nutritious fish feed produced by local commercial and/or imported feed manufacturers is unaffordable to smallholder aquafarmers. • Tariffs on imported feeds and feed ingredients are high, resulting in high feed costs and prices.	• Use fish processing coproducts (wastes) in local fishmeal production to reduce cost in importation of fishmeal. • Invest in identifying nutrient-dense locally available feed ingredients to reduce feed costs. • Farmer and professional associations should lobby government to reduce import tariffs on feeds and feed ingredients.
Smallholder productivity and profitability are limited by sub-optimal feed and husbandry management at farm level.	• No effective technical support service, including on farm husbandry and feed management, is available to smallholder fish producers.	• Corporate sector farms with technical capacity should build partnerships with smallholder farmers as out-growers and with government extension services to deliver best management practices to smallholder farmers.
Aquaculture productivity and production is challenged by diseases at hatchery and grow-out levels.	• No effective veterinary support service, including disease control and health management at farm level, is available for seed and smallholder fish producers.	• Invest in providing aquatic veterinary services, including rapid diagnostics, as private sector-based businesses, particularly targeting smallholder farmers. • Adopt/strengthen farm-level biosecurity measures, and explore opportunities to develop farm-level health management tools.
Mortality and spoilage occurs during live fish transportation.	• Poor transportation methods increase mortality during transportation, reduce fish quality and increase spoilage at the market, reducing incomes and profits of various value chain actors.	• Design, test and manufacture effective practical transportation equipment with aeration systems to increase survival of live fish.
Limited diversity of processed and value-added fish products in markets provide little buying choice to consumers.	• Fish processing in Nigeria is largely limited to smoking and drying, using basic technology and equipment, preventing diversification of value-added fish products in the market. • There is no food safety compliance during processing and almost no understanding of food safety among processors.	• Investing in improving fish processing technology will improve product quality, food safety and shelf life, reduce wastage and create employment, especially for women. Invest in fish-based products and fortifying food with fish-based products. • Fisheries and farmers associations and professional associations should lead in implementing a standards certification process. • Commercial-scale processors should invest in refrigerated transportation of fish and fish products. • Corporate sector farmers should invest in cold storage facilities, extending cold storage services to smallholder fish producers.

Issue	Bottlenecks	Private sector opportunities
Availability of fresh fish in rural areas is limited, and fresh fish must be smoked or dried within a limited period after harvest.	• There is a lack of a cold chain targeting locally produced catfish.	Invest in developing a cold chain as a novel private sector business or as business integration.
Smallholder fish farmers struggle to operate and expand due to lack of finance.	• There is a lack of capital and/or operational funds available to smallholders.	• Develop and implement business models for smallholders to enter aquaculture, especially as out-growers. • Develop viable, sustainable businesses to unlock corporate sector potential to assist them (provision of seed and feed). • Smallholder farmers should organize into cooperatives or cluster farms, linking with processors as anchors to qualify for the government-run ABP. • Farmer and producer organizations should lobby federal and state governments to resolve issues in land rights, which could be an asset for collateral to receive loans.
Fish diversity and nutritional benefits through consumption of indigenous species are limited.	• No science-based, organized inland fisheries management programs are in place, resulting in low and irregular catches and availability of nutritious inland indigenous species to consumers.	• Artisanal fishing communities should be empowered in identifying issues related to artisanal fisheries decision-making processes. • Establish rural fisheries organizations/groups and women's groups, fishers and women groups for partnership development and management. Develop an entrepreneurship plan for partnership management, including fishing plans.
There is limited market access and profitability because of insufficient price and market information.	• There is no market and price information system.	• Develop a private sector-led digital market and price information system.

Table 25. Issues, bottlenecks and opportunities for private sector-based inclusive aquaculture growth in Nigeria.

Notes

[1] All statistics and background information provided in this document refer to the situation before the COVID-19 pandemic. Potential implications and impacts of COVID-19 have not been elaborated.

[2] Unless otherwise referred to, all information and data presented in this document originated from the WorldFish/BMGF scoping study conducted during 2019. The process and methodology are given in Annex 1 (Nigeria scoping protocol).

[3] See also https://www.statista.com/statistics/382311/nigeria-gdp-distribution-across-economic-sectors/#:~:text=In%202019%2C%20agriculture%20contributed%20around,percent%20from%20the%20services%20sector

[4] In this document, we divided feed producers and suppliers into three categories: (1) imported feed, (2) corporate feed produced by local corporate feed companies, and (3) cooperative feed produced by farmer cooperatives and clusters. Smallholder feed produced by smallholder farmers (individuals) in their farms was for their use only (farm-made feed).

[5] See also Liverpool-Tasie et al. 2020b.

[6] This section is heavily drawn from Byrd KA, Ene-Obong H, Tran N, Dizyee K, Chan CY, Shikuku K M, Steensma J, Nukpezah J, Subasinghe R and Siriwardena SN. In press. Fish consumption patterns and diets of rural and urban Nigerians. Penang, Malaysia: WorldFish. Working Paper.

[7] There are considerable variations in annual per capita fish consumption estimates in Nigeria, ranging from 11 (Proshare 2016) to 13.3 (Allen et al. 2017) and 13.5 kg (Liverpool-Tasie et al. 2018). WorldFish's study estimates the current (2020) annual per capita fish consumption in Nigeria is 11.2 kg.

[8] This section is heavily drawn from Dizyee K, Williams G, Anastasiou K, Powell A, Shikuku KM, Tran N, Byrd K, Chan CY, Bogard J, Steensma J et al. 2021. Performance analysis of existing catfish and tilapia value chains and market systems in Nigeria: post-farmgate value chain scoping study. *Aquaculture Economics and management Journal*. (under review).

[9] In this analysis, we group aquaculture producers (farmers) into three categories: (1) corporate sector producers (established commercial companies), (2) farmer cooperatives (registered smallholder farm cooperatives) and farm clusters (non-registered smallholder farmer groups), and (3) smallholders (individual small-scale farmers).

[10] Commercial hatcheries depend on imported "Dutch broodstocks" from the Netherlands. Strains of African catfish, such as African sharptooth catfish (*Clarias gariepinus*), African catfish (*Heterobranchus bidorsalis*) and vundu (*Heterobranchus longifilis*), are used. Typically, *Clarias* females are crossed with *Heterobranchus* males to obtain a hybrid that is more robust, faster growing and has better disease resistance. Hatcheries also multiply and sell imported broodstock at a premium price to other commercial hatcheries and farms in Nigeria.

[11] USD 1 = NGN 362 (2019).

[12] This section is heavily drawn from Tran N, Shikuku KM, Cheong KC, Chan CY, Byrd KA, Dizyee K, Nukpezah JA, Steensma J, Fregene BT, Lydia AM and Siriwardena RSS. In prep. WorldFish Technical Report: Productivity and Profitability Performance of Aquaculture Production Systems in Nigeria. Penang, Malaysia: WorldFish.

[13] This section is heavily drawn from Dizyee K, Williams G, Anastasiou K, Powell A, Shikuku KM, Tran N, Byrd K, Chan CY, Bogard J, Steensma J et al. 2021. Performance analysis of existing catfish and tilapia value chains and market systems in Nigeria: post-farmgate value chain scoping study. *Aquaculture Economics and management Journal*. (under review).

[14] This section is heavily drawn from Chan CY, Chu L, Tran N, Cheong KC, Shikuku KM, Olagunju O, Byrd K, Dizyee K, Subasinghe R and Siriwardena SN. In prep. Foresight scenarios and nutrition implications of fish food system transformation in Nigeria. Food Security.

[15] Any of the numerous soft-finned schooling food fishes of shallow waters caught in artisanal fisheries in both fresh and marine waters.

[16] https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf

[17] See also Barange et al. 2018 as well as Bjørndal and Tusvik 2020.

References

[AU-NEPAD] African Union's New Partnership for Africa's Development. 2016. Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. Malabo, Equatorial Guinea, June 26–27, 2014. https://www.nepad.org/caadp/publication/malabo-declaration-accelerated-agricultural-growth

Ajepe AA, Okunade KS, Sekumade AI, Daramola ES, Beke MO, Ijasan O, Olowoselu OF and Afolabi BB. 2020. Prevalence and foetomaternal effects of iron deficiency anaemia among pregnant women in Lagos, Nigeria. *PLoS ONE* 15(1):e0227965. https://doi.org/10.1371/journal.pone.0227965

Akintola SL and Fakoya KA. 2018. Small-scale fisheries in the context of traditional post-harvest practice and the quest for food and nutritional security in Nigeria. *Agriculture & Food Security* 6(1):34.

Allen K, Rachmi AF and Cai J. 2017. Nigeria: Faster aquaculture growth needed to bridge fish demand–supply gap. FAO Aquaculture Newsletter 57:36–37. https://doi.org/10.3389/fmars.2017.00159

Amare M, Benson T, Fadare O and Oyeyemi M. 2018. Study of the determinants of chronic malnutrition in northern Nigeria: Quantitative evidence from the Nigeria demographic and health surveys. International Food Policy Research Institute (IFPRI) Working Paper 45 (September 2017). *Food and Nutrition Bulletin* 39:296–314. doi:10.1177/0379572118768568.

Amire AV. 2009. The challenges of piracy in the marine sector of capture fisheries in Nigeria. Proceedings of the 24th Annual Conference of Fisheries Society of Nigeria (FISON), Federal University of Technology, Akure, Nigeria, October 26–28, 2009.

Anderson J, Collins M, Musiime D and Thiam M. 2017. National survey and segmentation of smallholder households in Nigeria. CGAP Working Paper. Washington, DC: Consultative Group to Assist the Poor. https://www.cgap.org/sites/default/files/Working-Paper-Survey%2BSegmentation-of-Smallholders-Nigeria-Oct-2017.pdf

Barange M, Bahri T, Beveridge MCM, Cochrane K, Funge-Smith S and Poulain F, eds. 2018. Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries Technical Paper 627. Rome: FAO. http://www.fao.org/3/i9705en/i9705en.pdf

Belton B, Rosen L, Middleton L, Gazali S, Mamun AA, Shieh J, Noronha HS, Dhar G, Ilyas M, Price C et al. 2021. COVID-19 impacts and adaptations in Asia and Africa's aquatic food value chains. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Working Paper: FISH-2021-02.

Bjørndal T and Tusvik A. 2020. Economic analysis of the contributions of capture fisheries and aquaculture to future food security. SNF Report No 04/20. Norway: SNF. https://www.snf.no/Files/Filer/Publications/SNF-R%2004_20.pdf

Chatham House. 2020. Policy and public expenditure opportunities to support implementation of BMGF livestock and aquaculture strategy. Case study Nigeria (Unpublished). London: Chatham House. 57 pp.

Chinas IJ, Nnanna EJ and Ekene UC. 2017. Practices of farmers in processing and marketing of crayfish in Akwa-Ibom State, Nigeria. *African Journal of Agricultural Research* 12:3169–80.

[CGAP] Consultative Group to Assist the Poor. 2017. National survey and segmentation of smallholder households in Nigeria. Washington, DC: CGAP

Cusick S and Georgieff MK. n.d. The first 1,000 days of life: The brain's window of opportunity. Accessed September 21, 2020. New York: UNICEF. https://www.unicef-irc.org/article/958-the-first-1000-days-of-life-the-brains-window-of-opportunity.html

Dapel Z. 2018. Poverty in Nigeria: Understanding and bridging the divide between north and south. Nigeria: CGDEV. https://www.cgdev.org/blog/poverty-nigeria-understanding-and-bridging-divide-between-north-and-south

Dewey KG. 2013. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: An evolutionary perspective. *Journal of Nutrition* 143:2050–54. https://doi.org/10.3945/jn.113.182527

Effiong JAL, Aligbe JO, Uzoho BU and Eze EU. 2016. Evaluation of performance of trawling vessels operating in Nigeria. *International Journal of Agriculture and Earth Science* 2:.

[FDFA] Federal Department of Fisheries and Aquaculture. 2015. Fishery statistics of Nigeria (5th ed). Abuja, Nigeria: FDFA.

[FMARD] Federal Ministry of Agriculture and Rural Development. 2016. The Agriculture Promotion Policy (2016–2020): Building on the successes of the ATA, closing key gaps. Abuja, Nigeria: FMARD.

[FAO] Food and Agriculture Organization. 2016a. FAO/INFOODS Global Food Composition Database for Fish and Shellfish Version 1.0 - uFiSh1.0. Rome: FAO.

[FAO] Food and Agriculture Organization. 2016b. Influencing food environments for healthy diets. FAO: Rome. 135 pp.

[FAO] Food and Agriculture Organization. 2016c. Review of the livestock/meat and milk value chains and policy influencing them in Nigeria. Washington, DC: World Bank in Nigeria.

[FAO] Food and Agriculture Organization. 2017. Fishery and aquaculture country profiles: Nigeria. Country Profile Fact Sheets. Rome: FAO. Accessed June 23, 2020. http://www.fao.org/fishery/

[FAO] Food and Agriculture Organization. 2018. Smallholders data portrait. Rome: FAO. www.fao.org/family-farming/data-sources/dataportrait/farm-size/en

[FAO] Food and Agriculture Organization. 2019. The future of livestock in Nigeria. Opportunities and challenges in the face of uncertainty. Rome: FAO. http://www.fao.org/3/ca5464en/CA5464EN.pdf

[FAO] Food and Agriculture Organization. 2020. The state of world fisheries and aquaculture 2018: Meeting the Sustainable Development Goals. Rome: FAO. Licence: CC BY-NC-SA 3.0 IGO.

[FAO] Food and Agriculture Organization. n.d. Rome: FAO. Accessed January 16, 2021. http://www.fao.org/fishery/facp/NGA/en#CountrySector-Statistics

FAO and ECOWAS Commission. 2018. National Gender Profile of Agriculture and Rural Livelihoods – Nigeria. Country Gender Assessment Series, Abuja. 92 pp.

Frontier Strategy Group. 2018. Nigeria 2023: Outlook and scenarios. USA: FSG. www.frontirestrategygroup.com

The Guardian. September 20, 2019. Nigeria spends $1.2bn to import fish annually – Emefiele. *The Guardian*. Digital. https://guardian.ng/news/nigeria-spends-1-2bn-to-import-fish-annually-emefiele/

Hicks CC, Cohen PJ, Graham NAJ, Nash KL, Allison EH, D'Lima C and MacNeil MA. 2019. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature* 574(7776)95–98. https://doi.org/10.1038/s41586-019-1592-6

Ijeoma V. 2013. Sustainable development in fisheries of Nigeria. IAIA13 Conference Proceedings Impact Assessment the Next Generation. 33rd Annual Meeting of the International Association for Impact Assessment, May 13–16, 2013, Calgary, Canada.

Ikeyi PA. 2017. A Study of the medical and socio-economic impact of food and nutritional taboos practiced in Enugi State, Eastern Nigeria. *Medical Sociology & Community Health* 7:4172. https://www.omicsonline.org/conference-proceedings/medical-sociology-2017-scientifictracks-abstracts.digital

Isaacs M. 2016. The humble sardine (small pelagics): Fish as food or fodder. *Agriculture and Food Security* 5(1):1–14. https://doi.org/10.1186/s40066-016-0073-5

Ita EO, EK Sado JK, Pandogari A and Ibitoye B. 1985. Inventory survey of Nigerian inland waters and their fishery resources I: A preliminary checklist of inland water bodies in Nigeria with special reference to ponds, lakes, reservoirs and major rivers. Kainji Lake Research Institute Technical Report Series, No. 14. New Bussa, Nigeria: KLRI. 51 pp.

Kaminski OM, Kruijssen F, Cole SM, Dawson C, Beveridge MCM, Mohan CV, Suri S, Karim M, Chen OL, Phillips MJ et al. 2020. Inclusive business models and their application to aquaculture: Integrating smallholders into value chains. *Reviews in Aquaculture* 12:1881–1902 https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12415

Kolding J, Zwieten P, van Martin F, Funge-Smith S and Poulain F. 2019. Freshwater small pelagic fish and their fisheries in the major African lakes and reservoirs in relation to food security and nutrition. FAO Fisheries and Aquaculture Technical Paper. Rome: FAO. https://doi.org/10.4060/ca0843en

Lachat C, Raneri JE, Smith KW, Kolsteren P, Van Damme P, Verzelen K, Penafiel D, Vanhove W, Kennedy G, Hunter D et al. 2018. Dietary species richness as a measure of food biodiversity and nutritional quality of diets. *Proceedings of the National Academy of Sciences* 115(1):127–32. https://doi.org/10.1073/pnas.1709194115

Liverpool-Tasie LSO, Reardon T and Belton B. 2020a. "Essential nonessentials": COVID-19 policy missteps in Nigeria rooted in persistent myths about African food supply chains. *Applied Economic Perspectives and Policy* 2020:1–20. https://doi.org/10.1002/ aepp.13139

Liverpool-Tasie LSO, Sanu A, Reardon T and Belton B. 2020b. Demand for imported versus domestic fish in Nigeria. *Journal of Agricultural Economics*. https://onlinelibrary.wiley.com/doi/epdf/10.1111/1477-9552.12423

Liverpool-Tasi LSO, Sanou A and Reardon T. 2018. Demand for imported-frozen versus domestic-traditionally processed fish in Africa: Panel data evidence from Nigeria. Accessed March 2020. http://www.foodsecuritylab.msu.edu/

Love DC, Allison EH, Asche F, Belton B, Cottrell RS, Froehlich HE, Gephart JA, Hicks CC, Little DC, Nussbaumer EM et al. 2021. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *Global Food Security* 28:100494. https://www.sciencedirect.com/science/article/pii/S2211912421000043

Mainasara AS, Ibrahim KK, Uko EU, Jiya NM, Erhabor O, Umar A, Muhammad SK, Sanusi M, Garba A, Jidda ML et al. 2017. Prevalence of anaemia among children attending paediatrics Department of UDUTH, Sokoto, North-Western Nigeria. *International Blood Research & Reviews* 7(1):110. http://www.sciencedomain.org/abstract/17780

Marinda PA, Genschick S, Khayeka-Wandabwa C, Kiwanuka-Lubinda R and Thilsted SH. 2018. Dietary diversity determinants and contribution of fish to maternal and under-five nutritional status in Zambia. *PLoS ONE* 13(9):e0204009. https://doi.org/10.1371/journal.pone.0204009

[NBS] National Bureau of Statistics. 2020. 2019 poverty and inequality in Nigeria. Abuja, Nigeria: NBS.

[NPC and ICF] National Population Commission and ICF International. 2014. Nigeria demographic and health survey 2013. Abuja, Nigeria: NPC; and Rockville, US: ICF International. https://dhsprogram.com/pubs/pdf/FR293/FR293.pdf

Nigussie L, Minh TT and Sellamutu S. 2021. Youth inclusion in value chain for development: A case of the aquaculture in Nigeria. Addis Ababa, Ethiopia: IWMI.

Olawuyi ElO. 1992. An economic overview of the fish and shrimp production of the Nigeria fish trawling industry under the structural adjustment programme. Proceedings of the 10th annual conference of Fisheries Society of Nigeria (FISON), Abeokuta, Nigeria, November 16–20, 1992.

O'Meara L, Cohen PJ, Simmance F, Marinda P, Nagoli J, Teoh SJ, Funge-Smith S, Mills DJ, Thilsted SH and Byrd KA. 2021. Inland fisheries critical for the diet quality of young children in sub-Saharan Africa. *Global Food Security* 28:100483.

[PIND] Foundation for Partnership Initiatives in the Niger Delta. 2017. Fish feed value chain analysis in the Niger Delta. Abuja, Nigeria: PIND. https://pindfoundation.org/fish-feed-value-chain-analysis-in-the-niger-delta/

Proshare. 2016. Boosting domestic fish production in Nigeria. FBN Quest Research. Nigeria. ProShare. https://www.proshareng.com/news/Agriculture/Boosting-domestic-fish-production-in-Nigeria/31289

Roos N, Leth T, Jakobsen J and Thilsted SH. 2002. High vitamin A content in some small indigenous fish species in Bangladesh: Perspectives for food-based strategies to reduce vitamin A deficiency. *International Journal of Food Sciences and Nutrition* 53:425–37. https://doi.org/10.1080/0963748021000044778

Sachs J, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G and Woelm F. 2020. The Sustainable Development Goals and COVID-2019. Sustainable Development Report 2020. Cambridge: Cambridge University Press. https://onlinelibrary.wiley.com/doi/full/10.1111/padr.12366

Selig ER, Hole DG, Allison EH, Arkema KK, McKinnon MC, Chu J, de Sherbinin A, Fisher B, Glew L, Holland MB et al. 2018. Mapping global human dependence on marine ecosystems. *Conservation Letters* (May 2018):1–10.

Thilsted SH, Thorne-Lyman A, Webb P, Bogard JR, Subasinghe R, Phillips MJ and Allison EH. 2016. Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy* 61:126–131. https://doi.org/10.1016/j.foodpol.2016.02.005

Toriola AL, Oyeniyi P, Ajayi-Vincent O and Akindutire IO. 2017. Prevalence of overweight and obesity in Nigerian children. *Anthropologist* 30(2):86–94.

United Nations. 2019. World Population Prospects 2019 Revision. https://population.un.org/wpp/

[USAID] United States Agency for International Development. 2018. Nigeria nutrition profile. Abuja, Nigeria: USAID. https://www.usaid.gov/sites/default/files/documents/1864/Nigeria-Nutrition-Profile-Mar2018-508.pdf

World Bank. 2013. Fish to 2030: Prospects for fisheries and aquaculture. World Bank Report Number 83177-GLB.

World Bank. 2019. Nigeria economic update fall 2019: Jumpstarting inclusive growth. Unlocking the productive potential of Nigeria's people and resource endowments. Washington, DC: World Bank. http://documents1.worldbank.org/curated/en/394091575477674137/pdf/Jumpstarting-Inclusive-Growth-Unlocking-the-Productive-Potential-of-Nigeria-s-People-and-Resource-Endowments.pdf

World Bank. 2020. Nigeria in times of Covid-19: Laying foundations for a strong recovery. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/34046

WorldFish. 2018. WorldFish Nigeria strategy: 2018–2022. Penang, Malaysia: WorldFish. Strategy: 2018-09.

Annex 1. Nigeria scoping protocol

Background

Building on an earlier scoping undertaken by WorldFish in 2017, this project aimed to enable WorldFish to draw on lessons from Bangladesh and its global network of researchers and partnerships to fill critical gaps that remain in the knowledge base in Nigeria. The scoping study will provide an evidence base from which informed future investment decisions can be made. The project has an immediate objective of delivering, within 18 months of start-up, a scoping of aquaculture sector bottlenecks based on fish production, consumption, and value chain models that have high potential to positively impact smallholder income, nutrition, youth employment and women's empowerment at scale.

The project described in this protocol will be implemented by investigators at WorldFish, Mississippi State University, Washington University, the Commonwealth Scientific and Industrial Research Organisation, Australia National University and the International Food Policy Research Institute, who are being hosted by the International Institute for Tropical Agriculture based in Ibadan, Nigeria. Investigators are collaboratively involved in the project by providing recommendations and input on intervention strategies, recommendations on study design, sampling and questionnaire development, and they will be involved in the analysis of de-identified data.

Context

The scoping study will endeavor to answer five major researchable questions:

1. What will be the demand for fish in Nigeria over the next three decades, and how Nigerian will aquaculture production and trade/markets contribute to bridging the demand-supply gap?
2. Does/can aquaculture improve household income, diversify diets and empower women and youths?
3. Which aquaculture production systems and value chains contribute to socially and environmentally sustainable and inclusive growth, and provide better business opportunities?
4. How can the private sector contribute to meet challenges in aquaculture development, inclusive growth, improving household income, diversifying diets and empowering women and youths?
5. What investment strategies and business models would/could influence private-sector (large companies) engagement in improving inclusiveness and performance of aquaculture value chains toward increasing the contribution of aquaculture/fish to poor and vulnerable communities?

Components

The scoping study is divided into four major components, with a view to find answers to several sub-questions, while addressing the five main researchable questions.

Fish demand, supply and markets

- What was the demand for fish in Nigeria in 2020, and what will it be in 2030 and 2050 under different scenarios?
- How do capture fisheries and aquaculture production systems in Nigeria respond to the increasing fish demand in the future, considering complex interactions of domestic supply, demand, trade and imports?
- What are the driving factors that will influence future fish supply, demand and trade?
- What are the impacts of fluctuating (especially increasing) input costs, (feed, seed, labor, etc.) on aquaculture production in Nigeria?

- How will future fish demand and supply influence future fish markets, and what are the investment options and strategies that could improve/increase fish supply and availability to increase the fish sector's contribution of fish to Nigerian food and nutrition security?

Aquaculture performance and value chain sustainability

- What types of aquatic production systems are socially and environmentally sustainable, economically viable and inclusive, and have the potential to contribute sustainably and equitably to the increasing demand for fish in Nigeria?
- What interventions exist for improving systems sustainability, productivity and inclusiveness?
- What is the contribution of the fish value chain to economic growth? Is this economic growth inclusive? Is the value chain socially sustainable? Is the value chain environmentally sustainable?
- Who are the value chain actors, and is there any evidence of market transformation?
- Where are the opportunities along the value chain for interventions toward improving value chain performance?

Aquaculture for food, nutrition and income for the poor

- Are there opportunities for smallholder farmers to pull themselves out of poverty? Are there barriers to entry? Is the capital investment too high for smallholders and can it be lowered through investments, innovations, interventions and/or pro-poor business modeling? Is there enough demand for fish and fish-based products to generate profit?
- What fish are people eating? What percentage comes from aquaculture-fish? Is there a demand (will there be a lasting demand) for aquaculture fish? Are aquaculture fish available, accessible and affordable? Would including fish in the diet increase overall dietary diversity and thus nutrient intake? What nutritional and health roles do aquaculture fish/fish-products play during the first 1000 days?
- Are there sufficient opportunities for women and/or youths to participate equitably along the value chain? What bottlenecks exist for women to gain access to resources that do not exist for men? What barriers need to be addressed for women to be empowered by aquaculture?

Private sector engagement and investment strategies

- What are the challenges in fish value chain development, and how will the private sector contribute to meet the challenges?
- What opportunities exist for the poor to participate in the fish value chain?
- How does the private sector offer opportunities for entry of the poor as participants in value chain development?
- How can the private sector be involved in research and development of the fish value chain?
- What roles could the private sector play to ensure socially and environmentally sustainable inclusive growth through value chain development?
- Who are the major private sector players in Nigeria aquaculture? What are their current roles in the Nigerian aquaculture value chain and future vision? What are the links between major private sector players (companies) and small-scale farming communities? Are the major private sector companies and their engagement helping inclusive growth?
- What are the opportunities to influence major private sector players toward increasing inclusive growth and supporting fish-based food, nutrition and income security among poor communities?

- What business strategies and models are available for investment toward influencing and/or engaging/ unlocking private sector (major aquaculture companies) to support poor communities?

Study timeline

The study began with pre-testing of the quantitative survey questionnaires in mid-May 2019. Following pre-testing and revision of the quantitative surveys, supervisors and enumerators were trained in mid-June 2019. The data collection was scheduled to begin by the end of July 2019. Data collection continued for 3 to 4 months, at which point the dataset was finalized. Analysis and dissemination of the findings was expected to be completed by June 2020.

Research methodology

This scoping study aimed to collect both quantitative and qualitative data about fish production, trade and consumption throughout Nigeria, with a focus on the high fish producing states. Eight Nigerian states were selected for the survey by employing the following criteria: the number of operational farms in each state, allowable access to the state, poverty level as expressed by the Multidimensional Poverty Index (MPI) by assigning a weight to each criterion based on the purpose of survey and by considering the prevalence of stunting in each of the states. Regional representation was also considered when finalizing the states for the surveys. An additional state, Kebbi, was chosen for the household survey because of the high prevalence of stunting. The selected states with their summary characteristics are listed in Table 1.

Sampling and data collection for component 1: Fish demand, supply and markets – fish sector model
A number of models have been developed to project fish supply and demand, such as the fish IMPACT and Aglink–Cosimo models, which were both used to project the global fish sector in medium term. With a focus on the global scale, these models, however, lack the disaggregation level that is often needed to analyze the fish sector at the national level. Other models, such as the ASIA-FISH model, could provide more disaggregated projections, but require a large number of parameters to be estimated from real-life data using econometric techniques. It is not possible to fulfill this criterion in Nigeria due to the lack of reliable and quality data (disaggregated data often exhibits inconsistencies when compared from various sources).

To overcome this challenge, our approach is to develop a foresight model that minimizes the level of data demand while maintaining the key objective of being able to analyze the key scenarios and evaluate policy impacts on the Nigeria's fish sector. To do so, we limited the analysis to main fish species groups and production types, collected the most reliable information and then adjusted the modeling specification to fit with what is available. We will collaborate with the Department of Statistics from the Ministry of Agriculture and Rural Development Nigeria to collect and compare data from various sources and the cross-check and adjust to eliminate inconsistencies.

The Nigeria fish sector model will be specifically developed to accommodate the limited availability of data. A multimarket equilibrium feature that characterizes the equilibrium of Nigeria's fish supply and demand on all related markets will be formalized. The key purpose of building the "custom-made" models is to minimize the need for borrowing parameters and data from studies of other countries to meet the demand of a pre-built modeling template. This approach has helped improve the practicality of the projection outcomes.

The "Fish demand, supply and markets" component will be produced by a fish sector model, which will be developed using existing secondary information and data as well as data collected and verified through the quantitative surveys (producer survey, value chain survey, consumption survey). One quantitative and qualitative FGD to validate data gaps and to explore alternative scenarios was developed during the stakeholder consultation workshop in Abuja. Another FGD was planned for June 2019 to fill the gaps in required knowledge, data and information.

Sampling and data collection of components 2: Aquaculture performance and value chain sustainability
This component is divided into three surveys: aquaculture producer survey, value chain actor survey, and input and service provider survey.

Producer and production performance survey

This component will be implemented by applying both quantitative and qualitative methods. For the quantitative aquaculture performance assessment study, standardized recall assessment survey (quantitative) and FGD (qualitative) methods will be used. A recall performance assessment standardized farm survey with a stratified random sample of about 650 fish farms (15 of the largest commercial fish producers in Nigeria will be surveyed individually using a semi-structured questionnaire and face-to-face interviews) in the selected states will be conducted in the eight states selected. A multiple stage sampling procedure combining both probability and non-probability sampling techniques will be used to select aquaculture producers for the study.

In the first stage, supervisors will liaise with their respective state ADP to compile the aquaculture producer list and list of aquaculture production concentration areas/clusters in each state. In the second stage, aquaculture concentration clusters will be purposely selected for inclusion in the study, representing (a) a diversity of aquaculture production systems and farmed species, (b) a diversity of biological and socioeconomic characteristics of aquaculture producers in the state, and (c) a full continuum of aquaculture production scale (from small-, to medium- and large-scale producers). In the third and final stage, the aquaculture producer list from the selected aquaculture concentration areas will be compiled and producers will be randomly selected from the list. KIIs will be conducted with large-scale producers/ aquaculture farms to get a full understanding of aquaculture production performance in the country to provide insights on private-led aquaculture development interventions. The quantitative survey questionnaire to be used for the producer and production performance survey is given in Annex 2.

For the qualitative study, four standardized recall assessment surveys (quantitative) and qualitative FGD methods and KIIs will be administered. Several FGDs will be also held during the same fieldwork period to strengthen the qualitative survey results and findings. For the qualitative data collection, one macro-level FGD will be held, consisting of some 15 participants, representing different actors in the aquaculture industry.

The production survey will also be conducted in eight states (except Kebbi), with the aim of sampling 5 percent of all active producers in each state, with a maximum sample size of 150 and a minimum sample size of 50 in each state.

Value chain assessment:

The project inception workshop held in Ibadan, from January 8-16, 2019, identified five key types of actors for both catfish and tilapia value chains in Nigeria: producers, traders (wholesalers and retailers), processors and consumers. Both producers and consumers are accommodated within the producer and consumer household survey modules. In the value chain module, we will conduct quantitative surveys for traders (wholesalers), processors and retailers, supplemented by qualitative data collection related to key issues and opportunities. The Nigerian states for the value chain survey are selected based on selected states for both producer and consumer surveys.

Quantitative data collection
For the value chain surveys, we will select over 300 (wholesalers, retailers and processors) for the completion of a quantitative survey from the eight states selected (Table 2). For each state, study supervisors will identify geographic clusters (fish markets), considering community size and population density. Individual value chain actors will then be surveyed using a snowball sampling method within each cluster. As much as possible, a common principle to be applied is to maximize the number of clusters and minimize the number of units within a cluster, while ensuring that there is a sufficient number of units per cluster to give adequate precision of data within the cluster. Fifty percent of value chain actors will be selected from a rural agroecological zone, and 50 percent will be selected from an urban zone. In both the urban and rural

zones, we aim to reflect gender diversity as much as is practical and try to reflect the true nature of gender diversity among value chain actors. The quantitative survey questionnaire for the value chain assessment is given in Annex 3.

Qualitative data collection
We aim to conduct at least one FGD per state. We plan to interview a small number of respondents who represent diverse or extreme views in order to acquire a depth of information on fish value chain actors, opportunities and challenges in the sector, gender and inclusiveness and food safety along the value chain. Respondents will include a combination of value chain actors (wholesalers, processors and retailers) and local fisheries experts, including government representatives and local researchers. To conduct an FGD, we will purposely identify our respondents to be the most "informative" (rather than "representative") people in the community. The value of the findings focuses on the depth of information in this case rather than representativeness.

Input and service provider survey
For this section, we intend to carry out comprehensive semi-quantitative and qualitative surveys of almost all large-scale commercial hatcheries, feed companies, fish processors, importers and traders in the country. These will be done using semi-quantitative questionnaires, FGDs and face-to-face interviews and discussions. The survey will ensure all social (labor, income, gender, age, inclusiveness, etc.), environmental (input/output ratios, emissions, carbon footprint, wastage, etc.) and economic (cost-benefits, economic viability, profits, etc.) impacts will be captured along the value chain.

The semi-quantitative survey framework for input and service providers
We have also conducted sector reviews on (a) feed production and marketing, (b) fish processing and the cold chain, (c) seed production and distribution, (d) state policy and assistance, and (e) farmer associations and their contribution to national aquaculture development. These reviews will enrich the final analysis.

The survey of inputs and service providers (i.e. hatcheries, feed millers and suppliers, processors, buyers and traders, and veterinary service providers) was carried out using tailor-made semi-structured questionnaires, FGDs and face-to-face discussions/meetings separate from the three above mentioned questionnaires. This included 15 large-scale producers within the selected eight states and outside, 40 fish hatcheries, the three largest feed manufacturers, three largest fish importers and 10 veterinarians engaged in providing health management advice to the small-scale farming sector. Table 2 provides the envisaged number of samples of each survey category in each state.

Parallel qualitative surveys will also be conducted using qualitative survey methodologies. The number of FGDs and other meetings again will be based on the concentration of value chain activities in states. On average, each survey component will consist of three FGDs in each state and will also include small feed producers and small hatcheries operators.

Component 3: Aquaculture for food, nutrition and income of the poor – data collection tools
Household surveys will be conducted in all eight states. Study supervisors will select a rural town and an urban town in which to conduct the surveys. We aim to survey 100 households, 20 of which will overlap with the producer survey. Of the 100 households, we intend to sample 20 where there is a pregnant or lactating woman in the rural setting, and 10 households where there is a pregnant or lactating woman in the urban setting. This will result in a total sample size of 900 households.

FGDs will be led by the study supervisors and an assistant. FGD data will be transcribed and summarized immediately following each interview. The qualitative survey framework, including semi-structured questionnaires, discussion points and guidelines, capturing all aspects of social, gender, age, inclusiveness, etc., is being developed.

Component 4: Private sector engagement and investment strategies

This component will be addressed through literature reviews, landscape analyses and face-to-face discussions, as well as interviews and stakeholder consultations. A comprehensive landscape analysis on the engagement of the private sector in Nigerian aquaculture will be conducted. With the information derived from the landscape analysis and our information and contacts, a series of face-to-face meetings, discussions and interviews with a range of private sector aquaculture value chain actors, food processors, supermarkets and retailers will be conducted. Face-to-face discussions will also be held with state authorities charged with developing policies and making rules and regulations on aquaculture production, inputs and service provision, food safety and trade.

We will also conduct two or three stakeholder discussions with major private sector operators, state-level policymakers and national aquaculture societies to discuss opportunities to develop mutually beneficial, inclusive, private sector-driven investment strategies to improve the contribution of fish to food and nutrition security, employment and economic well-being.

We will use the information and recommendations collated from other components of the project to assist in designing and developing promising and innovative private sector-led solutions to increase the contribution of fish to the Nigerian people.

This component seeks to create partnerships between entrepreneurs, companies and other organizations to incentivize the harnessing of the power of private enterprise to create change, especially for vulnerable gender and age groups.

The "Private sector engagement and investment strategies" component will be developed from (a) information and inferences derived from the above quantitative and qualitative surveys, (b) a comprehensive landscape analysis of private sector engagement in Nigerian aquaculture, (c) face-to-face discussions with major private sector companies engaged in Nigerian aquaculture, and (d) stakeholder consultations. Planned face-to-face discussions will also be extended to better understand the visions of the private sector actors (companies) and the opportunities for developing strong partnerships to better support smallholders in the value chains as well as poor households. The insights thus gained will be used to formulate recommendations on private sector-driven investment strategies to improve the contribution of fish to the poor and vulnerable.

Use of secondary data

All analyses of the survey data, particularly the fish demand, supply and markets components, will be enriched through the use of secondary data from the FDFA, Federal Ministry of Agriculture and Rural Development (FMARD), Abuja, FAO database (FishStatJ), FAOSTAT, UN Comtrade and the World Bank's Living Standards Measurements Study. Data on fish production, imports, exports, markets, prices, consumption, GDP and population growth and the consumer price index will be gathered from appropriate national, regional and international institutions. Where possible, inputs will be verified via the literature review, primary data collection (Nigeria producer survey tool) and qualitative FGD data.

Data management

Once data collection teams are operational, a monitoring and quality backup system will be established to assess data collection progress on a weekly basis. A team from WorldFish headquarters in Penang, Malaysia, will supervise the data collection process and provide support and feedback to national data collection teams. In the field, data collection can be conducted offline, with enumerators submitting/uploading data daily or at least 3 days per week to the WorldFish server at internet connection points/towns. Survey teams will also be provided with USBs for storing data. Supervisors will supervise enumerators by phone or other convenient methods (field visits).

Study teams

Survey teams comprising a supervisor and five or six enumerators will be convened for the study. Survey team members will be sought from universities (lecturers and graduate students who work and have experience with farm surveys and interviews). Research institute and private company staff and sector associations can also join the data collection team, depending on their qualifications, experience and actor network knowledge. Survey teams will be trained in online data collection/performance assessment tools (Open Data Kit) and on techniques to run FGDs to collect qualitative data and information for the study.

Region	States	Number of farms	Presence of large-scale farms	Security concerns***	MPI	Total points scored	Recommended states
Southwest	Lagos	70	0	10	3	83	Lagos
	Ogun	60	10	10	5	85	Ogun*
	Oyo	50	10	10	5	75	Oyo*
	Ondo	50		8	5	63	
South South	Delta	70	0	6	5	81	Delta
	Rivers	50	0	6	3	59	Rivers
	Akwa Ibom	40	0	8	3	51	
	Cross Rivers	30	0	8	5	43	
South East	Anambra	40	0	10	3	53	Anambra
	Imo	20	0	10	3	33	
	Ebonyi	20	0	10	7	37	
	Abia	10	0	6	3	19	
North West	Kaduna	40		6	9	65	
	Kano	40	10	6	10	66	Kano
	Nasarawa	20		10	7	37	
North East	Adamawa	40		0	7	47	
	Taraba	30		10	10	50	
North Central	Kogi	50		6	5	61	
	Kwara	50		10	3	63	
	Plateau	40		10	7	57	
	Niger	40		10	9	59	Niger**

**States with large-scale commercial farms.*
***Niger is included to represent the North Central region, as Kwara shares cultural and socioeconomic features with the North West region.*
***See also "Assigning scores for each criterion" section below.*

Table 26. Summary characteristics of the states selected for the survey. Security concerns are derived from data in Figure 16.

State	Total farms	Farms: 5% max = 150 min = 50	Households	Traders (wholesalers)	Retailers	Fish processors smokers	Hatcheries	Large-scale producers and hatcheries	Veterinarians	Feed manufacturers
Lagos	3000	150	100	25	15	10	5		2	
Ogun	1660	83	100	15	10	10	5	5	1	1
Oyo	510	50	100	15	10	10	5	1	1	2
Delta	2910	146	100	25	15	10	5		2	
Rivers	1285	64	100	15	10	10	5		1	
Anambra	595	50	100	15	10	10	5		1	
Kano	790	50	100	15	10	10	5	1	1	
Niger	355	50	100	15	10	10	5		1	
Kebbi			100							
Others								8		
Total	**11,105**	**643**	**900**	**140**	**90**	**80**	**40**	**15**	**10**	**3**
Total samples	**1921**									

Table 27. Numbers of samples to be surveyed in selected states.

Survey state selection criteria

Selection of states for household, fish consumption and aquaculture farm performance surveys and value chain analysis are based on the following criteria:

1. adequacy of number of aquaculture farms, hatcheries and traders, which allows a reasonable random selection of a sample size for surveys
2. availability of large-scale commercial farms
3. allowable access without security concerns
4. high in poverty (MPI)
5. geographical/regional representation
6. stunting rate of children under 5 years of age.

Criteria 1–4 are directly relevant to all planned surveys, while the sixth criterion is more relevant for the household fish consumption survey. The fifth criterion was applied to maintain geographical/regional representation for the surveys.

State	Number of aquaculture farms
Lagos	3976
Delta	2910
Ogun	1656
Rivers	1285
Ondo	1220
Oyo	1053
Kogi	1032
Kwara	1000
Plateau	913
Kaduna	869
Niger	853
Kano	790
Akwa Ibom	600
Anambra	595
Adamawa	502
Cross River	434
Taraba	400
Nasarawa	398
Imo	350
Ebonyi	313
Abia	295
Total	**21,444**

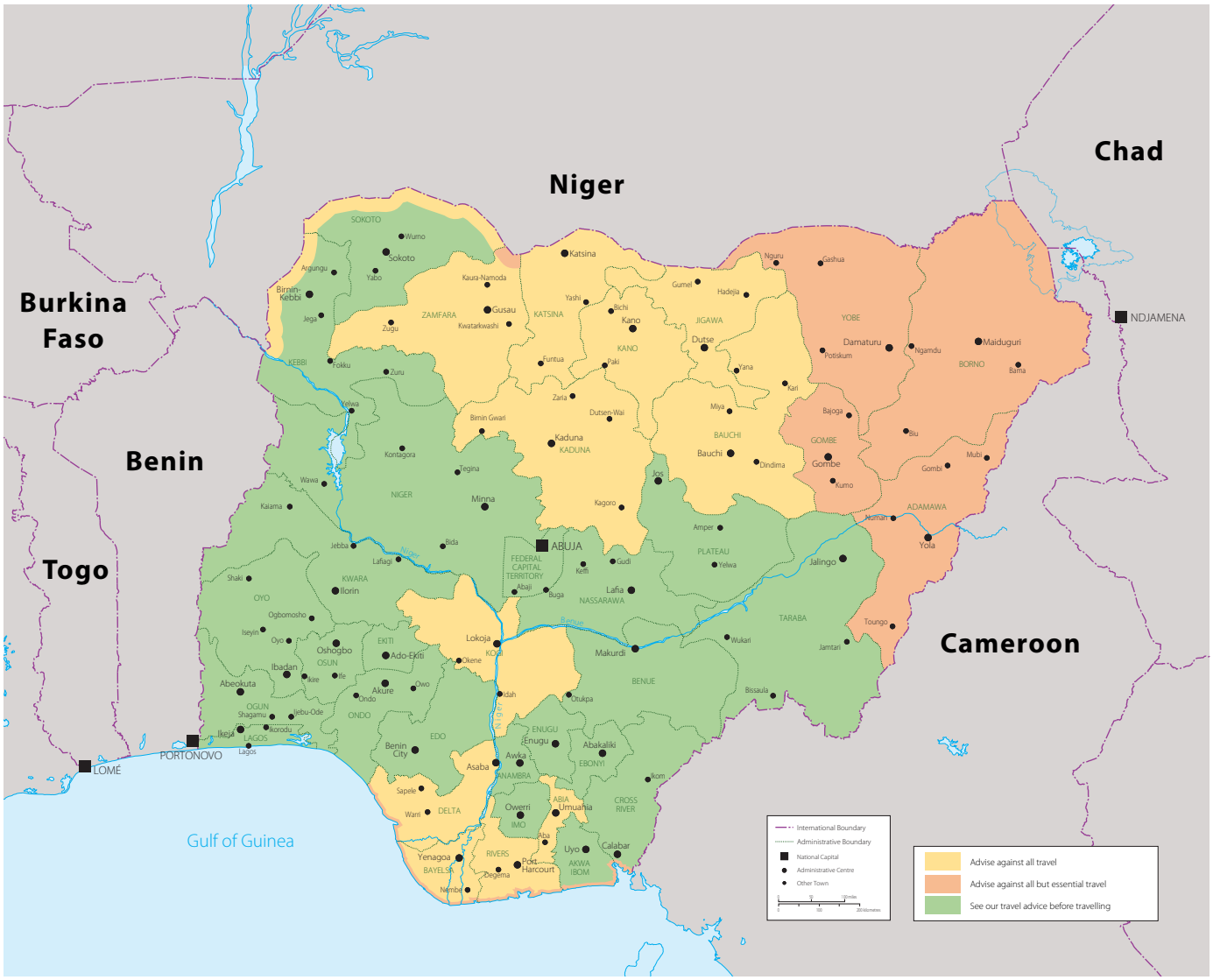
Source: fish farmers associations.

Table 28. Aquaculture activity, as assessed by number of farms, ranked in order from high to low.

State	MPI
Anambra	0.05
Lagos	0.035
Imo	0.083
Rivers	0.088
Abia	0.088
Kwara	0.099
Akwa Ibom	0.099
Delta	0.107
Ogun	0.112
Kogi	0.113
Ondo	0.127
Cross River	0.146
Oyo	0.155
Nasarawa	0.251
Ebonyi	0.265
Plateau	0.273
Adamawa	0.295
Kaduna	0.311
Niger	0.323
Kano	0.434
Taraba	0.448

Source: Multidimensional Poverty Peer Network: https://www.mppn.org/nigeria-national-mpi/.

Table 29. Poverty level, as represented by the MPI (low to high).



Source: Foreign and Commonwealth Office, Government of the UK.
https://assets.publishing.service.gov.uk/media/5937d9aded915d20f8000176/1670601_Nigeria_pdf.pdf.

Figure 16. Allowable access and security concerns in states.

Region	State	Number of farms	Security concerns	MPI
South West	Lagos	3976	Travel allowed	0.035
	Ogun	1656	Travel allowed	0.112
	Oyo	1053	Travel allowed	0.155
	Ondo	1220	Travel allowed	0.127
South South	Delta	2910	Essential travel	0.107
	Rivers	1285	Essential travel	0.088
	Akwa Ibom	600	Travel allowed (advice against in riverine areas)	0.099
	Cross Rivers	434	Travel allowed (advice against in riverine areas)	0.146
South East	Anambra	595	Travel allowed	0.05
	Imo	350	Travel allowed	0.083
	Ebonyi	313	Travel allowed	0.265
	Abia	295	Essential travel	0.088
North West	Kaduna	869	Essential travel	0.311
	Kano	790	Essential travel	0.434
	Nasarawa	398	Travel allowed	0.251
North East	Adamawa	502	Advice against travel	0.295
	Taraba	400	Travel allowed	0.448
North Central	Kogi	1032	Essential travel	0.113
	Kawara	1000	Travel allowed	0.099
	Plateau	913	Travel allowed	0.273
	Niger	853	Travel allowed	0.323

Table 30. Summary of travel concerns associated with states with aquaculture farms (Figure 16) and poverty levels as represented by MPI.

Assigning scores for each criterion

Scores are assigned for each criterion based on the importance of the criterion in the survey. Household and nutrition surveys do not target fish farming households and hence are independent of the number of fish farms and value chain actors in each state. However, they do consider stunting rate among children under 5 years old. The fish farm performance survey and value chain analysis target only farms and value chain actors and hence are assigned a higher score for a number of farms than for other criteria. Stunting rates are applied to ensure that the selected states for the farm performance survey and value chain analysis give a representative cross-section of stunting rates for the nutrition survey. States are also selected to ensure geographical/regional representation.

Criterion 1		Criterion 2		Criterion 3		Criterion 4	
Number of farms (70%)	**Assigned points**	**Presence of commercial operations**	**Assigned points (10%)**	**Security concerns (10%)**	**Assigned points**	**MPI (10%)**	**Assigned points**
>2000	70	Presence of large-scale commercial operations	10	Travel allowed	10	>4	10
1500–1999	60	Absence of large-scale commercial operations	0	Travel allowed with advice against in selected parts	8	3–3.9	9
1000–1499	50			Essential travel allowed	6	2–2.9	7
500–999	40			Advice against travel	0	1–1.9	5
400–499	30					<1	3
300–399	20						
<300	10						

Table 31. Distribution of assigned scores under different criteria (total aggregated score of 100).

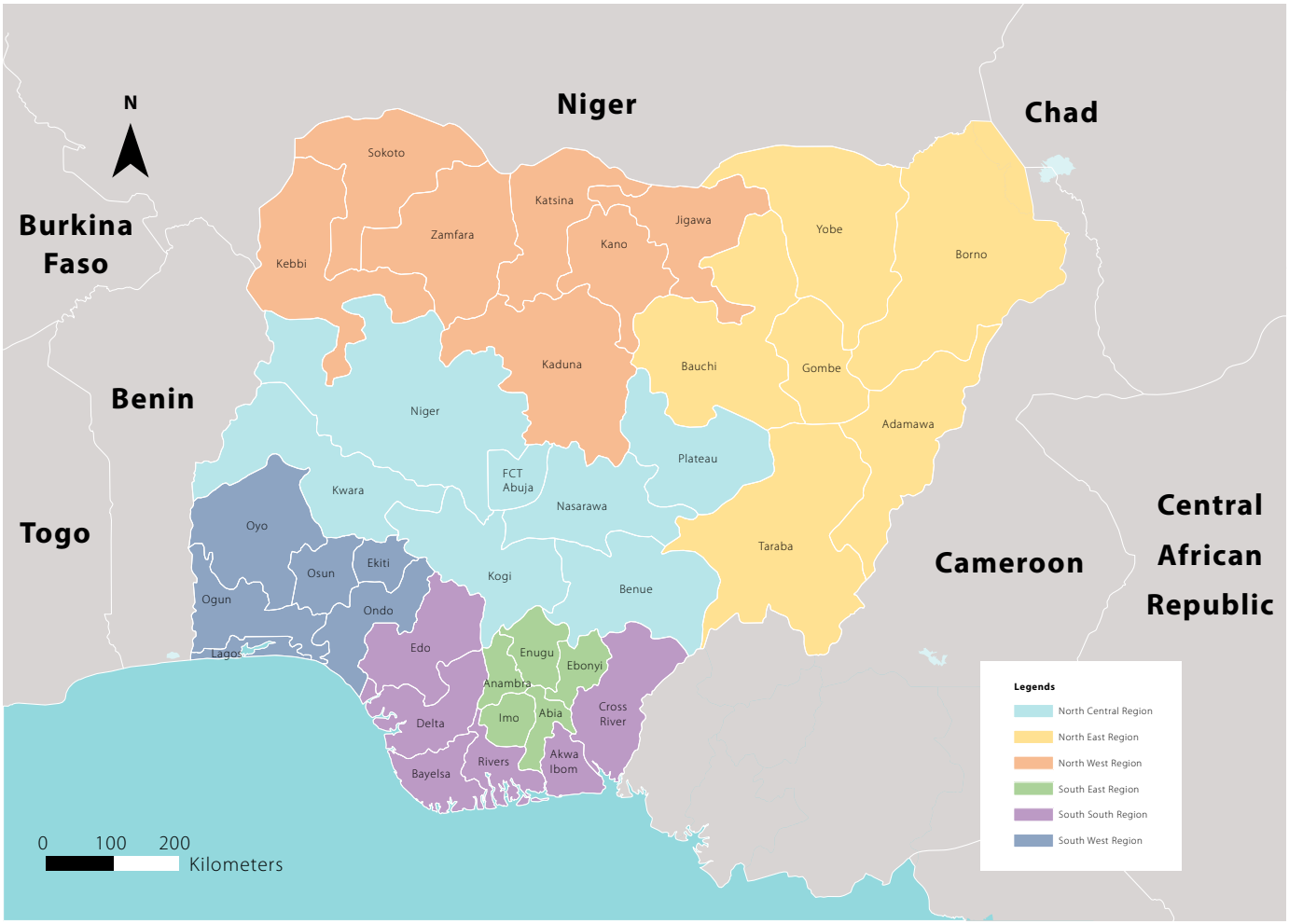
Region	States	Number of farms	Presence of large-scale farms	Security concerns	MPI	Total points scored	Recommended states
South West	Lagos	70	0	10	3	83	Lagos
	Ogun	60	10	10	5	85	Ogun*
	Oyo	50	10	10	5	75	Oyo*
	Ondo	50		8	5	63	
South South	Delta	70	0	6	5	81	Delta
	Rivers	50	0	6	3	59	Rivers
	Akwa Ibom	40	0	8	3	51	
	Cross Rivers	30	0	8	5	43	
South East	Anambra	40	0	10	3	53	Anambra
	Imo	20	0	10	3	33	
	Ebonyi	20	0	10	7	37	
	Abia	10	0	6	3	19	
North West	Kaduna	40		6	9	65	
	Kano	40	10	6	10	66	Kano
	Nasarawa	20		10	7	37	
North East	Adamawa	40		0	7	47	
	Taraba	30		10	10	50	
North Central	Kogi	50		6	5	61	
	Kwara	50		10	3	63	Kwara
	Plateau	40		10	7	57	
	Niger	40		10	9	59	Niger**

** States with large-scale commercial farms.*
*** Niger is included to represent North Central region, as Kwara shares similar cultural and socioeconomic features with the North West region.*

Table 32. Aggregated scores for each state and recommended states for BMGF field surveys and value chain analysis.

Stunting rates of selected surveys

The overall stunting rate of children under 5 for the states selected for farm performance and aquaculture value chain analysis gives a representative cross section of comparatively low (11.9%) to high (46%) stunting rates (Figure 17). In addition to the states selected for the farm performance survey and values chain analysis, Kebbi was selected for the nutrition survey as a state with higher stunting rates. Among the states with higher stunting rates (Figure 18), Kebbi was selected considering the accessibility due to security concerns.



State	Overall stunting
Lagos	12.9%
Ogun	**29.6%**
Oyo	23%
Ondo	24.2%

State	Overall stunting
Anambra	**11.9%**
Imo	16.8%
Ebonyi	**25%**
Abia	17.9%

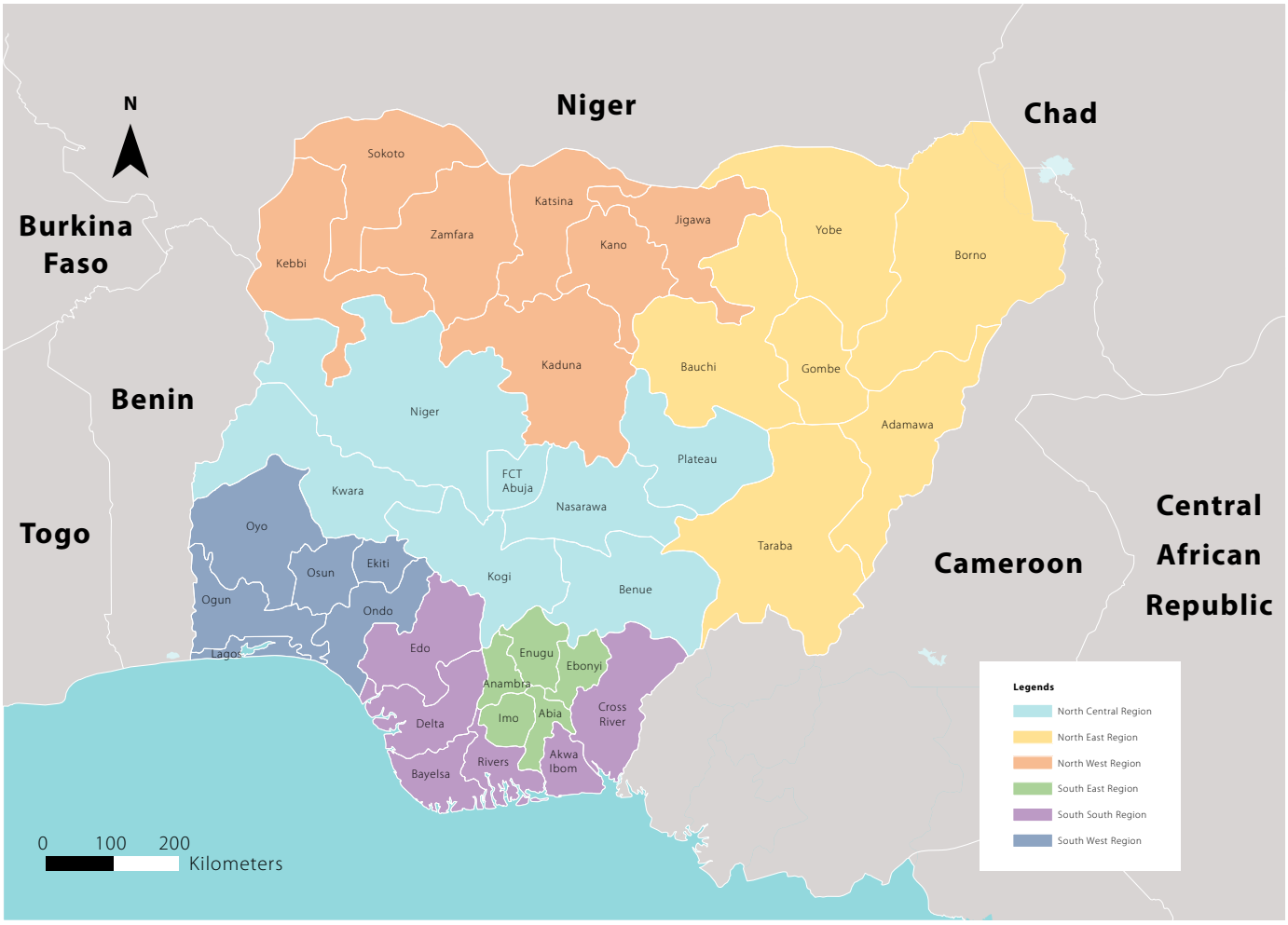
State	Overall stunting
Delta	**18.2%**
Rivers	**16.3%**
Akwa Idom	**25.7%**
Cross Rivers	22%

State	Overall stunting
Kogi	22.7%
Kawara	**29.4%**
Plateau	**42.8%**
Niger	**33.9%**

State	Overall stunting
Kaduna	42.9%
Kano	**46%**
Nasarawa	33.2%

State	Overall stunting
Adamawa	39.4%
Taraba	31.9%

Figure 17. Overall stunting rates of children under 5 years of age.



State	Overall stunting	State	Overall stunting
Bauchi	45.6%	Katsina	58%
Borno	37.3%	Kebbi	51.8%
Gombe	44.6%	Jigawa	54.1%
Yobe	55.8%	Zamfara	5.6%

Figure 18. States with high stunting rates of children under 5 years of age.

WorldFish

About WorldFish

WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

WorldFish is part of One CGIAR, the world's largest agricultural innovation network.

For more information, please visit www.worldfishcenter.org