

# The rise of peri-urban aquaculture in Nigeria

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The development of fish farming in Nigeria is traced from the colonial period through decades of mostly subsistence farming to large-scale commercial catfish farming today. Most African countries have encountered difficulties breaking into profitable commercial fish farming; however, Nigeria's strongly growing population at some 150 million and its very high demand for fish positioned the country on a much more strongly market-driven path based on commercial production in peri-urban areas. With investment in good management, selection of the hardy catfish for farming, development of intensively managed fish hatcheries and use of high quality fish feeds, farmers established a new model for raising fish in concrete tanks, which greatly reduced poaching and allowed farmers to get full return on their investment within one year. The paper details costs and benefits. With prospects of good profits, a number of medium-scale investors, invested in farming fish in tanks in 'fish farming villages' (also called fish farm estates) located in peri-urban areas near large markets, where several hundred tanks were cooperatively managed. With high demand and market prices, they were able to obtain credit, using professional business plans and security documentation required by lenders.

**Keywords:** African catfish farming; fish farming villages; Nigeria; tank fish farming

Nigeria's aquaculture development has followed a similar development path from the colonial era, during which more than 2,000 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, as well as its very high demand for fish, has now placed it on a much stronger market-driven path, based on the commercial production in peri-urban areas. This has shown a remarkable 20 per cent increase in growth per year for the past six years, with high growth in small-to-medium-scale enterprises and a number of large-scale intensively managed fish farms. Together with Egypt and South 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 per cent 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 per cent of new investments 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 investments in others. By 2003, a nation-wide inventory totalled 2,642 fish farms (Miller, 2003; AIFP, 2004; Brummett, 2007) with annual production estimated at some 30,000mt by the Federal Department of Fisheries (FDF, 2007). Increased market demand has dramatically impacted annual production which has now reached some 120,000mt annually, whereas tilapia production is less than 5,000mt per year. Although

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not the outcome of a single project, this remarkable growth has arisen from a confluence of market, social and 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.

## Processes

### 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 had 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 catalysed commercial fish farming development, bringing farmers to recognize fish farming as a viable, profitable business.

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

2. *Species choice – focus on the African catfish*: Consumer demand focused farming on the African catfish (*C. gariepinus*) in contrast to the tilapias (*Oreochromis niloticus*, etc.) that had been a 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 (Potenkhram and Miller, 2006).

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 and 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 led to the recruitment of experienced international fish-farming consultant-managers, with the aim 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 of awareness raising and engagement is critical for continued development (Muir *et al.*, 2005).

Government extension support staff have until relatively recently shown a lack of 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 in opening up credit for some farmers with proper documentation and business plans; nevertheless, credit remains unavailable to the majority of fish farmers.

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 under way for continuous stock improvement.

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 that they can make greater profits with the faster-growing fingerlings purchased from the best hatcheries; the 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 the application of best management practices and improved conditions for the handling and transport of brood stock and fingerlings. This is also reflected in the apparent absence of serious disease outbreaks. Additionally, farmers have developed techniques for shipping fish to destinations around Nigeria via public transport.

5. *Development of fish feeds*: With high demand and very favourable 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 are unavailable, reliable sources indicate that total local capacity now exceeds 100,000mt per year, with feeds ranging from 32 to 45 per cent crude protein. Both sinking and extruded (floating) forms of fish feed are now produced locally. However, these still compete with imported feeds, and although 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), and then switch to locally produced feeds

for the grow-out period of topping up production to market size. Although 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 per cent 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 per cent or more of fish farmers still produce their own feeds on-farm (USAID MARKETS, 2007) 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 per cent of the 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.

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 by using professional business plans and security documentation required by lenders. They launched catfish farming in groups of concrete tanks measuring some 8m × 2m × 1.2m, 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 (Miller and Tunde, 2008) is managed as a cooperative by a supervisor and two or three 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, and 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 southeast and north where prices are 25 per cent higher than in the southwest. 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 southeast. The cooperative culture of the Yorubas, in the areas where the systems first developed, has also greatly facilitated successful management.

A cost–benefit analysis of tank catfish farming is presented at the end of this paper. Many farmers were able to have profits of close to US\$1.00/kg produced in the initial stages of these systems, and some farmers had claimed a 30+ per cent return on investment. 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 tonne of fish per cycle. With two production cycles per year, they could be producing 1.5 tonnes of fish per year from tanks having a total surface area of some 50m<sup>2</sup>. 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 per cent 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 have encouraged an as yet undocumented number of backyard fish farmers.

### **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 10 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 long-standing international research programme on the 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-organized 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 southwest Nigeria. The presence of supportive institutions is also especially strong in the southwest region where the business-minded Yorubas have aggressively pursued fish farming. The two main professional support organizations FISON and CAFAN originated in the southwest 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 and the

Nigerian Institute for Freshwater Fisheries Research, have provided research support to aquaculture development training and capacity development.

### **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 is 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 1970s. 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 to 1,000m<sup>2</sup> or more. Most tanks are built in contiguous series of two or three tanks with common walls, thus reducing construction costs. The tanks are small at some 16m<sup>2</sup> each, making management fairly simple in spite of the relatively high stocking density of 30–75 fish/m<sup>2</sup>; tanks are often constructed inside the 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 the production capacity. Intensive flow-through systems are being used in areas where water is abundant, whereas 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 the importation of high-quality equipment.

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 taxis.

With the 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).

## **Outcomes**

### **Number of farmers adopting**

With the number of fish farmers increasing beyond 5,000 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 in the southeast and north and limited supply in these areas, some fish farmers in the southwest are now shipping fish to these markets and these fish fetch  $\geq 50$  per cent 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 under way 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 700,000mt/year of imported fish (FDF, 2008), the industry has significant potential to expand, creating considerable further employment. To this end, recent government initiatives to engage young people in aquaculture, providing training and practical experience, are noteworthy and may have significant social implications.

### **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 southwest of the country has depressed the prices of fish in this region compared to the rest of the country, where the retail price of catfish may be 25–50 per cent higher per kg (USAID MARKETS, 2007). 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 favourable 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 of further expansion, especially in the southeast and north. Suppliers are moving into these areas to meet the 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 are 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 that 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 costs 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 the cost of production, through better targeted feeding and improved handling to reduce mortalities and injured fish. They are also practising more grading of fish to better respond to sizes preferred by consumers; depending on the markets, preferred sizes vary from 400 to 1,000g and even larger. Traditionally, many consumers desire large catfish of 1.0–2.0kg average size. However, to be more profitable, fish farmers need to be producing fish of less than 1kg 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 (FISH, 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 the 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.

### **Effects on food production or productivity (either yields or total production)**

Catfish production from different aquaculture systems is estimated to account for 17 per cent of Nigeria’s total domestic fish production, some 680,000mt/year. In less than seven years there has been significant progress in the growth in production thanks to much investment and labour. 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 1,000–1,500kg/ha/year, while those for intensive catfish production in tanks may reach 50–100mt/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 per cent 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 the recycling of water and agricultural by-products, thus helping us to reduce risks and to lower costs. Many fish farms receive organized visits by schoolchildren, which serve 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.

### **Effects on environmental services (e.g. standing and soil carbon, biodiversity, water and soils)**

The sector, and its development, has been closely observed by the Environmental Protection Agency and environmental groups. Investors understand that

Table 1 | Tank fish farming in Nigeria : summary of costs and benefits

Expenditure item	Unit cost (US\$)	Total cost (US\$)	Comment
<i>Capital costs</i>			
1. Construction of tank (16m <sup>2</sup> )	38.46/m <sup>2</sup>	615.38	2 or 3 tanks built contiguously are cheaper
2. Allowance for cost of infrastructure, water supply, small equipment		184.61	Estimated at 30% of tank costs
<i>Operating costs</i>		Cost per crop	
1. Fingerlings – 2,000 purchased; with 20% mortalities and fish spread to three tanks, there will be 530 fish per tank of 16m <sup>2</sup>	0.075–0.16 (0.12 average cost)	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 1.0lb (454g)	1.15/kg 0.52/lb	413.40	Cost of feeds (\$0.78/lb assuming an FCR of 1.5) for 530 fish harvested at 1.0lb each for 530lb (240kg)
3. Labour cost – assumes costs of feeding and other interventions spread over 150 tanks	15.00/month	90.00	Could be reduced or eliminated with family involvement
4. Depreciation of tank and other facilities over 20 years	30.76 plus 9.23 per year	15.38 plus 4.61 = 19.99	Based on contiguous tanks in pairs
5. Interest on construction capital at 10% annually	61.54 plus 18.46 per year	30.76 plus 9.23 = 39.99	
Total (direct) production costs		567.00	
Total production costs including depreciation and interest (rounded up)		627.00	
<i>Income generated</i>			
1. Sale of fish – 530 fish at 1.0lb each × US\$1.40/lb		742.00	
<i>Profit considerations</i>			
Gross profit (net of depreciation and interest)		175.00	US\$350 per tank per year of operation
Net profit, including depreciation and interest		115.00	US\$230 per tank per year
Including tank construction costs: 1.6 harvests would break even. This would occur in 9.6 months			

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

environmental soundness is necessary to ensure sustainability. As noted earlier, 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 the 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, this is not a serious problem as farms raise only indigenous fish species. No negative impacts of fish escapes have been reported.

## Cost–benefit review

The following Table 1 is a summary of the costs and estimated benefits of tank farming of fish in Nigeria. This is based on costs for a single 16m<sup>2</sup> tank with a fish production cycle of six months.

## Future prospects

Although the aquaculture industry in Nigeria is still subject 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 increased competition and resulted in cost savings that are passed on to farmers and the potential ability for expanding into wider markets. Veterinary services for the 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 (<10ha) and varying levels of release of eutrophic waters.

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, although 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.

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