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Nigerian aquaculture:
An investment Framework for Improved Incomes, New Jobs, Enhanced Nutritional Outcomes and Positive Economic Returns

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Executive summary

With sub-Saharan Africa poised for immense population growth over the next three decades, consumer demand for animal protein is projected to increase dramatically. Fish is expected to make up a significant part of this growth as Africa currently consumes only 9.9 kg per capita annually, which is less than half of the global average of 20.3 kg. By 2030, it is estimated that Africa will need an additional 4.4 million metric tons of fish to maintain current levels of consumption, and 21.8 million metric tons to bring it on par with the global annual average.

Nigeria in particular represents an attractive and growing market for aquaculture. It is buoyed by several macro market forces, such as attractive demographics (its population is expected to more than double by 2050 to 402 million), growing wealth accumulation, currency restricted imports and the nation's increasing demand for dietary protein. Nigeria's annual per capita fish consumption is 11.2 kg, just 54% of the global average. In 2018, the country had a total supply of 2.1 million metric tons of fish. Of this total, 291,000 t came from aquaculture (98% catfish and 2% tilapia); 866,000 t from artisanal fisheries; 940,000 t from imports; and 11,600 t from marine capture. As is evident, even if overall market demand does not increase, there is significant opportunity to replace imports with domestically produced fish, and the artisanal fisheries have the potential to do so. Specifically, Nigeria has an existing network of clusters in almost every state where aquaculture is practiced. These range in size from 25 to 2000 farmers and hold immense investment and production potential if such cooperatives can be transformed into robust commercial enterprises. Given these trends and existing clusters, we believe the promise and potential for Nigerian aquaculture—both for tilapia and African catfish—is very exciting from a commercial return as well as a social impact perspective.

That said, Nigeria will have to overcome some existing hurdles to optimize its current aquaculture industry to meet the growing demand and fully capitalize on its investment potential. For example, there are currently market failures at several levels. In production, there are high disease burdens, inferior genetic quality of seed, the unaffordable cost of commercial feeds for smallholders operating low-productivity systems, and little or limited access to investment capital. Among markets, access to markets is poor, there is a dearth of consumer knowledge about benefits of fish, and price signaling is inadequate. Regarding regulation and policy, there are problems with national policies, including food quality, safety and land rights. And for investors, the small deal sizes pose a challenge, as do perceptions of high risks. Combined, these failures at various levels pose hurdles for investors and overall sector development alike. These hurdles are also holding up the rapid evolution of state-level clusters into sustainable enterprises. However, we remain optimistic that such challenges can be overcome through public and private investment and strategic collaboration that will set the stage for rapid growth of Nigeria's private aquaculture industry.

Therefore, building on WorldFish's expertise on aquatic food systems and its role as a global non-profit, the purpose of this Nigerian investment framework is to briefly frame the market opportunities ahead and summarize the structural challenges faced by the aquaculture sector. The goal is to provide public and private investors as well as Nigeria's development partners with a roadmap of the gaps and potential investment opportunities. The framework focuses on the overall market structure, value chains and human capital within small-scale producers (SSPs), small and medium enterprises (SMEs) and women-led enterprises. Many SSPs, SMEs and women-led enterprises currently exist within the country's aquaculture clusters. To accelerate their growth and transformation into commercial enterprises, distributed solutions related to feed, seed, technology and improved access to capital need to emerge and be supported.

This document presents a brief overview of the Nigerian market (Section 1), examines the systemic challenges facing the three pillars of a sustainable market as they exist today in the country (Section 2), details several exogenous issues impacting investment in the sector at present (Section 3) and enumerates specific "shovel-ready" and longer-term investment opportunities available to public and private financiers at both the cluster and SSP levels, as well as the national level, to help the Nigerian aquaculture market reach its full potential (Section 4).

We also provide a detailed investment case study on Genetically Improved Farmed Tilapia (GIFT) in Section 4.15, which indicates that, within a 10-year span and a program involving 150,000 smallholders, Nigeria has the potential to produce an additional 720,000 t of GIFT, with a total farmgate value of USD 1.4 billion. Additional benefits include the following:

- 280 (small-, medium- and large-scale) GIFT hatcheries employing nearly 2500 people
- 1.8 million GIFT broodstock, producing 1.5 billion all-male fingerlings
- 150,000 smallholders farming GIFT in ponds, providing at least 300,000 jobs
- 5000 SSPs farming GIFT in cages, providing 20,000 direct jobs
- 650,000 jobs created along the value chain, 50% of which will be filled by women and 25% by youths
- indirectly benefiting 3.25 million households
- 1.2 million metric tons of GIFT produced using 1.5 million metric tons of feed and delivered to consumers with minimal waste
- new income pathways for both SSPs (e.g. a single 1000 m^2 pond can make an annual profit of USD 4600, for a return on investment (ROI) of 44.9%) and SMEs (e.g. five cages making an annual profit of USD 22,500, for a 63.34% ROI)
- a savings of nearly 50% of Nigeria's current foreign-exchange expenditures on fish imports.

That said, this investment framework is neither prescriptive nor exhaustive. Investment is needed at all points of the aquaculture value chain, and a complete assessment and evaluation of individual investment opportunities, particularly from a private sector perspective, is beyond the scope of this document. Therefore it is difficult to quantify the exact magnitude of investment required. We believe it is likely to be at least USD 50 million but, with return possibilities of USD 1.5 billion, the ROI offers rich potential. We also recognize that—despite almost universal agreement about the promise and future profitability of Nigeria's aquaculture sector—some private investors may be selective in the near term. There are several reasons for this that are inherent to the country. Market development is relatively long and customer education activities still need to occur, ticket sizes are small, electricity supplies and foreign exchange rates are unstable, and economic and operational challenges are perceived to be high. However, we firmly believe that the medium- and long-term outlook for this sector and investment returns inherent in its continued growth are compelling and positive, and will indeed benefit from a collaborative public-private approach to building this industry in Nigeria.

Given this, many of this investment plan's recommendations fall more within the purview of public, impact and/or public-private partnership investors whose time horizons, return requirements and risk appetites may be better aligned with the required investments needed to help set the overall framework of the market, further develop the requisite value chain components, and scale the human capital needed, with a particular focus on small-scale and/or women-led enterprises. As specified in Sections 4.1 and 4.2, we are particularly optimistic about investments that will transform SSP "clusters" into enterprises by decentralizing seed and feed production and aggregating both the buying and marketing power of the fish producers themselves. We also believe there are compelling commercial and strategic return opportunities in health and technology, specifically digital marketplaces.

In sum, we feel Nigeria's aquaculture sector offers investors a myriad of clear paths to positive returns and/or strategic interventions that will help set an accelerated trajectory for this very exciting Nigerian commercial sector in the years to come.

1. Market landscape

Before analyzing market gaps and investment opportunities, it is useful to recap the current scale and rich future potential of Nigeria's aquaculture market for potential investors.

1.1. Macro indicators

With a sizable and rapidly growing population, Nigeria will be the third-most populous country in the world by 2050. By 2023, it is poised to become sub–Saharan Africa's largest economy in GDP terms (Frontier Strategy Group 2018) by a considerable margin. The country's consumer class will grow from 36 million people in 2018 to 44.4 million in 2023. Also, by 2023 Nigeria will have the second-largest public spending budget in sub-Saharan Africa, totaling USD 33 billion. 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).

1.2. Fisheries and aquaculture

Fisheries and aquaculture currently make up approximately 3%–4% of Nigeria's annual GDP. The sector is also a key contributor to fulfilling the population's nutritional requirements, accounting for about 50% 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).

1.3. Fish demand and supply

Projections from WorldFish's foresight model indicate that, under the business as usual (BAU) scenario, 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. To provide a brief enumeration of the growing market opportunity, as Nigeria's population increases from 196 million in 2018 to 263 million in 2030, WorldFish future research indicates that the country would need 752,000 t more fish to maintain current national per capita fish consumption, 11.2 kg, and would need 3.14 million metric tons more to reach current global per capita fish consumption, 20.3 kg, by 2030.

Fish imports will play a role in bridging the fish supply-demand gap, but they come at a price. Fish imports currently cost the Nigerian government USD 1 billion a year of valuable foreign exchange. Therefore, pursuing a strategy to reduce fish imports while increasing fish supplies by facilitating inclusive aquaculture growth and increasing inland artisanal catch is far more likely to meet the future fish supply-demand gap and improve the national economic outlook. This market situation provides significant new opportunities for smallholders, jobs along the value chain, and women's empowerment.

1.4. National aquaculture strategy

Nigeria is currently planning the development of a new national aquaculture strategy in partnership with WorldFish, the Food and Agriculture Organization (FAO) and other relevant national industry/scientific stakeholders. This strategy will lay out key policies and industrial steps needed to further stimulate aquaculture growth in the country and should provide better opportunities for commercial aquaculture development—and access to finance (both investment capital and credit)—in the coming years. The discussions related to this new approach are soon to begin and will likely tackle issues such as technical assistance, the high cost of inputs and services, difficulties in accessing capital investment and finance, and other challenges preventing smallholders from expanding their operations and/or engaging in the aquaculture business.

Policies on land rights for agriculture/aquaculture are unclear, and land rights will need to be better defined as, at present, about 95% of agricultural land is not titled, effectively nullifying its capacity for use as collateral for financial transactions. This new national aquaculture strategy is expected to propose practical solutions and supportive policies that encourage aquaculture businesses (smallholders and SMEs) all along the value chain. Government-run extension services for the aquaculture sector currently suffer from inadequate state financial resources. Partnerships between government, producers and private sector input and service providers (feed manufacturers, seed producers, health services etc.) might be able to provide a more effective extension system.

Photo credit: D.Oguntade

Smoked catfish processing.

2. Sustainable market pillars: Improved productivity, broad and inclusive participation, and supportive policy and regulatory structures

This investment plan is focused on building sustainable aquaculture markets in Nigeria for tilapia, African catfish species and other species in the future, specifically through the transformation and activation of SSP clusters and cooperatives into productive and profitable SMEs over time. Nigeria does possess tremendous scope to diversify its aquaculture industry into additional species, such as shrimp, but tilapia and catfish represent the most "ready" near-term investment opportunities. Therefore, this investment plan aims to delineate opportunities that will help improve productivity and production of tilapia and catfish to increase and improve domestic fish consumption and, ultimately, generate export opportunities for Nigerian-raised fish.

If this transformation can be set in motion at scale, we anticipate that global and Nigerian investors alike will readily identify and place capital with Nigerian SSPs, SMEs and other entrepreneurs poised to drive significant market growth. However, the development of functional Nigerian aquaculture markets that reward increased productivity and quality with income and return opportunities for investors and SSPs alike must be built upon three main pillars: (1) increasing aquaculture productivity for SSPs to help meet the demand enumerated in Section 1.3, (2) increasing the number of SSPs—especially those led by women—regarding engagement, empowerment and participation in the overall aquaculture sector, and (3) improving the policy and regulatory structures within which Nigerian SSPs operate. A brief examination of these pillars and current challenges within each will set the stage for the investment analyses presented in Section 4.

2.1. Increasing aquaculture productivity: Overcoming feed, seed, health and technology challenges

While significant progress (technology, health and management) has been made globally to increase aquaculture productivity, Nigerian SSP aquaculture, although profitable, underachieves relative to global leaders. With improved productivity, Nigerian aquaculture would become more profitable and thus spur further expansion, scaling and intensification. Among the most significant contributing factors to the relatively low levels of productivity is the current proliferation of distributed farmers versus centralized seed, feed and health providers. Nigeria's aquaculture industry has a large number of clusters, each of which ranges in size from 25 to 2000 farmers. If the industry is to advance rapidly, these clusters need to be organized into more commercially oriented enterprises. These enterprises can either start their own small-scale hatcheries or distributed feed mills or be better positioned to negotiate as unified larger "buyers" with established, centralized vendors to obtain more competitive pricing or access credit that simply is not available to individual SSPs or SMEs. We believe the following areas offer the most potential to increase productivity if addressed through public and/or private investment.

2.1.1. Seed

For Nigeria's aquaculture sector to flourish, there is a critical need for disease-free, high genetic quality seed that is accessible, affordable and available year-round. WorldFish is supporting Nigeria's efforts in this sector by introducing its GIFT strain and has started work on African catfish genetic improvements as well. This will aim to help address the following challenges and market requirements:

- Nigerian SSPs suffer from a lack of quality fingerlings, so improved productivity relies directly on technologies, solutions and systems that can help scale affordable access to high quality fish seed.
- Such seed must be locally produced and cost-effective to enable the approximately 200,000–400,000 Nigerian SSPs to exploit its potential.
- There must be efficient and sustainable distribution mechanisms for the fingerlings so that the largely rural SSPs can access the improved seed. Specifically, WorldFish

estimates that the country will need 1.5 billion fry/fingerlings in order to double current smallholder aquaculture production in Nigeria by organizing tilapia farming and using GIFT. This clearly indicates the large-scale opportunity for designing and implementing an organized domestic seed supply chain.

2.1.2. Fish nutrition and fish feed

In addition to seed, feed is a significant challenge facing Nigerian aquaculture overall and SSPs in particular, representing a significant opportunity for domestic commercial feed development and distribution. To achieve the goal of doubling its aquaculture production, Nigeria will require nearly 1 million metric tons of additional and affordable commercial feed. Both global and nationally owned feed companies can produce quality feed, but often not at price points affordable to most SSPs. Imported feed is similarly often not an affordable or a long-term sustainable option for most SSPs because of transportation costs, exchange rate issues and supply chain disruptions, and very few SSPs have the scale to negotiate with mills or get their own containers. Some specific issues include the following:

- **Quantity and availability**: It is important that efficient feed production be activated and scaled to support growing numbers of SSPs, which will require significant amounts of feed not currently being produced in Nigeria. Specifically, as Nigeria's population increases from 196 million in 2018 to 263 million in 2030, WorldFish future research indicates that the country would need 752,000 t of additional fish to maintain its current national per capita fish consumption level of 11.2 kg. Using a feed conversion ratio of 1.4, that means an additional 1.053 million metric tons of feed will be required. And for Nigeria to produce the 3.14 million metric tons more fish to reach the current global per capita fish consumption rate of 20.3 kg by 2030, an additional 4.396 million metric tons of feed will be required.
- **Quality**: At present, while some African-made feed is available in Nigeria, there is no widescale domestic production of quality tilapia feed in the country, and productive aquaculture requires improved feed that is currently not widely used by Nigerian SSPs. There also needs to be further research—as in other parts of Africa—into novel protein sources, such as insects, seaweed, recirculated waste, etc., which could replace fishmeal and oils in aquatic feeds.
- **Cost**: Feed must be available to SSPs at price points that match offtake market signals. Locally produced, high quality feed cannot be so expensive that SSPs cannot make money at current fish price points. Commercial feeds are often considered too expensive for most SSPs and SMEs.
- **Distribution**: Currently, there are few Nigerian feed mills, and they are typically located near urban areas whereas SSPs are typically rural. This misalignment needs to be overcome through investment into innovative feed mill business models or partnerships, as will be discussed in Section 4.1.1.

In sum, there are significant return opportunities for improving the nutritional quality of feeds used by smallholders or SMEs and for increasing smallholders' access to feed in many remote locations around the country. These will be examined in detail in Section 4.1. However, one potential solution may include driving investment toward small-scale feed mills that operate through off-grid electrical sources, which would eliminate the need to transport feed long distances. Similarly, existing centralized feed mills could be encouraged to invest in remote distributed mills if they see a certain amount of capacity being demanded, capacity that may exist if the clusters aggregate their buying needs.

In sum, there are significant opportunities for investing in genetic improvements, seed production, and dissemination. These include a central broodstock facility and hatchery that are complemented by a series of satellite multiplier hatcheries around the country.

2.1.3. Fish health

The establishment of distributed health services, remote health and diagnostic services, or digital diagnostics will help Nigeria's aquaculture sector overcome the following hurdles:

- inadequate discovery, development, production and delivery of quality aquatic food health products needed by Nigerian SSPs, including vaccines, biologicals, probiotics, therapeutics and diagnostics

- inaccessibility of such health products from both a logistical/distribution perspective as well as a financial affordability perspective.

One such digital diagnostic innovation that has the potential to help address this constraint is WorldFish's "Lab in a Backpack." This solution features a small and easy-to-use USB device that makes the genomic sequencing cheaper and faster, allowing users to identify and track outbreaks in close to real-time. The information generated will then be accessed in a user-friendly format via a smartphone, enabling Nigerian aquaculture inspectors to provide biosecurity advice and management plans to farmers in the palm of their hands. It will also let local manufacturers know what to put into custom vaccines and which farms need it.

In sum, however, it is currently very difficult for many SSPs to obtain timely diagnoses across largely rural ponds and aquaculture facilities that can then be correctly and rapidly treated with widely available, cost-effective therapies.

2.1.4. Production technology

Simple improvements to production techniques currently used in Nigeria hold vast potential to improve productivity, especially for tilapia. For instance, providing aeration would increase stocking densities. In fact, WorldFish research shows that simple aeration can make a four-fold increase in tilapia pond productivity. Renewable energy solutions that permit off-grid SSP and SME farming are also needed. As one example, solar powered aeration, coupled with water management technology that could be linked to remote/digital sensors, would be attractive if it could be provided affordably. Technology is also needed for the post-harvest sector of the value chain to increase productivity.

2.2. Increasing SSP engagement, empowerment and participation in a vibrant Nigerian aquaculture market

Investments into improved seed, nutritious and cost-effective feed, and enhanced health solutions would address a number of hurdles

Packs of frozen tilapia, Premium Aquaculture Limited.

currently holding Nigeria's SSPs back from reaching their optimal potential. However, there are other opportunities for investors and donors to consider sustaining a flourishing, profitable aquaculture sector in the country. These training, empowerment and engagement opportunities would address the following gaps:

2.2.1. Human capital / training

Unlike many developing nations, Nigeria has a relatively strong human capital pool upon which the aquaculture industry can be built. There are many SSPs, and Nigeria's large population of job seekers means that there are potentially many other individuals outside the sector—a number of whom are university graduates and/or advanced learners—eager to explore gainful and profitable opportunities should the market continue to grow. Women and youths (aged under 35 years old) are actively engaged in fish value chains, and about 50% of post-farmgate value chain activities (processing, wholesaling and retailing) are controlled (owned) by women, of whom 35% are youths. Due to efforts of the Government of Nigeria and nonprofits such as WorldFish over the years, there is a repository of technical knowledge and expertise that exists with SSPs, with pockets of enhanced skills held by those who have received advanced training.

Therefore, Nigeria's human capital challenges revolve more around how to train SSPs, SMEs and other relatively well-educated individuals in farming methods and business practices that will enable and empower them to transform traditional aquaculture clusters into viable commercial enterprises. This will involve several measures: (1) providing significant numbers of SSPs with training on how to increase aquaculture productivity, (2) managing and growing businesses, (3) developing and tracking business plans, (4) improving financial management, and (5) developing cadres of individuals across the overall sector who have received training, mentoring and exposure to business, branding, packaging, handling, food safety and other activities that a more structured and integrated Nigerian aquatic foods market will demand. One specific human capital need relates to aquaculture extension services. Because of aging and staff retirements, especially at the state Agriculture Development Programmes (ADPs), these services are severely lacking. The average ratio of extension staff to farm families in Nigeria is 1:4000 compared with FAO's recommendation of 1:800. Therefore, Nigeria requires significant support to develop human capital, expand knowledge and increase professionalism from the pond level all the way up through the regulatory level.

2.2.2. Credit/financial capital

Access to capital through credit and/or grant systems to facilitate investment in fish production, processing and transportation technologies is one key priority to unlocking the potential of aquaculture value chains in Nigeria. At present, high interest rates prevent a flow of debt capital to entrepreneurs, and limited access to such financing inhibits value chain actors from investing in technologies to improve post-farmgate fish handling standards. Therefore, there is a risk-sharing investment opportunity awaiting donors, philanthropic and/or impact investors who want to explore (1) innovative programs or sector platforms that provide smallholder credit programs, (2) cooperative working capital structures or (3) other liquidity enhancing mechanisms. Other mechanisms should also be explored, including instruments for technical assistance and research, such as debt, guarantee facilities and grants. Programs will need to be trialed and evaluated, and a "one size fits all" solution is highly unlikely. Digital, online credit schemes, as used elsewhere in developing nations, should be developed to deliver finance at scale.

2.2.3. Market structure: Disaggregated, nonexistent or inaccessible value chain actors

Nigeria's aquaculture market is, for the most part, disaggregated and faced with challenges ranging from local inconveniences to nationwide obstacles that block accelerated growth of the sector. In the post-farmgate value chain, fish production typically moves through up to three main activity value chain actors (wholesalers, retailers and processors) before reaching consumers. However, as addressed in Section 4, there may be compelling investment opportunities to help aggregate and/or disintermediate the market to allow SSPs and SMEs to receive higher margins for their products.

At present, most fish in Nigeria are sold fresh because of cultural traditions as well as a lack of cold chains. While the fresh fish market is expected to continue to grow in the years ahead, a nascent market for frozen fish is developing, particularly in areas where no fish are produced locally. However, in general, freezing or chilling is not common among SSPs given the dearth and cost of cold storage facilities and equipment. Also, much of fish processing is currently ad hoc, with many SSPs using rudimentary, unstandardized techniques, which can compromise fish quality and food safety. Therefore, as discussed in Section 4.2, there are compelling investment opportunities in cold chain technology, improved processing, and value-adding activities.

2.2.4. Lack of technology: A market "stuck" in Aquaculture 1.0 because of cost and power constraints

Technology also has a role to play beyond the farm/productivity level. There is exciting potential for digital marketplaces to provide an aggregated and disintermediated market structure that will better support outcomes for SSPs and SMEs. This transition to Aquaculture 2.0 is one area of potential investment that will be explored in Section 4.2.3.

2.2.5. Improving efficiency and environmental sustainability along the value chain

The last area requiring investment to enable Nigeria's SSPs to gain more engagement in the country's aquaculture sector is the effort to help them decrease perishability, reduce waste and improve efficiency along the value chain for both inputs and outputs. Improved use of water, feed and post-harvest handling holds significant potential for SSPs to gain market share simply by raising, selling and transporting fish more efficiently.

2.3. Improving Nigeria's aquaculture market, policy and regulatory structures

While progress has been made in past years to develop supportive aquaculture policies, further efforts to help Nigeria develop a strong enabling environment of robust regulatory, policy and market frameworks are required. Nigeria is currently planning the development of a new national aquaculture strategy in partnership with WorldFish, FAO and other relevant national industry/scientific stakeholders. This updated and dynamic country planning strategy will be supported by a comprehensive data and evidence platform to measure, evaluate and track developments in the sector and should provide more opportunities for investment. National-level food quality, safety and trading standards, including traceability, must be established. Land rights must be able to be confirmed if investment is to accelerate. Furthermore, there needs to be significant advocacy for the sector in which relevant industry experts, investors and SSPs engage with government officials to improve, remove and/or initiate regulations that will support scaling of the industry.

In addition to comprehensive policies and strategies at the national government level, there are fundamental market development activities that require investment in order to support the robust success of the aquaculture industry. After all, Nigerian SSPs do not just have to produce locally farmed tilapia or African catfish; there must also be concerted efforts to get people to buy fish and fish products in quantity. This will require a significant amount of marketing investment itself, as well as the right people to activate the market demand, and will likely require SSPs and farms to diverge from traditional marketing chains and start to change their fish's route to market.

Finally, without a reliable nationwide market information network, including an efficient price information mechanism, Nigerian aquaculture will struggle to reach its potential. At present, due to the dearth of storage and transportation infrastructure, pricing is mostly local in nature, so it not does reflect market demand opportunities in other parts of the nation. This challenge has been overcome in other developing countries and is an interesting investment opportunity that will be explored in Section 4.2.6.

3. Exogenous investor challenges: Deal size, input costs, political risk and currency risk

This investment plan primarily examines market characteristics and conditions inherent to Nigeria, and investment opportunities that result. But it is important to consider that investors—particularly private investors—have a range of regional and global opportunities from which to choose and external return requirements they must fulfill. Therefore, while many global investors may be initially attracted by the potential of tilapia and catfish in sub-Saharan Africa in general and Nigeria in particular, there are several sticking points. The timeframes for returns/exits are relatively long, ticket sizes are small, electricity supplies are unstable, and there are high levels of economic and operational risk brought about by conflict, kidnapping and rampant currency devaluation in the country. All of these lead to spikes in feed prices with little to no increase in the price of the final product, resulting in lower profit margins for farmers.

Some of these challenges can and will be addressed by collaborative public-private investment and blended finance. That said, others simply require the sector and Nigeria in general to continue to develop and mature. Specifically, ticket size is a significant hurdle. Because of transaction costs, due diligence requirements and ROI goals, many private investors require deals to be of a certain size to align with their investment mandates and time horizons. So far, only a handful of medium and large farms and feed mills in sub-Saharan Africa have managed to attract significant investment, with most coming from development finance institutions and impact investors. But, as we have seen in other sub-Saharan marketplaces, as SMEs mature and/or cooperatives begin to transform into commercial enterprises, their sizes start to approach that required by some private investors. In sum, it is simply a function of the market maturing somewhat. In the meantime, however, there are other public/impact investors and some private donors who are willing to step into smaller ticket sizes.

Feeding catfish.

4. Investment opportunities: Shovel-ready and aspirational investments with compelling ROI potential

Having reviewed the structure and macro trends driving Nigeria's market growth, and enumerated the challenges—both internal and external—to fulfilling such potential, we believe there are a number of compelling near-term "shovel-ready" as well as longer-term investment opportunities available to public and private financiers at both the SSP cluster level and the national level. These investments will help Nigeria produce the 752,000 t of additional fish to maintain its current national per capita fish consumption of 11.2 kg as its population increases from 196 million in 2018 to 263 million in 2030 or, ultimately, the additional 3.14 million metric tons needed to reach current global per capita fish consumption of 20.3 kg by 2030.

To achieve such positive potential outcomes, we have organized a number of investment opportunities into two categories: (1) those that are more apt to occur at the operating level, such as investments into clusters, SSPs and/or medium- to large-scale commercial enterprises, and (2) those at the macro/national level. We also note that a number of these opportunities may fall more within the purview of public, impact and/or public-private partnership investors whose time horizons, return requirements and risk appetites may be better aligned with the near-term requirements needed to help set the overall framework of the market that will be able to attract the private capital needed to build out the production-sized farms and supporting value chain infrastructure that an integrated aquaculture industry needs.

4.1. Operating-level investment opportunities (i.e. clusters, SSPs and/or medium- to large-scale enterprises)

4.1.1. Fish nutrition/feed

As noted in Section 2.1.2, larger-scale local feed companies do exist in Nigeria. But transportation and other costs mean such feed is unaffordable for many SSPs. This gives rise to a compelling investment opportunity for smaller, decentralized feed production ventures likely based on clusters or adjacent clusters (depending on fish production levels) similar to the proliferation of small-scale feed mills observed in the chicken sector worldwide. There are three primary investment needs for these distributed feed producers. The first is capital. The second is equipment, such as pellet producing machinery and extrusion devices. The third is training on how to formulate feed, though there are some existing apps and training materials available for this.

In addition to feed mills themselves, there may also be investment opportunities along the feed production value chain, namely the potential to source local ingredients/grains such as soybean meal, peanut meal, cotton seed meal, rice bran, etc. Nigeria has historically produced some of the crops used in fish feed production. Table 1 indicates the expected feed ingredient demand for GIFT-based aquaculture in Nigeria by 2030.

Ingredients used in commercial tilapia feeds	Potential inclusion in commercial feeds (%)	Amount of ingredient required (t)	Amount of crops required (t)
Soybean meal	27.3%	548,700	684,617
Peanut meal	11%	165,000	330,000
Cotton seed meal	50%	750,000	1,500,000
Maize/Cornmeal	20%	300,000	480,000
Wheat bran	10%	150,000	789,474
Rice bran	20%	300,000	3,750,000
Cassava peels	20%	302,550	1,008,500

Table 1. Expected feed ingredient demand for GIFT-based aquaculture in Nigeria by 2030.

Additionally, Nigeria's catfish production (which currently dominates domestic aquaculture production) is expected to grow, driving increased demand for feed ingredients.

4.1.2. Fish seed

Decentralizing the seed supply via private sector multiplying hatcheries is necessary not only to drive growth of the industry overall, but will also provide compelling investment possibilities. By 2030, the demand for GIFT broodstock to help supply 1.5 billion fry would be 3.86 million. Catering for a demand of 1.5 billion fingerlings will create a significant commercial investment opportunity. Catfish will require a similar growth in fingerling production as well.

Investment into hatcheries will comprise capital for equipment that can range from simple cages in a few outdoor ponds to more elaborate tanks, aeration solutions and reticulation equipment in indoor facilities. Training will also help support the development of the seed industry, specifically around subjects such as how to feed fish, how to identify when fish are close to breeding periods, the best ways to "pair" fish, etc. Capital is also required for SSPs to purchase broodstock. There may be opportunities for standardized, modular hatcheries to be used to fast-track industry development.

4.1.3. Fish marketing and sales

For many SSP clusters and even mid-sized farms, marketing and distribution will be relatively new activities that require significant investment and expertise to develop and manage. Expansion of distribution channels has been a priority for major farmers outside of Nigeria, such as FirstWave Group and Lake Harvest Group in Zambia and Uganda, Victory Farms in Kenya and Tropo Farms in Ghana. As such, we believe that part of the professionalization of Nigerian cluster aquaculture is likely to follow the same transition. Venturing into these types of marketing and distribution activities—even if initially done by developing partnerships with existing wholesalers or retailers—will likely require the clusters to eventually invest in their own network of wholesale and/or retail shops. This will allow them to take control into their own hands and manage their own brand development and promotion to expand their market and customer base.

4.1.4. Primary processing enhancements at the farmgate

There is a widespread lack of primary processing capabilities in Nigeria, which impacts the post-farmgate quality of fish. In addition, several factors are likely to compromise the nutrition benefits of consuming fish. These include 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 environmental conditions along the value chain, like high heat and humidity. Therefore, a range of investments at the SSP cluster level into these activities, training related to such, or even basic supplies, such as rubber gloves and masks, would be helpful and likely drive quick ROI from loss reduction.

4.1.5. A practical example: The positive economic and employment return of GIFT

Looking at GIFT in particular, WorldFish research indicates that, within a 10-year span and a program involving 150,000 smallholders, Nigeria can produce additional 720,000 t of GIFT, with a

Ingredient	Potential inclusion in commercial feeds (%)	Amount of ingredient required (t)	Amount of crops required (t)
Soybean meal	35%	185,094	230,943
Peanut meal	25%	132,210	264,420
Cotton seed meal	25%	132,210	264,420
Palm kernel meal	15%	79,326	198,414
Maize/Cornmeal	15%	79,236	126,921

Table 2. Projected commercial catfish feed ingredient requirements by 2030 (based on WorldFish research).

total farmgate value of USD 1.4 billion. This level of production opportunity will naturally open up several commercial investment opportunities, such as seed supply, feed supply and grow-out. This level of increased production will require strong post-harvest value chain improvements, including cold chain development and value-added processing. This increased production of fish and the availability of versatile fish products will also improve and increase the market potential for fish in Nigeria.

There are several key indicators that may drive future aquaculture expansion in Nigeria. WorldFish research and forecasts indicate that during a 10-year span Nigeria will be able to achieve the following using GIFT:

- 280 (small-, medium- and large-scale) GIFT hatcheries employing nearly 2500 people
- 1.8 million GIFT broodstock, producing 1.5 billion all-male fingerlings
- 150,000 smallholders farming GIFT in ponds, providing at least 300,000 jobs
- 5000 SSPs farming GIFT in cages, providing 20,000 direct jobs
- 650,000 jobs created along the value chain, 50% of which will be filled by women and 25% by youths
- indirectly benefiting 3.25 million households
- 1.2 million metric tons of GIFT produced using 1.5 million metric tons of feed and delivered to consumers with minimal waste
- new income pathways for SSPs (e.g. a single 1000 m^2 pond can make an annual profit of USD 4600, for an ROI of 44.9%) and SMEs (e.g. five cages making an annual profit of USD 22,500, for an ROI of 63.34%)
- savings of nearly 50% of Nigeria's current foreign-exchange expenditures on fish imports.

4.2. Macro/national-level investment opportunities

4.2.1. Cluster mapping

Much of Nigeria's SSP and SME aquaculture industry revolves around clusters spread throughout the nation's fish producing states. However, there is no current national database or visual "heat map" that investors, or government officials for that matter, can use to identify and measure such clusters. Investment by donors into the production of such a visual database of where the clusters are located, what their current production levels are, etc., would give investors a "jump start" on where to look for clusters that could likely sustain feed or seed investments, either on their own or by linking together two or more adjacent clusters.

4.2.2. Fish health

Potential fish health investment opportunities revolve around monitoring, diagnosis and treatment. As is discussed in Section 4.2.3, sensors can help SSP and SME fish farmers track and monitor pond and fish health. In terms of diagnoses, there will be compelling investment potential in both telehealth systems that share knowledge about local aquatic health issues and challenges as well as—when the sector matures—a scaled veterinary services industry. Finally, in the longer-term, there may be investment possibilities for the development of vaccines specific for tilapia and African catfish diseases prevalent in Nigeria. Such investment cases will be built upon advanced analysis of projected/potential economic losses from disease.

4.2.3. Production technology

The identification, development and deployment of "Built for Africa" technologies throughout Nigeria's aquaculture value chain hold vast investment potential. Solutions such as the following will have been analyzed for ROI:

- precision aquatic food farming systems to support Aquaculture 2.0
- pond-level, Internet of Things enabled, sensors and other monitoring systems to identify, diagnose and mitigate disease
- renewable energy, such as solar aeration, pumps, chillers, freezers and driers.

Of these general areas, the most compelling and near-term technologies and business systems that Nigeria needs include the following: (1) mobile aeration technology for live catfish and tilapia transportation, (2) individual SSP farm-level solar enabled aeration, (3) renewable energy enabled

cold chain solutions to reduce loss and allow for national sales, and (4) distribution and logistics related business systems that can move live fish from rural production areas to urban consumer centers while being able to distribute fertilizers and other necessary agricultural chemicals among the SSP clusters.

Detailed investment analysis of the nexus between (3) cold chain solutions and (4) distribution and logistics is warranted. Cold chains would improve fish value chains in Nigeria, increasing access to fish for both rural poor communities as well as domestic and international sales channels. A cost-benefit assessment should be carried out regarding the development of domestic cold chain hub and spoke networks to allow fish to easily and cost-effectively move from coastal and aquaculture production zones to buyers and consumers. Investments in improved fish processing and transportation technologies would also enhance fish quality and food safety standards along the value chain. These include refrigerated trucks, certified processing facilities, processing "hub and spoke" networks and/or efficient live fish transportation.

4.2.4. Training

Nigeria needs training throughout all components of its aquaculture value chain to achieve the dynamic growth potential the market offers. The government's ADP has been implemented by state governments and includes extension training. Like many developing countries, however, the program has been under-staffed and under-funded. Therefore, exploration in the development of partnerships with leading aquaculture companies, such as Aller Aqua, Skretting, OLAN and others, may be a productive path for the nation to consider—and donors to invest in—to help scale the skillsets the sector needs in the decades ahead.

4.2.5. Finance/provision of affordable capital

There is a range of potential opportunities for donors, philanthropic and/or impact investors to alleviate the capital constraints that impact most SSP and SME producers. These may include SSP microcredit programs, lease-to-own schemes to help SSPs overcome capex and working capital constraints, cooperative working capital structures or other liquidity enhancing mechanisms. A case study of the Fish Card innovation is presented in Section 4.3. That said, such innovative programs will need to piloted in a trial and evaluated, and it is highly unlikely that a "one size fits all" solution will present itself.

4.2.6. Digital marketplaces

The increasing accessibility and availability of online services, specifically downstream digitalization and/or digital distribution of pricing information, comprise several compelling investment possibilities:

- Phone-based pricing information, updated regularly, has the potential to go a long way in supporting Nigeria's smallholder and community farmers to adapt and grow their profiles and investment decisions according to national trends versus just local needs. This is particularly vital as/when freezing and storage capabilities develop along the value chain, as fish and processed fish products can be sold when there's actual demand and reasonable price support.
- Data-driven digital marketplaces, enabled through farm-level technology and enhanced product traceability, are needed to link producers to buyers. Such platforms typically provide services to producers to help them increase productivity and optimize product specifications to obtain higher prices for their products, while at the same time linking them with buyers.
- Distribution of digital training and advisory information through digital platforms can offer associated market potential, when packaged with e-commerce for consumables and equipment used in the sector.

These platforms are, at present, still typically business-to-business, but are increasingly also developed for the business-to-consumer market, enabled by the fast growth of home-delivery models. In such a case, fish could potentially be delivered straight from the farm to the consumer's doorstep, as is now occurring at scale in India.

4.2.7. National food safety, quality and trading standards

Establishing a robust investor environment for aquaculture in Nigeria requires some national-

level food quality, safety and trading standards, including traceability. Typically, this can only be done at the policy and government level, and falls outside the scope of any private donor or investor. Nigeria must continue to enhance and, most importantly, implement and monitor such standards through appropriate policy, legislation and law enforcement to support a productive and investable sector.

4.2.8. Building market demand: Marketing and consumer advocacy for fish consumption

For aquaculture to grow as an industry in Nigeria, there needs to be more effort and investment in encouraging consumer acceptance of tilapia and other fish as a source of protein. Consumers must be made more ready to accept fish as a healthy and tasty source of protein that can compete with chicken and other protein sources. They must also be made aware of the attractiveness and benefits of enjoying fish that is not smoked if there is hope to build a sector characterized by processors, cold storage, etc. The market for locally farmed tilapia will take expertise and investment to grow. Not only in messaging and communicating the benefits of such to consumers, but also SSPs and farms will have to change their fish's routes to market.

4.3. Potential investment case study: BankAsia Fish Card

One example of an innovative approach may be taken from Bangladesh, where Bank Asia, working in partnership with WorldFish, developed a "Fish Card" for farmers so that they could access seed and feed as needed, with low interest rates and long repayment periods. This was also linked to financial literacy training and the establishment of micro-merchants to support provision of finance at scale.

4.4. Potential investment case study: eFishery

One exciting example of the potential of a fully integrated digital aquaculture solution can be found in Indonesia's eFishery (https://efishery.com/). This free application was created to help farmers run their aquaculture business and places the convenience of fishery cooperative services into a farmer's hands. This model received significant private sector investment and may prove to be an example of how Aquaculture 2.0 could evolve in Nigeria. The application can be set up using only a cellphone number and opens up access to a variety of services from eFishery, from feed to funding.

Figure 1. The Right Fish provides fish farmers with content, advisory services and e-commerce via a Facebook platform in Bangladesh (left). The Fish Card introduced by Bank Asia Ltd facilitates farmer digital payment of inputs at low interest rates with time to pay (right).

Conclusion

Nigeria's aquaculture sector has a promising future, buoyed by growing demand and potential productivity gains driven by improved seed, feed, technology and human capital, as well as national policies and strategy. While not all the investment opportunities today have the size, return or risk characteristics attractive to private investors, we believe that such characteristics will become more and more common as the market continues to grow and mature. In the interim, we believe there are compelling blended finance, collaborative investment and impact investment opportunities that should be evaluated and considered. We are particularly optimistic about investments that will transform SSP clusters into enterprises by decentralizing seed and feed production and aggregating both the buying and marketing power of the fish producers themselves. We also believe there are compelling commercial and strategic return opportunities in health and technology, specifically digital marketplaces.

In sum, we feel Nigeria's aquaculture sector offers investors a myriad of clear paths to positive returns and/or strategic interventions that will help set an accelerated trajectory for this very exciting Nigerian commercial sector in the years to come.

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About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

For more information, please visit www.worldfishcenter.org