omnipresent constraints are: (i) lack of good quality seed; (ii) lack of good quality feed; (iii) lack of capital; (iv) lack of access to appropriate information; and, (v) lack of markets. In the aggregate, these "big five" affect aquaculture development as much today as they did in the 1970s.

LEARNING FROM THE PAST

Aquaculture in Africa has almost been a mystic endeavour. With near pious fervour, enthusiasts have lobbied for support to the sub-sector; often in the complete absence of any tangible benefits. Accordingly, as with many enigmatic ventures, when disappointment struck, there was a negative backlash – aquaculture transformed from a panacea to a pariah.

Today we have the extravagance of analysing past efforts without suffering the trials and tribulations experienced by those who were first attempting to make the sector work. Unfortunately, much of this analysis is done in the abstract without the benefit of the first-hand accounts of preceding actors. In fact, as previously mentioned, there has been an acute loss of institutional memory over the last 20 years which makes learning from the past that much more difficult and important.

If the present is a reflection of the past, the present situation for most national aquaculture programmes in Africa could be typified by several thousand, widely dispersed family (non-commercial) fishponds producing 500-1 000 kg/ha/yr, at best. To this can be added varying, but increasing, amounts of contemporary commercial production from a combination of small-, medium- and large-scale producers.

Consequently, many national aquaculture programmes are comprised of two parallel components corresponding to commercial and non-commercial production systems. Future efforts to establish productive and sustainable national programmes must take into account this dual architecture from the perspective of what historically did or did not work.

The following two sections will highlight experience gained from field-level aquaculture development efforts over the past thirty-five years: those actions that did not foster sustainable results, although they expanded the knowledge base; and those actions that produced enduring results and which now form the foundation of many of today's development strategies. These generalities will be complimented by specific examples of aquaculture projects and producers, presented in boxes. Following these discussions, the experiences will be synthesised into a succinct list of lessons learnt.

What Went Wrong

Project Design

At the onset, there was practically universal acceptance that aquaculture was a good idea. Having a pond in and of itself was often considered as a worthy accomplishment, irrespective of its true costs and benefits. This phenomenon was witnessed by the fact that many early projects targeted

numbers of ponds and farmers as opposed to the production from these units: quantity vs. quality.

Figure 1: Abandoned and semi-abandoned government fish stations can be found in nearly all countries. Unless divested, they pose a drain on public coffers, a poor use of resources and sometimes a public health risk (Madagascar).

Many development efforts focused on institutional strengthening and capacity building. The normal approach was to support the appropriate government agency and subsidise the services it provided to the aquaculture sector. At field level, this often meant building public infrastructure; supporting a series of government stations, hatcheries or centres, which planners hoped would serve as hubs around which aquaculture would develop. Stations were to provide inputs (seed and frequently feed), be the base for extension support, serve as training and demonstration centres, undertake research and produce food fish (and other produce) for sale to offset operating costs.

Along with establishing infrastructure, this approach also entailed the training and equipping of extension agents to undertake what has been widely referred to as the Training & Visit (T&V) extension system, in which the extension agent receives training from a subject matter specialist housed at the extension headquarters and then transfers the knowledge gained through periodic farm visits.

These agents were most often "dedicated" extensionists – specialists working only in the field of aquaculture as opposed to agriculture generalists. Equipment included a means of transport, whether a bicycle or motorcycle. Freshly trained and equipped aquaculture specialists would be based at a station and assigned an extension "zone" which could have a radius of more than 50 km but include fewer than 20 practicing fish farmers.

This "station & motorcycle" approach was used in more than 20 African countries. In all cases, it proved to be unsustainable. The recurrent costs were simply too high. Although increased production, and certainly increased participation could be directly attributed to the presence of the extensionists, in the absence of donor funds, government agencies were unable to provide adequate budgets to keep stations functioning and agents moving. These interventions left in their wake a large number of widely dispersed family fishponds which were difficult, at best, to monitor.

"Dedicated" aquaculture extension services are expensive and, in most instances, inefficient means for assisting far-flung fish farming families. In theory, the marginal increase in fish production attributable to extension support should be several times more than the cost of providing this service. In reality, many dedicated aquaculture extensionists worked in zones where the value of fish produced was a fraction of the service cost.

Transport has been one of the main linchpins in extension delivery. With low farmer density, either due to lack of sites or lack of interest, single agents must cover large areas requiring motorised transport, including fuel as well as maintenance costs. With higher producer densities, bicycles have been proven as successful means of transport. But bicycles also require spares and maintenance. Some pioneering projects have stockpiled spares and provided upkeep training for agents, but ultimately have still been faced with the scenario where the agents were immobile due to a lack of functioning transport.

Figure 2: In struggling national programmes, private facilities also vacillate between periods of activity and inactivity; each renewed spurt of effort requiring considerable cost to get the farm back into an acceptable state where a crop of fish can be raised (Madagascar).

Aside from its practical financial limitation, there was also a fundamental flaw in the "station & motorcycle" approach; it addressed principally the interests and prescriptions of government and donors and was not suitably sensitive to the desires of farmers, or requirements for sustainability.

It is now widely accepted that any innovation must be economically viable, socially acceptable and environmentally friendly if it is to be sustainable and an asset to the overall "public good". However, two decades ago farmers were asked to adopt aquaculture because it was "a good thing"; its economic comparative advantage, social compatibility and environmental suitability being unknown or unproven.

Technology

At the farm level, many interventions stressed self-sufficiency, where the farmer became autonomous from uncertain government support; producing seed, using on-farm feed and selling (if at all) to rural neighbours on the pond bank. Extension support to these farmers was seen as catalytic; after several years of direct assistance and training, the farmer was weaned of external help and expected to become a stand-alone fish producer. Through the benefits of training and extension support, it was also expected that these farmers would become more and more astute; each subsequent harvest being better than the one before.

Box 1 US Peace Corps: Starting in the late 1960s, the Peace Corps posted aquaculture volunteers in Africa. At its zenith, aquaculture volunteers were working in more than 10 countries. Volunteers were trained as self-contained "mini" aquaculture extension services. The underlying principle was that government agencies were too weak to be able to provide meaningful extension support. Consequently, volunteers were initially programmed to work directly with farmers, teaching the farmers how to do basic fish farming. It was felt that several years of volunteer assistance would lead to self-sufficient fish farmers who did not need further government support; farmers who produced their own seed, used on-farm feed and sold their fish on the pond bank or ate them with the family. At the onset, volunteers had motorcycle transport and we able to cover relatively large geographic areas; not infrequently more than 2,000 km^2. As the programme and host institutions evolved, many volunteers shifted to working with national counterparts; most often government aquaculture extensionists who had a secondary education and some specialisation in aquaculture from technical schools or training centres. The first volunteers had general Bachelor of Science degrees and received intensive 12-week training on fishpond construction and management. With time, budget constraints necessitated shorter and shorter training and volunteers become more generalists; also exchanging their motorcycles for bicycles due to fear of road accidents. At present, the sole remaining significant Peace Corps aquaculture programme is in Zambia, with a much smaller effort underway in Ghana. Over the years, Peace Corps successfully demonstrated that motivated people with very basic knowledge could make an impact in terms of transferring aquaculture technology in a sustainable way. Follow-up reviews after the closure of volunteer posts have demonstrated that for years following the departure of the last volunteer at least some of the farmers who had worked with the volunteers continued to raise fish. However, the cost of this technical support is very high – often more than five person years of effort to develop a sustainable group of 10-20 farmers. The volunteers, almost by definition, worked on the fringes, or even outside the formal government structure. This may have been appropriate decades ago, but clear links to the public sector are now needed as well as assurances of value added. The Peace Corps also demonstrated the critical importance of technically sound postings. When political imperatives overshadowed technical prerequisites, volunteers were assigned to nonviable posts to the frustration of all. To a large extent, the achievements of the Peace Corps programme, in spite of its weaknesses, can be attributed to its social and not technical soundness: volunteers integrated into local communities and had ample time to work intimately with farmers and their families. The programme contributed considerably to the multitude of family ponds scattered across the landscape, but rarely had a cohesive strategy or business orientation – to the point of commonly not encouraging record keeping or doing any reporting. Additional details concerning the Peace Corps/Congo programme are presented in Box 3.

However, as results from the field became available, it was apparent that there was no progressive increase in yield, the first harvest often having been the best due to a combination of factors including high motivation by a new fish farmer, high background fertility from the newly denuded ground and relatively high(er) quality fingerlings provided from the government station.

Since on-farm inputs were the major nutrient sources, these were greatly dependant upon the availability of time to gather them. Excited new farmers

spent more time in collecting inputs than their seasoned, and often jaded, counterparts. Thus, new ponds tended to have better management and more food available.

Figure 3: Small family operations can require considerable maintenance and, unless well managed, can be a poor use of resources in areas where land and water resources are limited (Madagascar).

Attempts to enhance the availability of on-farm inputs included encouragement of "integrated aquaculture" where complementary enterprises such as poultry or pig husbandry were undertaken in conjunction with fish raising. In many cases, the animal husbandry units were actually built above fishponds so that excreta and other wastes automatically fell to the pond for the fish's benefit. Although these systems were *sensu stricto* more associations than integrations, they attempted to make more nutrients available with less labour input. But, most did not succeed.

Problems in *fish-cum-chicken*, *fish-cum-duck* or *fish-cum-pig* associations were not generally biological; barring disease, the linked animals grew and the fish did benefit from the automatic manuring, significantly increasing yields. The problems were socio-economic: managing multiple enterprises more intensively required greater resources, skill and markets for the increased production – requirements not easily mastered by most farmers without external support. Anyway, animal feeds and medications still had to be purchased or collected locally, doing little to alleviate the original problem of input shortages.

As the limitations of on-farm nutrients became increasingly apparent, some projects invested effort in systems that relied on supplemental feeds in the form of brans, brewery wastes, oilseed meals and other agricultural by-products. However, these were inevitably subsidised as raw material and transport costs were such that, given low yield levels, most farmers would not be able to pay their full price. Likewise, few other inputs such as lime

Figure 4: For many ponds scattered around rural areas, it is difficult to know if the pond is active or abandoned (Cameroon).

or inorganic fertiliser were used due to their costs vis-à-vis the low level of productivity of most aquaculture systems.

Figure 5: Most ponds are hand dug. Although most claim to use "cut-and-fill" technology, inevitably the dirt is heaped at the closest location and rarely compacted. The result is a leaky pond with too much levee on the shallow side and too little on the deep end (Cameroon).

Standard techniques included harvesting ponds by draining. As most farmers did not have nets, baskets were used to cover the drains and, as the pond approached empty, "fingerlings" (e.g., 5-10 g fish), normally of tilapia, were captured from the mud and transferred to small holding ponds nearby where they would be kept while the pond bottom was dried and any maintenance done, after which time they would be used for re-stocking the pond. Not only did poor handling result in weak fish that seldom survived more than a few days, these "fingerlings" were often sexually mature fish which began reproducing within days after re-stocking; the pond quickly reaching carrying capacity.

Tilapia was considered as the "wonder fish" that would suffer all varieties of abuse and still produce good results. The chief drawback was long acknowledged to be the tilapia's tendency in ponds to mature early and spawn (often at less than 30 g), upsetting planned stocking and feeding strategies. Early solutions to this problem relied on predators to control over-reproduction or hand sexing to obtain a (nearly) all-male population and thereby greatly limiting recruitment.

Figure 6: The apparent advantages of building poultry or pig houses over ponds were quickly adopted in many areas. However, the costs of building and maintaining the poultry enterprises were often high and the farmers reverted to a free-range style (Cameroon).

Catfish of the genus *Clarias* were of initial interest, not as a primary culture species, but as a predator on unwanted tilapia fry. The first challenge for catfish culture was controlled spawning, followed closely by problems of low fry survival. While considerable progress was made in identifying appropriate technologies to resolve these challenges, technology transfer to the private sector was difficult and catfish remained a minor culture species in much of the region.

As catfish languished in the background, governments and farmers searched aggressively for "better" fish to replace tilapia. Chinese carps were introduced into several countries in the hopes of superior performance. In many cases, the mono-climatic tropical environments did not provide the needed triggers for reproduction and carp spawning became a new challenge. As with catfish, induced spawning through hypophysation enabled the production of carp in Nigeria, Cameroon, Mozambique, Rwanda, Kenya and Uganda, to name a few countries that at one time had high expectations for these Asian introductions. The most notable, and successful, introduction was in Madagascar (see following section).

Box 2 Central African Republic: From the 1960s, the Central African Republic (CAR) served as the headquarters of a regional FAO project covering Central Africa. This programme was housed at a major fish station in each participating country (e.g., Djoumouna in Congo, Lanja in CAR and Foumban in Cameroon). These government stations played the critical roles of the time: training, demonstration and input supply. The regional programme began tapering off in the 1970s but the national programme remained into 1990. During this period, the national programme also received support from a number of other partners including Peace Corps and the United Nations Children's Fund, UNICEF. At its pinnacle in the 1980s, the CAR programme was reported to be one of the "best" in Africa: there were thousands of fishponds reporting very high yields, in some cases more than 4 t/ha/yr. A state-of-the-art *Clarias* catfish hatchery had been built and was producing large quantities of fry. A great variety of training, educational and technical materials had been prepared including thorough economic analyses of the systems being promoted (*fish-cum-chicken* prominent among these). A network of public hatcheries had been built, a programme of credit put in place and extensionists (*moniteurs piscicoles*) trained. There was even a programme for Farmer Leaders, where better farmers were given a stipend and bicycle to provide extension support to their nearby colleagues. However, within 10 years, the programme was in decline due to a combination of natural and political misfortunes. Drought led to the drying-up of ponds, economic woes led to the inability of government to support a programme that relied nearly completely on extra-budgetary funds. Catfish fry could not be distributed from the central hatchery due to budget restrictions. The Farmer Leaders spent more time lobbying to be integrated into the civil service than in helping their neighbours. Peri-urban fish/chicken producers found themselves in direct competition with politicians who prioritized their own fish farms within the programme, and dropped out. Credit schemes had nearly a zero repayment rate. And, cottonseed meal, the previously free input which had facilitated good yields, now came into short supply as cotton gins closed and market competition from cattle producers increased. The downward trend has continued and aquaculture as an active rural or peri-urban programme has nearly ceased. Some farmers continue to raise a few fish in small poorly managed ponds, but the programme's momentum is lost. Nevertheless, it did achieve important results in terms of developing a catfish spawning programme and generating a wealth of information on many aspects of aquaculture development, much of which is still relevant today. The programme stimulated great enthusiasm among participating farmers, some of whom had commercially viable fish farms. The programme ultimately demonstrated that impressive short-term outputs can finish as disappointing outcomes without inherent sustainability based on a solid and economically viable private sector foundation, which can function independently of the vagaries of public sector politics.

Box 3 Zaïre, Projet de Pisciculture Familiale (PPF): This joint USAID/Peace Corps project started in the late 1970s. At that time, the project was unique in the sense that it based its extension model on the premise of income. Since many cash crops in central and west Africa are seasonal, most farmers do not have a guaranteed source of regular monthly income. Yet, a fish farmer with six ponds growing tilapia on a six-month cycle could harvest and sell every month. The project was also innovative in providing a degree of planning to Peace Corps service that had heretofore been unknown; volunteers were programmed to work at a post for six years – three two-year terms – each term having an exclusive job description to try and avoid the conundrum that the first volunteer at a post was perceived as having the best job because this was when everything was fresh and new and no one was following on the shirt-tails of a some one else. This "Triple Six" (i.e., six ponds for six months with six years of support) approach was novel and an indication of how hard many people were trying to make aquaculture work. However, in spite of the best intentions, sustainability was still an issue. While the six-pond-model made perfect sense, it did not take the farmer's opportunity cost into account. In mixed cropping systems, farmers carefully allocate time to all activities including leisure. It was discovered that, in most cases, the amount of time a farmer allocated to fish farming was not proportional to the number or size of ponds (i.e., a more-or-less fixed amount of time was budgeted for fish). With organic fertilisers as the major nutrient input, input requirements for six ponds are significantly greater than for one or two ponds. Moreover, the greater the requirement of input the greater the requirement of time since most organic fertilisers were gathered and prepared from on-farm or near-farm sources. In the end, the farmer generated a fixed quantity of input based on the fixed availability of time; this quantity used for the ponds – be they two, four or six. This meant that the greater the number of ponds the lower the per pond productivity. More ponds allowed for better scheduling of harvests but the overall farm fish production was nearly the same regardless of the area in production. The six year volunteer model was more successful although at times difficult to apply. The allure of being the first volunteer at a post was difficult to dispel and it was sometimes politically difficult to keep volunteers at a post for six years or, conversely, to move them out after six years. The biggest issue, in retrospect, was that the farmer was the volunteer's counterpart and the volunteer was outside of, and independent from any public sector structure. Even if these public structures were fragile and at times disjointed, long-term sustainability required stronger ties with government.

The search for the ideal culture species continued, using both alien and indigenous species. Numerous native cichlids were cultured on research stations and other facilities. *Labeo*, *Lates*, *Bagrus*, *Macrobrachium*, *Heterotis* and a wide assortment of other African aquatic genera were scrutinized for their potential in aquaculture. Channel catfish, Indian carps, American crawfish, trout and bass were among the plethora of alien species imported with little forethought, and often serious negative environmental consequences, in hopes of finding the ideal culture species for Africa.

This process has resulted in wide transboundary movement of genetic material. Although this may have been admissible one or two decades ago, conservation of biodiversity is now an essential ingredient in all development efforts. Numerous international covenants and conventions exist to control the movement of genetic material. Unfortunately such agreements are more

easily endorsed than implemented and many private fish farmers continue to import species without adequate controls.

Box 4 White Elephants: It may seem as though most of the unsustainable early efforts were related to development projects and programmes involving international donors and host governments. Nonetheless, the private sector was equally prone to commit what today are viewed as *faux pas*. People from Burkina Faso to Nigeria and Congo, to name but a few, were ready and willing to buy into the alleged aquaculture miracle. Whether as a private sector initiative or a parastatal firm, large investments were made in fish production systems that may have benefited the promoters or middle-men, but that produced pitifully few fish. Among these were various, relatively hi-tech systems including raceways and recirculating units which were poorly conceived and sited in completely unsuitable locales. In some extreme cases, governments were repaying loans for these monuments years after they had been abandoned. They remain painful lessons as to the importance of understanding the technology and being able to apply it in the suitable economic environment.

In the final analysis, it was not the fish, but its management in culture that was the central issue. As time passed and national programmes matured, production per farm rarely increased. In fact, it often decreased. In spite of new culture organisms, improved technologies, better training and extension support, there were still diminishing returns.

It became clear that for systems relying on on-farm inputs, the primary investment on the part of the farmer was time; and farmers would typically only invest a certain amount of time in fish farming, as other activities competed for the family's labour resources. Thus, nutrient input level was tied to time availability; the latter being often in short supply. Harvests remained low and the poor quality of seed meant that average size at cropping was small.

Nonetheless, farmers were repeatedly led to believe that "good" farmers should be able to get harvests with an average size tilapia of 300-400 g. This was what farmers expected, but mixed-sex tilapia systems based on on-farm inputs were hard pressed to routinely produce this size fish, even with good management, and certainly not with the level of management that prevailed in most locales. Furthermore, it has been well documented that producing the smallest acceptable size fish is the most profitable production strategy. Nevertheless, people still tried to grow the biggest fish they could.

Even when producers managed to overcome these many technological barriers, marketing of the fish was largely ignored, most commonly because of high demand for fish within the local community. This approach turned out to be highly de-motivating. Most of the farmers who succeeded with aquaculture did so out of a strong desire to better their lot, both economically and in terms of household food security. African traditional social security systems mitigate against this. Successful farmers are under extreme pressure to share their fish with the village or at the very least, sell them or, more typically, barter them at charity prices.

Box 5 Rwanda Projet de Pisciculture National (PPN): In the early 1980s, PPN was one of the last big national aquaculture projects. Funded by USAID, this project aimed at establishing a viable government-led fish farming programme. While its design was typical of similar efforts elsewhere (i.e., build a government training centre, renovate government infrastructure including regional hatcheries, train and equip dedicated aquaculture extensionists and develop a cadre of technical management through overseas training), it was ambitious in the sense that it undertook these activities in a high altitude country with the highest population density in the region. After a five-year period of implementation, the project was bestowed with accolades; 7,000 families were growing fish in ponds, supported by 55 recently-trained extensionists and eight extension supervisors. Five local hatcheries were producing quality tilapia seed, using tools and methods developed by the project. Overall, family fishpond production increased by 425%, with 20 percent of farmers producing 2,000 kg/ha or more by the end of the fifth year. The project attempted to learn from past experiences and adopt a practical approach; bicycles and not motorcycles were used by extension agents who had a fixed schedule of visits based on a pre-established calendar that facilitated supervision. Technology transfer was periodically monitored by an objective survey instrument which attempted to quantify the adoption of new practices deemed appropriate for the high altitude, cool climate. Survey results were analysed and used to revise training curricula. However, the subsequent political turmoil endured by the country not withstanding, in spite of all efforts to the contrary, the project was likely destined to leave an unsustainable government structure in its wake. Symptomatic of the prevailing project approach, extensionists and their supervisors received indemnities and/or other perks paid by the project. Hatchery, extension and training materials were imported using project funds. Operating costs were born by the project. In short, in classic donor dependency style, the post project structure was based on procedures and processes elaborated during the project and financed by the donor – procedures and processes that could not be born easily by the government, even in the face of convincing arguments. The project had comprehensive data documenting costs and benefits and was able to show that each dollar invested produced more than two dollars worth of fish. But, this level was not sufficient to attract long-term support; some saying a multiplier factor of 5-10 would be needed if government were to divert resources to the post project phase.

Even if this exchange has positive, if non-fiscal, benefits for the community, incentives for a poor farmer to continually subsidize less productive neighbours are low. Additionally, when cash or commodities are traded only within a local economy, there is no net gain in village wealth (unless the village begins printing its own negotiable currency, which is generally frowned upon by government). For the village to actually become richer, it must trade commodities with the outside world.

Many embarked on aquaculture schemes without even looking at the external market. When they did, many discovered that their produce was more expensive than other fish on the market. Cheap imported frozen products combined with periodic high-season flooding of markets from local capture fisheries meant that few farm-raised products could compete unless they were sold as luxury items.

Targeting

While productivity and individual fish size did not increase as anticipated, expansion in number of ponds or number of farmers was also not as expected. Expansion in some areas had noticeable limitations in terms of suitable land or available water which imposed ceilings on aquaculture expansion. In addition, aquaculture projects often targeted the wrong audience. While traditional or political leaders were often the first to express interest in building a pond, their motivation was frequently not for profit or food but rather prestige or amusement. Accordingly, emulation by the population as a whole was minimal. Just as a public facility was not the best demonstration since farmers knew that governments had means that greatly exceed their own, the local elite also were seen a part of an exclusive class whose activities could not easily be replicated by the "common man".

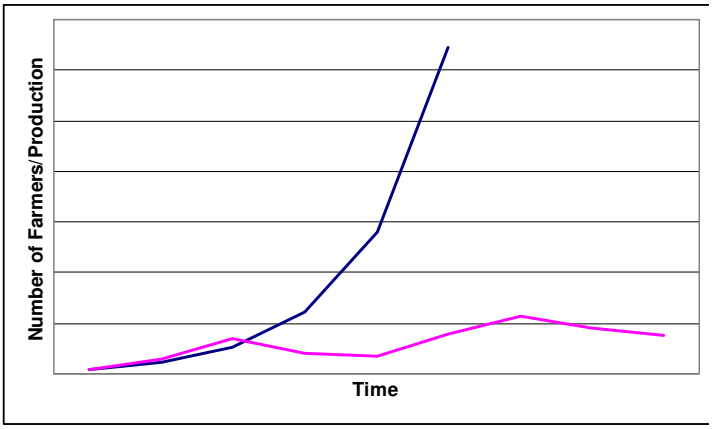

Figure 7. Anticipated (blue line) Vs realized (pink line) trends in African aquaculture development. Planners envisaged more or less logarithmic growth. More typically, once a project ends, adoption and production decline. Each successive project gradually increases production, but much more slowly than planned.

Errors in targeting included a focus on communal aquaculture. Although group labour unquestionably relieved the drudgery of building ponds and dams, and also may have addressed issues surrounding the access to, or use of common property, it was most often an unsuitable management choice. When it came to managing the pond, every one wanted some one else to take the responsibility. When it came to sharing the harvest, every one wanted the choicest items. This was a clear recipe for conflict and not a good role model.

A corollary to the communal pond was the tactic used in quite a few projects where groups were assisted to build one common pond with the idea that this would be such a positive example that each member would subsequently build one or more ponds him/herself. This too was a poor choice and has a very poor track record. Experience has now unmistakably demonstrated that facilities development should be an individual matter. If a group is the chosen entry point, then the collective work should be limited to the infrastructure (e.g., roads and canals) that benefits all members; each member building his/her own ponds or other production units.

More formal than a simple communal pond, farmer associations have also been promoted as key elements of a workable aquaculture development paradigm. Unfortunately, as with credit, there are few surviving examples of

thriving organisations or societies. Inevitably, interpersonal rivalries arose and the group suffered. This approach has merit, but the mechanisms to achieve sustainable and cohesive groups remain to be verified.

Tangential to farmer associations has been the frequently used approach of "farmer leader" (a.k.a. "master" farmer) who was to be the model for use of appropriate production technologies. This mechanism had several permutations, in some of the more complex, the farmer leader was seen as a contact point for extension; it was planned that these farmers would, in turn, advise a group of farmers in their area, or other members of their association – i.e., become surrogate extensionists.

In some cases, farmer leaders were to "spread the word" altruistically; true devotees who had ample time to undertake outreach activities on top of managing their own farms. More realistic methods foresaw the need for compensation for this added effort and attempted to accommodate this need in cash and/or kind. Regardless of the structure, whether compensated or not, these activities were rarely sustainable. When compensation was offered, it was invariably linked to extra-budgetary resources and short-lived. Furthermore, if aquaculture did take off in the locale, the leader soon realised he was helping the competition and found little justification to continue.

Where farmer-to-farmer outreach systems have worked, as further explained in the following section, these have involved structures whereby the lead farmer becomes a service provider with a vested interest; by one means or another provision of technical assistance is linked to increased income for the provider. To date, this has most often happened with private hatchery operators (e.g., in Ghana, Madagascar and Uganda) whose interest is in selling seed; the better harvests obtained by their customers the more seed they can potentially sell. Similar situations would apply to individuals providing feed.

In conjunction with any collective activity in rural Africa are the subjects of gifts and associations. Projects have all too often attempted to stimulate interest in aquaculture by giving gifts: construction materials, credit, nets, seed, feed, etc. This did not work. Groups readily formed to benefit from the gifts, but once these were obtained they disbanded.

Credit, in particular has been one of the major, if unintended, gifts used by projects to encourage participation. In some cases, projects felt that credit was such an essential input that the projects themselves served as the lending agency. This was an unmitigated failure for a couple of reasons:

1. Most farmers and, indeed, local extension agents see foreign projects as givers, not receivers, of money and hence very rarely paid back their loans.

2. Farmers often resented extension agents asking for loan payments, and either avoided them or actually chased them away.

In other cases, projects provided blocks of funds to formal lending institutions for assisting aquaculturists; but un-guaranteed loans quickly depleted these resources. In those few cases where provision of credit appeared to be beneficial and sustainable, micro-financing was provided through community-based organisations such as revolving funds available to the aquaculturists in the community or group.

Credit became associated with so many failings that recent recommendations were that credit was neither necessary nor advisable for smallholder aqua-farmers; the best tactic being to avoid the subject completely.

Conclusions

Many of the promoters of aquaculture as a quick fix to the problems of food security and poverty in rural communities were, and still are, largely unaware of the history of aquaculture in Africa. These well-wishers include civic leaders, business men and NGOs who wanted to help their communities, but generally worked in isolation from either internal or external sources of quality information, in regard to both technology and approach.

Even when national aquaculture institutions were engaged, the weakness and disorganisation of these reduced their ability to provide appropriate information and other services. For example, aquaculture as a discipline had been assigned to a wide variety of administrative homes: fisheries, agriculture, animal husbandry, rural development, environment, natural resources, etc. In extreme examples, the sector was juggled between a myriad of agencies and bureaus as it sought to find a suitable home. This administrative shuffling aggravated the loss of institutional memory and made time-series data difficult to obtain.

It is true that aquaculture is a multi-faceted undertaking with many interwoven themes. It is not intuitively obvious, perhaps, where there is the best fit in terms of a bureaucratic base. Nonetheless, it would appear that political autonomy and technical uniqueness are best served when housed as a department within a fisheries ministry, or the equivalent.

It is important to remember that things that went wrong did not do so out of malfeasance or deliberate mismanagement. Aquaculture was not only an innovation, but the process of aquaculture development was also a novelty. Development started with a focus on appropriate technology. As technologies became available, it became apparent the productive use of these was a question of economic viability. Technological appropriateness was redefined in terms of economic efficiency and financial solvency. However, as potentially economically viable activities also failed to meet expectations, it was noted that the next step in the adoption process was to ensure the social compatibility of the introduced technology. Through this reiterative process, it was discovered that successful development needed to have technical, economic and social dimensions to achieve sustainability. This realisation

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.