has become a fundamental ingredient of recent aquaculture development efforts.

Finally, it is worth noting that much of what is now seen as being "wrong" was perceived as being "right" at the time it was undertaken. In this optic, in fact, many early efforts were successes in the sense that they accomplished what they set out to do – e.g., "station & motorcycle" projects built infrastructure, equipped agents and grew fish. The assumption seems to have been that state support to these activities would be on-going such that a private, independent aquaculture sector never considered. New approaches with self-sufficiency as a main goal are truly a result of a major paradigm shift.

What Went Right

It may seem as though very little has gone right. This is, however, not the case. The process through which African aquaculture has passed has itself been enlightening and those who have benefited from its lessons are more effective today than they were fifteen years ago.

Figure 8. Aquaculture has gained recognition as a worthwhile investment in Africa. Investors, however, are not looking for extensive or low technology systems. Many businesses investing in fish farming and other aquaculture systems are looking at high yield methods including complete feed, improved seed and full-time aeration (Ghana).

It is now well-accepted that aquaculture development is a multi-disciplinary process encompassing economic, environmental, ecological, social, cultural, financial, biophysical, biochemical, hydrological and other factors. The technical part of raising fish is, by comparison, easy when weighed against developing a programme that is sustainable and making significant contributions to a country's development.

Despite the slow rate of growth, by the 1990s aquaculture had been transformed from an unknown and little-understood activity to an accepted part of most farming systems and agricultural programmes. Farmers in Africa no longer saw fish as mysterious beings that lived by eating water, but understood they were organisms to raise, very similar in their needs to chickens or pigs.

These views of aquaculture were accompanied by tangible and important technological advances in areas such as the identification of farmer-friendly spawning and rearing methods for catfish combined with a general improvement in hatchery and fish seed technology and handling.

Critical Mass

By the turn of the century, aquaculture was beginning to be seen as a business. In Madagascar, Mozambique, Angola, Côte d'Ivoire, Cameroon, Zambia, Zimbabwe, Kenya, Uganda, Nigeria, Ghana, Gabon, South Africa, Namibia, DR Congo and Tanzania, farmers were making profits raising aquatic products.

Figure 9. Some private farms represent very significant capital investment. There are cases where financing has been facilitated through third parties such as donors concentrating on economic growth – often focusing on small- and medium-enterprise development (Ghana).

In some cases, these farmers were the same individuals to whom aquaculture had been introduced through national "stations & motorcycle" programmes. Often they were initially farmers who had adopted the "self-sufficiency model". In all cases, they were farmers with an adequate resource base to be able to practice profitable aquaculture.

As the number of such farmers increased within areas of higher biophysical potential or market access, some farmers found they had passed some critical economic threshold density. As farmer density increased and demand for inputs such as feeds, fingerlings and market infrastructure became more concentrated, farmers could break out of the self-sufficiency dogma which required them to divide their resources among a variety of different, if inter-related, activities. When one farmer concentrated all his/her resources on seed production, producing reliable supplies of good-quality and cost-effective seed, other farmers no longer needed to produce their own seed but could specialise in grow-out.

Integration

While reliance on on-farm inputs had demonstrated limitations, and associated aquaculture systems were generally not appropriate for many smallholder farmers, these experiences did lead to a revamping of the principle of integrated aquaculture. In cases where farming investments were sufficiently large and sophisticated, *animal-cum-fish* feeding strategies could be economically viable. More importantly was the identification of technological and management options for integrating aquaculture with irrigation. These systems were true integrations with the intent to re-use water ("*more crop for the drop*"). Rice integrated with fish, for example, widely promoted across the region as a small-scale option with very minimal success, was found in Madagascar to be profitable at a slightly larger scale, where carp integrated with rice has since been sustainably incorporated into

many farming systems and is now a very important contributor to national food security.

Extension Model

Another successful aspect of the Malagasy programme was the privatisation of government infrastructure. Early projects had subscribed to the "station & motorcycle" model, attended by the typical degradation of infrastructure and loss of investment seen elsewhere. As carp seed demand grew with the expansion of rice/fish production, government privatised former public sector facilities. Many of these were taken over by private seed producers who dramatically out-performed the previous owners.

Subsequently, privatisation of public infrastructure has become a hot topic for debate in many other African countries. While the pandemic of government station abandonment continues, and there appear to be few realistic alternatives to divestment, some governments have difficulty overcoming inertia. Although, for example, Cameroon, Ghana, Zambia, Uganda, DRC and Nigeria have agreements in principle to cede redundant public sector facilities to the private sector, these are slow in being implemented. Many installations have a political past, being in the home area of an important personage, living or dead, or being a "sink-hole" into which so much has been invested that political expediency has a difficult time letting go. Nevertheless, little by little as the choices become clearer, privatisation is continuing.

Needless to say, in some places, lessons refuse to be learned. Even as some government stations are being liquidated, in another part of the country a donor or lender is supporting the establishment of a new government station which is likely to be redundant before it is inaugurated.

The many, repeated attempts at establishing workable aquaculture extension programmes have clearly demonstrated that aquaculture is a specialisation that is not easily diffused by generalist extension services. Providing national-level, specialised aquaculture extension services are, however, financially and logistically unrealistic.

Figure 10. Tilapia and catfish hatchery which has proven itself as a viable small business using locally available material and management (Uganda).

Regardless of the extension structure, past experience has clearly demonstrated that the adoption process is relatively long. Initially, extension support should be frequent and last several years; slowly tapering off to

periodic "check-ups". In addition, the Training & Visit System was not particularly well-suited to the specific needs of aquaculture and more promising results have been achieved from a structure based on research-

Box 6 Aquaculture for Local Community Development (ALCOM): ALCOM started as a Swedish-funded global programme in the late 1980s, evolving a decade later into the southern Africa regional programme on Integrated Aquatic Systems for Smallholder Farmers funded by Sweden and Belgium and ultimately based in Harare, Zimbabwe. The programme developed the "*ALCOM Model*" as a methodological link between research and development and to strengthen and mobilise national institutions and government services. This model was built on the acknowledged complexity of the small-scale aquaculture development process. By undertaking case studies which reflected the cultural, climatic, social and environmental diversity of the region, common strategies to problem solving were identified. These strategies were then adopted by other programmes in the region, quickly and cheaply multiplying the number of beneficiaries. ALCOMs objective was to promote an increase in cash income and/or animal protein in the diet of rural communities through increased production of fish from small-scale integrated aquaculture integrated or as a complement to traditional small-scale fishing. The corresponding target communities were those who depended on family scale mixed farming systems or small-scale fisheries for their livelihoods. Guidelines to enhance the role of women in inland fisheries and aquaculture were an explicit objective. The programme was innovative in taking an integrated approach to development; using participatory technologies and focusing on the social and economic aspects as much, or more than technical issues. Extension and outreach were critical elements to scale up pilot activities to national and sub-regional levels. ALCOM operated through a series of local pilot projects representing variations on a common theme (e.g., three sites in three countries developing demonstrations of sustainable integrated aquaculture and four sites in four countries demonstrating improved small-scale capture fisheries). Pilot sites were chosen to represent different development scenarios so that aggregate results reflected the true variety of technical options available. Pilot sites were overseen by a team of national project staff and seconded national officers, sometimes complemented by an international project staff member. Overall pilot operations were supervised from the programme's offices in Harare where one technical officer each was responsible for aquaculture and fisheries. The programme developed a regional information service with a library, newsletter, series of technical documents and a sub-regional GIS with integrated database. With greater human and financial resources, ALCOM was often able to have impact where governments could not. The programme became a regional catalyst and resource and was expected to culminate in its institutionalisation into the Southern African Development Community (SADC). However, this incorporation was never accomplished and the programme slowly atrophied, leaving only a strong sense of what had been lost. The enduring lesson of ALCOM was the demonstration of a technical approach and operational structure that could be successfully applied to other sub-regional or regional interventions. The programme successfully built national capacity through high quality regional backstopping. While today's priorities might well suggest an ALCOM-like programme focus on commercial and not non-commercial producers, the holistic approach remains as a positive example of potentially sustainable development – potentially because of the programme's premature end.

Box 7 Uganda Small-scale Hatcheries: One of the first efforts to establish sustainable private hatcheries or nurseries as viable small businesses was undertaken in eastern Uganda from 2002 to 2004 through the FAO's Technical Co-operation Programme. The project's motto was "Rural aquaculture development through improved access to quality fish seed – promoting farmer-friendly approaches and techniques to aquaculture through improved seed production, distribution and marketing." The starting point for the project was to answer to the question: How big must a rural aquaculture investment be to return enough money to be sustainable? Once a consensus was reached concerning a suitable level of monthly income necessary to attract serious investors, project staff set out identifying zones where a fish seed distribution business would be able to generate this level of income. Instead of following administrative boundaries, zones for investment were prioritized according to technical criteria combined with an estimate of the present and future level of fish culture activity (critical mass). Ultimately, a zone was considered as having a working radius of approximately 50 km and encompassing a sufficiently large number of fish farmers to constitute adequate economic demand to support a private seed production enterprise in each zone. Among practicing farmers, there were to be at least five "model" farmers with a minimum water surface of 500 m^2 who were willing to be trained in improved management practices. In each zone, another farmer, an "operator", was selected to specialise in seed production. A preference was given to individuals with at least five ponds and/or 1,500 m^2 of pond surface. Given the fact that fish seed distribution is at least as great a problem as seed production, operators were initially seen as managers of nurseries, buying small catfish fry from a large-scale hatchery and serving primarily as a distribution centre, making fingerlings more accessible to local buyers. As the project evolved, operators gained skills in hatchery and nursery operations for both tilapia and catfish, facilitated by expertise from Southeast Asia provided through the project. As the methodologies developed, a production cycle of 30-40 days was found suitable to raise fry to sellable fingerling size. As operators managed multiple cycles, survival for catfish increased from 2 to 47 percent, while for tilapia the corresponding increase was from 54 to 90 percent. It was also determined that an operator should sell at least 1,600 tilapia fingerlings and 1,100 catfish per production cycle to reach profit levels. It was initially thought that, as in Madagascar (Box 9), operators would also serve as extensions since they had a vested interest in the expansion of the sub-sector. However, the realities of the situation were such that the operators rarely visited other farms and, although they may be a source of technical information, they are not effective mobile extensionists. The project successfully called attention to the different options of seed delivery: few central large-scale hatcheries with satellite nurseries Vs numerous smaller-scale local hatcheries. Other issues coming out of the project include questions of quality control of seed, need for seed certification and licensing of growers, matters involving the control of brood fish quality, the need for input distribution networks and the persistent problem of providing quality aquaculture extension support.

extension partnerships and joint extension teams. In some areas, Farmer Field Schools have proven useful in moving knowledge from researchers to farmers while also providing complementary mechanisms to provide support services to aquaculturists.

Sharing Knowledge

Local successes not withstanding, a widely applicable model for sustainable and cost effective extension is yet to be demonstrated. It appears likely; however, that some kind of highly focused and qualified service aimed at clusters of producers in high potential zones appears would be more effective than some previously tried methods.

Figure 11. The growing commercial approach to aquaculture in Africa has led to investment in modern infrastructure. However, the region's comparative advantages often lie in terms of relatively cheap land and labour. Production increases in many cases may best be achieved by expansion rather than intensification through expensive facilities (Angola).

While the keys to success for aquaculture associations remain elusive, there is general and widespread agreement that producers must band together. In general, successful farmers tend to be individualistic and it is clear from past experience that any such group must find value added in working.

In some cases, the political lobbying potential of the group has motivated aquaculturists and they have found the most expeditious means being to incorporate aquaculture into the array of agricultural activities covered by the national farmers' union which then becomes their spokesperson. In other cases, farmers have joined forces at the village level to secure information exchange; a farmer representative attending "outside" training sessions and then returning to share the message with fellow village members.

The value placed on information is another demonstration of positive change over recent years. Before the "information age" many practitioners worked in semi-seclusion, unaware of the volume of relevant information available and having few prospects of being able to access this source of data. If someone wanted to gain knowledge, re-inventing the wheel was often the only option.

Today, the information revolution has struck and, although still well below global standards, Africa is progressively entering the new age of rapid electronic communications and greatly increased access to information. Researchers, educators, producers and other stakeholders now no longer have to derive their own data but can benefit from a vast storehouse of information, fine-tuning this to meet their specific needs.

From the point of view of the development process, catfish might actually be a better candidate for start-up aquaculture than tilapia. With existing technology, catfish hatchery and nursery operations foster a level of

Box 8 Nigeria Commercial Farms: In the 1970s, the government of what was then known as Midwest State sponsored one of the first large commercial fish farms in Nigeria: Aviara Fish Farm. When it stopped operations in 1982 it had 56 ha in carp and tilapia production, with harvests averaging 2,000 kg/ha and expansion underway for an additional 100 ha of ponds. The farm suffered from the chronic constraint of feed unavailability despite contracts with three local suppliers. Interestingly, the farm's major crop was carp, but it had never done any market analysis to estimate the demand for this product. Initial problems with fingering production overshadowed other concerns and it was only after the farm was under production that concerns were expressed as to how to market the crop. In the two decades since Aviara closed, the aquaculture industry in Nigeria has blossomed. There are now more than 100 commercial farms, at least two large-scale hatcheries producing more than a half a million fry a month and several local feed mills and distributors of imported fish feed. Today's aquaculture industry is based on catfish and is truly market-driven. When investors realised the opportunities for supplying highly-prized catfish to a massive domestic market, in spite of negligible public sector support, they made the commitment to "go it alone" and develop the industry. Pioneer producers had to do it all themselves: seed, feed, training and marketing. These early investors were obliged to fully integrate their operations and become self-sufficient, stand-alone firms. This individualistic, self-reliant approach was necessary for the industry to take root. Today, Nigeria's fish farmers have crossed the threshold and have both an economic and political critical mass. It is now time to specialise. It is time to adjust and for some to take responsibility for quality seed production and distribution while others devote their facilities and resources to producing table fish. This shift to inter-dependence comes at a rather high psychological cost for independent producers who have previously learned hard lessons about relying on external inputs or services. Nevertheless, it is necessary and must take place if the industry is to continue to grow. The Nigerian experience has broadened the horizons in terms of how and where to raise fish. Contrary to programmes in most other countries, much of the commercial production does not take place in ponds but in small-, medium, and large-size concrete tanks and even recirculating systems with sophisticated bio-filtration. To a large extent, the considerable investment needed for these systems has been facilitated by the high profit levels which are in turn driven by the high market price of catfish. Rapidly expanding aquaculture, however, will ultimately have a significant effect on supply and prices should fall. In anticipation, producers are exploring other options including a diversification to tilapia, at a significantly lower market value, as well as niche marketing for such things as portion-size products for the growing fast food industry. With all its dynamism, the Nigerian industry remains confronted by time-honoured constraints. The best quality feed is imported and expensive – almost prohibitively so. Producers are attempting to develop local suppliers but variable quality still favours the imported products. The private sector is also still functioning at a tangent to public sector programmes with little government technical support (extension) or monitoring. Recent supporters from segments of the public and private sectors have proposed the elaboration of a national aquaculture development strategy to address the nearly disparate tracts embarked upon by government and farmers as well as to harmonise activities across the complex federal structure of the state.

Box 9 Madagascar Rice/Fish: Rice/fish culture has been introduced into many African countries since the early 1970s. However, the sole spot where it has been adopted on a large scale is in Madagascar, a major rice producing and consuming nation. Rice/fish culture is now the dominant aquaculture system in the central highlands where many farmers routinely stock carp, or sometimes tilapia, into their rice crop. Madagascar's aquaculture history was not too different from other countries in the region and it had its share of redundant public infrastructure and dysfunctional services. In the 1990s, within the context of a joint UNDP/FAO development project, Madagascar undertook the privatisation of its government stations; ceding or leasing these to private farmers or farmer associations. The operators of these stations became PPAs: *Producteur privé d'alevins* (private fingerling producers). With cold, dry winters, the carp spawning season corresponds well with the time of planting rice seedlings in paddies. During this season, the PPAs are in full swing, sometimes bringing carp brood stock from tanks near their homes (as a safeguard against theft) to small earthen ponds where they are spawned and fingerlings nursed. PPAs were conceived as being extensionists as well as seed suppliers, acknowledging government's inability to provide direct support to the country's thousands of fish farmers. The assumption was that the more seed the PPAs sold, the more profit they made. Hence, the better they promoted good aquaculture practices, the better farmers' yields and the more seed they would buy. The logic seemed sound but the realities were different. As in Uganda (Box 7), PPAs rarely left their hatcheries where they were fully involved in the short spawning season. Even though not visiting farmers, PPAs do provide technical advice to their customers when they pick up their seed. They are also government's acknowledged local focal point and keep records as to how much seed has been provided to growers; these records forming the basis for the government's aquaculture reporting procedures. A decade after divestment, the PPAs and their hatcheries are generally doing a good job in support of the sub-sector. During this period, however, they have lost their monopoly and must compete openly amongst each other as well as amongst seeming charlatans who catch any sort of wild fish and try to sell these as fingerlings. The Madagascar industry is now experiencing a new challenge: suspected in-breeding of domestic stocks has reduced carp growth rate and farmers are considering a shift to tilapia.

assiduous husbandry that may not be frequent in tilapia growers. Once mastered, catfish hatchery systems can be easily transferred to tilapia. In contrast, a small-scale tilapia hatchery would have trouble with any other species.

Production Systems

In part due to this improved availability of information, recent years have also witnessed a notable diversification of culture technology. Cages, tanks and raceways are now becoming more common as investors learn more about available aquaculture opportunities and, most importantly, as fish prices increase due to over-exploitation of declining capture fisheries, investors see greater opportunities for profit.

Many of these new culture practices focus on improved results from the established species, tilapia and catfish, as opposed to continuing the hunt

for the elusive perfect culture animal. It is also of interest to note that the earlier choice of tilapia as the best indigenous species due to ease of culture

Box 10 Lake Harvest: Lake Harvest (Pvt) Ltd., established in 1997, is the single largest aqua-business currently operating in the region. This cage "farm" is located in the Zimbabwean waters of Lake Kariba. The farm consists of a 10 ha pond-based hatchery unit which supplies seed to six cage sites, each with 14 cages and capable of producing 800 t/yr. Tilapia (*Oreochromis niloticus*) are grown to 750 g and processed in an EU-standard plant with a capacity of 15 tons of whole fish a day. The main market is in Europe, but local and sub-regional consumers are also targeted. The firm's operations are impressive and have stimulated considerable regional interest in aquaculture in general and in cage culture in particular. The firm is now planning on expanding to other countries, most notably Uganda. Lake Harvest is a pace setter and a real African model for industrial-scale aquaculture. Enterprises of this magnitude can unquestionably be players in the global market as well as important stimulators of the local economy where they engage a wide variety of goods and services. Enterprises of this magnitude also require major investment. Nevertheless, Lake Harvest is a model which can be scaled down and which has demonstrated the economic viability of large-scale aqua-business in Africa. The firm has been confronted with the main constraints that befall producers of all scales; difficulties in obtaining good quality inputs and in keeping market share in the face of aggressive global competition. With a daily demand for tons of high quality feed, reliable supplies of acceptable quality feed have been a continuous challenge and a persistent risk. Equally important to the bottom line is the performance of the fish being raised. To date, African producers have not had access to better performing strains raised by industries situated in other regions of the world (e.g., GIFT tilapia). With reports that improved strains will grow twice as fast, there is strong motivation to lobby for the immediate access to such faster growing animals.

was perhaps a miscalculation. In hindsight, tilapia is actually quite a complicated culture subject, not only due to its precocious reproduction but also due to its environmental requirements for good growth. These impediments can now be partially addressed through the use of sex-reversed seed and may be further improved as better performing strains are selected.

However, most fish farmers, even unsuccessful ones, know about tilapia and know they spawn in ponds. Less wealthy farmers, in particular, are thus reluctant to pay for the better quality seed available from private suppliers, because they know they can get them free from their own ponds, even if the quality is lower.

Conversely, farmers also now know that catfish generally do not spawn in ponds. They are, thus, more amenable to purchasing catfish seed which, when grown under suitable conditions, will actually produce larger sized individuals than tilapia.

In general, it is best to use available culture species during the inception of a project; concentrating on improved management to improve growth rates. As happened in Madagascar (Box 9), inbreeding of domestic stocks might reduce growth, but, unlike with alien species such as the carp, new brooders of local species can always be collected from the wild.

Figure 12. Cage culture has been promoted in different areas for thirty years. While there were some early success stories from the lagoons of Côte d'Ivoire where an international petroleum company funded a cage operation, most of the initial attempts failed either due to poor cage design or to unprofitable management procedures. With the entry of Lake Harvest (Box 10) into the arena, cage culture has gained prominence and is now an accepted, if under-used culture system. Ghana has a producing cage farm (photo) with new entries planned. Medium- to large scale operations are also underway in Uganda and Malawi with smaller operations in Angola, Kenya and Madagascar (to name a few).

Cutting across production systems, is the pivotal question of good management. Field results have repeatedly demonstrated that good management, using the locally available genetic material, can lead to up to a 400 per cent increase in yield. If improved stocks are available, yield can again be doubled or tripled.

Good management, depending upon the production system, often required investment, bringing up the subject of credit. By and large, farmers did not have easy access to credit. Although small- and medium-scale commercial producers realistically required capital to purchase quality inputs as these became available, sources of financing were few and far between. Fortunately, in recent years considerable progress has been made in community-level micro-financing arrangements. Farmers are beginning to have access to modest sums through rural banks, NGOs or other user-friendly community-level mechanisms. Concurrently, the availability of more substantial financing through the formal lending and banking systems is becoming more accessible as lenders view aquaculture with less trepidation and a better understanding of how it can function as a profitable business.

As a business approach becomes a more common course of action, the importance of the market becomes increasingly obvious. Few producers now take it for granted they will automatically be able to sell their crop for a profit. There is renewed awareness of the need to respond to market forces, providing products that optimise profit. In general, growing the smallest marketable product tends to be the most profitable and some growers are actively assessing how this can be applied to fit consumers' needs.

Markets themselves are also changing, and are no longer exclusively local. Regional, often large urban, markets are badly under-supplied and often rely on poor-quality imported frozen products. Many export-oriented producers tend to look far a field for new opportunities in Europe or the US which, although more tightly controlled, are more transparent and ultimately perceived as more accessible than African markets where transactions are clouded by a variety of unfamiliar and frequently changing edicts. Nonetheless, as production expands, intra-African markets will be increasingly served by local aquaculturists.

Figure 13. It may be difficult to imagine how static-water concrete tanks can be profitable production systems. However, tanks of this sort are numerous in Nigeria, raising high densities of catfish with minimal water exchange and using relatively mediocre feeds.

Conclusions

Over-arching all of the above observations is the wisdom gained in terms of how to, and how not to promote aquaculture development. Across the region, there are thousands of poorly built and/or poorly-sited. When people are motivated, they can indeed accomplish amazing tasks – including moving huge volumes of earth to build levees of ponds that will never produce fish. Over-expectation on the part of these eager beavers was a major component of many aquaculture failures. With an incomplete understanding of the real requirements for, and potential contribution from aquaculture, many people extolled the virtues of becoming an aquaculturist without comprehending what this activity entailed.

In the Third Millennium, the picture is much clearer. Past failures have sensitised most as to the realities of raising aquatic products for sale. Those who enter the field today should do so with their eyes and minds open. In general, the lessons learned can be summarized as follows:

- ✓ Aquaculture is not a cure-all. It has real costs and benefits which must be systematically weighed before undertaking the activity.
- ✓ There are a variety of aquaculture systems and it is necessary to find the right fit between system and environment; undertaking prerequisite analyses before starting site development.
- ✓ Profitable and sustainable aquaculture systems most often do not produce cheap food.
- ✓ A focus on private sector development will provide complementary benefits to the public sector.

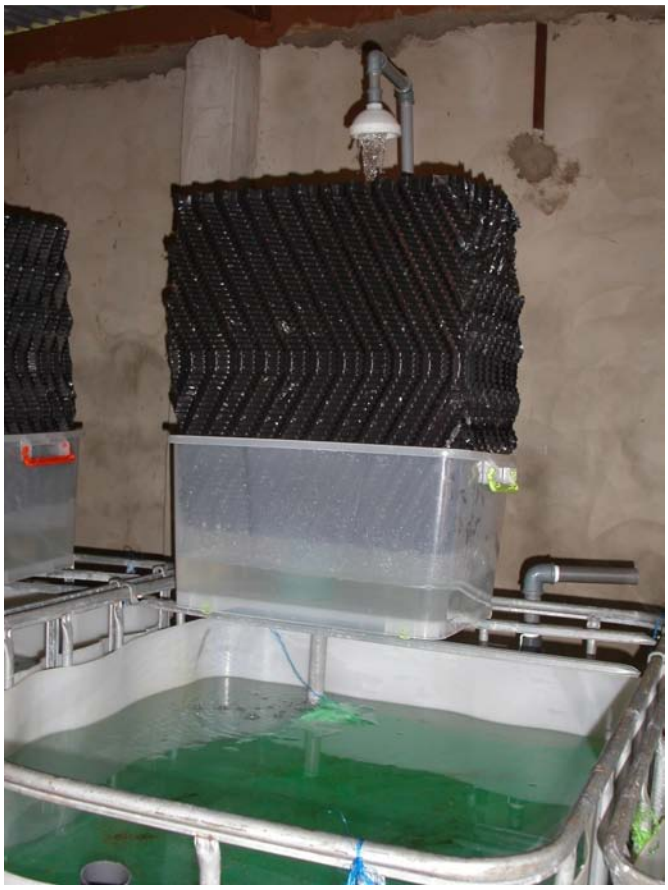

Figure 14. One of the keys to successful private hatcheries is the innovative use of locally available materials. Vats used for shipment of industrial chemicals can be used as fry nursing tanks with homemade bio-filtration and imported media (Nigeria).

- ✓ Aquaculture development is multi-disciplinary.
- ✓ Sustainable aquaculture must be economically viable, socially acceptable and environmentally benign.
- ✓ There is a growing quantity of erroneous or incomplete information available about how to do aquaculture.
- ✓ Good management, of both fishponds and the business aspects, is essential for sustainable and profitable aquaculture.
- ✓ Producing the smallest product acceptable to the market will generally be the most profitable.
- ✓ Seed distribution is just as much a challenge as seed production. A few centralised (large-scale) hatcheries producing large quantities of good quality fry which are, in turn, purchased and grown by satellite nurseries before being sold to the final grower, may be the best option for seed distribution under many circumstances.
- ✓ Stocking the smallest/youngest seed (particularly for tilapias) is frequently the best tactic for non-commercial producers. Conversely, commercial operators can shorten their production cycles by stocking more advanced juveniles.
- ✓ Small- and medium scale commercial producers will be the "motors" of aquaculture development.
- ✓ Credit is an important asset for commercial producers of all scales of operation.
- ✓ Where land and water are relatively inexpensive, further increases are often best achieved by expansion and not intensification.

- ✓ Markets are critical and need to be carefully analysed before undertaking investment.

- ✓ Aquaculture development based on on-farm inputs will make relatively modest contributions to sectoral growth. While these systems may appeal to some growers, significant aquaculture production will require the availability of aqua-feeds; either supplemental or complete.

- ✓ Aquaculture is a density-dependant enterprise. Public sector support of widely dispersed stakeholders is very expensive. A consolidation of effort is necessary to be able to focus on sites where there is acceptable return on investment.

- ✓ Aquaculture development should be private-sector-driven with the accompanying divestment of redundant government infrastructure.

- ✓ Input supply and delivery should be a private sector responsibility.

- ✓ Neither agricultural generalists nor thinly spread aquaculture specialists can offer sustainable, cost-effective and technically efficacious aquaculture extension. Extension and other public sector services must be concentrated in areas of high potential where there are opportunities to establish economically viable clusters of production.

- ✓ Given the realities of providing reliable logistic support to outreach services, it appears sustainability is highest for a relatively small number of highly trained extension teams making quarterly or bi-annual, etc. visits.

- ✓ A large part of the responsibility for information delivery must be given to producers themselves. This is best facilitated through producer groups. These groups should correspond to the aforementioned clusters, generally affiliated with input supply or suppliers. Their initial organisational structure should be based more on expediting input delivery and marketing and less on hierarchical design and bureaucracy.

Figure 15. Brine shrimp rearing can be expensive but is a worthy investment when the prices for high quality seed are high and there is consumer confidence that quality is maintained (Nigeria).

- ✓ While producer self-sufficiency may be important at some stages of development, as programmes mature and establish centres of

economically viable production, producers should specialise and become inter-dependant.

- ✓ Communal or collective site development and the giving of gifts should be strongly discouraged.

- ✓ Non-commercial aquaculture systems are most often by definition integrated into the whole farming system with a recycling of nutrients. However, specific associations (*fish-cum-chicken*, *fish-cum-duck*, *fish-cum-pig*, etc.) are likely to be profitable only under particular circumstances.

Figure 16. Indoor systems can be very capital intensive, based on imported materials. These systems can also, however, be quite simple and use locally available materials as seen in the case of this farm near Port Harcourt which uses a borehole and small portable gasoline pump as its water supply (Nigeria).

- ✓ Aquaculture integrated into irrigation systems has under-used potential.

- ✓ Effective national co-ordination of the sub-sector is necessary. This requires concerted and harmonised efforts guided by clear national strategies.

- ✓ Tax-exemptions on production inputs or other forms of modest subsidies can stimulate commercial production.

- ✓ Start-up production systems should use the best locally available culture stocks.

- ✓ Improved stock will improve yield and these should be developed on a regional basis, with consideration given to the use of available improved species pending the development of regional strains.

- ✓ Introductions and translocations of aquatic organisms need to be effectively monitored and controlled.