

Review

Aquaculture Development in Nigeria: The Second Biggest Aquaculture Producer in Africa

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Abstract: Today, fish farming has become one of the fastest-growing farming businesses, turning Nigeria into the second biggest aquaculture producer in Africa. Also, Nigeria is the leading country in the production of African catfish (*Clarias gariepinus*) and African bonytongue (*Heterotis niloticus*). The great quantity of land, inland water surface, and coastland, which are suitable for fish farming, have placed Nigeria at a very advantaged position to develop aquaculture further. Here, the development of brackish and marine aquaculture represents a promising field for future expansion. An adaptation of aquaculture development has to reduce the impact of climate change as outlined. Furthermore, disease management has to be urgently improved. Among others, the availability of commercial feed pellets is a bottleneck that has to be overcome. Unfortunately, Nigeria is far from self-sufficiency in its fish supply, with a deficit of about 2.5 million tons being imported, but national initiatives envision an expansion in the future to increase the supply of the population with high-quality protein and the prevention of malnutrition. This study identifies challenges and opportunities of the aquaculture subsector and tries to give some recommendations for future development, highlighting potential governmental interventions and support.

Keywords: aquaculture development; sustainability; African catfish; malnutrition; food resilience; aquaculture governance



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1. Introduction

Fish production is an important constituent of global food security and aquatic ecosystem management. Fish farming, on the other hand, is considered a key agricultural sector of food production all over the world. It is viewed as a crucial agricultural activity that can reduce nutritional deficiencies considerably on a global scale and therefore reduce poverty effectively [1].

Interestingly, aquaculture or fish cultivation offers a major source of animal protein and contributes heavily to household diets, livelihood, and economic development in many countries and regions of the world [2]. Nigeria is not left out. In the agricultural sector of the Nigerian economy, aquaculture has been recorded as having the fastest growth rate. Since 2000, it has been growing at 13.6% per year, contributing significantly to economic development, although in the last years, a stagnation has been observed (Figure 1).

Fish accounts for nearly 40% of Nigeria's protein intake, as fish consumption hovers between 11.2 and 13.3 kg/person/per year [3–7]. Still, Nigeria's per capita protein intake is lower than the Sub-Saharan African average. Importantly, fish is cheaper than other sources of animal protein [8]. Annual fish production has reached 1 million metric tons. Aquaculture contributes 275,645 metric tons, and 805,210 metric tons originate from fisheries (Figure 1).

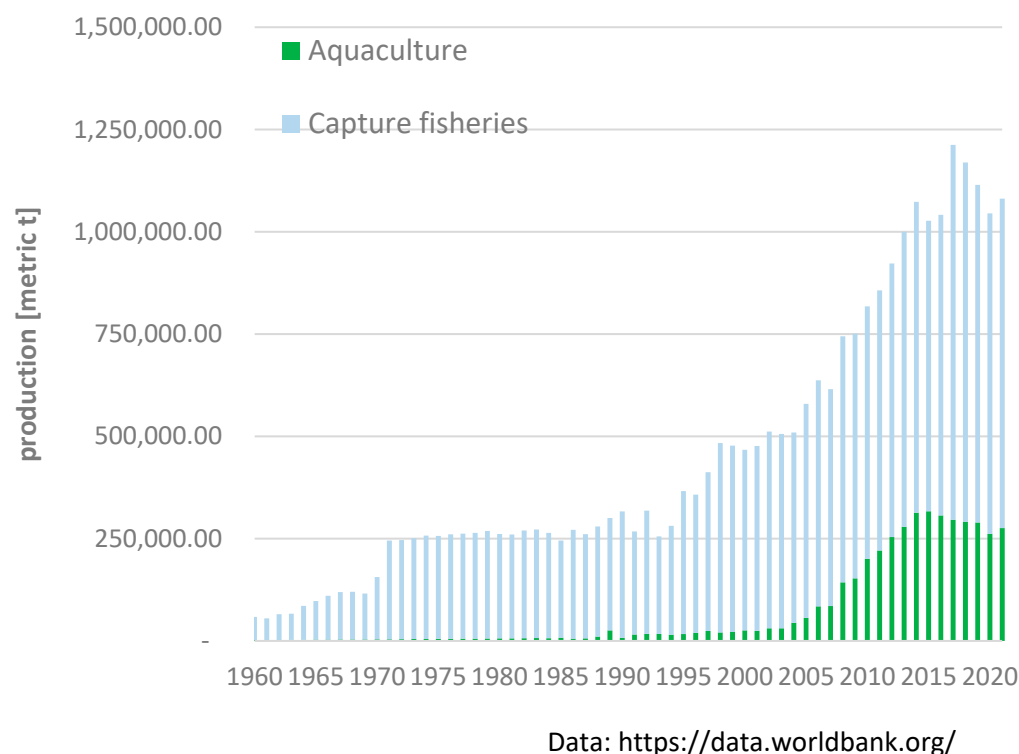


Figure 1. Aquaculture and capture fisheries' production from 1960 to 2020.

Although the National Aquaculture Strategy was formulated in 2008 [9] to increase domestic fish production and conceptualize future development, production figures did not increase substantially over the last ten years (Figure 1). Nevertheless, the aquaculture subsector plays a very important role in the Nigerian economy—similar to the economies of other African countries—with regards to job creation and income generation [4,10]. The suitable area available for aquaculture has made the endeavor very worthwhile to develop, and a production increase to 2.5 million t has been envisioned [8].

Nigeria is a coastal country. It covers 0.69% of world land area (including inland water surface area) [11]. It represents 0.28% of world inland water surface area and 0.11% of world coastline length, with 853 km of coastline. Nigeria contributes 0.52% to the total renewable water resources of the world. It includes 256,000 km² of the continental shelf, comprising an exclusive economic zone of 210,900 km² and a marine region of 46,000 km² [12,13]. On the other hand, there are 14 million hectares of reservoirs, lakes, ponds, and major rivers in Nigeria. About 75% of these are moderately suitable for aquaculture production, and 112,085 km² are considered as very suitable [9,14,15]. These have shored up the production of more than 1 million tons of fish each year. Nigeria has been recognized as one of the most suitable regions for aquaculture in the world. This is because of the good climatic conditions, favorable land, and desirable aquatic resources. Currently, over 60,000 ha are existing ponds [9,16].

In this review, we present a comprehensive overview of the aquaculture sector in Nigeria. Further, we identify challenges and opportunities of the aquaculture subsector. We provide recommendations for sustainable development and outline the most recommendable governmental interventions.

2. History

From a historical perspective, modern fish culture in Nigeria started during the period of the Second World War (1939–1945). The colonial master (Britain) initiated a study to evaluate aquatic resources in Nigeria [14]. The study revealed a huge potential of the fisheries' resources. In 1941, the colonial authorities established a fishery organization in Lagos. By 1945, the fishery organization was merged with the Department of Commerce

and Industries, and later, in 1950, it was renamed the Federal Fisheries Services. It was subsumed under the Federal Ministry of Economic Development. In 1951, a 160-hectare industrial-scale fish farm was established at Panyam near Jos for the culture of carp [3,17]. Today's production comprises subsistence ponds (500–800 kg/ha/a), homestead ponds (1000–1500 kg/ha/a), commercial farms (5000–20,000 kg/ha/a), and recirculation aquaculture systems (300–400 kg/m³/production cycle of 4–6 months) [16].

Furthermore, fish culture intensified in the mid 1960s, supported by close cooperation with the Food and Agriculture Organisation [18]. Starting in 1965, the feasibility of culturing grey mullet (*Mugil* spp.), pink prawn (*Penaeus durorarum*), tilapia (*Tilapia* spp.), and common carp (*Cyprinus carpio*) was studied. Other projects related to brackish water aquaculture emerged in the vicinity of Lagos around 1968. Thereafter, the number of fish ponds and fish farms steadily increased all over the country.

From 1960 to 1970, the volume of fish produced increased by ten folds. This gave confidence to more Nigerians to venture into fish farming. Today, fish farming has become one of the fastest-growing farming businesses in Nigeria [1,19]. In the same vein, the aquaculture production in Nigeria increased its contribution to the global production from 0.07% in 1995 to 0.21% in 2022 [20], turning Nigeria the second biggest producer in Africa.

Since the early 1960s, different species of fish were introduced, some native species and some imported ones. The indigenous species include tilapia, catfish, and African bonytongue. Among the tilapia species, *Oreochromis niloticus*, *O. mossambicus*, *O. aureus*, *Sarotherodon galilaeus*, *S. melanotheron*, and *Coptodon rendalli* were predominantly cultured [17,21,22]. The catfish species comprised the African catfish *Clarias gariepinus* and the sharptooth catfish *Heterobranchus longifilis*. A hybrid of the two catfish species, "Heteroclarias", was also farmed. The African bonytongue (*Heterotis niloticus*) is an emerging candidate for pond aquaculture (see Section 5.3). Farming of *Lates niloticus* and *Chrysichthys* spp. was also reported [17,23]. Though limited in number, these species were successfully cultured, either singly (monoculture) or in combination (polyculture) [17].

The species that were imported included the grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*), Indian carps such as mrigal (*Cirrhinus mrigala*) and rohu (*Labeo rohita*), silver carp (*Hypophthalmichthys molitrix*), channel catfish (*Ictalurus punctatus*), and largemouth bass (*Micropterus salmoides*) [24,25]. Unfortunately, out of all the imported species, *C. carpio* was the only one established as an aquaculture species [26].

Alluding to the data of Offem et al. [27] from southeast Nigeria, it can be adduced that the common fish species currently contributing to over 90% of production are (Figure 2) *Clarias gariepinus*, Torpedo-shaped catfishes (*Heterobranchus longifilis*, hybrid *Heteroclarias*), carp fishes, tilapia (mainly *Oreochromis niloticus*), Aba, and Nile perch. In general, the wide acceptability, high price, and robustness of African catfish and tilapia are the main reasons for their predominant position in African aquaculture [21,28]. Catfish is hardy; it grows tremendously at warm temperatures. Furthermore, as a facultative air breather, it survives in low oxygen content and can be farmed at high densities of up to 400 kg/m³ [28,29]. It can be harvested within 6–9 months of age at a market size of between 1 and 3 kg [29,30].

The success of Nigerian aquaculture is based on the production of the African catfish [22]. Nigeria is currently the largest producer of African catfish in the world [3,31]. African catfish is one of the most commercially important freshwater fish species in Africa. In Nigeria, it is the most popular fish on the local market [3,31]. In the early 2000s, the explosion of catfish production was a result of the technology transfer of catfish breeding, enabling the mass production of fingerlings [3].

Nigeria is ranked as the leading aquaculture-producing nation in Sub-Saharan Africa [3]. Aquaculture production in Nigeria rose from about 2000 t in 1960 to more than 300,000 t by 2015 (Figure 1). This rate dropped in 2019 to 290,000 t and furthermore decreased to 260,000 t in 2020 because of the COVID-19 impact. The last production figures revealed 275,645 t. The FAO [11] has reported that Nigeria dominated the global aquaculture production of bonytongues (*Osteoglossiformes*), with nearly 80%. Catfish was the largest

aquaculture product nationally at 65.61%, but globally, it contributed only 2.85%. The contribution of characins to world aquaculture production is also noteworthy at 4.6%.

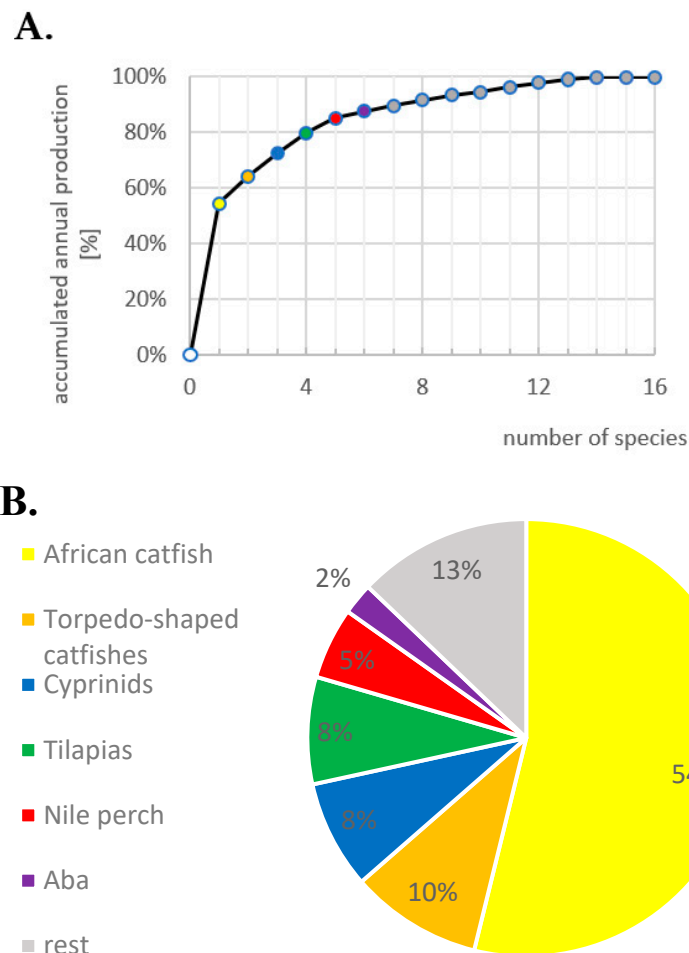


Figure 2. Diversity of the aquaculture sector in Nigeria. (A). Characteristic curve of the accumulated annual production in 2023 (assessed 23 April 2023, FishStatJ v4.03.06) ranked by intensity reveals a less diverse sector dominated by African catfish. (B). Contribution of the six most relevant species to the total production.

3. Socioeconomic Aspects and Marketing

Aquaculture in Nigeria contributes significantly to the creation of employment, the generation of income, national development, and the supply of nutritional requirements. The Federal Ministry of Agriculture Nigeria has reported that 10 million Nigerians are actively engaged in different categories of fisheries' operations [32]. In the first quarter of 2021, the fisheries sector contributed 3.24% to the country's GDP according to the National Bureau of Statistics (NBS).

Nigeria stands out in Africa as the largest consumer of fish and also ranks among the largest fish consumers in the world [33]. About 3.6 million tons of fish are consumed annually in Nigeria [15,32]. This more than double the amount compared to 2004, with 1.4 million tons [34]. This increase in demand for fish has been attributed to population growth and changing dietary preferences [11]. Coincidentally, based on the Nigerian production of fish of 1.04 million tons (fisheries 75%, aquaculture 25%) [35], a deficit of about 2.5 million tons must be supplemented by importation [36–38]. This shows that Nigeria is far from self-sufficiency as envisioned in the National Aquaculture Strategy (NAS). Interestingly, it has been reported that the Government of Nigeria has set up plans to expand and develop aquaculture as one of the priority food value chains to reduce the level of fish imports and decrease the drain on foreign exchange [39].

Considering the fish supply deficit in Nigeria (2.5 million tons), up to 90% of fish produced is marketed in the local market to provide an affordable source of protein for the growing population [40,41]. The fisheries sector has supported the development of a strong distribution value chain by local businesses. This made it possible for SMEs to undertake the delivery of live or frozen catfish and tilapia products to their destinations [15].

Cheke [42] reported five different types of fish markets in Nigeria. The first is the “Fresh fish market”, where captured and artisanal fisheries are sold. The second is the “Live (catfish) market”, where aquaculture products are sold. The third is the “Imported fish market”. This market makes use of cold rooms, refrigerated trucks, and other modern facilities. The next is the “Industrial fish market”, where trawler operators sell some of their landings. Such markets are equipped with cold rooms, refrigerator trucks, and other modern facilities. Lastly, in 2010, the Federal Government of Nigeria established modern fish markets in the six geopolitical zones of Nigeria [43]. The markets are fenced all around and provided with constant power supply, electric generators, and water boreholes [42]. They are also equipped with fish processing houses and lock-up shops, among other facilities.

The marketing and distribution of artisanal and aquaculture produced fish in Nigeria are handled by both males and females. Males and females play major roles in fish farming, but women dominate the retail part of the production cycle. Similarly, in the capture fisheries sector, where trawling and artisanal fishing are prominent, males dominate at the production level, and females control the processing and selling of the products. Tran et al. [44] posits that the Nigerian aquaculture operations are dominated by males, but more women are found at the retailer level than men. In a specific survey of a retail fish market, Fumilayo [45] reports the dominance of female participants at a ratio of one-to-four.

4. Fish Processing Methods in Nigeria

The key roles of storage and processing are the major factors impacting fish marketing in Nigeria, substantially increasing the shelf life of products [46,47]. Processed fish is sold as smoked or dried fish. There are also other varieties like fish fingers, cakes, and ready-to-serve fish foods that stimulate wider interest in marketing, distribution, and consumption [48]. This huge local processing industry is dominated by women. It is characterized by individual, small-scale enterprises, which are predominantly home-based [46]. The products are entirely bought in markets by wholesalers who are also mostly women. The wholesalers take over the distribution of fish to inland markets all over the country. Ismail et al. [41] confirmed that the fish marketing channel in Nigeria is dominated and carried out through wholesalers and retailers of fresh and processed fish.

Olayemi et al. [49] and Gawi and Sogbesan [50] reported that fish processing is dependent on traditional processing methods. These methods include mud-type, drum-type, pit oven, sun light, and smoke drying. The most common of all these processing techniques is smoke drying [50]. The combination of smoke, salt, and drying is considered to be one of the earliest methods of food preservation [49,51]. Unfortunately, these traditional methods have been confirmed to not be very effective in preventing microbial spoilage of harvested fishes [52].

The limitations of traditional methods brought about the introduction of an improved fish smoker kiln. The improved fish smoker kiln was introduced in 1997 by the United Nation Development Program (UNDP). Agricultural development programs (ADPs) thereafter undertook the grassroots extension delivery dissemination for usage of the new fish processor technology [53]. Considering the need for more improvement, Agbebi [46] has suggested the introduction and development of large-scale post-harvest technologies. Also, there should be improvements in transportation systems in the country to support the delivery of fish products to the markets. These interventions will be important steps towards improving aquaculture productivity in Nigeria. Furthermore, government control and food safety enforcement are mainly lacking, and goals to improve food safety measures in a chain-wide distribution are urgently required [54,55].

5. Challenges to Future Expansion of Aquaculture

5.1. Climate Change

Climate change has been placed on the front burner of developmental policies and global governance [16,56–60] (Onu and Ikehi, 2016; Onada et al., 2021). Effects include drastic changes in weather extremes (Wang, 2023), changes in hydrological regimes of inland water, and increased incidences of flooding and drought [56,61–63]. These effects obviously affect fish productivity [63,64]. Fish disease infestation is also on the rise and has reduced aquaculture productivity [16].

Nigeria has a tropical climate with two seasons—dry and rainy. Inland areas, particularly those in the northeast, experience the biggest temperature fluctuations. According to the World Bank and the Climate Scorecard (2019), Nigeria is among the ten countries that are most vulnerable to climate change. Nigeria has three distinct climate zones, a Sahelian hot and semi-arid climate in the north, a tropical savannah climate in most of the central regions, and, in the south, a tropical wet climate [65]. Consequently, a gradient of decreasing precipitation from south to north is reported. The southern regions experience strong rainfall during the rainy season from March to October, with annual rainfall above 2000 mm, occasionally reaching 4000 mm and more in the Niger Delta. In coastal areas, a short dry season is reported, with most rainfall from March to October, reaching about 1200 mm. The central regions experience a sharp single rainy season from April to September and a dry season from December to March. This dry season is under the influence of the Harmattan wind from the Sahara. In the northern regions, rain occurs from June to September at 500 mm to 750 mm, whereas hot and dry weather is reported for the rest of the year. Northern areas have a high annual variation in rainfall, which results in flooding and droughts.

In climate change scenarios, the steppe region is expanding to the south, and tropical monsoon regions expand to the north. This will first increase the vulnerability towards desertification and breaking down of the soil. The effect of increasing temperatures will hinder the growth of food crops such as rice [65]. Here, aquaculture may represent alternative crops, increasing the resilience of food production in the respective areas.

Nigeria is also prone to flooding [61,66]. In 2012, it experienced an extreme flooding event, turning two million people homeless. Just a year later, another flooding event hit the country, this time affecting less people due to the lessons learned. Floods occur almost every year. There is a trend of increasing temperatures [67] and a decrease in rainfall, with high variability [61,62,65].

Amare and Balana [59] observed that the impact of climate change is already putting the fragile environmental and socioeconomic system of Nigeria at risk. Severe weather conditions—protracted dry seasons and shorter but more extreme rainy seasons—are worsening the challenges faced by local communities. Ipinjolu et al. [68] reported increasing empirical evidence of climate change effects on fisheries and aquaculture in Nigeria. The implications of these events are becoming serious and affecting the livelihoods of communities as well as food security in Nigeria.

Increased temperatures affect the rearing water and influence fish physiology, altering breathing rates, increasing feed consumption, raising enzyme activities, and elevating oxygen consumption and feed metabolism [68–70]. These issues affect fish growth, reproduction, and the shelf life of products. Most importantly, increased temperatures bring about a severe reduction in oxygen solubility in the water. This also amplifies the survival and proliferation of parasites and bacteria. These situations certainly reduce fish survival and influence their natural foods. Reduced rainfall in some areas has also become a problem for fish culture. Expected profits will be depleted to make up for the cost of water used during fish rearing. On the other hand, floods resulting from excess rains will cause overflowing of culture enclosures, thus introducing losses for aquaculture ventures.

Ipinjolu et al. [68] posited that the impacts of climate change on fisheries and aquaculture in Nigeria still basically rely on observations, projections, and the experiences of other countries due to a lack of quantitative data. Several authors point out that issues relating

to climate change and aquaculture are not presently prioritized in Nigeria [16,60]. Areola and Fakoya [71] confirmed a lack of national attention regarding the aquaculture sector in terms of national policy and strategic planning on climate change, which is brazenly threatening the potential of these subsectors. More attention from the government and citizens is urgently needed. As a recommendation, we suggest shortening the production cycle in the dry zones and the promotion of marketing of smaller-sized fishes to counteract the shortage of water. Thereby, aquaculture production could be focused on times with adequate water supply. In regions with risks of flooding, brackish aquaculture of tilapia and shrimp will reduce the risk of saltwater intrusion. Nevertheless, climate change stresses the need for comprehensive spatial planning to reduce the risks further.

5.2. Mariculture

It has been reported that 80% of the aquaculture fish production is realized from small-scale farmers involved in brackish and freshwater cultivation [1,72]. Unfortunately, mariculture has recorded several setbacks and has not been developed much [7,29], despite the 729,000 hectares suitable for mariculture [7,73].

Mariculture can be carried out in estuarine, brackish, coastal, and offshore waters and in enclosures such as ponds, pens, tanks, or channels. The organisms cultured include seaweeds, mollusks, crustaceans, and fish. Brackish water aquaculture systems focus on fish farming and the production of quality fin and shell fish that are found in the creeks, lagoons, and estuaries [74]. Nigeria is naturally gifted with a long coast line, which lies along the shores of the Atlantic Ocean [74,75]. It has been reported that approximately 729,000 ha of saline mangrove swamp still exist, and aquaculture development poses a high risk of its destruction [73,76]. Therefore, sanctuaries should be established before developing commercial shrimp farming.

There are a lot of fin and shell fish species abounding in brackish water areas that can be potentially cultured in most coastal communities with negligible capital input. Since emerging aquaculture activities will not be abandoned, spatial planning is of utmost importance, and a zoning system should be established to protect mangroves.

Considering the potential of mariculture, multinational oil companies have shown interest to invest in this area. These include the Shell Petroleum Development Company (SPDC), Mobile Oil, and Agip Oil [77,78]. The SPDC has committed funds and supported shrimp culture in the Niger Delta [79,80]. Other national fishery professionals and institutions have invested to develop shrimp farming [81]; for example, Sulalanka (Sri Lanka consortium) received approval to begin the inland culture of marine black tiger shrimp [82]. Also, the Nigerian Institute for Oceanography and Marine Research (NIOMR) made it their main concern to invest in shrimp farming [83].

However, the pioneering effort of the SPDC to invest in commercial shrimp farming in the Niger Delta failed [78]. Nevertheless, it stimulated the current interest of other public and private sector actors in shrimp aquaculture [78].

5.3. Feed Sector

The impressive expansion of African catfish has been propelled, among other factors, by the upcoming availability of high-quality feed. Undoubtedly, affordable high-quality aquaculture feed represents a major constraint impeding future development [84]. Currently, feed costs comprise between 40% and 60% of the total expenditure [84,85] and 60–80% of the operation costs [86]. Future expansion will highly depend on a reduction in costs without decreases in feed quality. A major effort is required to professionalize feed manufacturing, thereby reducing the dependency on imports. Nigeria has the highest number of feed mills in Sub-Saharan Africa, although small-scale operators dominate the market, producing about 60% of local production [85].

As such, much of the fishmeal in Nigeria used by the livestock and aquaculture sectors is imported. Also, the fishmeal production capacity is not able to match the increasing

aquaculture production. This has therefore resulted in the importation of fish feed (up to 75%) [87].

Among others, one step will be the use of byproducts not designated for human consumption. Here, the use of blood meal and offal is worth mentioning. Also, insect meals should be explored more. Ideally, high-quality compound feeds would incorporate 5–10 ingredients to reduce the antinutritional effects of plant-derived ingredients such as oil press cakes. Some ingredients that are available in larger quantities in Nigeria include groundnut cake, spoiled groundnut, palm kernel cake, rice bran, guinea corn/sorghum, blood meal, and soybean cake [17,87,88]. Among the interventions that have already been partly implemented, though not very effective so far, are input subsidies, credit granting, pricing policies, and market liberalization [7].

5.4. Diseases

Disease outbreaks are a key problem in aquaculture. They are responsible for huge economic losses on a global scale. In Nigerian catfish farming, mortalities have been estimated between 1.9 and 19.7% per production cycle [89]. Next to the availability of drugs and the high costs of quality feed, aquaculture hygiene management has been identified as a major obstacle in the prevention of diseases [89,90]. Disease causes death in aquaculture, particularly in the hatchery. Increases in outbreaks have been linked to rises in temperature brought about by climate change. Unfortunately, several reports have shown that the level of awareness of the impact of disease, as well awareness of disease prevention and symptoms, is lacking in Nigeria [89,90]. Therefore, government should play an active role in dealing with disease issues in the future. The following suggestions should be undertaken:

- (a) There should be massive investment in professionals, researchers, and extension workers in water quality management, disease prevention, and hygiene and diagnostics.
- (b) The Ministry of Agriculture, being responsible for the development of aquaculture activities, should provide specialized training courses for farmers, increasing their awareness and providing necessary information on the respective measures established for hygiene in aquaculture.
- (c) Centralized and well-equipped laboratories should be set up in different regions of the country, integrating existing expertise from the universities.

5.5. Diversification

The aquaculture in Nigeria is currently dominated by carnivorous catfish, in particular African catfish. This dominance reduces the resilience of the aquaculture sector, particularly with regard to potentially emerging pathogens. Therefore, a diversification of the sector should be encouraged, preferentially with herbivores that require lower amounts of protein and are usually less prone to the antinutritional effects of plant ingredients, allowing for higher fishmeal substitution rates.

From our point of view, there are two highly recommendable candidates for diversification. One is the African Arowana *Heterotis niloticus*; the other one is the obscure snakehead *Parachanna obscura*. Using an evaluation matrix, Oboh et al. [22] scored *Heterotis niloticus* as the most promising candidate and snakehead as the third most promising. Still, the second best candidate according to Oboh et al. was the Silver catfish, scoring better due to a higher level of domestication and the maturity of technology [22].

Heterotis niloticus (the African bonytongue) was introduced into aquaculture first in the 1950s [91]. It seems to be an ideal candidate for diversification with regard to its high growth rate (3 to 4 kg in 1 year) and good meat quality. It is an herbivore and has a relatively high market price on the local markets. The domination of Nigeria in the global production of African bonytongues (80%) provides an even more compelling reason to consolidate its gains. However, no consistent progress has been made over the last decades. Such progress will require an all-inclusive research strategy that cuts across reproduction, nutrition, and growth so as to deliver reliable protocols for farmers. The government will be expected to provide funds for research institutions and universities that are to undertake the process.

The obscure snakehead is similarly attractive. It is an omnivorous species that breeds throughout the year. As a facultative air breather, it tolerates low oxygen levels and high ammonia and is well known for its hardiness [92]. Therefore, it seems ideally suited for areas with high contents of suspended solids, such as the Niger Delta. It exhibits a tremendous growth rate of 1 kg after 4–5 months [93,94]. In snakehead, intensification has been reported as the minimum goal for improvement. Indeed, it is highly valued, and current supply (mainly from fisheries) does not meet the demand.

6. Aquaculture Governance in Nigeria

Planning of the growth and development of aquaculture can only be sustained through good aquaculture governance. According to the FAO, appropriate planning will motivate and direct the development of the sector by providing encouragement and safeguards [95]. It will propel the attraction of investment, thus boosting development. Furthermore, it will facilitate the long-term economic, environmental, and social sustainability of the sector. This will ultimately contribute to economic growth and the need for poverty alleviation in the country. Production and regular updates of aquaculture development strategies and plans by nations are enshrined in the FAO Code of Conduct for Responsible Fisheries as very pertinent and prerequisite goals for ecological and sustainable aquaculture development [95].

Nigeria lacks a specific legislation for aquaculture at the national and state levels [96,97]. Neither aquaculture nor aquaculture-related activities are mentioned in the Sea Fisheries Decree and Regulations of 1971 and 1992. Notwithstanding this legislative loophole, Veliu et. al. [96] insist that the government has actively worked hard to develop aquaculture in the last four decades. There have been concerted efforts to establish demonstration fish farms and extensions of aquaculture technology.

In 1988, the Federal Ministry of Agriculture, Water Resources, and Rural Development presented the “Agricultural policy for Nigeria” [98]. Interestingly, fisheries were mentioned as a major component [98]. This policy presented measures to facilitate inclusive and efficient agricultural and food systems. One of the issues emphasized included increasing the water supply for food crop production through the construction of irrigation structures, dams, and boreholes in strategic food crop production zones. The government granted subsidies selectively on farm inputs, farm equipment/facilities, and farm services to reduce the costs of agricultural production as well as agricultural product prices to improve farmers’ revenues.

The policy was targeted to shore up the growth of specific areas of agriculture like livestock and the fish production subsector. The effectual and efficient utilization and conversion of agricultural byproducts was also prominently captured in the policy. The Inland Fisheries Decree and the Sea Fisheries Decree fine-tuned these developments and introduced synergy in the administration, management, protection, and improvement of the fisheries’ resources [99].

Due to the assumed failure of previous fisheries policies [99,100], a new Nigerian agricultural policy document was finalized and launched in the year 2001. The new policy document had common features with the former, but it was more focused and better articulated [101]. The aims of the new agricultural policy are (i) to achieve self-reliance in basic food supply and the realization of food security; (ii) to improve the production of agricultural raw materials for industries; (iii) to expand the production and processing of export crops by using improved and updated production and processing technologies; (iv) to ensure the generation of gainful employment [102].

One of the main thrusts of the new policy is (i) the advancement of strategies that will facilitate self-sufficiency and the enhancement of technical and economic efficiency in food production. Actions to be undertaken in pursuit of this goal include (a) the adoption of improved seeds and seed stock, (b) the introduction and adoption of enhanced husbandry and suitable machinery and tools, (c) proficient utilization of resources, (d) support for ecological specialization, and (e) acknowledgment of the small-scale farmers’ roles and

potentials as the main producers of food in the country. The new agricultural policy emphasized the roles of the federal, state, and local governments. The private sector was not left out. Thereby, overlapping functions of these groups were removed.

In 2008, Nigeria presented the National Aquaculture Strategy [9]. Since then, no new document has been produced. As a sectoral document, the NAS is aimed at realizing increased domestic fish production on a sustainable and renewable basis. It intends to produce fish that will help Nigeria attain a level of self-sufficiency and be able to export its aquaculture products.

The NAS took account of some cross-sectoral elements dealing with fish farms and live fish transport and handling. Eight main strategic objectives were formulated: (i) supporting private sector-led investment in collaboration with the public sector and all operators in the fisheries subsector; (ii) investing in the socio-economic life of fishing communities by facilitating accessible fishing inputs, equipment, facilities, and credit; (iii) deliberately enacting policies that will reduce annual import of fish and fish products by 25% within five years; (iv) improving fish disease diagnosis, control, and prevention through network activities; (v) shoring up organizations related to fisheries so that they can contribute favorably to fisheries research and development; (vi) realizing an effectual safety and quality assurance system nationally to protect the health of consumers and enhance foreign exchange earnings via the exportation of fish and fish products; (vii) emphasizing value addition in fish processing; and (viii) developing efficient local and international marketing of fish and fishery products.

Interestingly, the NAS put together a blueprint, stipulating the responsibilities of the public and private sectors in the following areas: (i) production systems; (ii) access to inputs such as feeds, seeds, and capital; (iii) research; (iv) outreach programs; (v) education and training; (vi) fish product quality assurance and control; (vii) marketing and value addition; (viii) regulations; and (ix) monitoring, evaluation, and control.

7. Governmental Interventions

With regards to the substantial fish supply deficit in Nigeria, successive governments have embarked on interventions to diversify the economy and increase food and aquaculture production [103,104]. The government—in addition to other agencies—has taken active part in boosting fish production in Nigeria. The support to aquaculture, especially fish farming, has been a key policy initiative by past governments [105]. These governments paid attention to the facilitation of fish breeding: making fishery/aquaculture inputs available, promoting hatchery development, and standardizing hatchery-cum-fish-breeding processes [106].

From 1980, the Government of Nigeria implemented two major projects to develop aquaculture in the country. Between 1980 and 1992, the Federal Department of Fisheries (FDF) established the Fish Seed Multiplication Project (FSMP) and the Pilot Fish Farm Project (PFFP) [107,108]. The FSMP was designed to utilize all available and ubiquitous water resources from irrigation dams and inland waters for fish production. Issa et al. [13] reported that zonal seed production and training centers were set up between 1978 and 1980. The River Basin Development Authorities (RBDAs) took charge of the project. The RBDA was mandated by the Federal Government to set up commercial fish farms that will evidence the economic viability of aquaculture, functioning as a nucleus for aquaculture development. The FSMP also started to provide fish farmers with fingerlings for stocking their ponds. Furthermore, aquaculture technology centers were established by the government in the northern, western, and eastern regions of Nigeria Kaduna State. Unfortunately, the interventions did not have the required impact.

The Federal Government of Nigeria went on implementing other agricultural development policies, strategies, and programs. One of these programs was the National Fadama Development Programme (NFDP).

Phase 1 of the National Fadama Development Project (NFDP-1), known as Fadama I, was implemented between 1993 and 1999. It focused on crop production, with its goal to

promote simple, low-cost, improved irrigation technology under a World Bank financing arrangement [109–111]. The project provided farmers with boreholes and pumps through simple credit facilities but neglected support of postproduction activities (commodity processing, storage, and marketing) [109]. Fadama I was adjudged very successfully though.

The Second National Fadama Development Project (Fadama II) was launched in 2004 to increase the incomes of crop and fish farmers [110,111]. The primary goal was to empower local communities in order to improve governments' capacity to reach out to poor people. Within the six years of Fadama II, specific technologies were introduced and disseminated to the fish farmers to develop their capacities and production [110]. It was observed that the Fadama II project brought about economic benefits through solutions such as increased production output, increased income, and decreased production cost. Technological, technical, and social benefits were also identified [110,111]. Tihamiyu et al. [110] has recommended that development projects should utilize the demand-driven, bottom-top, family- and community-driven method used in Fadama II to address the needs of the poor in rural areas.

In 2010/2011, the Federal Government of Nigeria targeted a reformation of the agriculture sector through the implementation of a strategy called the Agricultural Transformation Agenda (ATA) [112]. The ATA strategy spanned from 2011 to 2015. The major thrust of the ATA was to grow the agricultural sector and turn Nigeria into an agriculturally industrialized economy [111]. Regarding the transformation of fisheries, the expected outputs according to FMARD [113] included 1.25 billion fish seeds per annum; the production of 400,000 t of fish feed per year; the production of 250,000 t of table-sized fish annually; and the creation of 100,000 jobs per annum for five years starting from 2011.

To achieve this, the Federal Government provided an easier way for farmers to access input like fertilizers through an important component of the ATA, called the Growth Enhancement Support (GES) [114]. The scheme was designed to encourage key actors to work collaboratively for the improvement of productivity, household food security, and boosting farmers' incomes [114]. Fish farming benefited from the ATA in numerous ways [115]: the government installed fish cages at 21 strategic locations nationwide, established three fish markets for fish farmers in different parts of the country, supported the export of fish and shrimp exports, and issued catch certificates to exporters. However, it is argued that several challenges bedeviling aquaculture in Nigeria significantly limited the attainment of the laudable desired targets of the ATA [112].

8. Conclusions and Future Perspectives

In Nigeria, the demand for fish keeps on rising owing to an increase in population and changing dietary preferences (Table 1). This growing population represents a large labor force that is often already working in agriculture and may thus profit from their respective experience and knowledge. Continued sustainable development of aquaculture in Nigeria has become necessary to meet future demand for fish. On the other hand, Nigeria's water resources—both freshwater and marine—will support future expansion. Presently, there are serious weaknesses that need to be overcome, most importantly the access to high-quality feed, lack of adequate training, in particular with regard to disease prevention and hygiene management, as well as consistent, supportive governance for the future development of the industry. As a strong example, Nigeria's catfish farming is world-leading and may serve as an example for the professionalization of other farming activities. Undoubtedly, there are promising opportunities for the expansion of aquaculture, for example, brackish water shrimp farming or the emerging culture of bonytongue *Heterotis niloticus*. Among the challenges to come, financial support and access to credits will be an utmost important prerequisite for the development of the industry. Aquaculture governance should be strengthened and become one of the mechanisms to ensure sustainable aquaculture development. All stakeholders will be expected to participate meaningfully. Based on the information gathered and put together in this article, it becomes pertinent to summarize the strengths and weaknesses of the institutional and policy context before making a definite

verdict about the current status of aquaculture development in Nigeria. The following table summarizes the SWOT analysis of the existing aquaculture sector in Nigeria.

Table 1. SWOT Analysis of the aquaculture sector in Nigeria.

Strength	Weakness
<ul style="list-style-type: none"> Increasing demand (declining wild stocks, rising incomes, and increased protein consumption) Big population and large labor force; many are already in the agriculture sector Large coastline and freshwater resources suitable for aquaculture production Very good conditions for tropical freshwater and marine fish culture Outstanding success with catfish aquaculture (knowledge and technology transfer) Compensation of fish imports by expansion of aquaculture sector 	<ul style="list-style-type: none"> Lack of capacity for feed production and inadequate supply of high-quality feed Lack of capacity for seed production and inadequate supply of high-quality seed Poorly organized value chain, inadequate market access and integration High mortality rates at hatcheries as a result of weak biosecurity (disease, poor water quality and access to appropriate feed) Poor farm management, resulting in low yields and increased risk of disease Inadequate technical capacity, lack of technical training and education Shortage of verifiable scientific data and statistics for management decisions in Nigeria's fisheries sector Inadequate infrastructure and insufficient resources High rate of corruption Lack of specific aquaculture policies and deficiency in effective implementation of existing policies and frameworks Lack of effective plan to tackle climate change effects on aquaculture
Opportunities	Challenges
<ul style="list-style-type: none"> Fast-growing population and high preference for affordable fish protein Improving employment opportunities in rural areas and providing attractive and stable employment Advancing food and nutritional security by providing cheap animal protein using fish Growing economy Possibility to improve the state of youth employment and migration Many aquaculture enterprises available to provide solutions in areas of seeds, feeds, veterinary inputs, logistics, and production facilities Current disposition of Nigerian Government to diversify agriculture including aquaculture Growing interest of the youth for involvement in aquaculture Providing avenue for foreign direct investment from international aquafeed companies Introduction of new candidates into aquaculture like <i>Heterotis niloticus</i>, which has a wide appeal and acceptability by consumers 	<ul style="list-style-type: none"> Production of high-quality, sustainable feeds Improved seed production by participation of the private sector Extension of market access, improved storage (cooling, freezing equipment) Training of fish farmers (hygiene plans, disease monitoring, water quality) Research on the biology and ecological requirements of endemic fish species with aquaculture potential Realistic aquaculture development plan, integrated in national policies Training of staff by network of universities and labs Networking between stakeholders Climatic change adaptations Water supply Unreasonable cultural factors (i.e., community norms and rules)

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