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Tilapia and Catfish Aquaculture in Nigeria: Yesteryears, Today and Tomorrow

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Abstract

Aquaculture was introduced to Nigeria in the 1950s with the culture of tilapia. The sector which started on a subsistence level has grown to be the one of the most significant and strongly growing aquaculture sectors in sub-Sahara Africa and the market has been a key factor driving growth. The most important species in this industry are catfishes, mainly *Clarias gariepinus* and *Heterobranchus spp,* and tilapias such as *Oreochromis niloticus, Coptodon zilli* and *Sarotherodon spp*. There was phenomenal growth in catfish production from aquaculture from 6,837 tonnes in 1996 to 142,160 tonnes in 2011, equivalent to average annual growth of 22.4%. Although tilapia production showed 10% annual growth during this period, the trend established catfish as the dominant aquaculture species. The contribution of tilapias to total aquaculture production declined from 16.7% to 6.2% during this period compared to the contribution of catfish which increased from 35.1% to 64.3%. This trend shows that almost 90% of new investments in fish farming was exclusively on catfish in the last ten years. However, in view of the massive potentials and projections, aquaculture development in Nigeria has failed to live up to expectations because of the exorbitant prices of feed and regular resorts to the use of unstandardized feeds. Much knowledge that is also required to understand the dynamics of pond aquaculture which is mostly the practice. These have been generated through research in universities and research institutes in Nigeria, towards the development of new techniques for producers. The techniques vary with fish species cultivated, management systems, seasons, and eco-climatic zones. Early research efforts were directed towards technical, biological and chemical dynamics of aquaculture systems in order to encourage economic development through aquaculture production. However, these need to align with economic (subsistence, commercial) and social environment of the adopted techniques. Challenges facing Nigeria aquaculture include ambiguous government policies, ineffective use of qualified professionals, limited training capacity, limited access to credit, excessive taxation of producers and limited research funding. Strategies for the future development of aquaculture will include integration of aquaculture with agriculture, promotion of an economic environment conducive with greater insertion of the small-scale sector within the formal economy, strengthening of aquaculture production and management systems and their effective implementation, support of pilot-scale or model projects to test the technical feasibility and economic viability of aquaculture systems among others.

Keywords:
Tilapia, Catfish, Fish farming, Technical feasibility, Pond aquaculture

Introduction

Aquaculture was introduced to Africa with the culture of tilapias in Kenya in 1924 (Balarin, 1985) and is now practiced in different aquatic environments, ranging from freshwater, brackish water to marine, and with the intensity of production ranging from extensive to intensive. Aquaculture has experienced a long developmental process in Nigeria, with early beginnings in the 1950s also with farming of tilapias.

Fish is considered as either a cash crop (for employment and income generation, capital investment) or subsistence crop (for nutritional subsidy, labour investment). Initially, fish farming was promoted as a subsistence level agricultural activity with many small farm ponds built across much of sub-Saharan Africa, which contributed little to fish production, particularly due to inadequate fish seeds, poor quality fish feeds and/or low technical assistance. However, it helped farmers reduce risk and many continue to contribute modestly to livelihood needs, poverty alleviation and food security. In Nigeria, there is increasingly widespread interest in identifying and promoting more significant, viable and productive forms of food fish culture.

Nigeria's Aquaculture Sector

Aquaculture production has shown a remarkable 20% increase in growth per annum for the past eight years (2005-2013), mainly in small-to-medium enterprises, and a few large-scale intensively managed fish farms. Nigeria has one of the most significant and strongly growing aquaculture sectors in SSA and the market has been a key factor in driving growth. A further phase of expansion is currently being developed by government including youth employment programmes (FDF, 2012), which focuses on fish farming training. Aquaculture development is approached through the entire value chain, led by the private sector, while the government plays a facilitative role of providing conducive business environment.

Fish constitutes about 40% of the total animal protein intake of Nigerians and there is increasing demand for fish. With high demand for fish and consumer preference for the African catfish (*Clarias gariepinus*), the private sector launched fish farming in 2000, with the rehabilitation of many abandoned fish farms and new investments. By 2003, a national inventory reported 2,642 fish farms (Miller & Atanda, 2004) with annual production of 30,000 tonnes (FDF, 2007). Recently, fish production has reached 221,000 tonnes annually (FDF, 2012). Commercial fish farming is now very popular in Nigeria with more than two-thirds of the 4,000 fish farms sited in the south-west and southern parts (Figure 1), where the climatic and environmental conditions (temperature, rainfall, humidity, soil type, perennial good quality water supply are more favourable in addition to the social and economic disposition of the population (Satia, 1990; Miller & Atanda, 2010).

Tilapias (*Oreochromis* spp., *Sarotherodon* spp., *Tilapia* spp.) and African catfishes (*Clarias* spp., *Heterobranchus* spp., and their reciprocal hybrids) are the most widely cultured food fishes in Nigeria and are suited to low-technology farming systems. This is due to their fast growth rate, hardiness, efficient use of natural foods, propensity to consume supplementary feeds, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity, and tolerance to wide ranges of environmental conditions. In order of consumer preference and economic returns based on a survey of cultivated food fishes and inventory of fish farms (Miller & Atanda, 2004), which is reflected in the current level of investment, the African catfish, *C. gariepinus* is the most popular (80%), followed by tilapias - Nile tilapia, *Oreochromis niloticus*, *Coptodon zillii* and other tilapias (14%); while other species in order of preference and culture are *Heterotis niloticus* (2%), *Cyprinus carpio* - common/mirror carp (2%), *Chrysichthys* spp. - brackish water catfish (1%) (Atanda, 2007).

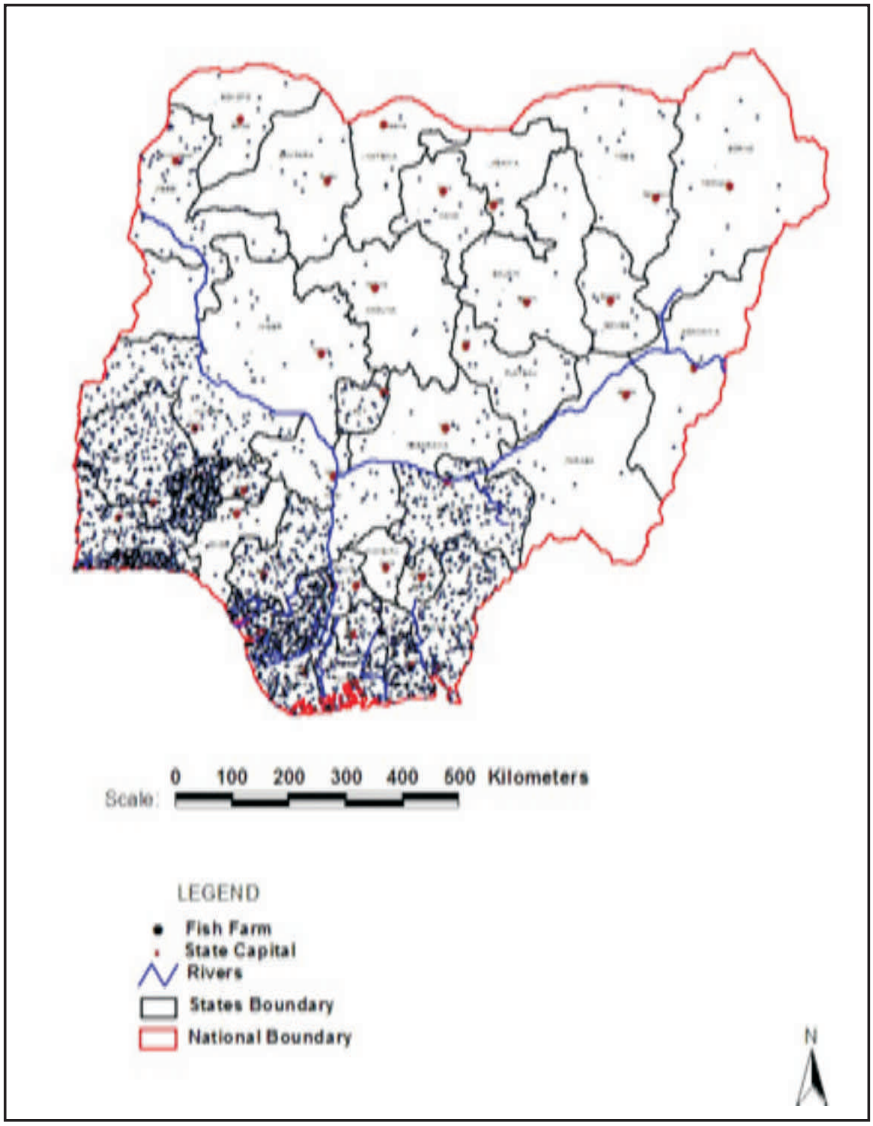

Figure 1:
Distribution of fish farms in Nigeria (Abdullah, 2007)

According to Miller (2010), African catfishes dominate cultured fish production in Nigeria and almost all fingerling production is carried out by private fish hatcheries. This development was pioneered in southwest Nigeria where majority of cultured food fishes are produced (Miller and Atanda, 2007), but fish farmers now produce fish across the country to meet the ever increasing demand for food fish. The reasons for the successful tank culture of the African catfish in Nigeria include: low production costs, an excellent market for catfish, availability of good quality fingerlings, availability of good quality feeds, availability of technical assistance, and availability of credit through cooperative societies. Some commercial fish hatcheries produce about 0.5 million catfish fingerlings per month and there are many small hatcheries producing several hundred thousand fingerlings each per year to meet their own needs with a portion available for sale. In 2010, there were about 5,000 fish farms in Nigeria and total catfish fingerlings production was 70-80 million (Miller, 2010).

Presently, the private sector driven aquaculture industry is expanding with more catfish production and tilapia production which is planned for intensive cage farming (Miller, 2010). Tilapias and catfish are widely cultivated in a variety of culture enclosures and are suited to low-technology farming systems

because of their fast growth rate, hardiness, efficient converters of supplementary feeds, resistance to disease, ease of reproduction, and tolerance to wide ranges of environmental conditions (Fagbenro, 1987). Tilapia culture remained largely a subsistence level activity until 2000, when it began to expand rapidly following the successful commercial farming of catfishes (Alfred and Fagbenro, 2006; Afolabi *et al*., 2000).

Figure 2 shows the phenomenal growth in catfish production from aquaculture from 6,837 tonnes in 1996 to 142,160 tonnes in 2011, equivalent to average annual growth of 22.4%. Although tilapia production showed 10% annual growth during this period, the trend established catfish as the dominant aquaculture species. The contribution of tilapias to total aquaculture production declined from 16.7% to 6.2% during this period compared to the contribution of catfish which increased from 35.1% to 64.3%. This trend shows that almost 90% of new investments in fish farming was exclusively on catfish in the last ten years.

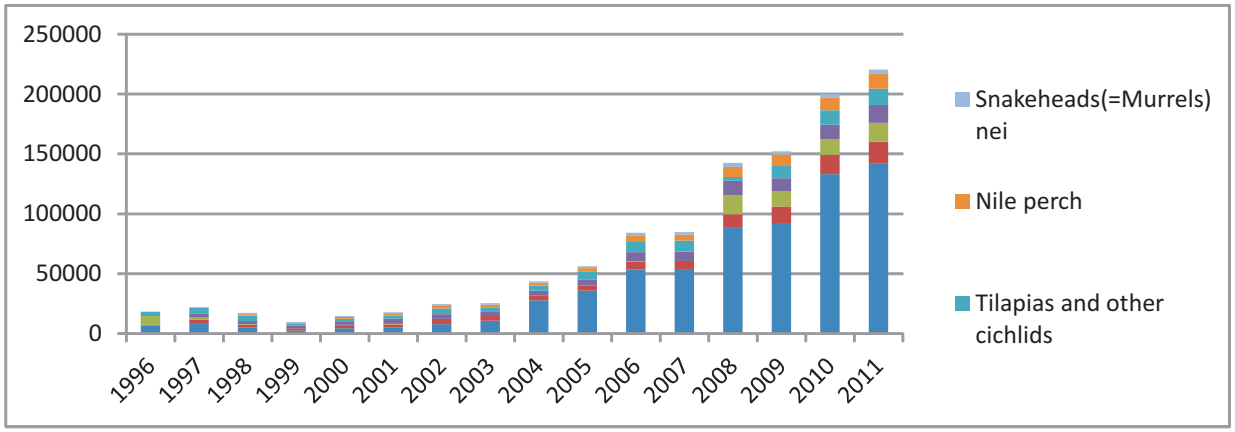

Figure 2: Aquaculture production in Nigeria (tonnes)
Source: FAO FishSTAT

Fish Feeds

Aquaculture development in Nigeria has failed to live up to expectations because many fish farmers put limited effort in developing standardized feeds. Both intensive and semi-intensive systems involve input of supplementary feeds and complete feeds, which account for 40-60% of production costs, respectively (Fagbenro, 1987; Fapohunda and Fagbenro, 2006). Two main types of feeds are produced by both sectors namely tilapia feeds, (30-35% protein) and catfish feeds (45-50% protein) as presented in Table 1. The use of floating, imported fish pellets with occasional use of local fish feed, have gained popularity among fish farmers. Many brands of floating, imported fish feeds are available in shops of animal feed dealers and distributors (Table 2). Factors such as affordability, ready product availability and quality influence the decision-making of fish farmers to buy a particular brand. Type of packaging used (strength, size variation, durability, inclusion of nutrient content label) also plays a significant role in the choice of fish feed brand purchased by farmers.

Table 1: Least cost feedstuffs used for African catfish and tilapia feed production in Nigeria

$g.kg^{-1}$ diet	African catfish		Tilapia
	Grower	Broodstock	
Fish meal (65% crude protein)	250	250	150
Soybean meal (45% crude protein)	350	350	450
Blood meal	100	100	-
Maize	150	100	250
Fish oil	60	90	40
Vegetable oil	40	60	60
Mineral-vitamin premix	30	30	30
Binder	20	20	20

Source: Fagbenro & Adebayo (2005)

Table 2: Major commercial fish feed suppliers in Nigeria

	Brand name	Protein content (%)
Durante Fish Industries	Skretting (Holland)	45
OT&T Global Ventures Ltd.	MultiFeed (Israel)	45
Felimar Aquaculture Centre	Coppens (Holland)	42
AEC Integrated Enterprises	Multi Feed (Israel)	45
Grand Cereals	Vitafeed	
Aller Aqua Fish Feed	Aquafeed (USA)	45
Animal Care	Multifeed (Israel)	45
Nigeria Institute for Oceanography & Marine Research (NIOMR)	NIOMR Feed	42

Source: FDF (2012)

Economics of Fish Farming

Much knowledge that is required to understand the dynamics of pond aquaculture have been generated through research in universities and research institutes in Nigeria, towards the development of new techniques for producers. The techniques vary with fish species cultivated, management systems, seasons, and eco-climatic zones. Previous research efforts were directed on technical, biological and chemical dynamics of aquaculture systems in order to encourage economic development through aquaculture production, which need to align with economic (subsistence, commercial) and social environment of the adopted techniques (Abiodun, 1986).

Enterprise budget is the basis of aquaculture production analysis being an estimate of all incomes and expenditures of a specific enterprise and an estimate of the profitability at a single point in time (Shang, 1981; Kay, 1986). Enterprise budgets is hence an economic tool often used to assess overall profitability, compare the relative profitability or relative cost components of different enterprises on a farm (feed production, fingerling production, table size fish production) (Chaston, 1988). Enterprise budgets have been used in Nigeria to analyse the profitability in different production systems (earthen ponds, concrete tanks, monoculture, polyculture, with/ without fertilization and/or liming), for tilapias and African catfishes (Afolabi *et al*., 2000; Yesuf *et al*., 2003; Fapohunda, 2004), Miller & Atanda, 2007 (catfish); Olagunju *et al*., 2007 (catfish); Kudi *et al*., 2008 (catfish); Adewuyi *et al*., 2010; Olawumi *et al*. 2010; Ayanda, 2011 (tilapia, catfish), Ele *et al*., 2013). A summary of selected fish farm characteristics, input quantities and prices are presented in Table 3, which includes:

- species of fish cultured (monosex or mixed sex tilapias, African catfish, hybrid catfish)
- stocking densities (fish size and number per pond/tank water surface area)
- type of feed used (supplementary, complete, floating, sinking)
- duration of culture cycle (6, 8, 9, or 12 months)
- prevailing fish price (farm gate, market)
- operation costs (fish seeds, fish feeds, lime, fertilizers, medication, transportation, insurance)
- labour (skilled, unskilled, family, hired)
- investment costs and risks
- source of credit (agricultural bank, commercial bank, cooperative societies, family members)
- interest rate loans (5%, cooperative societies; 15%, agricultural banks; 20%, commercial banks)

Table 3: Selected fish farm characteristics, input quantities and fish prices in southwest Nigeria.

	Nile tilapia	African catfish
Culture system	Concrete tank, Monoculture, Intensive	
Dimension and area of tank (4 tanks)	10m x 5m x 1.2m; Total = 200 m^2	
Stocking density (pieces/200m^2)	5000 pieces = 20/m^3	4000 pieces = 16/m^3
Fingerling weight at stocking (g)	20	25
Fish survival (%)	90	90
Feed (% crude protein)	30%	40%
Growth rate (g/day)	1.3	1.8
Culture period/cycle (days)	180	270
Average fish weight at harvest (g)	350	450
Fish sold at harvest (pieces)	4500	3600
Labour (national minimum wage ₦5,000/month)	30,000	45,000

Source: Survey in southwest Nigeria (2017)

This economic information gives an indication of the required initial investment, labour costs, feed and other input costs, expected revenue from fish sale at harvest, and economic profitability of various management options in order to develop a fish farm enterprise budget. Table 4 presents a comparison of the costs and estimated benefits of concrete tank farming of Nile tilapia African catfish in Nigeria.

Table 4: Enterprise budget (estimated costs and returns) for raising tilapia and catfish per cycle in southwest Nigeria

	Monosex tilapia (200m^2) 6 months cycle				African catfish (200m^2) 9 months cycle			
	Unit Cost ₦	Quantity	Total Cost ₦		Unit cost ₦	Quantity	Total Cost ₦	
VARIABLE COSTS			Per cycle	Per annum			Per cycle	Per annum
Fingerlings	15	5000	75,000	150,000	30	4000	120,000	160,000
Feeds	250/kg	300 kg	75,000	150,000	300/kg	500kg	150,000	200,000
Labour*	5,000	1	30,000	60,000	5,000	1	45,000	60,000
Security personnel*	5,000	1	30,000	60,000	5,000	1	45,000	60,000
Total Variable Costs (TVC)			**210,000**	**420,000**			**360,000**	**480,000**
FIXED COSTS								
Concrete tanks construction	62,500	4	250,000	250,000			250,000	250,000
Depreciation (10%/annum)			12,500	25,000			18,750	25,000
Total Fixed Costs (TFC)			**262,500**	**275,000**			**268,750**	**275,000**
TOTAL COSTS (TVC + TFC)			**472,500**	**695,000**			**628,750**	**755,000**
REVENUE								
Fish sold at harvest/cycle		4500 pieces				3600 pieces		
Fish sold at harvest/annum		9000 pieces				4800 pieces		
Tilapia (market size, 350g)	₦400/kg		630,000	1,134,000				
Catfish (market size, 450g)	₦600/kg						972,000	1,296,000
Total Revenue (TR)			**630,000**	**1,134,000**			**972,000**	**1,296,000**
NET FARM INCOME [TR – (TVC + TFC)]			**157,500**	**565,000**			**343,250**	**541,000**

* Labour and security cost based on approved National Minimum Wage of ₦5,000 per person per month
Source: Computed from primary data (2017)

The numbers in the Table are computed from primary data collected from a survey in southwest Nigeria in May 2014. In Nigeria, construction of one unit of concrete tank costs about ₦60,000 each and costs are reduced by building four tanks together with contiguous walls. Most tanks are built without drains as it is easy to use a siphon for water draining and harvest of the fish. A fine mesh netting is stretched over the tanks to avoid bird predation. Tanks are built in the open without a shed. By grouping the tanks together, security is facilitated. To account for evaporation and water loss, the water level of about 1m is maintained by pumping water. The corners of most tanks are rounded to reduce oxygen deficits and provide a continuous wall for the fish to follow with reduced injuries.

Most farmers stock fish fingerlings of 15-20 g which cost $0.12-0.16 each and raise them through nine months' cycle. They anticipate up to 10% mortality due to handling or predation. Many of the farmers' stock catfish fingerlings at a high density of 125 fish/m^2. Note that this is a lot of fish in a small area and that this is impossible with tilapias, which can tolerate only up to 3-4/m^2 or so in such mostly static tanks. Many fish farmers raise fish with imported, pelleted feeds which cost up to $1.50/kg. Such feeds contain 45-50% which make the fish grow very fast during its accelerated growth period, up to 10-15 cm in length. Following this period of 6-8 weeks, the fish are then fed a locally produced feed of 35-40% protein. Fish are fed sinking or floating pelleted feeds 3-4 times daily. Sinking pelleted feeds are fairly common and less costly to manufacture than the floating, or extruded, floating feeds. Table 4 features the enterprise budget for raising monosex tilapia and catfish per cycle in Nigeria. Catfish culture had greater profit potential per cycle and per annum as a commercial business venture than the tilapia monoculture. Table 4 shows that the estimated costs and returns from monosex tilapia culture over two cycles of 180 days each are high enough to justify investment in Nile tilapia. As suggested by Kaliba *et al.* (2007), the tank size of 200m^2 may be too small to be economically efficient. Raising two crops of

tilapias per year would be more profitable, more so that a commercial farm would need to supply market size (adult) tilapia on a year-round basis (Neira *et al.,* 2009).

Risk Management in Aquaculture

In Nigeria, risk measuring is unpopular and rarely considered. Fish farmers are interested in the frequency, cost and its economic consequences on aquaculture ventures. The current status slows development of aquaculture in Nigeria and makes the quantification of risks very individualistic for the farmer and his farm. Many farmers do not make these types of analyses or have the right level of risk capital available at the start of their projects. Pond culture of fish (including tilapia) faces a lot of risks. The main risks facing the activity in Nigeria include:

- Pure risks due to extreme climatic and meteorological conditions (flooding, drought, deposition of silt)
- Social risks (theft/poaching, malicious damage, fraud)
- Political risks (riot, sabotage)
- Legal risks (litigations on land issues)
- Business risks (late delivery of supplies of fingerlings and other inputs or services, lack of adequate technology or technical information and expertise as regards hatchery propagation),
- Financial risks (unstable government financial policies, change of government, terms of credit facilities obtained, changes in the operational cost)
- Increase in competition for both inland and coastal waters and space from tourism and recreational industries, delayed or non-renewal of lease (if he does not own the property) or limit important expansion plans.
- Market and consumer-related risks (loss of fish quality, lack of market information, role of middlemen, loss of consumer appeal, health regulations, and actions of the consumers.

As expected, commercial fish farmers in Nigeria manage/control their risks through the following:

- Pursuance of a business plan and management strategy, which anticipate absorbing risks
- Formation of professional associations (cooperatives), by setting appropriate standards and adopting codes of practice
- Applying the highest economic standard in locating the venture
- Adherence to laws and regulations regarding the movement, handling and marketing of diseased stocks so as to reduce the risk of spreading the disease
- Agricultural insurance schemes - boost the confidence of lending institutions to make credit available to farmers.

Social Performance

Livelihoods

Fish has contributed significantly to the livelihood needs and sustenance of many Nigerians in terms of employment and wealth creation. Jobs are created along the value chain from tilapia seed collection from the wild, seed production in hatcheries, fry nursery and rearing operations; earthen pond, concrete tanks and cage construction; fish feed production, marketing and sales; table fish production; fish processing and value addition; transportation; distribution and product marketing. Over the next three years, commercial tilapia production in cages can reach 10,000 tonnes which will translate to additional 2,000 new jobs along the value chain as more investors embrace the practice and technology.

Gender Issues

Fish farming technology is gender-friendly and there is no stage along the value chain that gender is a liability. There are more women involved in tilapia processing, value addition and marketing than men. This is because for cultural and religious reasons, fish processing is a business for northern housewives who are mostly restricted to work indoors, while in the south > 70% of fish processors are women. In parts of Nigeria where culturally married women are mostly housewives who at best only engage in petty domestic trade, fish processing into either sun-dried, oil-fried or made into paste as condiment, is a major source of income to supplement the family income. Fresh, smoked or grilled fish is served at local eatery, mostly run by women in form of stew or pepper soup.

Education and Training

Facilities exist for training in tilapia and catfish aquaculture for all the three levels of core personnel required for the aquaculture industry, namely senior aquaculturists, technicians and extension workers. With regard to training of senior aquaculturists, there are four research institutes – Nigerian Institute for Oceanography and Marine Research, Lagos, National Institute for Freshwater Fisheries Research, New Bussa, Lake Chad Research Institute, Maiduguri, and African Regional Aquaculture Centre, Port Harcourt. In addition, there are three Colleges of Fisheries, closely affiliated with the three fisheries research institutes, that train students for the award of Diplomas and several Universities that train both undergraduate and postgraduate students for degrees in aquaculture, where outdoor facilities for both tilapia and catfish culture research and production have been upgraded and strengthened. All these institutions offer vocational training of technicians, extension agents and farmers. With these institutions having the mandate responsibility for tilapia and catfish aquaculture research, there is generally a broad range of aquaculture research skills in Nigeria.

Aquaculture Professional Organizations/Stakeholders

Organizations for both professional fisheries and aquaculture operators exist which serve as avenues for the exchange of scientific and technical information as well as pressure groups to encourage and influence favourable government policies on fisheries and aquaculture development. Professionals are members of the Fisheries Society of Nigeria (FISON) while aquaculture operators belong to Nigerian Association of Fish Farmers and Aquaculturists (NAFFA). Specifically, catfish farmers belong to Catfish Farmers Association of Nigeria (CAFAN), and in June 2014, Tilapia Aquaculture Developers Association, Nigeria (TADAN) was formally established as an affiliate member of FISON. The association became duly registered on June 6, 2014 and held the first meeting on June 29, 2014 at the FISON Secretariat, in Lagos to develop her concept note. The most recent is the Association of Nigerian Fisheries Scientists (ANIFS) comprising members who have a deep passion for the development of fisheries research and are drawn from research institutes, universities and colleges.

Challenges and Way Forward

Despite the great potential fish farming has in Nigeria, there are numerous challenges that need to be addressed which include, among others,

i) Low level of Private Sector Investment
ii) Ambiguous Government policies
iii) Ineffective use of qualified professionals
iv) Limited training capacity
v) Limited access to credit
vi) Excessive taxation of producers
vii) Limited research funding

Strategies for Aquaculture Development

a. Integration of aquaculture with agriculture: Using technologies applied in schemes which contemplate water storage practices, including micro-irrigation and small ponds; encouraging aquaculture in irrigation networks and integrated rice-cum-fish culture.
b. Promotion of an economic environment conducive to greater insertion of the small-scale sector within the formal economy: This entails the availability of affordable institutional credit; adjustments of taxes, levies and unnecessary regulations; and added emphasis on providing adequate infrastructure and services.
c. The strengthening of aquaculture production and management systems and their effective implementation, through enhanced applied research, institutional involvement of research and industry in decision making.
d. Support pilot-scale or model projects to test the technical feasibility and economic viability of aquaculture systems.
e. Recognize aquaculture as a priority sector for investment.
f. Use international financing and assistance to ensure proper role of aquaculture in rural development programmes.
g. Provide computerized aquaculture information systems.
h. Support regionally coordinated systems-oriented adaptive research on fishes whose culture methods are already known.
i. Establish regional networks of multidisciplinary training and research programmes for producing core aquaculture personnel.
j. Set up a national advisory panel on aquaculture

Conclusion

African aquaculture research and development are producing promising results, despite the economic difficulties under which much of these are undertaken. The future of tilapia farming remains bright, despite the somewhat disappointing recent statistics. In Nigeria, wherever inland aquaculture flourishes, tilapias are likely to be a major farmed fish commodity next to catfishes. This can be true if research is better directed towards farmers' needs; if better breeds and farming systems are developed together; if anti-tilapia attitudes are changed where they are ill-founded (Alfred & Fagbenro, 2006); and if aquaculture becomes a more sustainable and environmentally compatible enterprise, well-integrated with other development initiatives. There is considerable potential for achieving Nigeria's objectives in increasing fish protein production most especially in the urban centres by farming tilapia in family-based homestead concrete tanks. This practice will greatly enhance the current low per-capita fish protein intake, and when widely accepted and extensively practiced, will probably reduce the existing deficit between fish supply and demand in Nigeria.

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