The Rise of Peri-urban Aquaculture in Nigeria

A paper presented at the 25th Annual Conference of Fisheries Society of Nigeria (FISON) on 27th October,2010 at ASCON, Badagry, Lagos State.

James W. Miller[1] and Tunde Atanda[2]

Aquaculture has experienced a long developmental process in Africa, with early beginnings in the colonial period of the 1950's with farming of tilapias. For decades fish farming was promoted as a subsistence level agricultural activity with thousands of small farm ponds built across much of sub-Saharan Africa, most of which contributed little to the supply of fish. Without adequate fish seed, feeds or technical assistance, these ponds did not achieve significant production. However, in some areas they helped farmers reduce risk and many continue to contribute at a modest level to rural food security, involving both men and women. With capture fisheries under pressure and with regional fish consumption declining, African governments are increasingly looking to aquaculture to fill the supply gap. As a consequence, there is increasingly widespread interest in identifying and promoting more significant, viable and productive forms of aquaculture.

Nigeria's aquaculture development followed a similar development path from the colonial era, during which more than 2000 small-scale subsistence level ponds were built, with some growth continuing in rural areas. However production has been insignificant in national food supply terms. Nigeria's strongly growing population, at some 150 million and its very high demand for fish, has now positioned it on a much stronger market-driven path, based on commercial production in peri-urban areas. This has shown a remarkable 20% increase in growth per year for the past six years, with high growth in small-to-medium enterprises, and a number of large-scale intensively managed fish farms. Together with Egypt and S Africa, Nigeria is now one of the most significant and strongly growing aquaculture producers in the region. As noted by Muir et al (2005), Nigeria's fast growth in aquaculture is a replication of that observed in other regions where the market has been a key factor in driving growth. A further phase of expansion is now being developed, with government youth employment programmes, some 20% focusing on fish farmer training, to promote wider social engagement and to attempt to stem the exodus from rural areas. It is reported that 30% of new investment in agriculture programmes are in fish farming with bankers now more informed and willing to consider loans in this sub-sector.

With high demand for fresh fish and consumer preference for fresh water catfish (*Clarias gariepinus*), the Nigerian private sector launched fish farming in earnest around 2000, with the rehabilitation of many abandoned fish farms and new investment in others. By 2003, a nation-wide inventory totaled 2,642 fish farms (AIFP, 2004; Brummett, 2007) with annual production estimated at some 30,000 MT by the Federal Department of Fisheries (FDF Annual Report, 2007). Such has been the impact of market demand, this has now reached some 120,000 MT annually, while tilapia production is less than 5,000 MT per year. Though not the outcome of a single project, this remarkable growth has arisen from a confluence of market, social and

[1] James W. Miller, Aquaculture and Small-scale Fisheries Consultant, 707 Timberwyck Drive, Hixson, Tennessee 37343, USA. Tel. +1-423-875-496; E-mail: jimfishafrica@gmail.com. James worked in Nigeria in artisanal fisheries in the Nigeria Delta from 1991- 99 and led FAO's Aquaculture and Inland Fisheries Development Project from 2003-06. He consults in Nigeria for the private sector, USAID, FAO and other international agencies.

[2] Tunde Atanda, Assistant Director, Federal Department of Fisheries, Abuja, Nigeria. Tel. +234-803-587-1102; E-mail: nigeriaaquaculture@yahoo.co.uk; tundeatands@yahoo.co.uk

technical change factors. This review presents the Nigerian experience and sets out the several key processes and innovations that launched aquaculture as a successful and expanding sector.

i) Processes

a. Who developed the technological or institutional innovation?

The Nigerian experience is a useful study, as it brings into focus several innovative "firsts" in African aquaculture development. Responsibility for these innovations was primarily attributable to the awakening of a range of private sector agents, the strong consumer preference for catfish and the consequent market opportunity. Much pond infrastructure already existed and was relatively easily put into production, moving from subsistence low-input tilapia culture to more intensive and commercialized catfish farming. The major issue driving these innovations was the profitability of fish farms consequent on investment in sound management, establishment of efficient fish hatcheries and the initial import of high quality feeds. Key aspects are as follows:

1. Market forces: low supply and high demand for fresh fish catalyzed commercial fish farming development bringing farmers to recognize fish farming as a viable, profitable business.

Agriculture accounts for up to 30% of GDP, with fisheries contributing an estimated 4% of this amount; aquaculture represents 15-20% of this. This apparent economic opportunity has also brought government to support programmes for development of fish farming across the country, to encourage growing numbers of underemployed younger people towards remunerative, productive livelihoods.

2. Species choice – focus on African catfish: Consumer demand focused farming on the African catfish (*Clarias gariepinus*) in contrast to the tilapias (*Oreochromis niloticus*, etc.) which had been the common focus in subsistence fish farming projects of the past. The catfish has been described as a fish "made for African fish farming and consumers" as it is extremely hardy and can be raised at much higher densities and production levels than tilapias (Atanda, 2007). It can also be sold live and can be held for days or transported in containers with small volumes of water. Catfish fingerling production has proven to be easily managed in well organized hatcheries with induced spawning and intensive feeding of fry (Potenkham and Miller, 2006).

Brood fish of *Clarias gariepinus*. Nigeria

Most catfish are raised in earthen fish ponds although there is increasing interest in producing them intensively in concrete tanks in static, flow-through or recirculating water systems. They can easily be sold live in traditional markets, or transported more widely. Most consumers lack refrigeration but they can purchase a catfish and take it home alive and hold it several more days in a bucket of water

before preparing a meal. Tilapias cannot be held in such stressful conditions and are sold dead with or without ice. Traditionally catfish has also been marketed as a smoked product and this has also developed on the basis of increased supply, expanding into valuable exports to supply ethnic markets in Europe and the US.

3. Investing in sound management: The growing demand for catfish was becoming evident in 2000 and 2001 when farmers began rehabilitating many fish ponds and farms that had been abandoned. Opportunities seen by a number of key investors were noted. Declines in capture fishery supply were increasingly evident in the markets and their strong price trends. Farmers wanted to produce catfish to meet the high demand, but realized they lacked experience in managing commercial fish farms. In the past, Nigerian farmers had invested heavily in infrastructure (fish ponds, tanks, feed mills, equipment) but not management (Miller, 2006). School leavers with no experience were hired to manage fish farms of absentee owners; this is a problem in many countries in Africa and often results in failure and lost money to the farm enterprise (FISH, 2009). As institutional technical support was seriously lacking, experienced aquaculture managers were brought in from Europe, several fish farm owners participated in training courses in Holland, Israel and the UK, and key investors made visits to fish farms in Europe and elsewhere. This lead to the recruitment of experienced international fish farming consultant-managers, to launch intensive fish farming on an industrial scale. Given the great demand for fish and high prices, these investors profited and served as examples to be replicated. Local human capacity has been strengthened through this process however, institutional capacity needs further support and for this to occur, the process for awareness raising and engagement is critical for continued development (Muir, et al. 2005).

By mid 2003, some ten fish farms had developed intensive catfish hatcheries and were achieving high production, using brood stock of known origin and imported, high quality fish feeds. Two such farms established recirculated water hatcheries in the Ibadan area, each with production of some 0.5 million catfish fingerlings per month. With a large expanding market, their owners trained other farmers and assisted in the construction of some 100 intensive recirculating systems active in the country today. Although some investors still hesitate to invest in good management, its value had been clearly demonstrated; particularly for this initial period of development, while local skills were being built up in more intensive techniques.

Government extension support staff, have until relatively recently lacked capacity in commercial aquaculture but have gained significant knowledge from the private sector. A number of extension staff have also moved into supplying private sector technical assistance. With the rise of many unqualified aquaculture consultants, Nigeria's two principal aquaculture professional associations, FISON (Fisheries Society of Nigeria) and CAFAN (Catfish Farmers Association of Nigeria), together with the Federal Department of Fisheries (FDF) have been involved in organizing training programmes for capacity building. FISON has also contributed to the education of lenders in the banking sector, which helped to open up credit for some farmers with proper documentation and business plans; nevertheless, credit remains unavailable to the majority of fish farmers.

Although the number of consultants nationally is unknown, a certification programme for aquaculture consultants and quality control of fish fingerlings and feeds is also being planned. Compared with another growth sector in Nigeria's modern food supply, the poultry industry,

investors also note that fish production has so far been much less affected by the disease outbreaks common in that sector, and so overall investment confidence is relatively good. Reports indicate that a few fish importers, increasingly aware of the national supply gap and the potential market opportunities, are now investing in domestic fish production.

4. Development of hatcheries: Intensive fish hatcheries were established for massive production of fish fingerlings to support fish farms with quality fish seed of known origin. Today there are more than 15 intensive catfish hatcheries and many fish farmers have become involved in small-scale fingerling production to meet their own needs, with limited quantities for sale to others. Primarily focused on catfish, several farms are now also producing tilapia fingerlings. Several private hatcheries have breeding programmes underway for continuous stock improvement.

Small catfish hatchery in Niger Delta

In the past, production ponds were commonly used for fingerling supply, particularly for tilapia. However this resulted in negative selection as the larger, faster growing fish were sold for consumption while the remaining slower growing fish were used to spawn and provide fingerlings. Now specialized hatcheries exist for both catfish and tilapias, with quality brood stock of known origins, selected for good body conformation and fast growth at low feed conversions. More fish farmers have realized they can make greater profits with the faster growing fingerlings purchased from the best hatcheries; demand for fingerlings from such suppliers has far exceeded supply and most quality hatcheries are over-booked most of the time. Nigerian operators have also greatly enhanced quality control with application of best management practices and improved conditions for handling and transport of broodstock and fingerlings. This is also reflected in the apparent absence of serious disease outbreaks. Additionally, farmers have developed techniques to ship fish to destinations around Nigeria via public transport.

Intensive catfish hatchery using recirculating aquaculture technology and recycled tanks for low-cost fingerling production. To encourage feeding and growth, such hatcheries are kept dark and warm.

5. Development of Fish Feeds: with high demand and very favorable market prices, early entrants were able to import high quality feeds to launch the industry. This evolved into local feed production with at least four quality national producers of high capacity now established, using experienced imported technical expertise. Although data on fish feed production is unavailable, reliable sources indicate total local capacity now exceeds 100,000 MT per year, with feeds ranging from 32% to 45% crude protein. Both sinking and extruded (floating) forms of fish feed are now produced locally. However, these still compete with imported feeds, and though the earlier performance gap is diminishing, some producers use high quality imported fish feeds for the first month to accelerate growth when small quantities of these expensive feeds are required (in weight), then switch to locally produced feeds for the grow-out period of topping up production to market size. Though Nigerian fish farmers benefit from a wide variety of feeds, with imports from at least

eight countries including Holland, Israel, Indonesia, Brazil, USA, and EU countries, transport and import duties make up some 25% of the cost of imported feeds.

The competitive market for fish feeds has contributed to greatly raising the quality of locally produced fish feeds; however many farmers tend to favour purchase of imported feeds over those of local manufacture. This follows a general feeling that imports are always better than locally produced products. Some studies indicate that 15% or more of fish farmers still produce their own feeds on-farm (USAID MARKETS, 2009) in an effort to reduce costs; however in most cases this is negated by more costly longer growth periods and higher feed conversions than those demonstrated by the higher quality manufactured feed. Cheaper feeds may appear attractive to small producers, but if they keep records, they will realize the comparative advantage of more costly, high quality feeds (FISH, 2009). Still, record keeping remains a neglected management tool for most fish farmers. Nevertheless, the value chain has expanded with more specializations; farmers are realizing that it is best to invest in high quality feeds rather than produce feeds on-farm which are usually incomplete, with poor quality ingredients and unbalanced nutritionally. The quantity of imported fish feeds has greatly expanded since 2005 when one Dutch supplier had 60% of market share of the imported market. With the upsurge in quality, locally produced fish feeds, there is talk of imposing government restrictions on fish feed imports.

Local sinking fish feed compared to high quality imported floating fish feed.

Feeding with demand feeder to catfish in Nigerian indoor recirculating fish farm

6. Fish Farming Villages: With prospects of good profits, a number of medium-scale investors, typically government civil servants and retirees, invested in farming fish in concrete tanks in "fish farming villages" (also called Fish Farm Estates) located in peri-urban areas near large markets. These investors lacked suitable land and other resources as well as the time to manage a fish farm, and so they sought the means to organize production, employ others who were well-qualified to manage their operations, and obtain a sound return. With high demand and market prices, they were able to obtain credit, using professional business plans and security documentation required by lenders. They launched catfish farming in groups of concrete tanks measuring some 8m x 2m x 1.2 m, typically two or three contiguous tanks to reduce costs. One such site near Ibadan had a complex of some 200 tanks in 2005, which has now increased to some 800 tanks. Such intensively managed tanks can accumulate much wastes and feed, but this is overcome by regularly flushing out the tanks. A number of such locations have now been developed, across the country close to large fish markets. The typical fish farm village is managed as a cooperative by a supervisor and 2-3 technicians who keep individual records for each tank and owner. The fish tank owners pay a small fee for the management and security of their tanks, fish and feeds. This system has been successful for more than five years as markets remain good, credit is available, construction costs and water supply costs are low, quality fingerlings, feeds and technical assistance are available. Even though input prices have risen for feeds, new entrants continue to build tanks and make sustainable enterprises in different areas. Some have been able to improve their market position by selling fish in the SE and North where prices are 25% higher than in the SW. Growth continues in fish farming and is expected to continue for the next five years as demand has not yet been met in the North and SE. The cooperative culture of the Yorubas, in the areas where the systems first developed, has also greatly facilitated successful management.

Fish tank farming in Nigeria. Several hundred such tanks are cooperatively managed at this site.

A cost benefit analysis of tank catfish farming is presented in annex. Many farmers were able to have profits of close to USD 1.00/kg produced in the initial stages of these systems, and some farmers had claimed a 30+% return on investment (ROI). With good supervision and management, profitable production continues, albeit at lower margins due to increased input and transport prices. Nevertheless, some farmers with a series of two or three tanks report total production of 0.7 tons of fish per cycle. With two production cycles per year, they could be producing 1.5 tons of fish per year from tanks having a total surface area of some 50 m^2. Although no aeration is used, the tanks are usually flushed several times during the production period to remove wastes and water of poor quality, making this a type of flow-through production system. With the ability of catfish to be grown intensively and the ease and low cost of construction, thousands of such tanks have been built across the country and Federal Fisheries Department staff estimate up to 50% of Nigeria's fish culture production to derive from such systems. This is a significant achievement that now has a well-developed value chain. Such

tank systems also respond to the needs of those small-scale investors with limited access to land and water and has encouraged an, as yet, undocumented number of back-yard fish farmers.

b. What partnerships helped?

Investors responded to the market call for more catfish, based on their own evaluation of local markets and consumer demand. Realizing the limited capacity in supply of inputs and lack of qualified local technical assistance, experienced international consultants were recruited to launch the industry. Initially fewer than ten consultants were involved, and several developed partnerships that still continue. Thus, partnerships were created with private European and Indian firms for technical assistance, establishment of modern, intensive fish hatcheries and supply of high quality feeds. Former staff and graduates from the University of Wageningen, the basis of a longstanding international research programme on African catfish, became key consultants and developed enduring partnerships with local firms. Local universities continue to provide courses in aquaculture and fisheries and several developed their own research facilities of ponds and tanks. However, limited funding opportunities handicapped efforts by universities in general.

Credit institutions are also in partnership for loans, mainly with the more well-organised and successful farmers. In view of the particular rise of the private sector to "develop the industry on their own", public-private sector partnerships have been slow to develop. However smaller farmers have benefited from development and technical assistance projects from FAO, the World Bank and others. Growth in the sub-sector has also encouraged a number of NGOs who have found niches in training and technical assistance in the value chain.

Much collaboration was required to sustain the "fish farm village". In an environment where collaborative efforts usually fail, this initiative benefited from the positive conditions of the strong cooperative, business-minded culture of the local ethnic group, the Yorubas, who have supported fish farming development for many years throughout SW Nigeria. The presence of supportive institutions is also especially strong in this region. The two main professional support organizations FISON (Fisheries Society of Nigeria) and CAFAN (Catfish Farmers Association of Nigeria) originated in the SW and have both played increasing roles in driving the national aquaculture industry. Additionally, several universities in this region as well as the National Institute for Oceanography and Marine Research (NIOMR) and the Nigerian Institute for Freshwater Fisheries Research (NIFFR), have provided research support to aquaculture development training and capacity development..

c. **To what extent was social capital development a part of the project?**

Social capital development with respect to production communities in the traditional rural context has not been a significant feature of this case. However, other aspects of social capital and its development – directly or incidentally, can be identified as contributing to the success of the sector. At the consumption level. traditionally people prefer to eat their fish in two forms: as a smoked product or in the national dish, "fish pepper soup". Smoked catfish are sold locally and in export markets, where networks of diaspora are a key feature of demand. Fish pepper soup is widely consumed in small, popular restaurants called "bukas" (USAID

Popular Buka restaurant where people eat the popular fish pepper soup. (USAID MARKETS photo).

MARKETS, 2006), where a wide variety of people congregate after work, often for soup and beer. Greater prosperity has increased the number and use of these places, with evolving social exchange and capital building, and demand for catfish has strengthened accordingly.

As earlier noted, the mores and strong cooperative culture of the Yoruba created the setting for success in cooperative fish farm village. With a good organizational structure established for supervision and technical management, the owners of the fish tanks are able to enjoy producing fish at arm's length, knowing that their investment was being well managed with little risk of theft of fish and loss of investment. Fish farmer professional associations have also strengthened the capacity of such farms through training and technical assistance, which was greatly facilitated by having the farmers in one location.

d. What was the mix of agricultural or food innovations – new seeds and breeds, new agro-ecological or agro forestry innovations?

Most of the catfish raised in Nigeria are referred to as the Dutch variety as it was bred over the years at research facilities of the University of Wageningen in Holland. Some of the original stock was taken to Holland from the Central African Republic where a catfish hatchery had been established, with an FAO project in the late 1970's. After years of breeding, Dutch consultants brought this variety to Nigeria for raising intensively in earthen ponds and/or multiple concrete tanks. A wide variety of ponds exist with areas ranging from 100 m2 to 1000 m2 or more. Most tanks are built in contiguous series of 2 or three tanks with common walls thus reducing construction costs. The tanks are small at some 16 m2 each, making management fairly simple, in spite of the relatively high stocking density of 30-75 fish/m2; tanks are often constructed inside compounds of homes providing increased security. Tank construction with concrete blocks is also much cheaper than pond construction, which requires expertise that is largely unavailable. Such tank systems also allow farmers to start small and build up production capacity. Intensive flow-through systems are being used in areas where water is abundant, while in other areas, particularly in peri-urban locations, water recirculation systems have been successfully developed, often using local designs and construction materials for filters, aeration and other forms of water treatment. Nevertheless such intensive systems have benefited from importation of high quality equipment.

Fish tanks where up to 1.5 tons of fish can be produced per year in 2-3 tanks of 16m2 each. Flushing of tanks is used to reduce wastes.

The use of catfish is another innovation in that this species is much more resistant to the stressful conditions of intensive cultures of high densities, low oxygen and waste build-up. In spite of these conditions, the African catfish can usually gain weight with low feed conversions at low cost. Hatchery operators are now successfully shipping their fingerlings in special small tanks with battery driven aerators on public transport buses and taxies.

With use of high quality fish fingerlings and quality feeds, the production period of some producers was reduced from 6-7 months to 4-5 months, providing the opportunity for 2.5-3 harvests per year with low feed conversions of 1.0-1.3: 1. This resulted in significantly increased production and revenues (USAID MARKETS, 2007; FISH, 2009).

Some fish farms and tank production units are also integrated with agriculture for irrigation of intensively managed gardens downstream from the fish production units. Thus, farmers are able to reuse nutrient-rich waters from ponds into field crops.

ii) Outcomes

a. Number of farmers adopting?

With the number of fish farmers increasing beyond 5000 in 2009 and a highly developed value chain of upstream suppliers and downstream processors and marketers, Nigeria's aquaculture industry has achieved high production and continues to grow with new farmers opening pond or tank-based fish farms, and with increasing use of more intensive aquaculture systems. With increased cost for inputs and transport, profits are decreasing somewhat, but farmers and investors remain convinced of profitability. With growing demand and very limited local supply in the southeast and north, some fish farmers in the southwest are now shipping fish to these markets which fetch 50% or more above the prices for fish in the southwest. The value chain has been well-developed and input suppliers have developed to the point where quality fish seed and feeds are widely available in very competitive markets. Plans are underway to update the inventory of fish farms, which was first completed in 2003, and to make this a more comprehensive evaluation of the industry with detailed profiles of fish farms and production systems. Markets for fish are expanding locally and regionally and Nigerian farmers have begun exporting value-added, smoked catfish to Europe and the USA, targeting ethnic markets. With the 700,000 MT/year of imported fish, the industry has significant potential to expand, creating considerable further employment. To this end also, recent government initiatives to engage young people in aquaculture, providing training and practical experience, is also notable, and may have significant social implications.

b. Number of hectares covered by technology or practice?

Fish farming has evolved a great deal and it is no longer possible to quantify areas to estimate production. Aquaculture systems started with earthen ponds, progressing to static concrete tanks, then in locations where water is abundantly available, flow-through tanks, and since 2006, more than 100 farms, around the country, use sophisticated recirculating aquaculture systems. There are thus a number of physical factors that determine production capacity, from land area and water exchange, to volume flow to size of biological filters for removal of wastes and use of aeration. Biological and chemical factors include species, feeds, density of stocking, temperature and general water quality.

Sophisticated recirculating aquaculture systems recycle water and have been successful in fish hatcheries such as this one in Ibadan

Though ponds continue to be the main production units, concrete tanks are increasingly used and production from such tanks and recirculating systems are estimated to have expanded to produce up to 50% of the total estimated annual catfish production of 120,000 MT (FDF, 2009). One estimate indicates total earthen pond areas to exceed 40,000 ha, but production is relatively low (1.5 MT/ha/yr assuming 60,000MT production). Improved management of such farms can greatly increase catfish production up to levels achieved in Uganda of 8-15 MT/ha (FISH. 2009). The total area of

Concrete Fish Tanks are used in various sizes in Nigeria from 16 m2 to these 380 m2 tanks.

the "fish farm villages" has not been estimated, but the original site near Ibadan in Ijebu-ode has now expanded and this has occurred elsewhere. Concrete tanks have been built in all areas of the country; the total number is not presently known, but is estimated to be in the tens of thousands.

c. Predicted trends for both farmers and hectares into the future?

Trends for aquaculture production depend much on the interplay of supply and demand, and the influences of input costs and substitution prices. Already the concentration of fish farms in the SW of the country has depressed prices of fish in this region compared to the rest of the country, where the retail price of catfish may be 25-50% higher per kilogramme (USAID MARKETS, 2006). Some farmers are now raising tilapias on a more commercial level, given their demand for more luxury markets and for export, but the market for catfish remains favorable at present in spite of rising costs of feeds and transport. With government programmes and the trend to reduce imports, investment in aquaculture development continues and shows promise for further expansion, especially in the SE and North. Suppliers are moving into these areas to meet demand for fingerlings and feeds. One feed producer in the North central zone is doubling its production capacity for extruded, floating fish feeds, in anticipation of continued growth in the industry. As in all industries, some investors profit while others, who may cut corners or experience management problems are unable to sustain their enterprises and may be forced out. Nevertheless, the better fish farmers have expanded operations, and there is positive evidence of future profitability. However the prospects of a substantial replacement of the shortfall in national supply is less likely, as the production cost profiles of aquaculture are normally higher than the market prices of cheaper imported fish.

Input costs are a key issue in the future viability of aquaculture systems, particularly those which operate more intensively. Transport costs are also rising. With production increasing, perhaps more rapidly than market growth, prices will also tend to stabilize or fall. With increasing energy costs, some recirculating units are also experiencing difficulties and are lowering recirculation rates to reduce cost for electricity; flow-through systems reliant on pumped water are likewise constrained. This requires much more careful management to control the risks for loss of fish due to ammonia build-up and lower oxygen levels.

Farmers are making efforts to reduce cost of production, through better targeted feeding and improved handling to reduce mortalities and injured fish. They are also practicing more grading of fish to better respond to sizes preferred by consumers; depending on the markets, preferred sizes vary from 400 to 1000 g and even larger. Traditionally, many consumers desire large catfish of 1.0 to 2.0 kg average size. However, to be more profitable, fish farmers need to be producing fish of less than 1 kg and in some markets the smaller size is appreciated as with the smoked fish market in the north. Similar findings were confirmed in Uganda by the FISH Project (2009). Some consumers are starting to understand that the smaller fish are tastier and less oily and fatty. Larger fish may also accumulate more "off flavours" from algae and bottom mud. To widen development and ensure viability at lower production costs and market prices, several NGOs and development projects (Government, FAO, World Bank and USAID), are focusing on local farmer-driven research and development and increased access to input

materials. A process has also been launched to strengthen professional associations and for certification of private sector consultants involved in technical assistance. Technical manuals are being produced and a "buyer's guide" to aquaculture equipment and suppliers is being developed.

d. Effects on food production or productivity (either yields or total production)?

Catfish production from different aquaculture systems is estimated to account for 17% of Nigeria's total domestic fish production, of some 680,000 MT/year. This is significant progress in growth in production in less than seven years as much investment and labor have been concentrated for this remarkable progress. As earlier noted, the use of catfish, farmed intensively in small water units, with improved seed , feed and management techniques, has also resulted in a major change of productivity as defined by annual output per hectare. Typical levels of subsistence tilapia productivity are some 1000-1500kg/ha/yr, while those for intensive catfish production in tanks may reach 50-100 MT/ha/year or more.

Aquaculture development may also have an effect on other areas of food production. The 2003 inventory of fish farms indicated that some 40-50% employed some integration with other husbandries such as poultry, pigs and goats/sheep as well as crops. Many producers, including some in the "fish farm villages" also benefit from multiple water harvesting with irrigation of and fertilization of gardens downhill from their fish ponds, and almost all integrated agriculture programmes include fish farming. Clearly the sector can facilitate other farming activities as ponds and tanks may serve in recycling of water and agricultural by-products, thus helping reduce risk and lower costs. Many fish farms receive organized visits by school children, which serves as a learning tool for both youth and adults. At home, children discuss their school activities and field visits with their parents, thus children are involved in educating their parents, many of whom have limited formal education.

e. Effects on environmental services (eg standing and soil carbon, biodiversity, water, soils)?

Some fish farmers use fish ponds as a back up water supply to irrigate vegetable crops

The sector and its development has been closely observed by the Environmental Protection Agency and environmental groups. Investors understand that environmental soundness is necessary to ensure sustainability. As earlier noted, some farmers are recycling waters from ponds to irrigate crops, while intensive recycled systems require very little water for production, although requiring higher energy inputs. Nigeria's National Aquaculture Strategy and Plan specifically supports environmental protection and encourages partnerships between the farmers and environmental groups. It also supports best management practices to promote protection of biodiversity, and controls are in place to prevent importation of non-endemic species. The growth of the aquaculture industry is also considered to have had a positive effect in reducing fishing pressure on wild stocks. Although most fish farms are potentially at risk of escaping fish, though this is not a serious problem as farms raise only indigenous fish species. No negative impacts of fish escapes have been reported.

Aquaculture farms produce an as yet poorly defined level of greenhouse emissions, and the more intensives systems have a higher footprint than others, primarily related to feed inputs and energy for water circulation and treatment. However, more broadly, pond-based aquaculture has the potential to trap carbon in phytoplankton and in sediments. For production in fish tanks, wastes are usually recycled back into the soils in integrated gardens, thereby potentially improving soil fertility. However, more detailed assessment of the effects, and their dependence on management practice, is still required.

f. Social outcomes – who are the key beneficiaries? Who are the losers?

Clearly fish farming has a variety of beneficiaries that are not limited to those involved in the value chain. General nutritional programmes in Nigeria promote increased consumption of fish and school feeding programmes include fish in their menus. With fish consumption estimated at some 9 kg/capita, it appears that farmed production may account for a bit less than 1kg of this. With much of the fish consumed in popular small, restaurants (bukas), many people of limited income benefit from improved nutrition from the fish. Additionally many people are employed in fish farming, and in areas where there may be competition for use of land, fish farming has been promoted for areas not suitable for crop farming. There are considerable expectations that further expansion of the sector can become a useful means of employing younger people and assisting the move away from rising urban unemployment. However, the effectiveness of this is yet to be determined. The rise of more intensive aquaculture has generally involved and benefited individuals or groups who have access to assets, though local employment may be enhanced. The rural aquaculture sector has continued to develop, and the wider availability of seeds and feeds has the potential to increase its economic potential, with better linkages to poorer rural communities. At this stage the gender implications of this development have not been assessed, though women are known to be involved in the supply and value chain – particularly in marketing, and in some cases are investors in production. They are involved in a growing trend of smoking catfish reared in various aquaculture systems in Nigeria; this value addition is helping some women and farmers make a little more profit in a tight market experiencing increased cost of inputs and transport. Smoked fish are most popular in the north and fish farmers can benefit from this market as there is a preference for smoking smaller fish ranging in size from 300g-600g fresh weight.

Women are involved in fish marketing and some are fish producers.

Smoked Catfish Sales are wide spread

iii) Options for spread, greater resilience and more productivity

a. How could technology or practice be spread to other agro-ecological zones or countries?

Fish farming is practiced throughout Nigeria and this is due to the variety of aquaculture systems that have now been developed, demonstrating both the adaptability of this method of food

production, and the ability of producers to develop systems, which are effective in specific contexts. The development of effective seed and feed technologies has been seen a significant turning point in aquaculture production, and within countries in the immediate region, Nigerian feeds and fingerlings have been used to support the development of aquaculture. More widely, the breakthrough effects of these changes have been a useful encouragement for national aquaculture; Uganda for example is now developing a national supply of fish feeds. The replication of fish farming villages as Aquaculture Parks in other countries has been one example of the Nigerian experience being extended elsewhere. This has been facilitated by FAO projects and the African aquaculture web site SARNISSA. Many exchanges have already occurred through study tours among countries, particularly in Africa.

b. What are the key elements of processes and actions that build system outputs and resilience?

Though the aquaculture industry in Nigeria remains subjected to input price fluctuations, the industry continues to expand. With a number of technical assistance projects focused on capacity building, skills continue to be developed to support the industry and strengthen the value chain. The industry was led by the establishment of intensive fish hatcheries and delivery of quality fish feeds through imports or greatly improved local production including extruded, floating fish feeds. Professional associations have also evolved to drive the industry with wider participation in the value chain as with training programmes, certification of technical consultants and quality control of fish seed and feeds. The value chain for input supplies has become very broad in a short time period, with many suppliers of fish seed and feeds. The wide variety of input suppliers has added competition and resulted in cost savings passed on to farmers, and the potential ability to expand into wider markets. Veterinary services for identification and treatment of diseases and parasites remain a weak area, but this is slowly being addressed as are issues concerning environmental management. While farms have not so far had issues of environmental impact, most have limited areas (< 10 ha) and varying levels of release of eutrophic waters.

Catfish small fingerlings

Floating Fish Feeds are now locally produced.

Floating Fish Feeds are preferred by fish farmers and several fish feed producers have invested heavily in extruder equipment for this technology and to better compete with imported feeds.

As the sector matures and as input prices rise and market values settle or fall, the commercial resilience of the industry is to be tested. To date, it has accommodated these challenges through efficiency improvements, and in a competitive environment, more successful producers appear to be emerging and may assume a greater share of national output. The ecosystem resilience of these systems so far shows little constraint, though if the industry expands, suitable locations with adequate environmental capacity may become a constraint. Socially, these systems appear to be providing a valuable source of income

diversification, and may in the future become a notable source of youth employment.

Cost Benefit Review

The following is a summary of the costs and estimated benefits of tank farming of fish in Nigeria. This is based on costs for a single 16 m2 tank with a fish production cycle of 6 months.

Expenditure Item	**Unit Cost ($US)**	**Total Cost ($US)**	**Comment**
Capital costs:			
1. **Construction of tank** (16 m2)	$US 38.46/m2	$US 615.38	2 or 3 tanks built contiguously are cheaper
2 Allow, for infrastructure, water supply, small equipment,		$184.61	Estimated at 30% of tank costs
Operating costs		Cost per crop	
1. **Fingerlings** - 2000 purchased; with 20% mortalities and fish spread to 3 tanks, there will be 530 fish per tank of 16 m2.	$US 0.075 – 0.16 ($0.12 average cost)	$US 63.60	Assume 80 % survival; this may be higher in well managed systems
2. **Fish Feeds**-assumes a 1.5 FCR and average final individual weight of 1.0 lbs (454 g)	$US 1.15/kg $US 0.52/lb	$US 413.40	Cost of feeds ($0.78/lb assuming a FCR of 1.5) for 530 fish harvested at 1.0 lbs each for 530 lbs (240 kg);.
3. **Labor Cost -** Assumes costs of feeding and other interventions spread over 150 tanks.	$US 15.00 /month	$US 90.00	Could be reduced or eliminated with family involvement
4. Depreciation of tank and other facilities over 20 years	$US 30.76 plus $9.23 per year	$US 15.38 plus $4.61 = $19.99	Based on contiguous tanks in pairs.
5. Interest on construction capital at 10% annually	$US 61.54 plus $18.46 per year	$US 30.76 plus $9.23 = $39.99	
Total (direct) production costs		$US 567.00	
Total production costs including depreciation and interest (rounded up)		$627.00	
Income Generated			
1. Sale of Fish – 530 fish at 1.0 lb each x $US 1.40/lb		$US 742.00	
Profit Considerations			.
Gross profit (net of depreciation and interest)		$US 175.00	$US 350 per tank per year of operation
Net profit, including depreciation and interest		$115.00	$230 per tank/year
Including Tank Construction Costs: 1.6 harvests would break even. This would occur in 9.6 months.			

In one year a farmer with three tanks could earn $US 1,050 of gross profit from this activity.

References

(1) Abdullah, A. Y. 2007. Evaluation of Fish Farming Potentials in Nigeria. An Approach through the use of Geographic Information System (GIS) PhD Thesis, University of Abuja 168 pp.

(2) AIFP Project. 2004. Inventory of Fish Farms in Nigeria, Aquaculture and Inland Fisheries Project, published by National Special Programme for Food Security. Project Technical Document. 148pp.

(3) Atanda, A. N. 2007. Freshwater fish seed resources in Nigeria, pp 361-380. In M. C. Bondad-Reantaso (ed.) Assessment of freshwater fish seed resources for sustainable aquaculture FAO Fisheries Technical Paper. No. 501. Rome, FAO 628p.

(4) Brummett, Randall. 2007. Fish Seed Supply Study: Africa Synthesis. World Fish Center Technical Paper. 23 p.

(5) FDF. 2008. Fisheries Statistics of Nigeria, Fourth Edition (1995-2007). Publication of the Federal Department of Fisheries.

(6) FISH. 2009. Failure and Success in Fish Farming. in *Manual for the Commercial Pond Production of the African Catfish in Uganda.* Auburn University FISH Project Publication. Karen Veverica, Team Leader. USAID Coop. Agreement# 617-A-00-05-00003-00. 238 p.

(7) Miller, J.W. and Tunde Atanda. 2008. Fish Farm Village: A Model for Replication from Nigeria? Technical Note. SARNISSA web site. 4 p.

(8) Miller, J. W. 2006. End of Contract Technical Report Aquaculture and Inland Fisheries Project (AIFP) of the National Special Programme for Food Security. 41pp.

(9) Miller, J. W. 2003 Inception Report of the Aquaculture and Inland Fisheries Project of the National Special Programme for Food Security. 44pp.

(10) Muir, J.F., Gitonga, N., Omar, I., Pouomogne, V. and Radwan, I. 2005. Hidden Harvests: Unlocking the Potential of Aquaculture in Africa. Technical Review Paper. NEPAD-Fish for All Summit. 22-25 August 2005. Abuja, Nigeria. 56 p.

(11) Potenkham, Kamthorn and Miller, J. 2006. Manual on Catfish Hatchery and Production. A Guide for Small to Medium Scale Hatchery and Farm Production Aquaculture and Inland Fisheries Project (AIFP). Published by National Special Programme for Food Security (NSPFS) 29 pp.

(12) Special Programme for Food Security. 2005. Fish Pond Construction and Management. A Field Guide and Extension Manual. 54 p.

(13) USAID MARKETS. 2006. Nigerian Aquaculture Marketing Study. By Susana Ohen and Graham Dixie for USAID MARKETS. Power Point Presentation. 59 p.

(14) USAID MARKETS. 2007. Development of commercial marketing and distribution strategy for local production of extruded and sinking fish feed pellets. By Saeed Lawal, Aquaculture Consultant. 67 p.