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Review on Status of African Catfish Aquaculture in Nigeria

[1]Chukwu G.U*; [2]Aga T.A; [3]Ulasi, G.F; [4]Ezeh E.O and [5]Gbande S.H

[1 and 3]Department of Agricultural and Bio-resources Engineering, University of Nigeria, Nsukka, Nigeria

[2 and 5]Department of Agricultural and Bio-Environmental Engineering Technology, Akperan Orshi Polytechnic, Yandev, Gboko, Benue State, Nigeria.

[4]Department of Agricultural and Environmental Engineering, Joseph Sarwuan Tarka University, Makurdi, Nigeria

**Correspondence Author*

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Abstract: World aquaculture production continues to grow to meet increasing demand for fish, especially as the fish catch has stabilized and is boosting aquaculture production as the only hope of meeting demand for fish. The aquaculture industry involves the farming of many species of fish of fresh or brackish origin and important freshwater fish species include the North African catfish, also called the African catfish (Clarias gariepinus). Its production is increasing as total aquaculture production is also increasing and its culture is spreading globally, with Nigeria officially declared as producing the largest annual aquaculture quantity of African catfish (clarias garipenous) globally at 3% of the total world production rate per year. There is a significant culture of African catfish in Ghana, currently approaching several decades with 1% of total world production. Ghana has been one of the largest producers of tilapia, pike, and catfish. This review focused on African catfish aquaculture in Ghana and Nigeria, comparing production and industry prospects in the two countries. This review indicates that Nigeria had a higher production rate of African catfish from the 1980s to 2018 than Ghana at the ratio of 3:1. Nigeria's catfish aquaculture industry has shown more significant advancements and expansion over the past two decades, Ghana has also experienced steady growth. Nigeria has established itself as a major player in the African catfish market, both in terms of production volume and international trade. Ghana's industry, although smaller, focuses on meeting local demand and has the potential for further development and expansion.

Keywords African catfish; Aquaculture; Ghana; Nigeria; Prospects

I. Introduction

The world is currently occupied by more than seven billion people and is expected to increase to more than nine billion by 2050, so this poses challenges to continue feeding the growing population. Fish are an important part of the human diet, but although demand has increased, the number of wild fish has remained constant over the past three decades [1]. Therefore, aquaculture represents a sustainable solution to meet the growing demand for fish and fishery products [2]. On the other hand, aquaculture production worldwide has increased in the last sixty years, and the Food and Agriculture Organization of the United Nations (FAO) defined aquaculture as the fastest growing food production sector [1,3]. While the aquaculture industry grew at an annual rate of 8.9% between From 1970 to 2005, the fishing industry grew at a rate of only 1.2%. Also, the production of meat grown on land increased in the same period by only 2.8% [4]. In the most recent period, between 2009 and 2014, the average annual growth rate of aquatic life was direct superhuman 6.6%, while the annual growth rate of fisheries decreased to 0.71% [1]. Aquaculture accounted for only 7% of total fish consumption in 1974, but gradually increased to 26% in 1994 and ten years later to 31%. In 2004, aquaculture contributed a total of 44.14%, i.e. 73.8 million tons out of the total 167.2 million tons of fish produced worldwide [1] and in 2018, about 88% (or more than 1 million tons -156)9 out of 179 million tons of fish. The total fish production was used for consumption [18]

The development of aquaculture farming is increasing in the world, except in Oceania, where it has decreased by less than 0.1% in the last three years. Overall aquaculture production in Oceania is low and reached a peak of 0.2 million tons in 2012. China and Asia still lead by country and region, respectively, in global milk production. This development includes all parts, including fish, aquatic plants, molluscs, crustaceans and other aquatic animals, including amphibians, in a soft, brackish and marine environment. The number of animal species reported to be cultivated and already cultivated in the world is 580 and this includes 362 fish out of 580 [1]. The most common fish farms in the world are carp, tilapia, salmon and catfish [5]. Among the most common catfish are Amur catfish (Silurus asotus), Channel catfish (Ictalurus puncuatus), Striped catfish (Pangasius hypophthalmus) and African catfish (Clarias gariepinus) and their contribution to fish production at the end of 2014 was -0.62%,

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0.53%, 0.52% and 0.33% [5] and at the end of 2018 they were 0.49%, 0.91%, 4.3%, 5.1% [18] . This review discusses the issue of African catfish in Ghana and Nigeria, comparing the cultivation and the future of the industry in the two countries.

II. African Catfish Aquaculture

African catfish (Figure 2) is an important species of marine animals that are farmed in different parts of the world. The most prosperous country is Nigeria followed by the Netherlands, Brazil, Hungary, Kenya, the Syrian Arab Republic, South Africa, Cameroon, and Mali [6]. The total production of African catfish officially by FAO reached 246,476 tons as of 2015 [7] and 1249 thousand metric tons in 2020, which is about 2.5% of finfish production [20]. However, some African countries such as Ghana, South Africa, and Egypt also produce a lot of African fish. Therefore, overall African catfish production may be over-reported. For example, the statistics provided by the Federal Ministry of Fisheries from 2001 to 2012 in Nigeria are very high compared to the FAO statistics [8]. It is said that this conflict was caused by the breeding of African catfish that are not only found in Africa but also in many Asian countries. Therefore, it is difficult to share the exact data of pure African catfish and FAO does not catch the product under the name of African catfish but it is reported as Clarias sp. (Xiaowei Zhou, 2017, Aquaculture Statistician, Food and Agriculture Organization of the United Nations, Pers.com 2 May 2017). According to Anetekhai [8], the breeding of C. Gariepinus can be traced back to the 1950s while it has been identified as a candidate for breeding in Nigeria since the 1970s [9]. The success of aquaculture in Africa can be attributed to the successful development of artificial aquaculture methods in the 1980s and a significant contribution to the development of aquaculture from the mid-1990s as seen in FAO FishStat, [6]. The increase in production has been supported by the acceptance of fish by consumers and farmers due to favorable factors including rapid growth, production, and other aspects as shown in tables 1 - 5 below:

Figure 2: African catfish (Clarias gariepinus)

Table 1; Factors considered in the growth and culture of African catfish [29]

parameter	Value
Temperature range	20-30^{0}C
pH range	6.5 – 8.5
Salinity tolerance	Low
Stocking density	5-20fish/m^2
Growth rate	0.5-1.0g/day
Feed conversion ratio	1.2-1.8
Harvest size	1-2kg
Culture period	8-12months

Table 2; Production rate of African catfish in different years [30][31]

year	Production(tons)
2015	120,000
2016	130,000
2017	140,000

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2018	150,000
2019	160,000

Table 3: Hematological parameters wish provides insight on the fish health [32][33][34]

parameter	Value
Hemoglobin (g/dl)	7.0-9.0
Hematocrit (%)	30-35
Red blood cells(10^6/ul)	0.5-1.0
White blood cells (10^3/ul)	5.0-10.0
Lymphocytes (%)	50-70
Neutrophils %	20-40
Monocytes %	5-10

Disease Outbreaks: Common diseases affecting African catfish include bacterial infections (Aeromonas, Edwardsiella), viral diseases (catfish viruses), and parasitic infections (Ichthyophthirius, Dactylogyrus) [35][36].

Major Breakthrough: One major breakthrough in African catfish culture is the development of improved feeds and feeding strategies to optimize growth and feed utilization [37][41]. Formulation of cost-effective and nutritionally balanced feeds using locally available ingredients has contributed to the success of catfish farming [38][39].

Table 5: Major breakthrough in African Catfish culture (past, present and future)

year	**Potential major breakthroughs in African Catfish culture**
2021	Development of advanced probiotics for disease control
2022	Integration of automated monitoriiing systems in ponds
2023	Nutritional enhancements in feed for better growth
2024	Application of genetic selection for disease resistance
2025	Sustainable recirculating aquaculture system design

2.1 African Catfish Aquaculture in Ghana

The aquaculture industry in Ghana is highly diversified consisting of farming both tilapia and African catfish. The fortunes of Ghana's catfish farmers have also risen substantially, and could outstrip tilapia in the near future.[40] Ghana's maraud into aquaculture started with the initiatory of the colonial administration led by British in 1953 when the first ponds were built as hatcheries to help the culture-based fishery development programme and as a way of appurtenance the national taste for fish and increasing livelihood chances [19,20]. After-independence in 1957, the government espouses a policy to constructs fishponds within all irrigation system in the country most especially in the northern part of the country [21]. Commercial fish farmers who use intensive culture systems though in the minority produce about 75 percent of Ghana's total aquaculture production [22][43]. Pond culture system is the prevailing production system in the southern and central part of the country, which covers about 98 percent of farms, which is also primarily small scale and semi-intensive in status [23][42]. In a couple of years past, nevertheless, the prevailing culture system for tilapia production has changed, and the immense bulk of cultured tilapia is now cultured intensively in cages, especially in Lake Volta [21]. Tilapia (Oreochromis niloticus) is the dominant and preferable fish species for farming and consumers in Ghana. Tilapia species account for over 80 percent of the farmed fish harvest, with a present production of little over 52,000 tonnes per year [24]. Catfish Clarias gariepinus and Heterobranchus species constitute the remaining 20 percent of farmed species. Ghana presently has about 5,000 fish farmers operating approximately 19,000 fish ponds and cages [25]. The aquaculture end product for 2013 was a little over 30,000 metric tonnes of fish, out of which nearly 88 percent came from cages [22], The ministry also set up the Ghana National Aquaculture Development Plan (GNADP)with challenging production target of 100000 metric tonnes of fish at the end of 2016, which is the increments from the 2010

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production volume of 10200 tonnes and the 27000 tonne production in 2012 respectively [25]. The aquaculture sector in Ghana plays a significant role in the national economy. It contributes about 3% to 5% to the Gross Domestic Product (GDP) and provides employment opportunities to the populace [28]. Ghana's current fish production from aquaculture is 52,470.49 metric tonnes a year [24]. The most important source of animal protein in every part of the country, poor or rich, village or cities comes from fish in Ghana [26]. About 10 percent of Ghana population is dependent on the aquaculture sector for their livelihoods [27] The development of aquaculture is critical and nonnegotiable to the Ghanaian government to serve as one of the strategies to bridge the gap between demand and supply of fish and to produce in excess for exports; a statically analyzing on fish production and contribution by sector was done in 2016 as shown in table 6 and figure 4.

Table 6: fish production in tons from 2010 to 2016 in Ghana

System	2010	2011	2012	2013	2014	2015	2016
Aqua production	10,000 tons	20,000 tons	30,000 tons	40,000 tons	50,000 tons	60,000 tons	70,000 tons
Inland production	80,000 tons	90,000 tons	90,000 tons	80,000 tons	80,000 tons	80,000 tons	80,000 tons
Marine production	320,000 tons	330,000 tons	340,000 tons	320,000 tons	280,000 tons	310,000 tons	340,000 tons

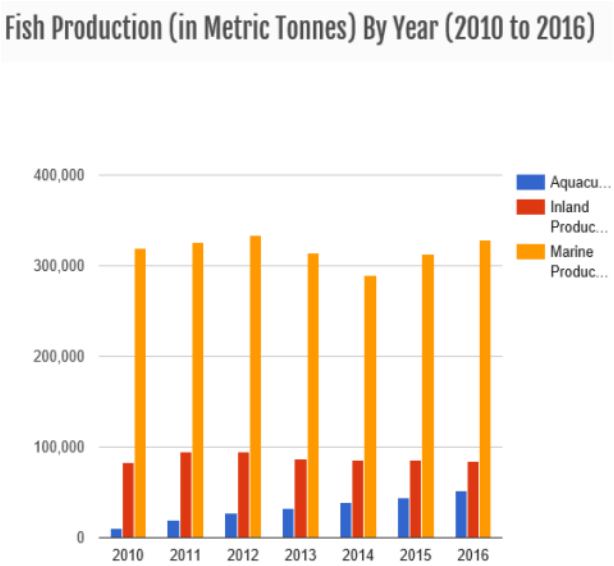

Figure 4: Ghana's Fish production sector contribution and fish production for African Catfish Source: Ministry of Fisheries and Aquaculture Development.[44][45]

2.2 African Catfish Aquaculture in Nigeria

Aquaculture in Nigeria is a growing industry, which is expected to continue due to the needs to meet up with a large deficit (over a million tonnes) between fish production and consumption [48]. The aquaculture industry in Nigeria is restricted to inland freshwater aquaculture, despite abundant marine water resources, and only a few species such as Clarias, tilapia and carps are being cultured. Nigeria imports about 0.72 million tonnes of frozen fish that was valued at over $US 500 million annually, this ranked Nigeria as the highest importer of seafood in Africa [3][49]. The history of fish culture in Nigeria can be dated back to 1951 when the feasibility of farming common carp Cyprinus carpio and tilapia in Panyam, Jos and Onikan, Lagos, respectively, were tested simultaneously [8,12]. African Catfish aquaculture later started in the 1970's and the production substantially increased in the 1980's when artificial propagation methods were successfully developed along with better understanding their nutrients requirements [13]. This industry continued to grow gradually and in the mid-1990, catfish became the dominant fish culture in Nigeria and is currently responsible for the major aquaculture output of the country [7]. Adewumi et al. [14][50] opined that C. gariepinus gave Nigeria a niche in the global aquaculture production, and it is currently the second highest producer of aquaculture products in Africa and the highest producer of African catfish in Africa as well as the world [7].

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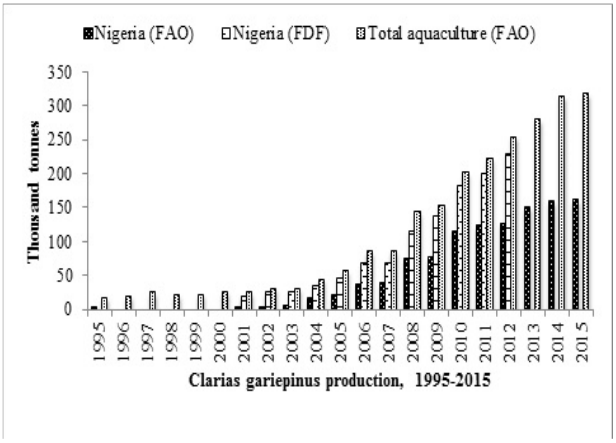


Figure 5: Clarias gariepinus production in Nigeria, in comparison with total aquaculture production, from 1995 to 2015. Data obtained from Food and Agriculture organization and Federal Department of Fisheries (FDF), Nigeria. [46][47]

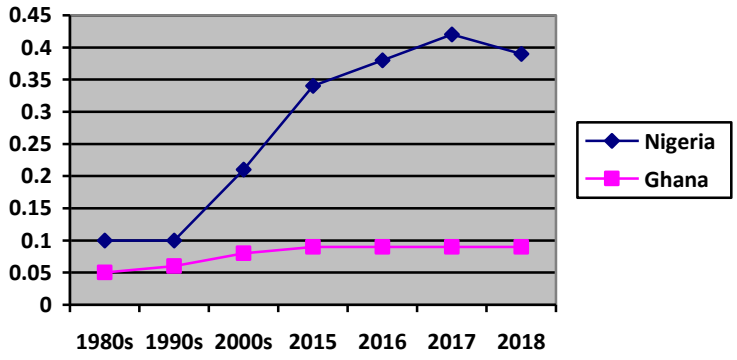
According to FAO reports, the share of African catfish aquaculture in Nigeria's total production increased from 7.8% to 53.2% in 2001 and 2013, respectively (Figure 5). According to FAO data from 2015, the total production of African catfish in Nigeria was 160,295 tones out of 316,727, which is 50.61%. In turn, the Anetekhai report [8] on the production of African catfish, based on data obtained from the Federal Department of Fisheries in Nigeria in 2001-2012, showed that the share of African catfish in aquaculture production in Nigeria ranged from 80% to 90%. This discrepancy may be related to the aforementioned personal communication with the FAO statistician that the official report of C. gariepinus in the FAO database belonged to pure C. gariepinus, while its hybrids and others not confirmed were reported as Clarias sp. (Xiaowei Zhou, 2017, aquaculture, food and agriculture statistics United Nations, Pers.com May 2, 2017).

III. Comparison Between Catfish Aquaculture in Ghana and Nigeria in the Last Two Decades

The catfish aquaculture industry in Nigeria and Ghana share many similarities. For example, it represents the leading fish farming in both countries and both have experienced great development in the last two decades, as seen in Table 1 and Figure 6(a and b),

Table 1; Aquaculture production of Catfish in Nigeria and Ghana from 1980s to 2018

Country	1980s	1990s	2000s	2015	2016	2017	2018
Nigeria	0.10	0.10	0.21	0.34	0.38	0.42	0.39
Ghana	0.05	0.06	0.08	0.09	0.09	0.09	0.09



(a)

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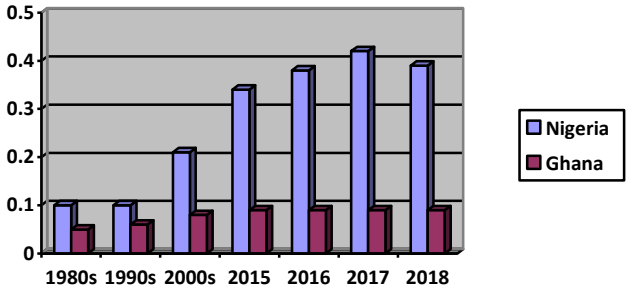

(b)

Figure 6(a) and (b); showing the trends of Catfish production in Nigeria and Ghana from 1980s to 2018

Africa catfish production is diverse, note that Nigeria is the largest in the entire period deducting from figure6, where the production in Nigeria exceeds that of Ghana, which peaked in 2017 and since 2018 has decreased. The percentage contribution to either freshwater aquaculture or total aquaculture was higher in Nigeria than Ghana. This disparity is largely due to the nature of total aquaculture in the two countries. The industry in Ghana is highly diversified with other finfish, tilapia and aquatic plants. In Nigeria, there are only a few species of finfish being cultured and very little production coming from the freshwater giant prawn, Macrobrachium rosenbergii. African catfish in Nigeria has a high market price of about 2000 naira/Kg, which is equivalent to US$ 2.8 USD. On the other hand, African catfish in Ghana is sold at about Cedi 45.8/Kg, which is equivalent to US$ 1.5. The dominant catfish culture system in the two countries is ponds. Therefore, expansion and intensification of production to meet market demands may have some challenges to sustainability. Over the last two decades, both Ghana and Nigeria have experienced significant developments in their catfish aquaculture industries. While Ghana's industry has shown steady growth, Nigeria has established itself as one of the leading producers of African catfish. Here is a comparison of the catfish aquaculture sectors in Ghana and Nigeria over the past two decades:

1. Production Volume: Nigeria has consistently maintained a higher production volume of catfish compared to Ghana (see figure 6). Nigeria's aquaculture industry, including catfish farming, has experienced substantial growth, driven by increased investment, improved farming practices, and a large domestic and international market demand. Ghana's industry, although smaller in scale, has also seen growth, with a focus on meeting local demand.
2. Market Share: Nigeria dominates the African catfish market, both within Africa and on the international front. Its larger production volume allows for a significant market share, and Nigerian catfish products are exported to various countries. Ghana primarily focuses on supplying the domestic market, with limited exports. However, both countries have the potential for further market expansion.
3. Farming Practices: In both Ghana and Nigeria, pond-based farming is the most common method for catfish aquaculture. However, Nigeria has seen more diversification in farming practices, including the adoption of cage culture, recirculating aquaculture systems (RAS), and integrated farming systems. These innovations have enabled larger-scale production and increased efficiency in Nigeria's catfish industry.
4. Feed Availability: Both countries face challenges in terms of feed availability and affordability. Nigeria has made significant progress in the establishment of commercial feed mills, leading to increased availability of quality catfish feed. Ghana, on the other hand, relies more on imported feed ingredients and has been working towards developing local feed production capacity. The industry in both countries would benefit from continued efforts to improve feed availability and reduce costs.
5. Research and Development: In the last two decades, both Ghana and Nigeria have invested in research and development initiatives to support catfish aquaculture. These efforts have focused on improving breeding techniques, developing disease management strategies, and enhancing farming practices. Research institutions, universities, and government agencies have played crucial roles in providing technical support and knowledge transfer to farmers.
6. Government Support: Both Ghana and Nigeria have recognized the importance of aquaculture, including catfish farming, and have implemented various policies and programs to support the sector's growth. This includes providing training, financial assistance, and creating an enabling environment for investment in infrastructure and technology. Nigeria's government has implemented specific policies, such as the Aquaculture Value Chain Development Program, to promote the growth of the aquaculture sector.

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IV. Prospects of African Catfish Aquaculture in Ghana and Nigeria

There is good hope for catfish in Ghana and Nigeria because these two countries are currently importing fish from other countries [1]. Therefore, aquaculture has great promise to fill the gap between supply and demand back and forth, and at the same time, it will improve food quality and create jobs [51]. Ghana is one of the largest breeders of fish in the world and this trend is expected to increase [15][52]. This indicates that fish production will continue to increase and therefore African catfish production is likely to increase due to rapid growth and consumer acceptance. Nigeria has not been able to be self-sufficient in fishing and needs support from the government to increase the number of fishermen in the country [16][53]. It has been projected that Nigeria needs an average annual increase of 3.8% in fish production to keep up with demands of an ever-increasing population [15]. This might lead to increased production of African catfish in the country because of a relatively good knowledge regarding their culture techniques and high market demands. In fact, the demand and market price for catfish are higher compared to tilapia or carps [17][54]. Comparatively, the trends towards higher production in Nigeria than Ghana may continue in the future, although Ghana has a larger potential for aquaculture growth because it is highly diversified [10,11]. In Nigeria, there are on-going efforts to diversify the aquaculture industry through increased production and domestication of some indigenous species such as snakehead (Parachana africana and obscura), but African catfish production might still enjoy the lead for a long time [55].

Some key prospects for the industry in both nations:

1. Growing Domestic Market: Both Ghana and Nigeria have a large and growing population, which translates to an increasing demand for fish, including catfish. As consumers become more aware of the nutritional benefits of catfish and its culinary versatility, the demand for catfish is expected to continue rising. This provides a significant opportunity for catfish farmers in both countries to meet the local market demand.
2. Export Potential: While Nigeria currently dominates the African catfish market, there is also export potential for both Ghana and Nigeria to expand their reach in the international market. African catfish, known for its taste and versatility, has gained popularity in global markets. By adhering to quality standards and establishing export-oriented production systems, catfish farmers in Ghana and Nigeria can tap into the export market, thereby increasing their revenue streams.
3. Technology Adoption: The adoption of modern technologies and innovative farming practices can enhance productivity and profitability in catfish aquaculture. Both Ghana and Nigeria have been making efforts to promote technology transfer, research, and development in the sector. This includes the adoption of recirculating aquaculture systems (RAS), improved breeding techniques, feed formulation, disease management strategies, and water quality management. Embracing these technologies can lead to increased production efficiency and reduced production costs.
4. Value Addition and Processing: There is a growing emphasis on value addition and processing in the catfish industry. By processing catfish into various products such as fillets, smoked fish, and fish-based snacks, farmers can cater to diverse consumer preferences and create additional revenue streams. Investments in processing infrastructure and value-added product development can open up new market opportunities and increase the value of the catfish industry.
5. Government Support and Policies: Both Ghana and Nigeria have recognized the importance of the aquaculture sector, including catfish farming, and have implemented supportive policies and programs. These initiatives aim to provide financial assistance, training, and technical support to farmers, and create an enabling business environment for investment. Continued government support and favorable policies can further boost the prospects of catfish aquaculture in both countries.
6. Climate Resilience: African catfish is known for its adaptability to a wide range of environmental conditions, including varying water temperatures and quality. This resilience makes catfish aquaculture suitable for both Ghana and Nigeria, as they have diverse ecological and climatic conditions. Farmers can leverage this resilience to expand production and explore farming in different regions, contributing to the industry's growth.

V. Conclusion

African catfish aquaculture may not be large globally based on available statistics, but it is an important industry in Ghana and Nigeria. Although it represents the main finfish culture in Ghana for about a decade, it has been responsible for the aquaculture development in Nigeria and the development of aquaculture in Nigeria is essentially that of African catfish. Nigeria is currently the second largest producer of farmed African catfish in Africa and this mainly depends on how the African catfish is produced which has also placed it as the largest producer of African catfish in Africa and in the world based on available statistical data from FAO2020. The future of African catfish aquaculture in the two countries tends to be great, considering available resources in terms of land and water, and the tendency of increase population with a consequent increase in demand for fish. African catfish being the dominant fish culture at the moment and with a lot of favorable attributes may experience an increase in production to meet up with the increase fish demands. However, the future increase in production is likely to be higher in Nigeria than Ghana, given the increase in population, the diversification of the aquaculture industry in both countries, the need for technology and the

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adoption of African catfish. The growing domestic market, export potential, technology adoption, value addition, government support, and climate resilience provide a favorable environment for the expansion and development of the catfish industry in these countries. With continued investment, research, and supportive policies, catfish aquaculture can play a significant role in meeting local fish demand, generating income, and contributing to food security and economic development in Ghana and Nigeria.

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