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Fish *for* All

HIDDEN HARVESTS

Unlocking the Potential of Aquaculture in Africa

Technical Review Paper - Aquaculture

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By

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HIDDEN HARVESTS:

ACTION SUMMARY

What are the issues?

- Aquaculture has long been promoted in Africa, but in most cases it has delivered very little of the promise expected of it. Does it really have a future, and why invest in it at all? A number of important factors and trends suggests a strong case for well targeted development.
- The region is undergoing significant change- with increasing population and natural resource pressure, and with major issues of poverty, nutrition and human health.
- Fish and aquatic products have a key role in health and income, and aquaculture is likely to be the only means of adding significantly to supply to meet current and expected needs.
- Political change, democratization, decentralization are key trends; at the same time opening boundaries within the region and with the outside world; with both threats and opportunities
- Public sector roles are shifting; private and NGO sectors take a greater role in investment, economic growth, and service delivery; modernised economies have significant prospects for change and development benefit.
- In natural resource based sectors such as aquaculture there is great potential for growth, but a matching public sector concern for resource management and social equity; these need to be
- There are challenges for stimulating domestic production and food supply, and to support sustainable production for export and income; considerable trade potential can be identified.
- The past record of failed development intervention in aquaculture suggests that other approaches are needed; however, our experience suggests that there are positive ways ahead.

What can we do?

- Aquaculture will have to grow by some 10% annually across the region if it is to meet expected needs; it may have to develop much faster in key centres to make up for slowing growth in established areas where production may be stabilising.
- Annual production in the region would have to rise from ~700,000t to more than 3 million t, worth some $1-2bn, in the next 15 years, with annual investments of some $200-500 million.
- There are suitable physical resources. Growth could provide employment for at least 5 million, affordable food for millions more, and export potential of $50-100 million annually.
- There is a growing view of significant and realisable potential, but this needs to be addressed in a practical and realistic manner; it will not work everywhere, or meet everyone's needs.
- Similar growth rates have been observed in other regions and aquaculture sectors, and lessons can be drawn and adapted from elsewhere for the African context.
- Experience shows that market drivers, diversity of systems and products, and public-private sector partnerships are key factors, and need to be identified and built on to achieve aims.
- There are key interactions of technical aspects such as seed supply, water management, fertilising and feeds, with positive and sustainable growth, knowledge is available, but human and institutional capacity needs to be built.
- Evidence suggests that sector growth can have very positive and pro-poor effects on rural economies and for urban consumers, but good growth pathways are essential.
- Links with wider sector infrastructure resources, particularly in management, post-harvest capacity, communications and transport can be critical, and a number of opportunities for synergy could be identified.
- As in the wider fishery sector, appropriate policies and institutions will be essential, and need to respond to changing local and global conditions. A process of awareness raising and engagement has been shown to be critical for successful sector development.

Who, how and when?

- A major regional level initiative would be required, based on a diversified strategy of good quality investment, targeted outcomes and goal-oriented partnerships, with active private sector investment in production and services
- Innovative knowledge development, skill transfer, and service delivery will be critical and would need to be built around existing and future human and institutional capacity.
- Technical development issues such as water management, seed supply, nutritive inputs and husbandry management are important but primarily require sound application in local contexts rather than high levels of innovation.
- Clusters of development, with concentrated skills, resources and services would have particular potential; at least three regional zones can already be identified, with good prospects for others,
- Effective knowledge-based partnerships with dedicated champions, targeted objectives and practical goals would be needed to provide the technical base for sustainable growth.
- This can be done both within the region and with external commercial and development partnerships; the source of linkage may be less important than its quality and integrity.
- National support in developing policies and institutions will be critical; this can be linked with broader aquatic sector and national development aims;
- Within this, the public sector will need to redefine its role from that of centralised and top-down strategic development investment, to one of sector strategy, setting up of relevant and effective standards, and quality monitoring, and wider service delivery
- There is no cause for delay; development and private sector investment opportunities exist to start now and will deliver benefits in a definable and time-bound manner; the challenges of the next decades are great, and momentum needs to be built as early as possible..

What are the next steps?

- The NEPAD 'Fish for All' initiative is a key Champions of change will be required at several levels to raise awareness, promote practical options and support development
- An agreed Plan of Action and the commitment of investment of various forms would be required to stimulate development and provide the necessary targets and milestones.
- A framework plan defining interconnected agency roles, involving public and private sector partnerships, outlining collective responsibilities and aims;
- The development of networked regional resources in knowledge, based on strategic aims with agreed themes, including a social, technical, economic, policy and other fields.
- Capacity building initiatives to promote the development of human and institutional strength in development, strategy and service functions.
- Putting in place a system of feedback and process moving towards longer term aims, and ensuring that the benefits of sectoral development are communicated and shared. .

1 BACKGROUND

African fisheries make vital contributions to food and nutrition security of 200 million people and provide income for over 10 million engaged in fish[1] production, processing and trade. Fish has also become a leading export commodity, with an annual export value of US$ 2.7bn. The role of fisheries and aquatic products in supporting livelihoods and economic output, and improving food supply in the region is critical. Yet these are at risk as the exploitation of stocks is reaching limits and aquaculture production has not matched its potential.

In 2002, Africa produced 7.31 million t of fish. Of this, 4.81 million t was from marine and 2.5 million t from inland environments. Since the 1990s recorded output in capture fisheries has stagnated, at some 6.85 million t in 2002. For aquaculture, by 2000, Africa produced about five times the volume produced a decade earlier, or 404,571 t., though this was insignificant in global terms (Table 1).

Table 1 Regional share of aquaculture production

2003	%world production
Asia	91.22
Europe	4.02
South America	1.96
North America	1.60
Africa	0.97

The three top producers were Egypt, alone accounting for 85.6% of total, Nigeria with 6.5 % and Madagascar, at 1.8%. Production has increased, but much more slowly than elsewhere. Only in Egypt has development been notable, from 85,000 t in 1997 to 376,000 t in 2002, an average annual growth of 34.6%. Current levels are more than 550,000t. Thus though the region's compound annual rate of growth from 1990-2000 was 17.2 %, if Egypt is excluded, growth rates and output levels remain very low. As shown in Table 2, other producer states in the region contribute negligible amounts

Table 2 10 biggest African aquaculture producers in last 3 years of recorder output

Country	2001	Country	2002	Country	2003
Egypt	342,864	Egypt	376,296	Egypt	445,181
Nigeria	24,398	Nigeria	30,663	Nigeria	30,677
Madagascar	7,749	Madagascar	9,713	Madagascar	9,507
Tanzania,	7,300	Tanzania,	7,630	South Africa	7,720
Ghana	6,000	Ghana	6,000	Tanzania,	7,002
Zambia	4,520	South Africa	5,555	Uganda	5,500
South Africa	4,329	Uganda	4,915	Zambia	4,501
Dem Rep. of Congo	2,744	Zambia	4,630	Dem Rep. of Congo	2,965
Uganda	2,360	Dem. Rep. of Congo	2,965	Zimbabwe	2,600
Zimbabwe	2,285	Zimbabwe	2,213	Tunisia	2,130

Source: FAO

UN predictions suggest that the population on the African continent is set to expand rapidly, reaching 1 188 million (medium variant) by 2010. A 2004 study by IFPRI and the WorldFish Center suggested that to maintain food fish consumption at present levels (8 kgs per person-year) supplies should increase from some 6.2 to 9.3 million t per year in 2020. However, current supply trends, combined with population growth mean that per capita consumption of fish in Africa is stagnating, and in sub-Saharan Africa has fallen. To support future needs, capture fisheries will need to be sustained and if possible enhanced, and aquaculture developed rapidly, to increase by over 260% (an annual average of more than 8.3%) by 2020 in sub-Saharan Africa alone.

[1] The term 'fish', unless specifically noted, is used here in the generic sense, to cover all aquatic production, including fish, crustacean, molluscs, aquatic plants and other aquatic organisms.

Studies by FAO[2] and others have shown considerable physical potential for aquaculture. For Sub-Saharan Africa alone it was estimated that 9.2 million km² (31 % of land area), were suitable for smallholder fish farming. If yields from recent smallholder projects could be replicated, only 0.5% of this would be required to produce 35 % of the region's increased requirements to 2010. However this potential remains largely untapped, in significant contrast to many other regions with equivalent resource. By 2002 total production in sub-Saharan Africa was only 79,500 t, yields in most countries remain low, commercial operations have yet to develop in many areas, and producers were few in number, with very little organisation or capacity. As noted in Box 1, the legacy of disappointment in the sector has been clear, and there remains considerable doubt as to whether more fundamental constraints, earlier less recognised, may still apply.

Box 1 The hidden potential of Africa?

The perspective of numerous overviews, regional and national strategies developed by FAO and others after the landmark Kyoto Conference of 1972, and continuing to this day, is that physical resources show great potential, smallholder aquaculture can in theory be profitable, and that centralised support systems – R&D, dissemination, seed supply can underpin steady growth. Following the 1987' 'Thematic Evaluation of Aquaculture' and other studies (Harrison et al 1994) reviewing the perplexing failure of aquaculture to thrive it was concluded that:

- *Physical potential alone is not sufficient*
- *Development investment was largely wasted*
- *Central hatcheries and extension services didn't work*
- *While projects might succeed for short periods, there were few examples of sustainability*

As a consequence, donors in particular became increasingly sceptical and disaffected with the sector, increasingly convinced that issues of development of aquaculture were far more related to markets, policies and institutions, and that without the right conditions, very little investment was likely to be effective. The main exception to this had been isolated examples of (usually) large scale commercial development, ,particularly in shrimp culture. However much of this had been shown to extractive, delivering little local benefit. Is there any evidence so far that conditions are different? Why might things change? We examine some of the arguments here.

Yet there are many changes, and prospects for aquaculture to deliver benefits deserve careful re-examination. Growing urbanisation, improving markets and services, better skills, opportunities for private sector development, and new production technologies could all contribute. As Table 3 indicates, the growth rate of aquaculture in some states has been remarkable, and though commencing from a low base, offers prospects for an increasing presence in producer economies, national food supply and export.

Table 3 highest % production increase (94-03)

Uganda	2,973
Zimbabwe	1,900
Rwanda	1,612
Réunion	1,244
Mali	998
Togo	714
Sudan	700
Egypt	686
Côte d'Ivoire	640
Seychelles	561
Cameroon	540

Source: FAO

Over recent decades, fish trade has also increased substantially, and African exports were valued at US$ 2.7 bn in 2001, in a global total of US$ 56 bn. Exports to European and other overseas markets now contribute significantly to some national economies, and relatively quickly, the post-harvest sector has accessed tightly regulated markets by meeting international HACCP and SPS standards. There are also considerable exports via license agreement for fishery access by foreign fleets. While providing important trade revenue, the role of exports in removing marine and inland water capture fishery supplies from regional markets, also adds significant challenge to meeting domestic food needs. This has given rise to particular concerns in view of growing hunger and malnutrition as highlighted through the Millennium Development Goals. Aquaculture has so far played a relatively minor role in these interactions, but could be expected to grow in importance, with specific investment to meet high value export markets, and with expectations for meeting lower-cost domestic supply needs. The strategic implications of aquaculture, its position within the increasingly market-oriented economies of the region, and its role in trade within the

[2] Anguilar Manjarrez and Nath, 1998

region need to be considered more carefully so that the potential of production, trade and economic growth can be effectively harnessed while securing livelihoods and food supplies of regional populations.

This review aims to provide an authoritative analysis of current understanding of key issues with regard to aquaculture development in Africa. It considers the range of production systems from small-scale subsistence pond culture to intensive commercial pond and cage culture, in both inland and coastal systems. It has been prepared by a group of regional sector specialists in consultation with a range of agencies and development practitioners as a resource for the NEPAD workshop on aquaculture held in Egypt on 27/28 June, to review issues, investment requirements and policy aims for the sector. The workshop findings are intended to guide and inform the NEPAD 'Fish for All' Conference developed by the WorldFish Center, the NEPAD Secretariat, and FAO at the invitation of HE President Olusegun Obasanjo, to be held in Abuja, Nigeria in August 2005. The Conference will highlight how investments in fisheries development will help African countries and their international partners to achieve their commitments to the UN Millennium Development Goals and the WSSD Plan of Implementation. It will support NEPAD's role as a catalyst and facilitator of Africa's socio-economic transformation agenda by bringing together key stakeholders from AU member states, Regional Economic Communities, civil society, scientific institutions and international organisations. The process aims to identify future directions for investment in African fisheries and aquaculture, including priorities for research and capacity building in support of these investment areas, with the goal of enabling aquaculture to fulfil its potential in regional development..

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2 AQUACULTURE – FROM UNCERTAIN PAST TO POSITIVE FUTURE?

2.1 The recent record

Aquaculture has grown strongly in most regions of the world where the potential exists, except in Sub-Saharan Africa (see annex 1). In the entire African region, only Egypt has achieved the scale of change observed elsewhere. In spite of decades of investment and technical input, and the continued hopes of many, it has failed to thrive where expected, and in many cases remains precarious and marginal. However, aquaculture has grown in specific conditions and contexts, and in spite of the many current economic, demographic and social challenges in the region, a more positive perspective of market-led growth, and more realistic understanding of technical potential, linked with the possibilities of broader economic regeneration, suggests that future opportunities may be much more definite.

Including Egypt, the growth trend of aquaculture production since 1990 has been very positive (Table 4), with an approximately fivefold increase (15.7% annually), mostly from brackish water (broadly equivalent to coastal aquaculture), included in 'Africa inland waters' data. There has been only a small and fluctuating increase in marine aquaculture, primarily from the Atlantic zones. Strong growth related to brackish water environments has been primarily related to aquaculture in the Nile delta, and with some growth in coastal shrimp production. By contrast, compound growth in production in freshwater culture has risen by only 6.7% annually.

Table 4 Aquaculture production in Africa

Africa: total aquaculture production by fishing area in tonnes												
Area	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Africa - Inland waters	77289	83423	89630	79961	81172	87087	103625	108299	161141	249756	346124	361785
Mediterranean and Black Sea	1125	2574	3423	4445	5532	7390	9439	10387	17236	19155	43596	31514
Indian Ocean, Western	310	278	252	1056	728	1799	2740	3094	3173	3739	5247	5718
Atlantic, Southeast	1777	2451	2761	2901	3318	2727	2175	3070	3276	2892	2240	2680
Atlantic, Eastern Central	519	1938	1152	1013	1251	1290	120	276	202	196	177	156
Atlantic, Northeast	-	-	-	-	-	-	-	1	1	6	10	...
Total	**81020**	**90664**	**97218**	**89376**	**92001**	**100293**	**118099**	**125127**	**185029**	**275744**	**397394**	**401853**
Africa: total aquaculture production by environment in tonnes												
Environment	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Brackishwater culture	33746	36062	37973	34695	37130	41724	51590	65499	124684	191288	303180	302007
Freshwater culture	44731	49668	53479	47458	47332	51905	60316	52235	52359	76302	83979	90956
Mariculture	2543	4934	5766	7223	7539	6664	6193	7393	7986	8154	10235	8890
Total	**81020**	**90664**	**97218**	**89376**	**92001**	**100293**	**118099**	**125127**	**185029**	**275744**	**397394**	**401853**

Contributions in value terms of major producer countries are shown in Tables 5 and 6, respectively for countries recording more than US$5 million, and US$1 – 5 million output value annually (see also Annex 1 for minor producing countries). These data, derived from FAO Fisheries Statistics, and in turn from national records, demonstrate a relatively insignificant role in most national

Table 5 Trends in value of aquaculture by country, $'000

Country	1994	1997	2000	2003
Egypt	103,432	183,879	815,046	615,011
Nigeria	40,065	58,368	56,630	77,253
Madagascar	6,637	20,840	27,720	39,035
South Africa	8,501	9,179	13,785	29,912
Tunisia	7,548	9,489	7,107	10,182
Seychelles	2,132	7,008	4,098	10,050
D Rep.Congo	715	2,000	5,193	7,419
Zambia	12,458	14,159	6,996	5,669
Uganda	157	302	820	5,500
Zimbabwe	523	590	4,577	5,460
Morocco	11,014	8,907	5,054	4,726

economic accounts, though local impacts are likely to be considerable, and studies elsewhere have shown important economic multipliers in income and employment terms, with significant local impacts were production and services are clustered. While there are recognized difficulties in developing consistent and reliable first hand value data, let alone those for the value added in the supply chain, it is likely that aquaculture is steadily increasing its role. However, trends such as those shown in Egypt, the region's dominant producer, and for which production and value statistics are relatively well developed, show a more recent decline in value, while production has continued to grow. While this may have been influenced by exchange rate and other factors, prices of aquaculture products are known to have fallen as national market capacity at higher price levels is becoming absorbed.

Table 6 Trends in value of aquaculture by country, $'000

Country	1994	1997	2000	2003
Sudan	400	1,500	1,500	2,280
Ghana	835	700	9,404	2,251
Kenya	2,925	300	1,026	2,220
Côte d'Ivoire	183	841	1,605	2,131
Mozambique	174	neg	neg	1,943
Togo	270	31.7	144	1,601
Tanzania	836	806	1,313	1,472
Algeria	960	860	938	1,283
Rwanda	96	189	344	1,039
Mali	97	63	19.	1,011

Table 7 shows the key species groups by value, and as might be expected has a distinct connection with the major production sectors in Egypt, ie mullet and Nile tilapia. Note however, that the value of tilapia production has declined, primarily due to falling prices consequent on production increases.

Table 7 Key aquaculture species in Africa, by value, $'000

Species	1994	1997	2000	2003
Flathead grey mullet	25,635	48,898	279,773	260,847
Nile tilapia	49,261	67,107	285,782	242,873
Grass carp(=White amur)	3,556	41,307	115,120	92,362
Giant tiger prawn	4,423	20,640	28,098	45,915
Torpedo-shaped catfishes nei	4,522	21,274	12,912	22,448
Tilapias nei	14,189	13,091	15,970	22,122
Common carp	26,947	18,654	28,140	19,438
Perlemoen abalone	68	434	3,693	18,465
Gilthead seabream	10,127	16,795	61,543	14,983
North African catfish	11,507	340	2,242	14,938
Freshwater fishes nei	1,976	5,358	20,387	12,990
European seabass	12,775	18,692	72,713	12,855

Rainbow trout	5,141	4,201	6,826	5,962
Nile perch	-	944	3,418	5,363

The fall in value – linked specifically to lower market price, has been a very positive trend for markets and consumers in Egypt, for whom aquaculture now represents more than 50% of national supply, and provides continuingly affordable access. However, it has reduced margins to producers and raised concerns about the returns on current and potential future investment in the sector. This has contributed, together with technical factors such as water supply, seed quality and nutrient sourcing for intensification, each of which are seen to contribute to rising input prices, to a distinct slowdown in growth. However, trends elsewhere, relatively unaffected by market saturation or significant changes input costs, are broadly positive, and demonstrate continued growth and investment interest. The position in Egypt too, is a common evolution in other market sectors and has been observed elsewhere in aquaculture as production increases – resource access, efficiency and market development barriers are addressed as the sector matures, and the potential for further growth can be seen.

There are fewer specific data on regional production systems and their evolution, but national profiles (see later) confirm the continued importance of semi-intensive pond culture, using fertilizer and partial feeding, and the increasing role of small scale cage production, using open water bodies, often at local household level. As elsewhere in the world, resource access opportunities, together with low initial investment requirements and simple management needs, have made cage culture particularly attractive for artisanal producers. The development of commercial aquaculture, usually with more complete feeding in more managed systems, is also gaining ground where resources permit, and is again often linked to cage culture, though in larger and more commercialised production systems. It is clear in all of these areas that technical potential for aquaculture development, for fish, crustaceans and molluscs, is as good as anywhere else in the world, if not better, and that there is no significant technical constraint to expansion.

2.2 The production and development potential

While these developments of growth and value are positive, they are negligible compared with growth in other regions, notably Asia, and unless there is significant change of pace, would be insufficient to meet forecast demands for food supply and economic output. This realisation has promoted considerable development investment and sectoral promotion at both regional and national levels. The availability of natural resources and the opportunities for entering valuable export markets have also led to private investment initiatives, often with external capital, in wholly owned enterprises, or joint ventures. In many circumstances, local private investment has also been considerable, often by artisanal farmers, community development association and local businesses, with expectations of meeting local demand and diversifying household income. This has resulted in a range of outcomes, in different locations, including areas:

- where markets, resources and available technologies have combined to promote steady and substantial growth; there have been very few examples to date; within the African region as a whole, only Egypt shows this at a national level; otherwise, only small pockets of growth can be identified.
- which have had a long history of support for aquaculture, particularly for inland pond-based aquaculture, but which have grown very slowly if at all, with setbacks not uncommon; this represents the condition in many countries of the region.
- where more recent initiatives have attempted to promote aquaculture, often on a very large scale, stimulated by significant natural resource potential, primarily for export; shrimp farming in W and SE Africa, and more recently, cage culture of tilapia in Zimbabwe – with variable results in highly competitive global environments – but positive prospects.

- where national policy is attempting to promote a more diversified and sustainable base for aquaculture, but without significant progress, or with disappointing results.

Where aquaculture has developed, and particularly in regions such as Asia, where growth has been much stronger and involved many more people, the impacts of development are very clear. These include:

- Direct engagement, food supply and income, either as a full-time activity, or more commonly as a component in a mixed livelihood strategy, maintaining rural economies and opportunities for diversified livelihoods.
- Employment associated directly with commercial production, in linked parts of the supply chain, or with a range of support or service functions. This is also either full-time or part-time, may often be seasonal, but commonly offers important contributions to household incomes
- Consumption opportunities maintained and potentially increased as increased supply counteracts rising price trends and in ideal conditions continues and improves access for poorer households.

It would be expected that aquaculture development in Africa would bring about similar changes and with similar implied benefits. To date, however, the continuing features of much of the region's developments in aquaculture, much of which promoted through external development support, particularly in Sub-Saharan Africa, have included:

- An expectation that available water and land resources could by themselves lead to natural exploitable potential and create a new option for rural people;
- Little exploration of social, institutional contexts in which people might engage in aquaculture, or of issues such as resource access, equity, and policy support
- Little understanding of markets, market margins and real returns available to producers
- An emphasis on public-sector support, usually linked with the development of aquaculture extension capability within or linked with line agencies (eg Fisheries Departments);
- An emphasis on small-scale integrated aquaculture, in which freshwater fish farming in ponds is linked with a range of primarily family-supported mixed farming activities
- The use of state or parastatal agents for broodstock development and hatchery supply, with very variable and often disappointing results.
- Poor strategic approaches to pooling knowledge in developing seed supply, fertility and feed inputs, environmental, aquatic health and food safety issues.
- Limited knowledge of risk issues or of management responses to these

A consequence of this has been that many programmes of investment have had rather indifferent results, with limited sustainability of production after central support is reduced, and very few examples of internally generated growth typical of profitable and attractive enterprises.

2.3 Creating a change

Recent reviews of aquaculture, the latest in a series of national perspectives dating back to the 1970s and 1980s, continue to emphasise the need for investment in inputs, particularly related to technical support, typically associated with public sector provision in seed supply, feed production and extension. However, not only have investments in these been of limited and usually short-lived effectiveness, but public sector support to rural production has steadily decreased as a consequence of fiscal reform measures, while private sector mechanisms have largely failed to provide alternatives. The two primary exceptions to this are in Egypt, as earlier noted (see Box 2) , where accessible resources, private enterprise and strong domestic markets have combined to provide rapid growth, and in the small number of cases where external investment in larger aquaculture projects has provided its own resources of support services and

Box 2 The growth of aquaculture in Egypt

Within the region, the development of aquaculture has been most notable in Egypt, where a combination of tradition, market demand,, available and managed water resources, species opportunities and private sector initiative resulted in dramatic

technical expertise. There remain between these many thousands of small-scale aquaculture enterprises, many promoted primarily by perceived technical opportunity, by series of development programmes, or by hopes of local promoters, which have been only marginally profitable and have been unable to build up enough critical mass for active development and growth.

Box 3 Focus areas for revitalizing aquaculture in Kenya

- Aquaculture inventory and establishment of an accurate baseline data.
- Survey potential aquaculture areas, documentation and mapping.
- Set up a Geographical information system (GIS) to monitor aquaculture development
- Publicize viability of aquaculture as a business through:- documentaries, feature stories, field days, newsletters etc.
- Develop programs to show-case successful fish farmers, such as radio programmes, TV interviews etc.
- Develop Centres of Excellence in all potential regions to for research and technology development and transfer
- Promote private entrepreneurship in fish farming through facilitating access to affordable credit; enhancement of public/private partnerships in fish farming ventures; and capacity building in entrepreneurship skills for small scale farmers.
- Develop efficient extension packages and disseminate through public/private participation including use of contact farmers.
- Promote market access, enhance farmed fish quality and safety assurance, and facilitate development of cold chain and physical infrastructure.

However, economic conditions in the region are starting to change and in spite of many difficulties, opportunities for aquaculture might be opening up. With growing urbanisation, improved market integration and capture fisheries supply constraints, both small and large scale investors are gaining interest in aquaculture production. It seems plausible that where inland fisheries are important, small-scale household based aquaculture will grow steadily in parallel with commercial enterprises which may be more targeted towards overseas markets. However, at lest in the shorter term this will not be able to make up for stagnating capture fisheries supplies in domestic markets. Most marine aquaculture, except possibly some molluscs and lower value polycultured fish species, is likely to be targeted towards export markets and their direct contribution to local fish supplies will be marginal.

The challenge therefore will be to identify strategies to grow the sector, and at the same time to foster conditions in which both earnings and domestic food supply can be enhanced. A number of examples are starting to emerge of ways in which these aims might be realised. There is great potential to learn from these success stories and build the capacity of a wider spectrum of small and medium-sized enterprises to participate in these growth opportunities.

To support such an approach, there is urgent need to develop guidelines and policies that create a conducive investment climate while providing safeguards against environmental and social risks. Strategic investments are needed urgently to secure the future contribution of Africa's fish sector to poverty alleviation and regional economic development, to (i) improve management of natural fish stocks, (ii) develop aquaculture production, and (iii) enhance fish trade in domestic, regional and global markets. In support of this, capacity needs to be strengthened at regional and national level for research, technology transfer and policy development. As a first step, stakeholders in the region need to build a common and strategic understanding of the importance of fisheries and aquaculture for Africa's development and of the challenges being faced by the sector. From this in turn, national approaches such as that outlined in Box 3 can be further developed.

2.4 Key drivers

A number of elements can be distinguished as providing the conditions and incentives for growth, as summarised in Table 8, below..

Table 8 Driving forces in aquaculture development

Driving force	Examples	Notes
High market price	Aquaculture, normally intensive, of migratory and marine species such as Atlantic salmon, turbot, seabream, grouper, cod, halibut, shrimp. Attempts to culture lobsters, squid, cobia and others; interest in algal and other bioactive extracts	Many of these species drop in price once original production develops; the drive is then towards diversification
Technology change	Mediterranean seabream culture - hatchery production Offshore cage culture - various species; Inland cage culture - tilapia, salmonids; Feed development - general aquaculture	Can lead to a relatively rapid change in opportunity/potential, or a progressive gain over a defined period
Human resources	Atlantic salmon, cod culture - marine cage farming techniques; Backyard penaeus and macrobrachium hatchery production; Carp hatchery/fingerling production in India, Bangladesh	Changes are all consequent on the availability of trained personnel.
Institutional support	Infrastructure and investment support in Norway, Japan, Chile, UK; regional support for aquaculture in E Canada	Various forms of support; towards establishing a self-supporting sector
Other	Change in regulations for coastal aquaculture in Mexico, allowing private sector projects; change in fishery/ aquaculture policy in Sri Lanka; possible N American support for offshore aquaculture;	Changes having a recent positive effect on aquaculture opportunities

At the regional or national level, the mix of these varies, though the opportunities associated with high market price and more accessible technology are usually those which commence change, particularly in providing private sector incentives

Although not a specific feature of markets, technical change or institutional support, there are further practical issues concerning the rate at which aquaculture sectors can grow, such as:

- the rate at which broodstock and seed supply can be built up - which will depend on biological factors, the extent of control or manipulation possible and the provision of suitable facilities; also the rate at which commercial product and service suppliers can be brought into the market (though in practice this is usually less of a constraint)
- whether growth depends primarily on increasing output from existing producers, or whether new producers/suppliers have to be brought in , in which case new site development, investment, ownership, and adoption/training processes may be required
- whether the existing infrastructure can be used, but with higher productivity, which is constrained primarily with the application and skills involved, the availability of seed, and in some locations, increases in agricultural productivity and/or changes in its practice; this may require additional funding but can often be accommodated within current working budgets; this process can engender relatively rapid growth, as there are very few practical constraints as long as seed supply is adequate; if seed supply is constraint, this may be controlled by the rate at which broodstock can be built up and reliable stocks can be provided;
- whether growth depends on new infrastructure, in which case, its rate of development will depend on the process of obtaining resources - eg land areas, water rights, together if necessary with the time taken to obtain finance, and to develop and test facilities; is may also require training of additional staff;
- whether, in either case, new production levels or further growth is sustainable[3], eg if systems are over-intensified, they will produce extra quantities for short periods of time but will start to decline in productivity if the systems are overloaded, and wastes accumulate;

[3] used here in the restricted sense of whether the activity can be maintained – see section 2.4

Clearly as any aquaculture sector develops there may be increasing competition for resources such as land, water, feeds and human resources, and where these become more expensive to acquire or develop, there will be increasing pressure for economic return - which in many cases may lead to a shift away from lower-priced species. There may be linkages or sometimes conflicts with the capture fisheries sector, with the wider food production sector, and with rural development objectives, which are increasingly likely to be expressed and resolved within strategic resource planning frameworks (eg coastal zone management, catchment management).

2.5 Sustainable aquaculture

This has been a commonly stated objective of sector development in many regions, though not easily defined or promoted. Three major production objectives would be normally be involved:

- aquaculture should have appropriate conditions for growth, whether determined by market development, technical change, or institutional support;
- there should be social equity, either directly, in allowing all sectors of society to consume aquaculture products or even guaranteeing food security, or indirectly, in bringing other benefits which improve overall opportunities for food supply
- production should be carried out efficiently, while delivering its benefits with well-managed use of and minimal impact on natural resources;

The goal of sustainable aquaculture development may not be easy to achieve given likely trade- offs between social, economic and environmental considerations and between short and long term goals. The aquaculture industry is likely to remain relatively diverse with individual sub-sectors undergoing cycles of expansion, consolidation or stagnation. Relative economic performance will be the primary determinant of uptake of sustainable approaches, influenced by regulatory policies and consumer preferences. Over the longer term, more comprehensive data collection concerning all aspects of aquaculture and resource use combined with market traceability systems has the potential to form the core of an integrated information-rich approach to aquatic system management and better approaches to food safety and environmental protection. However, though useful steps are being taken, particularly with accreditation and labelling concepts, environmental issues are the most commonly addressed, while social impacts are much less involved. Nonetheless, development strategies for Africa should if at all possible recognise the need to consider and control environmental impact while optimising social benefits.

3 STRATEGIES AND OPTIONS FOR THE NEPAD PROCESS

3.1 Background

The NEPAD Cairo workshop aimed to consider approaches to developing aquaculture, based around four primary themes/strategic thrusts related to the NEPAD Comprehensive African Agriculture Development Programme (CAADP) – see Table 9

Table 9 The Comprehensive African Agriculture Development Programme (CAADP)

Strategic thrusts	Potential role of aquaculture	Key issues
extending the area under sustainable land management and reliable water control systems	improve water management practices at community and farm level, increasing returns from crop production in drought prone regions in southern Africa, improving viability of investment	link with agricultural production; increasing pressure of land and water use, need to improve strategies for integration, yield, efficiency
improving rural infrastructure and trade-related capacities for market access	marketing fish products, especially from small-scale fisheries, with infrastructure development, has opened many remote areas to wider markets, enhancing market involvement of rural producers	price and location factors of aquaculture production – possible stimulus for peri-urban production, better links with global markets?
increasing food supply and reducing hunger	fish contributes substantially and cost-effectively by supplying protein and other vital nutrients to the diets of 200 million Africans	increasing output through aquaculture at affordable costs for low-income consumers; specific access for women and children
agricultural research, technology dissemination and adoption	all contribute to increasing supply and could widen impact substantially. Success of commercial aquaculture in Egypt, now at over 50% of domestic fish supply, suggests good opportunities for regional technology transfer.	identifying and promoting processes which are relevant, cost-effective and responsive to evolving needs; key mix of technical, social, policy and other skills and approaches.

More specifically, four themes were identified, grouped into two workshop sessions, ie:

Theme	Workshop session
1 Production	Characteristics, opportunities, constraints and initiatives to address these.
2 Environment	
3 Food security	Characteristics, opportunities, constraints and initiatives to address these.
4 Markets	

These are then to be developed to identify opportunities, in short, medium and longer term, the constraints which may bear on these, and the practical ways (interventions) by which such constraints could be addressed. From this would be developed concepts of knowledge requirements and the way such knowledge could be managed, and in turn the appropriate institutional linkages.

3.2 Other NEPAD strategies

More widely, other aspects of NEPAD strategies were also to be considered, and as outlined in Tables 10 and 11, aquaculture development would have specific relevance for the NEPAD Market Access Initiative and for the Environmental Action Plan. In each of these the role of aquaculture could be defined, and a number of specific issues pertinent to its development could be recognised.

Table 10 The NEPAD Market Access Initiative

Strategic thrusts/broad issues	**Potential role for aquaculture**	**Key issues**
Competitiveness of African economies in global markets and enhancement of intra-African trade.	Resource base may provide key global advantages, internal markets also expanding	Comparative production costs, market access, product reputation, innovation; internal constraints to trade
Full potential not yet realized. Global and global demand to	Fish export value US$ 2.7bn/yr for Africa; aquaculture plays minor role	Expansion and market development; profitability in maturing sector; mix of

Table 11 NEPAD Environmental Action Plan

Strategic thrusts	Potential role for aquaculture	Key issues
conservation and sustainable use of marine, coastal and freshwater resources'	sector development would increase use of resources – land, water, possibly impact biodiversity, but good strategies and well managed systems could deliver benefits without unacceptable impacts	expansion and/or intensification strategy; bring in and adapt and develop strong image of best practice; develop indicators of impact with time-bound targets.
'cross-border conservation or management of natural resources'	role of aquaculture in major shared water bodies and catchments – environmental capacity, aquatic animal health, and biodiversity	develop safeguards for sector expansion; including benchmarking. Approaches can be based on extensive experience in modelling, community interactions.

3.3 Issues for discussion

The following points were provided as guidance/stimulus for group discussions at the Cairo workshop, but were not applied rigidly, rather to open debate. Responses to these, and associated or further emerging issues are to be found in the main workshop report.

Production

- What are viable targets for aquaculture production?
- How would this be distributed by region, system, production scale, market?
- What are the drivers for growth and investment?
- How easily can human and physical resources be mobilised?
- How should the private and public sector interact?
- How can performance, efficiency and competitiveness be defined?
- Are there likely to be most favoured production zones? What for?
- What policy issues need to be defined to promote sustainable production?

Environments

- How well are potential development areas identified?
- What are the implications for resource use of sectoral growth?
- What is the environmental capacity and how can that be managed?
- What are the implications for other users?
- What issues are there for environmental and food safety factors?
- How might export/trade criteria affect choices?
- What indicators could be used for sound development?
- What policy issues need to be promoted for good environmental conduct and for successful development and trade?

Food security

- What contribution could aquaculture make, and how?
- What forms of aquaculture would be best?
- How to balance the needs of urban consumers and rural producers?
- How could benefits of aquaculture best be targeted?
- Would aquaculture create negative impacts, and if so, how to limit these?
- Could it stimulate associated beneficial activity?
- What policy approaches need to be taken to realise food security aims?

Markets

- How strong are markets for aquaculture products, and where are they?
- How do they interact with other fishery products and with other foods?
- What are the apparent trends and where are they likely to lead?
- What are the market characteristics and consumer expectations?
- How well are these matched and what needs to be done?
- What is known about market segments, buying power, and access for the poor?
- What is the export potential, how can it be developed and who will it benefit?
- What are the secondary markets, and how can they be developed?
- What policy approaches are needed to ensure market issues are fully embraced?

3.4 Ways forward

The main workshop report provides the full description of suggested ways forward for the sector and for its strategic support, investment and policy support. The following sections outline some of the background context intended to provide a framework for this. A number of other tools for development planning and prioritisation were also suggested, based on a national strategy outline carried out for Uganda, an example of which is found in Annex 3.

4 A PROGRAMME FRAMEWORK FOR AQUACULTURE IN AFRICA

4.1 Introduction

The technical potential for aquaculture in Africa is clear, but developmental issues are significant. A practical approach would be required to address these issues, embracing a number of disciplinary contexts and involving a wide range of stakeholders. The use of development frameworks to set out and guide such approaches can be valuable at regional and sectoral level, and can equally be applied at project or community level. Ideally, a system-based hierarchy can be set out,, in which broad goals, eg with respect to regional development, MDG, WSSD goals can be defined, and within this, various sub-programmes be fitted to create an interconnecting assembly of development components. Thus regional goals can be achieved through investment in local activities supported within national support and policy frameworks. An initial description of such an approach can be given in standard logical framework form, as set out in Table 12,

Table 12 Primary logframe for aquaculture development

Component	Objectively verifiable indicator	Means of verification	Risks & assumptions
Goal; Achievement of MDG, WSSD or related goal definitions over agreed timespan in region (or target country, etc).	Agreed indicators for these goals – eg poverty, nutrition, employment, opportunity, vulnerability, rights	Regional and national statistics, survey data, indirect evidence – eg consumption, health	Environments remain suitable; wider policy conditions;, social equity issues supported
Purpose Aquaculture provides improved and sustained opportunities at target scale, involving defined numbers of people and enterprises	Output targets, numbers of households, industry structure, market sources, profitability and resource use	Sectoral data, market and employment surveys, household and community surveys	Sector partnership and co-ordination effective; other policy priorities do not constrain
Outputs 1 Effective institutional and policy framework based on diversified and socially inclusive strategies	Policies, institutions reviewed and updated; targets for poverty, vulnerability, implementation	Reports, workshops, policy documents, instruments	Governance capacity and function is adequate; other policy priorities allow
2 Well-developed and diverse artisanal production sector involving eg 1million people, producing eg 200,000 t	Widespread, productive systems in rural communities Range of livelihood strategies Local market supplies	Surveys, farm records, market reviews	Rural/peri-urban context allows aquaculture, credit, climate and other risks can be managed
3 Productive, efficient commercial aquaculture sector based on private and cooperative manage-ment, producing eg 500,000 t	Business and co-operative entities; investment and profitability, endogenous growth	Business registrations, licenses, income and production surveys	Wider economic growth and domestic purchasing power; efficient allocation of resources.
4 Profitable, socially and environ-mentally responsible export sector producing eg 100,000t	International investment and business operations operational and comply with key standards	FDI, JV developments, ind-ustry surveys, compliance records, export acceptability	Global trade conditions support responsible production
5 Value addition and service sector adding at least 50% to employment and 100% to first sale value	Businesses and service activities set up, employment created, urban and export markets based on more value-added production; active domestic R&D/service	Business and employment surveys, market chain analyses, R&D records	Positive environment for secondary activity, skills can be built up
Activities; a range of activities contributing to these outputs can be identified including as needed, specification of resource inputs required to achieve these. See also next tables.			

Here, the development of aquaculture is described in meeting higher level goals embracing food supply, poverty alleviation, opportunities for vulnerable people and communities. A range of features of this development can also be described. From an overview structure such as this, the following sections set out a broad aquaculture sector framework[4]. This and the following tables are in draft form and should ideally be used as the basis for discussions and agreements amongst stakeholders in appropriate contexts.

4.2 Policy framework

This framework is set out a regional level but could equally be applied at national level, adjusted as appropriate for local conditions of policy, business and market environment, sector potential, and exogenous issues. However, there is little merit in developing a massive and costly policy initiative if the sector's potential is never likely to be notable due to primary constraints such as limited availability of water, land or market access.. In such a case it would be more appropriate simply to ensure that aquaculture, its characteristics and practical potential are well recognised in wider sectoral issues. However, in a number of countries, well developed sector-specific policy, linked with wider cross-sector policy issues would be relevant and valuable.

Table 13: Policy framework

POLICY THEMES	Indicators			
	Past 5 years	**Current**	**10 years**	**Risks**
Recognition of sectoral objectives in production, social development and natural resource management, and needs to co-ordinate and implement	Production led, based on public sector establishment, farm units, output and export earnings	Statements of wider objectives emerging but unclear how these are to be reconciled/ optimised	Broad linked objectives espoused in sector co-ordinating and implementing agencies (SCIAs)	Without this, sector policy will be distorted and developmentally compromised
Effective linkages between sectoral natural resource policies and development/production aims.	Little or no linkage; contradictory aims; no overarching policy or priority setting.	PRSPs commonly require increased commitment to coordination	SCIAs provide effective coordination; enables this sectorally	Without coordinated resource policies little impact can be expected from public investments
Aquaculture policies effectively linked into wider fishery sector, implemented and updated through sectoral process.	Some defined but few implemented or linked to other NR policies	PRSPs and other processes urge greater coherence and linkage	SCIA links and implements develop-ment social, environmental aims in policy framework.	National sector policies, private, public activities not linked; development impacts much impaired.
International conventions embedded in national policies.	Signatory to major conventions, but not linked to national policies or effectively implemented	Little change, though more specific implem-entation guidelines now available	Good implementation of major conventions through effective policy formulation	Global policy implicat-ions – trade and other interactions could be compromised

4.3 Strategies

This section extends the framework to typical strategies which would connect with policy, either contributing to the policy formulation and implementation process, or developing from it. These

[4] This approach was originally developed for fishery sector development planning in Bangladesh, and subsequently modified and further refined for use in aquaculture.

could range from very generic, large-scale system issues such as those involving major climate, ecosystem or societal trends, to those targeted over a much more specific theme with expected outcomes over shorter time periods.

Table 14: Strategies

STRATEGIES	Indicators			
	5 past years	Current	10 years	Risks
Sectoral strategies for changing global conditions of trade, economic growth and climate/ecosystem impact	Lack of information and awareness; issues only just emerging/potential impacts understood; growing potential significance	Some awareness of specific issues but little connection to shorter and medium term implications, strategies or policy approaches	Continuing process of scenario development, global and regional engagement, awareness raising in sector, translation into policy themes	Without warning, mitigation, alternate options, major external forces will impact negatively on output, yields, social benefits
Commercial/private sector investment and support strategy to develop a sustainable aquaculture sector, and create public-private partnership benefits	Some gains from interventions in inland and coastal aquaculture, but without a framework investment has lead to inefficient growth	Little means to create coherent investment; constraints of markets, seed; quality assurance and international food safety; little public-private sector partnership	Public/private investment ands support; industry led quality/ certification; planning for large-scale aquaculture complies with CCRF. Greater engagement with civil society and private sector	Inadequate/poorly targeted investment; risk to export markets; poor access to income for smaller-scale producers National status in sector may be jeopardised
Strategies to protect and sustain rights and opportunities for poorer and more vulnerable people and communities.	Poverty and inequity increasing – resource access/control by elites; few livelihoods options in inland/coastal areas, declining support for rural enterprises	Resource pressures continuing; key issues better identified, some approaches set out, few implemented more widely NGO/CO/GO support very patchy.	Strategies implemented for sustainable aquaculture and engagement/protection of poorer groups. Increased engagement with civil society and private sector; better range of livelihood options	Absolute poverty may increase with loss of natural resource safety nets. Increased and more entrenched conflict, breakdown of community processes.

4.4 Agendas for action

A more specific focus at regional and national level can also be created by defining an action agenda, based around stakeholder discussions, sectoral analyses and the potential development impact. The following table gives examples of typical action agenda items. These can be further developed, and tailored for national action, with donor input as appropriate, based on further stakeholder consultation and goal setting.

Table 15: Action agenda

ACTION AGENDA	Indicators			
	5 past years	Current	10 years	Risks
Redefine approach for sectoral investment and development in aquaculture	Donor support to projects, public sector infrastructure; some micro-medium scale private investment; Monopolistic/exploitative commercial development	Less donor/public sector support; aim to increase private sector investment; cautious inter-action with major commercial FDI	Promote micro-medium private sector investment; sector coordinated donor input; effective JV/FDI; public sector investment in human capacity and institutional change	Misplaced investment will continue inefficiency, hamper growth and benefit, and may create unacceptable drain on economies
Create sector development network at	Many institutions involved, local actions	As before, poor use of investment, limited	Increased collaboration,	Decline of resource base, constraints to

ACTION AGENDA	Indicators			
	5 past years	Current	10 years	Risks
regional/national level to own and promote development agenda	and donor inputs, but no coordination in strategic management.	progress, resource problems, options and impacts unclear.	coordination, through involvement of key Ministries, civil society and the private sector	development, income and food supply, social/economic decline
Improve cross-sectoral linkages at institutional, policy and implementation levels – regional/national investment and change	Importance of cross-sectoral issues starting to emerge, but not addressed. Increasing demands and sectoral conflict	More cross-sectoral constraints; public/ private/ civil society agents disengaged.	Increased collaboration coordination through involvement of key Ministries, civil society and the private sector	Further inefficiency and loss; domestic and international investors will withdraw from the sector.
Equip key public sector agencies to meet strategic sector management and implementation needs	Increasing separation/ budget loss/incapacity of many agencies;	Some reorganisation and reorientation but little capacity development	Agencies can support new needs of the sector, co-ordinating within wider agent network.	Loss of confidence and relevance may restrict growth, reduce benefits and investment
Develop goal-driven knowledge partnerships, between public sector (NARS and universities) NGOs and private sector, linking biotechnical, social, economic and policy issues.	Public sector was useful in early technical work; but limited interests or impacts in other areas; approaches traditional and research station based, more interest-driven.	Key deficiencies in sector, requiring cross-disciplinary approaches in action research and learning process, involving stakeholders ; limited response only	Outcome-based know-ledge processes through linked partnerships and multi-disciplinary interactions, delivering tangible benefits.	Public sector investment is wasted; knowledge limitations restrict growth and benefits, and maintenance of natural resource base.
Involve civil society agents more fully in sector development and promotion of related social benefits	Though more involved in project initiatives, civil society had little influence in sector development	Some influence locally but limited at national level, poor connections with other agents	Civil society participates in sector management and promotion of social aims through the SCIAs	Poor disenfranchised; increasing resource conflict, misuse and depletion.
Involve commercial entities in sector development, value addition, pro-poor impacts, national economic growth	Some external and local commercial involvement, often extractive/exploit-ative; poor sustainability	More constraints but uncertain investment conditions, few guide-lines limit potentials	Active and profitable growth with responsible social and environmental practice, key benefits	Misplaced investment and poor/unsustainable growth, social inequity, resource pressure.

4.5 Activities

Finally, the same framework approach can be set out to define activities, which as in the overview logframe earlier can be specifically related to the strategies and action agenda frameworks. As with the previous examples, these can be further targeted through stakeholder consultation and priority setting in association with the preceding frameworks. In this example, activities are grouped in four themes, policy, resource, production, and services/support, though other groupings could equally be feasible.

Table 16: Activities

Sector & Expected Outcomes	Indicators			
ACTIVITES	**5 past years**	**Current**	**10 years**	**Risks**
Policy Overview of policy environments, based on realistic sector understanding; determine necessary changes in approach/content	Some policy exploration but often unconnected with practical conditions, continued vacuum	Awareness of need to address more clearly but limited activation	Positive and coherent policy environment creating good context for development goals	Continued constraints to investment at all levels, allocation and public sector inefficiencies
Identify and promote best practices, interactions from national to regional level.	Little opportunity to identify or share, though awareness of value	Some interchange of ideas, buy not subject to quality criteria	Regional policy well developed and effective through interaction	Region incompatibility, wasted human and institutional capital
Resource Strategic inventory, values and 'health of resources' overview to guide future investment and management decisions	Little data, limited instit-utional capacity, aware-ness of sectoral issues	Some data but little connected at system level, or prioritized	Sustained approaches to productive aquaculture development	Biodiversity/ecosyste m function/value loss, livelihood disbenefit, export sanctions
Biodioversity and production initiative based on protection of key resources/ habitats and select better species and strains for culture and stocking	New stocks/strains introduced, development of hatchery seed supply in culture and enhancement	Awareness of biodiversity and inbreeding risks, little practical response to address.	Public/private sector hatchery strategy,. better habitats support diverse and productive stocks	Decline in output/. productivity; disease loses shortage of seed, loss of fishery stocks
Strategic market-based perspectives on water, feed, nutrient supply for key aquaculture approaches/options	Some regional overviews but little sense of values/ allocation/access issues	Some resource access/value ideas, but limited scope	Clear perspectives allow strategic opportunities to be realised	Resource conflicts, non-viability, misplaced investment, disbenefits
Production Identify specific opportunities and promote sustainable and diversified aquaculture; for income and food	Disparate activities with little means to identify/ confirm good outcome	Better sense of work-able systems but not co-ordinated in aims	Output increased and sustained, food supply and livelihood impact,	Negative social impacts, reduced food security, trade sanctions
Efficient market systems with good potential to retain and add value, deliver benefit to poorer sectors as producers or consumers	Much rural production into local households and rural markets – safety net for poorer groups	Better infrastructure and urban markets; more earnings but less local food	Markets deliver efficiently to rural and urban consumers with good secondary impacts	Monopolies distort prices, returns, exploit poor producers/consumer s; trade sanctions
Service and support Develop research/ knowledge/ communication system to address multi-disciplinary sectoral challenges	Overspecialised, biotechnical, limited relevance to national sectoral needs	Awareness of wider needs but limited implementation.	Active process engaging and applying best practice/new knowledge	Wasted R&D investment, poor policy/development guidance; risks, losses
Develop efficient management information approaches	Some set up but little developed/sustained	Little further progress though need realised	Networked, objective-oriented system in place	Poor information, policy, management decisions
Environment, food safety and aquatic health support for aquaculture	Limited or imbalanced expertise with poor practical capability	Some improvements but largely inadequate and increasing risks	Sound and relevant approaches deliver safe, good quality products	Poor yield/productivity, increased losses, health risks, export losses
Quality processes embedded in supply chain	Perceptions very limited; export bans;	Increasing awareness but	Effective private/public sector	Loss of post-harvest value export

Sector & Expected Outcomes	Indicators			
ACTIVITES	**5 past years**	**Current**	**10 years**	**Risks**
delivering safety and value	public sector usually ineffective	actions limited and/or uncoordinated	partnership adding significant value	markets investment health risks, reputation
Develop human resources and institutions; across income and skill levels, based on needs, HR, gender objectives	Traditional extension; some shift to social institutional engagement,	Social/institutional issues more realised but few mechanisms	Wide network of instit-utions/agents ensure access to skill needs	Misapplied resource, poor institutions, productivity, social/economic benefit

5 IMPLEMENTATION [5]

5.1 Overview

The achievement of the goal of aquaculture development in Africa will require a broad strategy guided by clear perspectives on:

- the means by which output could be enhanced, resources used efficiently, and on
- how benefits can be made accessible to target populations through production, primary and secondary employment, consumption and food security.

It will also require significant mobilisation and engagement of key agents, with a shared perspective on opportunities and approaches. This will require an approach to investment which is well guided, and well informed based on specific and up to date knowledge, shared amongst stakeholders at a range of levels.

5.2 Developing and applying knowledge

A comprehensive sectoral perspective will be required, involving agents and processes at a range of levels, in a range of production regimes, together with a well-informed strategy for investment, human development, social inclusion and environmental acceptability. Key elements of this strategy will include:

1) Critical appraisal of existing and emerging systems, sectoral elements and trends. This will assess features and trends in investment, markets, efficiency, productivity and benefit at both farm and sectoral level and identify opportunities to enhance the financial, social and environmental benefits. The aim will be to identify both the opportunities for growth and productivity change in major producing systems and zones, and the means by which previously constrained areas may be able to share the benefits of the sector.
2) Analysis of mechanisms of change towards desired outcomes. Sector-wide review of urban-rural dynamics of resource access, market demand, employment and food supply, and assess legal, institutional and other barriers. The comparative roles of artisanal and commercial producers, options for promoting rural enterprise at a range of positions within the value chain, clarifying how development processes can be positively tuned to meet needs of poorer households and communities, and identifying practical strategies and policies for investment and scale-up from best practice will also be assessed. Running through these studies will be a focus on identifying who benefits and how, and what can be done to increase these benefits to the Campaign's target groups.

[5] This approach has been developed/built from the WorldFish Campaign approach for aquaculture, for which the current initiative is directly relevant .

3) Engagement of public, private and third sector (NGO,CSO, LCO…) agents in targeted strategies to achieve growth and efficiency aims. These strategies will seek to improve seed supply quality and diversity, system management, feeding, and risk management. They will work through participatory and technical research processes that will be managed to foster an active, knowledge-rich development environment, that will facilitate rapid and comprehensive uptake of improved strategies. Partnerships and IP (intellectual property) issues need to be established and managed equitably
4) Establishment of a broader framework for sectoral development. This will be pursued at local, national and regional levels, to achieve effective interactions with other resource users, production sectors and institutional agents, and place aquaculture and its benefits positively and sustainably within the broader social and economic context. Key processes to engage will include water and land use planning, community support, resource access and co-management, economic development and trade strategies, ecosystem protection and enhancement, and mitigative geo-management. .

5.3 Themes and partners

Major elements of sectoral change are summarised below, showing the main partners who would be expected to share responsibility and action, together with broad measures of achievement. Once agreed in principle, each component of this could be specified in further detail, to subject and sub-regional level, with timelines, investments and success measures/objective targets. This would normally be carried out in a consultative process with a broad mix of stakeholders.

Table 17: Partnerships

Theme area	Key partners	Performance/OVI
Growth and efficiency management	Commercial and development sector investors, national sectoral and economic development agents, environmental groups, community organisations, producer groups, research organisations, service agents	Collaborative teams, investment in change, joint ventures, goal definition, PAR/PAL, achievement of targets
Markets and access	Development sector investors, at macro and micro levels, economic and social development agents, commercial sector, NGOs	Description of markets, functional and power relationships, trading regulations, pro-poor sectoral policy
Diagnosis, planning, and values	Policy agents, development planners and investors, commercial sector	New approaches and tools, perspectives; application of improved sectorally coherent policy.
Socio-economic integration, inclusion and sustainability	Economic and social development agents, NGOs	Descriptions of sustain-ability contexts, wider valuation application and social processes
Structure and , competition	Economic development agents, commercial sector, policy agents, investors	Descriptions and analyses, valuation criteria, explanation of sectoral specifics, implications for poverty
Agents and institutions (public-private sector partnerships)	Policy agents, development planners and investors, commercial sector, NGOs, social researchers	Explorations of better ways of doing things, benchmarks, performance indicators
Physical and resource planning/allocations processes	National and regional resource and economic development agents, policy developers, public and private sector investors, inter-sectoral governance agents	More effective, holistic and value-driven approaches defined and applied; better rules of negotiation
Environmental and biodiversity impacts; strategies for geo-management	Global, regional and national policy, management and advocacy agents, community participative groups, environmental goods traders	Strategic framework for ecosystem quality and support; socially inclusive processes; holistic indicators
Human and social capital	All stakeholders	Defined changes in human capacity, social cohesion, use of knowledge

Clustered around the NEPAD initiative, partners might include (no specific priority implied)– World Bank, African Development Bank, International Finance Corporation, IFAD others; FAO, EU, key international foundations, INGOs, major commercial interests and producer organisation networks, environmental and social campaign agents. A conventional stakeholder analysis can be developed to identify their institutional goals, scope and influence, capacity strengths and needs, and the appropriate forms of strategic and operational interaction.

A number of partnership issues would be addressed. Depending on the issues and/or sectoral interactions, core and peripheral structures can be defined for partnerships, depending on the degree of common sectoral commitment and on linkages to other development interests. Where appropriate, rules of public-private conduct would need to be clearly set out, together with mechanisms for public-private and third sector goal-setting and investment returns

5.4 Projects/components

A number of specific areas of enquiry, knowledge development and capacity building can be identified at the outset, as summarised in the table below.

Table 18: Knowledge areas

Theme area	Key issues	Potential enquiry
Growth and efficiency management	Reduce the real price and resource demand of existing and new production, with diversified production base	Factor productivity, research investment strategy for seed supply, nutrient conversion, environmental impact, system diversity and resource demands
Markets and access	Clear perspectives on role of markets in meeting needs of target groups and communities, ensuring internationalisation supports equity	Market structures, institutions, dynamics. Access issues and impacts of changing resource value
Diagnosis, planning, and values	Developing effective and holistic approaches to sectoral description and policy approaches	Develop and apply innovative multi-disciplinary descriptive and analytical techniques for investment, operation and policy guidance
Socio-economic integration (inclusion?) and sustainability	Defining ways in which vulnerable and disadvantaged groups can derive benefit from aquaculture, and mechanisms to support these	Assess impacts and options in production employment and consumption, resource costs and access, institutional mechanisms, policy effectiveness,
Structure and , competition	Understanding global and national competitive forces and their application in industry structure, policy guidance, goal setting, economic efficiency	Analyse structural trends and efficiency/ cost profiles, sensitivities, assess policy impacts, effects of internationalisation, identify role of knowledge
Agents and institutions (public-private sector partnerships)	Understanding contexts and developing best practice in setting up effective shared mechanisms for investment, m operation, innovation, social delivery	Identify stakeholder frameworks and asses potential for win-win mechanisms in sharing/achieving goals
Physical and resource planning/allocations processes	Based on improved efficiency targets and better costing and internalisation approaches, develop better and more equitable means for sectoral and cross-sectoral allocation	Develop sound baselines and negotiate targets with key sub sectors/regional groups; develop and test improved allocation processes and institutions
Environmental and biodiversity impacts; strategies for geo-management	Define ways in which negative impacts can be avoided, new techniques be developed and applied to enhance ecosystem quality, and identify the role aqua culture could play in major global environmental change and its mitigation	Establish clear definitions of nature, risk and impact of sector interactions; identify sound practice and its impacts; identify ways in which aquaculture could mitigate environmental risk.
Human and social capacity	Promoting the necessary level of skill and co-ordinated application to bring about sustained and equitable sectoral change	Assess present levels, impacts of skill and knowledge, apply participatory processes to identify targets and approaches, examine comparative benefits of different strategies

5.5 Performance indicators

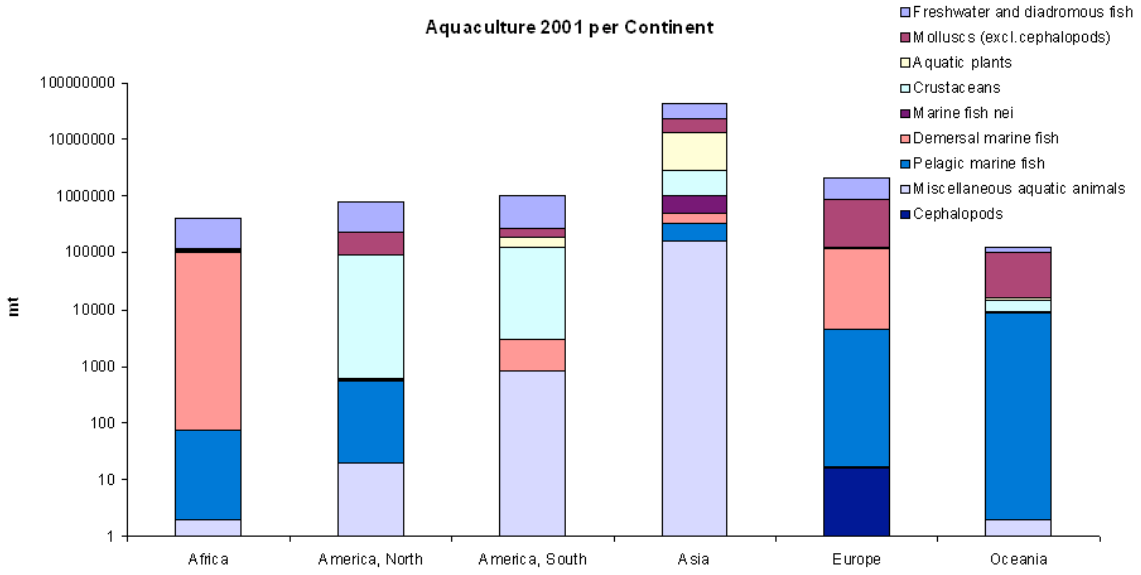
The indicators of successful achievement of goals for aquaculture development in Africa could be related to the logframe set out in Table 12 in the previous section, and further negotiated/agreed with investment and implementation partners. These would typically include:

- Investment, knowledge and implementation partnerships with shared goals and approaches at local, national and regional levels;
- Regional and national support for relevant and informed sector policy and investment
- National statistics in key areas demonstrate increase in output and value
- Market surveys demonstrate stable or falling real prices of aquatic products
- Household surveys of rural and urban populations demonstrate continued or improved food access and security, income, livelihood diversification;
- Analysis demonstrates outreach/impact to target numbers/groups
- Indicators of input and use of key resources – seed, feed, nutrients, energy, show clear efficiency gains.
- Biodiversity and ecosystem quality indices in key systems improve.

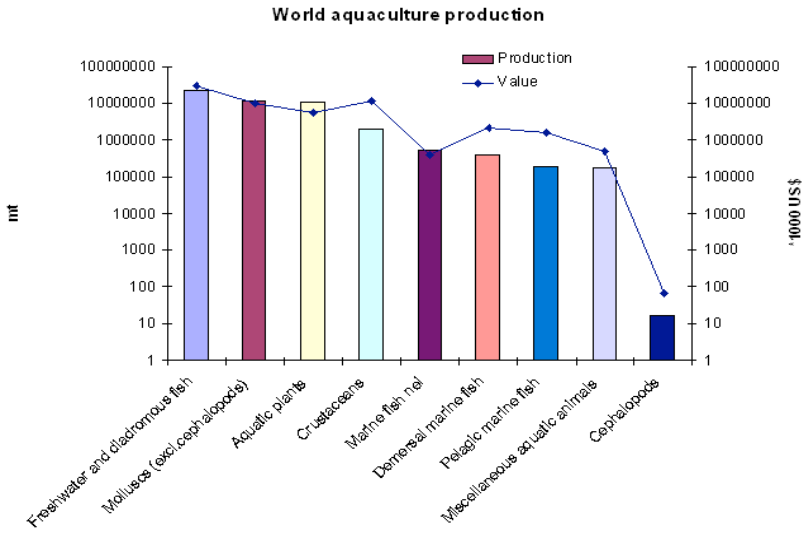
ANNEX 1

Global status of aquaculture

In 2000, reported total aquaculture production (including aquatic plants) was 45.7 million tonnes by weight and US$56.5 billion by value. This increased to 48.4 million tonnes and US$61.5 billion respectively, in 2001. (see Figs 1 and 2)



In contrast to terrestrial farming systems, where the bulk of global production is based on a limited number of animal and plant species, more than 210 different farmed aquatic animal and plant species were reported in 2000. This great diversity reflects the large number of aquatic species that are readily adaptable to the wide range of production systems and conditions present in the different countries and regions of the world.



The number of species farmed is probably considerably higher than reported, as more than 9.7 million tonnes (21.2 percent) of global aquaculture production was not reported at the species level in 2000. This "unspecified" group is likely to include species that have not yet been recorded individually as being cultured.

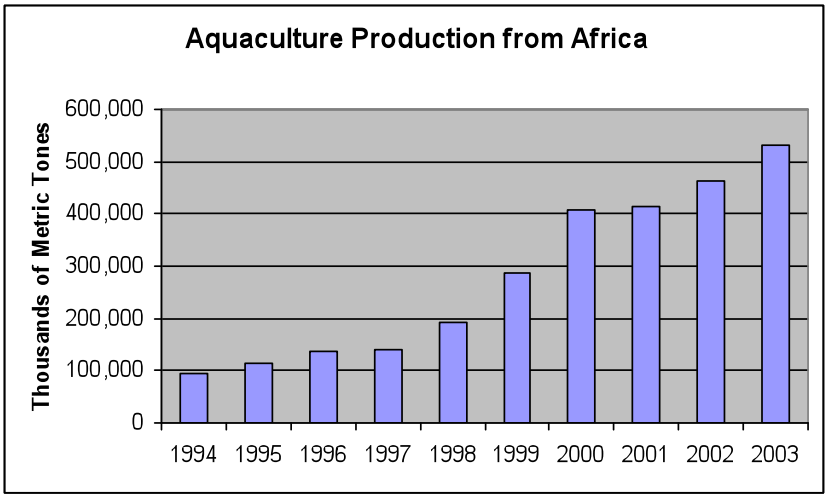
Status of aquaculture in Africa

As Table 1 shows, the contribution of Africa to global aquaculture production is negligible, though this has grown from around 3.5% over the last 10 years. However, much of this change has been due to output from Egypt, which in 2003 produced some 450,000 t, a substantial part of total regional production.

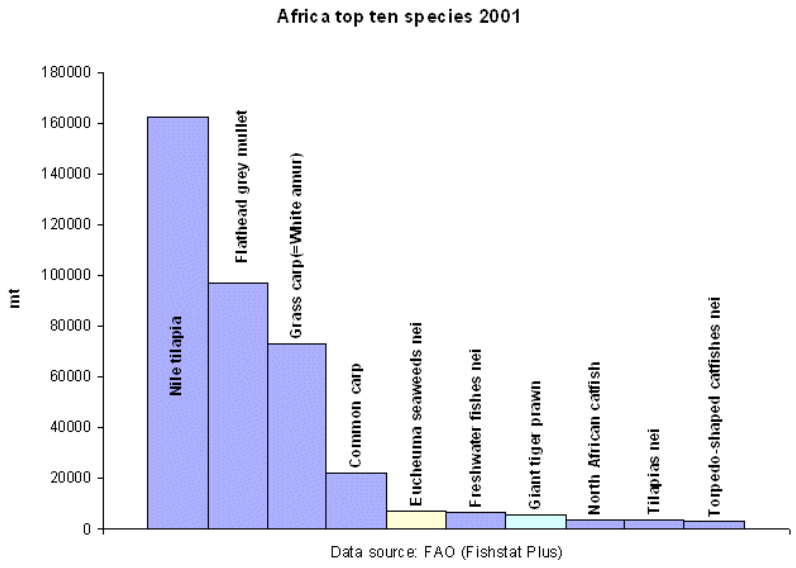
Table 1 Regional share of aquaculture production

2003	%world production
Asia	91.22
Europe	4.02
South America	1.96
North America	1.60
Africa	0.97
Oceania	0.24

Figure 3 shows the pattern of growth in the region, showing significant growth in the period from 1995-2000, with a relative slowdown thereafter.



This is primarily linked with the growth features of the Egyptian aquaculture sector, for which growth has slowed down in the most recent period, during to increasing constraints of resource access and cost, market prices, and tilapia seedstock availability. The significance of tilapia is further evidenced in Figure 4, which shows it leading position in production. Again dominated primarily by Egyptian production, this role has more recently increased further, with tilapia representing more than 50% of national output. The role of tilapia is usually even more pronounced elsewhere, though clarias catfish are increasing in importance, and where coastal resources are suitable, and international markets accessible, shrimp production is also attracting greater interest.



Sub-regional and national production

Summaries of regional production and trends are shown in Table 2, which

emphasises the dominance of the Near-East region – specifically Egypt, in regional production. Table 3 highlights this more specifically at national level.

Table 2 Aquaculture production by Economic Region

Region	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Near-East	56,893	72,915	92,237	86,804	140,489	227,376	341,193	343,964	377,896	446,781
Western	15,986	17,799	21,407	25,393	23,314	26,095	32,223	32,218	39,767	34,963
Eastern	13,473	15,460	14,884	18,490	15,789	20,566	23,770	26,800	32,537	33,872
Central	1,104	1,045	976	1,303	2,278	2,925	2,830	3,146	3,404	3,392
South	4,729	3,830	3,403	4,281	5,208	4,283	4,108	4,329	5,555	7,720
Northwest	2,989	3,401	3,757	4,526	4,286	4,138	3,793	3,725	4,121	4,144
Southern	144	169	174	142	151	130	147	150	96	125
Total	95,318	114,619	136,838	140,939	191,515	285,513	408,064	414,332	463,376	530,997

Table 3 10 biggest African aquaculture producers in last 3 years

Country	2001	Country	2002	Country	2003
Egypt	342,864	Egypt	376,296	Egypt	445,181
Nigeria	24,398	Nigeria	30,663	Nigeria	30,677
Madagascar	7,749	Madagascar	9,713	Madagascar	9,507
Tanzania,	7,300	Tanzania,	7,630	South Africa	7,720
Ghana	6,000	Ghana	6,000	Tanzania,	7,002
Zambia	4,520	South Africa	5,555	Uganda	5,500
South Africa	4,329	Uganda	4,915	Zambia	4,501
Dem Rep. of Congo	2,744	Zambia	4,630	Dem Rep. of Congo	2,965
Uganda	2,360	Dem. Rep. of Congo	2,965	Zimbabwe	2,600
Zimbabwe	2,285	Zimbabwe	2,213	Tunisia	2,130

Table 5 African Aquaculture production value by environments

Environment	1994	1997	2000	2003
Brackishwater	82,789.70	176,799.60	750,241.80	570,867.10
Freshwater	89,760.20	112,098.10	162,752.90	182,899.20
Mariculture	30,661.60	34,806.50	54,991.60	77,410.60

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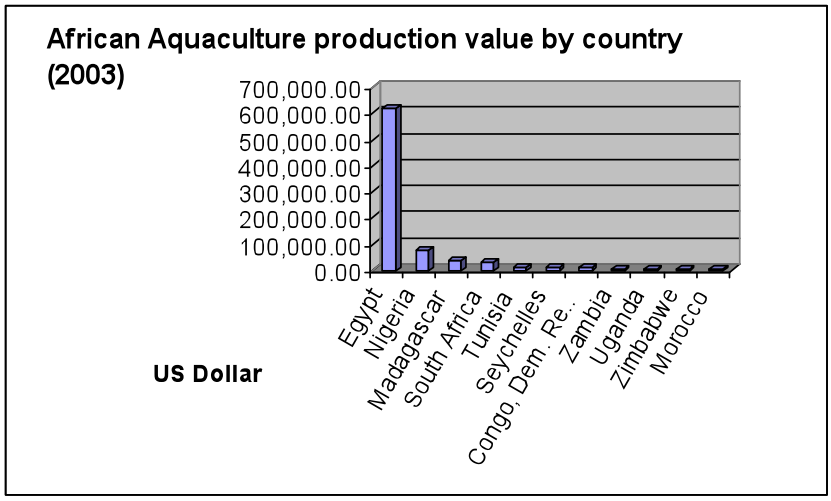

Table 4 shows the rate of increase of aquaculture production over the 10 year period from 1994-2003, though this does not relate closely to national output growth, as many of the countries had relatively low initial levels of production. Notable exceptions are Uganda and Rwanda, with strong programmes of pond culture development, Zimbabwe, with a major cage farming initiative, and Egypt, with its much larger sectoral growth.

Value of production

Figure 5 summaries key national contributors in value terms, again emphasizing the great significance of Egypt, but noting also that in a number of other countries, appreciable value was starting to be realised. This is given more detail in Tables 6 and 7 summarising major and minor producer countries respectively. In each table the total regional value is given. Table 8 identifies the key species groups by value, with a distinct connection between the major production sectors in Egypt, ie mullet and nile tilapia. Note however, that the value of tilapia production has declined, primarily due to falling prices consequent on production increases.

Table 4 highest % production increase (94-03)	
Uganda	2,973
Zimbabwe	1,900
Rwanda	1,612
Réunion	1,244
Mali	998
Togo	714
Sudan	700
Egypt	686
Côte d'Ivoire	640
Seychelles	561
Cameroon	540

Table 6 Trends in value of aquaculture by country, $'000

Country	1994	1997	2000	2003
Egypt	103,432	183,879	815,046	615,011
Nigeria	40,065	58,368	56,630	77,253
Madagascar	6,637	20,840	27,720	39,035
South Africa	8,501	9,179	13,785	29,912
Tunisia	7,548	9,489	7,107	10,182
Seychelles	2,132	7,008	4,098	10,050
D Rep.Congo	715	2,000	5,193	7,419
Zambia	12,458	14,159	6,996	5,669
Uganda	157	302	820	5,500
Zimbabwe	523	590	4,577	5,460
Morocco	11,014	8,907	5,054	4,726
Sudan	400	1,500	1,500	2,280
Ghana	835	700	9,404	2,251
Kenya	2,925	300	1,026	2,220
Côte d'Ivoire	183	841	1,605	2,131
Mozambique	174	neg	neg	1,943
Togo	270	31.7	144	1,601
Tanzania	836	806	1,313	1,472
Algeria	960	860	938	1,283
Rwanda	96	189	344	1,039
Mali	97	63	19.	1,011
Total	203,211.50	323,704.40	967,986.40	831,176.80

Table 7 Trends in value of aquaculture by country, $'000

Country	1994	1997	2000	2003
Réunion	120	798	1,036	975
Malawi	265	226	596	875
Cameroon	79	119	75	621
Mauritius	1,203	1,087	954	310
Burundi	66	70	140	280
Gabon	84	205	1,035	220
Namibia	99	94	110	163
Niger	54	26	23	95
Senegal	138	295	67	93
Rep of Congo	327	218	44	46
Liberia	neg	neg	30	31
Benin	.	.	.	11
Lesotho	36	29	8	10
Burkina Faso	neg	23	3	3
Ethiopia	82	59	na	na
Central Afr Rep	390	96	180	na
Gambia	-	2	na	na
Guinea	20	neg	neg	na
Libyan Arab Jamahiriya	135	150	150	na
Mayotte	-	8	12	na
Sierra Leone	25	33	39	na
Swaziland	132	155	170	na
Total	203,211.50	323,704.40	967,986.40	831,176.80

Table 8 Key aquaculture species in Africa, by value, $'000

Species	1994	1997	2000	2003
Flathead grey mullet	25,635	48,898	279,773	260,847
Nile tilapia	49,261	67,107	285,782	242,873
Grass carp(=White amur)	3,556	41,307	115,120	92,362
Giant tiger prawn	4,423	20,640	28,098	45,915
Torpedo-shaped catfishes nei	4,522	21,274	12,912	22,448
Tilapias nei	14,189	13,091	15,970	22,122
Common carp	26,947	18,654	28,140	19,438
Perlemoen abalone	68	434	3,693	18,465
Gilthead seabream	10,127	16,795	61,543	14,983
North African catfish	11,507	340	2,242	14,938
Freshwater fishes nei	1,976	5,358	20,387	12,990
European seabass	12,775	18,692	72,713	12,855

Rainbow trout	5,141	4,201	6,826	5,962
Nile perch	-	944	3,418	5,363

ANNEX 2 COUNTRY OVERVIEWS

1 AQUACULTURE IN MOZAMBIQUE, STATUS AND POTENTIAL

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SUMMARY

Aquaculture in Mozambique is a relatively new concept. While the culture of freshwater species such as tilapia existed for many decades (since 50's), the cultivation of marine species has emerged only over the last five years. Presently, 2003, the aquaculture industry consists of commercial farms of marine shrimp (*Penaeus spp*.) and seaweed (*Kappaphycus spp*.) and artisanal tilapia (*Tilapia spp*.) farms. Mozambique aquaculture farms produced in 2003 approximately 855 ton/year, but the perspective is a production of 5,000 ton by 2006 (Ministério das Pescas, 2003). Capture fisheries date reported in 2003 indicated a production of 89,111 tons of crustaceans, finfish and molluscs (INE, 2003).

Aquaculture practices ranges from extensive (tilapia and seaweeds), with few inputs and modest output, to semi-intensive (shrimp) with high inputs and output. The development of aquaculture in Mozambique plays an important role in the socio-economic development of the country: providing low cost protein and improving the population diet, creating jobs, generating income, promoting regional development.

The potentialities for aquaculture development in Mozambique are enormous: a favourable environment for investments, favourable climatic condition (tropical and sub-tropical clime); unpolluted environment, low population pressure and extensive resources: a potential of 33 000 ha of land suitable for coastal aquaculture; the existence of wild native species with potential for culture such as black tiger *Penaeus monodon*, white prawn *Penaeus indicus*, kuruma shrimp *Penaeus japonicus*, speckled shrimp *Metapenaeus* monoceros, the giant prawn *Macrobrachium rosenbergii*, tilapia *Tilapia spp*..

There is a specific aquaculture legislation that regulates all right and obligations of all stakeholders. The legislation defines specifically norms and requisites for aquaculture farms; establish procedures for licensing and parameters for each farming system (shrimp farms: extensive – 5 animals/m^2 and final biomass 100g/m^2; semi-intensive - 25 animals/m^2 and final biomass 400g/m^2; intensive - not allowed); establish restrictions to import of live animals and to conversion of mangrove into aquaculture ponds and establish other environmental and consumers protection measures.

STATUS AND POTENTIAL FOR AQUACULTURE DEVELOPMENT

Tropical and sub-tropical climate, unpolluted environment, vast natural resources and low population pressure provide favourable conditions for the development of aquaculture in Mozambique. Against this vast potential the development to date has been minimal and provides opportunities for development.

FRESHWATER AQUACULTURE:

Freshwater aquaculture started in a small way in 1950s and presently small-scale farming is practiced in ponds and cages.

Pond culture: the level of current activity in the inland small scale freshwater fish farming reflects the potential and can be indicated by the following figures: 3500 ponds in Niassa, Cabo Delgado, Zambézia, Tete, Sofala and Manica provinces and reports of new ponds in other provinces. There are no available data on productivity of the small scale fish farm but it is estimated that by the end of six month a production of 12kg/200m^2/pond is obtained. The species mostly cultured are Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*O. niloticus*), *Tilapia rendallii* and common carp (*Cyprinus carpio*). Of these, Nile tilapia and Common carp are exotic to Mozambique. In addition to these, other species available for culture are African catfish (*Clarias gariepinus*). Grass carp (*Ctenopharyngodon idella*), Silver carp (*Hypophthalmichthys molitrix)*, and Bighead carp (*Aristichthys nobilis)* and freshwater prawn (Macrobrachium rosenbergii). Although the Chinese carps were introduced in to the country in the 1990's for stocking reservoirs and ponds, they were never used in aquaculture extension.

There is no organized seed supply sector. In 1960s three hatcheries were established in public sector in Umbeluzi (Maputo province), Sussendenga (Sofala province) and Chowke (Gaza province) with water spread area of 0.5, 2.0 and 1.6 ha respectively. In 1982 another hatchery was established at Chilembene (Gaza province). In 1978-79, the government expressed a renewed interest in freshwater fish farming, particularly as mean of supply fish to rural population suffering from animal protein deficiency and beyond the reach of existing marine and freshwater fish distribution networks. Under the authority of the State Secretary for Fisheries, two experimental fish farms were rehabilitated at Umbeluzi (Maputo province) and Sussundenga/Chizizira (Manica province), and development research reinitiated. The hatchery at Umbeluzi was abandoned in 1980s and privatized in 1990s. The hatchery at Sussendenga renovated in 1990s produced 100,000-150,000 fingerlings of tilapia for stocking dams and small water bodies. Subsequently with the ending of funded projects in (ALCOM & GTZ) 1997, the station went defunct. In 2004 the station was privatized by the government and yet to be renovated and made functional.

In view of the lack of fish seed farms/hatcheries, the farmers depend on the breeding of tilapia that takes place in their ponds or procure fingerlings from other farmers. Because of continuous breeding of same stock in the ponds, there is observed inbreeding as evident from the slow growth of fish reported by the farmers. Further, the farmers are not sure what species of tilapia they are growing. It is possible that the seed being used could be hybrids between *O.mossambicus, O. niloticus and T. rendalli* in any combination as these species interbreed.

Cage culture: Cage culture of fish is of recent origin, with one Zimbabwean entrepreneur operating 8 cages in Chicamba Real (Revue River) in Manica province. Development of the site and construction of facilities started in 2002 and presently producing 1 ton of fish every three months which is sold at farm gate at a price of US$ 1.2 per kg. The facilities on land include raceways for production of fingerlings and a small shed for production of pelleted feed and 8 cages of 6 x 6 x 4m cages installed in the dam.

Potential for freshwater aquaculture: No detailed resource surveys were undertaken to assess the areas suitable for freshwater aquaculture in Mozambique, but some reports based on satellite imagery put the area suitable for aquaculture at around 238,000 ha of which about 2,000 ha is readily available.Mozambique has seven small lakes ranging from 8.1-63 km^2 in size and 4 large reservoirs ranging in size from 47-2665km^2. There are also about 400 brackishwater coastal lagoons with a total area of over 540 km^2. Small water bodies can be used for cage culture or restocked and fertilized to enhance fish production.

Constraints for development of freshwater aquaculture: The hatcheries that were established in public sector in 1960s as stated earlier have become non-functional. Privatization of the hatchery in Sussendenga district in 2004 is likely to result in availability of fingerlings to farmers in the province, but the capacity of the hatchery is not enough to meet the needs of farmers in other

provinces. Farmers are depending on seed produced within their farms or from other farms, the quality of which is uncertain.

Farmers are mostly undertaking monoculture of hybrids of *O. mossambicus* and *O.niloticus* or inbred strains of these species that have slow grow rate and result in low production. There are no researches activities in freshwater aquaculture in the country that can support the extensive activities. There is no formulated feeds available in the country, the only cage culture entrepreneur makes they on feed from local available ingredients.

The existing government infrastructure does not provide support to research and extension for freshwater fish farming in Mozambique. For successful freshwater aquaculture development a network of satellite stations in the high potential aquaculture zones that serve as demonstration sites for new technologies are needed.

Small-scale farmers and commercial entrepreneurs need access to credit. The prevailing bank interest rates are high and not easily accessible to small farmers.

Presently freshwater aquaculture extension is done by the agriculture/livestock extensions workers. They do not have adequate training in aquaculture technologies and are overloaded with other activities and are not addressing properly the aquaculture issues

COASTAL AQUACULTURE:

Shrimp farming: Commercial and profitable marine shrimp aquaculture is already practiced in Mozambique. There are currently three marine shrimp enterprises operating in Mozambique: Sol & Mar, with 500 ha, based in Beira, Sofala Province. The present output is 400ha/year. It is operational since 2002; Aquapesca with 1700 ha, based in Quelimane, Zambézia province. It is operational since 2004 and current production is still at 0.6ton/ha/cycle, the farm is still in implementation phase; Indian Ocean Aquaculture, with 980 ha based in Pemba, Cabo Delgado province, the farm is operational since 2004 and the first production was harvest at the end of 2004.

The species cultured are *Penaeus monodon* the tiger prawn and *P. indicus* the white indian prawn. The current production (2003) is at level of 450 tons/year. These enterprises are operating a full integrated farms with a hatcheries, nursery, grow out ponds and processing plant. One of then has built a feed meal in South Africa and the others are importing feed from Asia and from the French Island in Indian Ocean. These farms are foreign investment, and the production is directed to export. The main market is Europe (France, Portugal and Spain), USA and Asia (Japan and South Korea).

Seaweed farming: Seaweed (*Eucheuma spinosum* and *Kappaphycus alvarezii*) is farmed in Cabo Delgado (from Pemba to Macomia, including some island in Quirimba archipelago) and in Nampula (between Angoche and Nacala) provinces by two enterprises based on Zamzibar (Tanzania) experience. The Cabo Delgado operation, GENU, involve about 2000 local producers and 80% of then are women. The production reached 523 tons/year of dried seaweed in 2003 but decreased to 140 ton in 2004 due to drop in the market prices of *E. spinosum*, to the poor quality of the product and disease problems. The product is market to Denmark and Philippines.

The second enterprise, an NGO, KULIMA, started recently (end of 2004) the set up of a demonstration farm for multiplication of rootstock imported from Zanzibar and the first community members will start growing seaweed in the second half of 2005.

Potential for development: Mozambique is well suited for shrimp farming and the shrimp exports from the country command higher price in the European market. Studies undertaken by the Mozambican Fisheries Authorities have identified an area of over 33,000 ha for short and medium term development of coastal aquaculture, free from conflicting uses and protected resources. Of this, 7,500 ha is around Maputo, 19,200 ha in Beira and 6,100 ha in Quelimane. Approximately 2,000 ha

were also identified in Pebane and Angoche, north of Quelimane. In Maputo other potential zones along the Incomati and Maputo rivers is estimated to exceed 3,000 ha. Though no surveys have been undertaken, the northern coast may also offer potential sites for shrimp culture. The overall potential for coastal development is estimated in over 170,000 ha of coastal land not including mangroves. The indigenous species of shrimp suited for culture are: Tiger shrimp *P. monodon*, Indian white shrimp *P.indicus*, Speckled shrimp *Metapenaeus monoceros* and Kuruma shrimp *Penaeus japonicus*. Of these, *P.monodon* has the highest market value and as such preferred for culture followed by *P. indicus.*

As has been reported by the farmers in Cabo Delgado who were reportedly earning $60 per month on an average, seaweed farming could contribute significantly to the incomes and livelihoods of poor coastal communities. The advantages of seaweed forming revolve around its relatively low technical inputs, and the consequently easy transfer of technology to growers. In addition, over 90% of the farmers growing seaweed are women and this contributes greatly to increasing the economic status of women in the community. The capital investment costs for the farmers are very low and what is needed is the technical assistance from the buying company and an assured market for the product.

Assessment of sites appropriate for farming of mussels and other bivalves in the south, Maputo and Inhambane bays revealed availability of over 10,000 ha for the purpose. The research undertaken revealed the economic viability of culturing mussels in the coastal areas. However, the technology is currently not being promoted by the government. Besides *P. monodon* there could be other species of crustaceans that are suitable for culture. Lobsters are a high value commodity and with the availability of juveniles, there is potential for fattening these juveniles in cages installed in the sea as is practiced in Asia and elsewhere.

Constraints for development: Absence of public sector infrastructure to support small-scale farming, non-availability of post-larvae, knowledge of shrimp culture, access to needed financial resources and assistance in marketing constrain the development of small-scale shrimp farming in Mozambique. Lack of human capacity is at two levels: unskilled and skilled. All shrimp farms are employing low education of unskilled labour due to lack of trained personnel to assume technical and managerial work. In view of this, the industry is employing overseas workers in technical and managerial positions.

The high duties and taxes on import of equipment, feed and other inputs and high electricity charges, refrain investors to develop projects in shrimp farming in Mozambique. The main constraint in seaweed farming in Mozambique is the inconsistency of the international companies which provide technical assistance and controls quality, and buys the products.Other constraints are centred on transport cost and availability of transport and port facilities close to the area where seaweed is farmed.

PRODUCTION & MARKET

Fisheries in Mozambique are an important sector of the national economy and contribute significantly to the diet of the population. Registers of the artisanal production are estimated in about 67,074 ton (2003).

In 2003 registered total catch (from industrial and semi-industrial fishing boats) was reported as 22,037 metric tonnes and contributing with 10% in the country total export. The annual value of exported fish products was 79.7 millions USD in 2003.

Fig.1. Aquaculture production of Mozambique

(source: Ministry of Fisheries Statistics 2004)

Source: DNEP, 2005.

The aquaculture production was 855 tonnes in 2003 (Fig.1, table 1) valued in US$ 3,003.10 and 855 tonnes in 2003 valued in US$ 1,668.3.

Table 1 – Evolution of aquaculture production, t

Product	2001	2002	2003	2004
Shrimp	-	600	332	457
Fish	70	100	n.a.	3
seaweed	-	155	523	149
Total	70	855	855	609

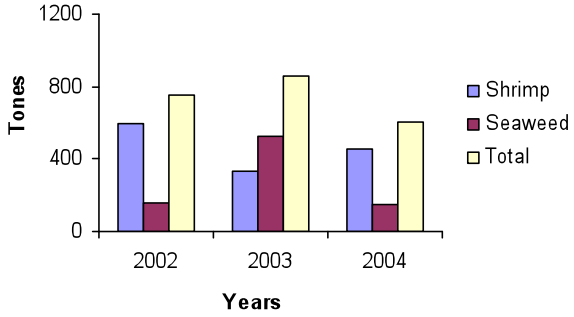

Table 2 – Evolution of fish/fisheries products including aquaculture

Units: tonnes

	2000	2001	2002	2003	2004
Total	**15,788**	**13,920**	**13,534**	**13,311**	**20,511**

Source: DNEP, 2005.

Fish marketing and distribution is undertaken by private sector (formal and informal). A wide range of marine fish products are available and marketed. Marine aquaculture production has served external market demands, while the freshwater production is for household consumption. The domestic market for marine products is small and consumption of such products is primarily confined to maritime areas. Fish consumption in the country is estimated at 7-10 kg/year. However, there are consumption imbalances between coastal and inland areas. High-value species such as prawns *Penaeus monodon* and *P. indicus* are exported. Europe and United State of America are the primary export destination for aquaculture exports. Small volumes are also marketed in South Africa and Asian countries. The production of cultured tilapia from cages is all marketed locally.

THE GOVERNING REGULATIONS

The legal basis of the fisheries is given by the Fisheries Law **(Law 3/90 of 26 September 1990)** and subsequent regulations. The Fisheries Law defines the role and responsibility of the fisheries administration and principles which guides the fishing activities. The maritime regulation **(Decree 43/2003 of December 10th)** a subsequent legislation, address issues regarding fisheries administration and management (licensing procedures fishing regimes and gears, quality control, management measures etc). There is a general aquaculture regulation that defines all right and obligations of all stakeholder s in Mozambique (**Decree 35/2001 of 13 of November**). The legislation defines specifically norms and requisites for aquaculture farms; establish procedures for licensing and parameters for each farming system such as: shrimp farms: extensive – 5 animals/m^2 and final biomass 100g/m^2; semi-intensive - 25 animals/m^2 and final biomass 400g/m^2; intensive -

not allowed; establish restrictions to import of live animals and to conversion of mangrove into aquaculture ponds and establish other environmental and consumers protection measures.

The Ministry of Fisheries through the Fish Inspection Department and the aquaculture Department has responsibility for controlling the use of chemicals in aquaculture. For that purpose a National Plan for control of residues of veterinary drugs, heavy metals, pesticides and other environment contaminants is elaborate and implemented every year. According to the plan the companies have to send samples (twice a year) to an approved laboratory for testing and copies of the results are sent to the competent authority.

Ministry of Fisheries through the Fish Inspection Department is the competent authority for the control of quality standards of all fish, fisheries products including aquaculture products. With expansion of aquaculture development and diversification of the products, specific standards have to be legislated by the Ministry of Fisheries. Mozambique is in List 1 of third country allowed to export fish and fisheries products to Europe. No regulation of governing quarantine of imported fish or aquatic specie. No specific regulation to control disease in aquaculture.

There are legal requirement for environment impact assessment for aquaculture farms bigger than 5ha and with annual output above 100 tons. An Environmental Law was approved in October 1997. The Framework Law refers to the prevention of environmental damage. An EIA is required for any project likely to significantly impact the environmental. The issuing of an environmental license is contingent upon the EIA and is a necessary prerequisite for the issuance of any other legally necessary licenses. The law also recognizes the need to guarantee the participation of local communities and to utilize their knowledge and human resources in the protection of the environment. There is a new regulation for control of effluent discharged by factories, industries plants and other development activities which establish specific water quality standards.

The Land Law was approved in July 1997 (N° 19/1997). That law follows the same path as the Constitution and is similar to the previous legislation (1979 Land Law) in that all land is still owned by the state. No private land right exists and all holdings are secondary rights. The land use planning is considered for the good of the society rather than market mechanisms and decentralised control over resources.

According to the Land Law, two types of rights are possible: i) land acquired through the state as the concession and leasehold and ii) land acquired via occupation. To obtain title via the state, the applicant must follow a legal process. To acquire land via occupation, communities can secure occupancy rights based upon customary norms and practices which are not contrary to the Constitution. Individuals and collective bodies may acquire renewable leases for up to 50 years. Occupation rights by communities are supposed to have equal weight as those acquiring rights through the formal titling procedures. The new law also specifies competencies of Council of Ministers, Ministry of Agriculture, and Provincial Governors to grant rights in land according to the extend of the requested area.

REFERENCES

Aquaculture Department, Ministry of Fisheries-Mozambique, 2004, Shrimp Aquaculture Production Facilities Monitoring Reports,

Boletim Da República, 2º Suplemento, 1996, I Série – Número 21, The Council of Ministers Resolution 11/96 Of 28 Of May.

Boletim Da República, 2º Suplemento, 1990, I Série - Número 3, Law 3/90 of 26 of September.

Boletim Da República, I Série – Número 50, Decree 43/2003 of 10 of December

Boletim Da República, 2º Suplemento, 2001, I Série - Número 45, Decree 35/2001 of 13 of November.
Instituto Nacional de Investigação Pesqueira, 2002, Desenvolvimento Sustentável da Industria de Aquacultura do camarão Marinho, 90 pp.
Omar, Isabel, 2005, Local Expert on Aquaculture Development Report; Commonwealth Mission: Assistance to Develop an aquaculture Policy

Ministério das Pescas, 2003, Plano Económico e Social do Sector para o ano 2003, 26pp.
Ministry of Fisheries, 2005. Development of aquaculture sector in Mozambique: potentials and constraints for development-policy and implementation needs. (Draf for discussion). 47pp
DNEP, Ministério das Pescas, 2005. Balanço do programa quinquenal do governo 2000-2004. Sector das Pescas. 20pp.
National Statistics Institute, 2003, Statistical Yearbook 2003 - Mozambique ,129 pp
Norwegian College of Fisheries Science, 2002, A Study of the Fisheries Sector in Mozambique, 88pp
www.ine.gov.mz
www.mozpesca.gov.mz

2 Current status and potential for aquaculture development in some francophone sub Saharan countries

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Other issues specific to Francophone African countries south of Sahara
From recent review and meetings focusing on aquaculture in the states of Africa south of the Sahara region, although historical background and potentialities differ slightly from a country to another, overall constraints are rather similar:

- Few success stories in a half century since starting, except through recent participatory and holistic approaches
- Inefficiency of top-down extension approach
- Irregular and insufficient funding of public demonstration stations
- Insufficient and poorly trained supportive staff
- Lack of reference stations with improved brood stock for seed multiplication
- Insufficient supply of seeds in general; unavailability of faster growing fingerlings

Specific country information:

Madagascar.
Aquaculture in Madagascar, dating from Andrianampoinimerina (1794 – 1810), really started as in other African countries by the 1950 under colonial administration. This starting period is characterised with a boom in the number of fish pond increasing from 1000 in 1952 to 75000 in 1962, and a production reaching 2000 tons. Forty years after, and in spite of many projects funded by international donors, the development of this sector remained tiny. In 2002, annual production hardly reached 1200 tons! The political environment is characterised by an over and over again changing in the aquaculture development strategic, with miscellaneous slogans such as "the protection of endemic ichtyofauna", "stopping pond construction permits to prevent swampy forest destruction", "state disengagement from productive activity", etc. Top down training and visit extension approach adopted has generated a good number of agents mastering the aquaculture techniques, but with poor appraisal capability of socio-cultural and politico-economical constraints of farmers.

Nevertheless, the promotion of an actual profession of Private Fingerlings Producers as an option to replace former government extension agents is appearing as a sustainable way to be tried in other African countries. At early 2003, there were about 150 PFP, distributing almost 2 millions common carp fingerlings to fish farmers.

In the marine field, aquaculture of shrimps is developing as from 1994, and is generating consisting cash for the national economy. Alongside with Maurice experience, commercial culture of crayfish in Madagascar can serve as school case for other African countries with similar bio physic and socio-economical features.
Source : Rafomanana, 2002.

Sénégal.
Fish farming in Senegal is still remaining in pilot and experimentation phase. *Oreochromis niloticus* is the only cultured specy, in the North and Southern part of the country. A new department focusing on Aquaculture inland Fisheries was recently created by the government, and may help strengthening the development of the sector.

Many punctual trials were performed with miscellaneous outcomes :
Taiwanese mission in Casamance with *Sarotherodon melanotheron*, *Tilapia guineensis* and *Mugil cephalus*. Production of 1.48 tonne/ha were registered. In the valley of the river Sénégal, poor results were obtained with cage culture, and extensive aquaculture. Rice-fish culture in Dagana 20 years ago with USAID, and some NGOs support ; interesting results obtained but with no follow up. At Matam as from 1986, poor results with intensive fish farming In 2000, Vietnamese mission under the frame of the Special Program for Food Security: production of 390.000 fingerlings; 5.9 tonnes/ha/yr fish production None of these trials have been extended to private producers. Source : Ministry of Fisheries, 2001.

Niger 1999 :
As most Sahelian countries, dry season is severe (7 months a year, with total evaporation reaching 2000 mm). However, existing water bodies and potential are under exploited on fishery point of view : in situation of scarcity, fish farming need obviously comes drinkable water and miscellaneous other water use. Fish supply is thus very low, vis-à-vis demand becoming higher and higher in urban area. Niger river and lake Chad are the main water resources, with in addition about 11000 ha small natural lakes and "intermittent ponds"

Acadja practice is known in Niger, with the concentration of fish inside a gathering of branches of shrubs where peryphyton can develop and serve as feed for tilapias and alternate species. This can be observed in the intermittent pond of Dolé (330 km Niamey South East).

Stocking of temporal intermittent ponds appear as the most sustainable aquaculture practice in Niger. The story of Thyss and Tafouka intermittent ponds reported at the end of the paragraph reveals the ethno-socio – economical sustainability of this practice in rural people in Niger. African catfishes of the genus Clarias are the most convenient species for the stocking of intermittent ponds. Such stocking are sometimes facilitated by government services or NGOs; in this case, impact assessment are scarcely conducted, and the administration is mostly interested in tax collection and mismanagement of highly funded operation (fish seed purchase, transportation, clerk per diem). Recent evaluation estimate that these intermittent ponds stand at about 50 to 150 kg / ha / year, with Clarias and tilapia as the most common species stocked.

Cage culture in Niger river started in 1982. The pilot phase was immediately followed by an extension phase in 1986, and a privatization phase from 1992 with the association of fish farmers ADA. Cage fish production culminate at about 35 tons in 1990 and 1995, but the process did not appear sustainable (less than 5 tons in 1998) : socio-economic appraisal of this culture system was not sufficiently done; investment cost appeared too high for the average Nigerian farmer, and the farm business culture for this size operation actually lacked within the environment.

Tafouka intermittent pond :
35 years ago, an inhabitant of Tafouka (400 km East Niamey) decides to stock a intermittent pond in the village, Chigit, using *Clarias* obtained from Nigeria. One year later, his children lines captured the first fish from the pond. The following years, the presence of Clarias in Chigit pond all the surrounding chain water bodies attracted professional fishermen from nearby city of Konni and from Nigeria.

This arrival of foreign fishermen generated conflicts linked to the access to the ponds, which Tafouka villagers at the front line. The property of Clarias is then recognized to the villager who first stocked the pond, who could then impose a "right of access" to all the foreign fishermen. Five years later, the village counted 5 new local agro-fisher head with family and helpers. The arrival of foreign fishermen did not only generate new profession. In 1979, a new fishing process, "in a hole",

generates more manpower investment from the villagers, who cannot afford purchasing expensive fishing gears.

At the beginning of the Eighties, the election of a new head close to the agro-fishermen of Tafouka, and more probably the dryness, involved the massive departure of the professional fishermen. In 1985, the agro-fishermen then dug the first well of storage of Clarias brooders within Chigit pond. Obliged to assemble the guard day and night to avoid the fish stealing, this initiative is not renewed the following year. But, in 1987, one of them proposes all to his mates to build a cemented basin in its own concession to store the brooders. The following years, 4 other basins are built, and the number fishing holes quickly multiply with the increase in the number of owners. One of the mobiles of the construction of these basins of storage is to share the ownership of the fish growing within the stocked hole. Some of the agro-fisher even stocked fishing holes outside Tafouka village, thus extending the practice outside. By 2000, the village counted 5 head agro-fisher with above 100 people gathered in the association of Tafouka fishers. Many hundred kg of Clarias brooders are yearly stocked in these pond, and current production is evaluated in dozen of tons, for many millions FCFA additional revenue to villagers. A great part of the production is exported to the nearby Nigeria for cash revenue.

This description seeks to emphasise on the spontaneous and sustainable initiatives from local population which is usually neglected, forgotten, in the profit of expensive and less sustainable approaches. The latter are necessary to get inside revolutionary highly productive system within the local environment, but indigenous knowledge should be regularly appraised and improved under FSRP approach. Source : Mikolasek, 2003.

Côte d'Ivoire :
Aquaculture development in Côte d'Ivoire is a bit similar to Cameroon. More expensive projects from multilateral funders are however registered (World Bank, African Development bank, and most obviously, AFD from France, etc.). The government has also invested in Aquaculture Research through IDESSA Bouaké in the Center, CRO in Abidjan, with the parrainage of French overseas research agencies CIRAD and IRD. As in Cameroon, ANADER (PNVRA in Cameroon), the World bank National Extension organism in Agriculture with the T&V approach has demonstrated its limitation under a scarcity of resources context. An evaluation of the current situation validates the assumption that participatory approaches are more sustainable than alternate approaches. Under the frame of the Periurban Project (Projet PAPU-CD-AFVP), based in Daloa (West-Central Côte d'Ivoire), the French NGO APDRA-F with its so called systemic approach appear to show more sustainable impacts. This approach departs from the following key words : the agrarian system which, thanks to a historical background, explains the current practice of the farmer as well in its social as in its agronomic dimension; the production system, which represents the system implemented by the farmer in his exploitation; the system of breeding, which explains the development of the practice in correlation to the constraints faced by the farmer for a livestock production (for example the fish); and finally for a more technical speculation as fish farming, the techniques itself.

This approach was tried in Guinea (Conakry) these last three years with promoting results. The approach is similar to the FSRP extended by WorldFish Center; it however remains too directive, and appears less sustainable in a context of limited resources related to civil war as currently experimented in Côte d'Ivoire. Oteme, 2002.

3 STATUS AND POTENTIAL FOR AQUACULTURE DEVELOPMENT IN KENYA

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The role of Agriculture in Sustainable Poverty Alleviation

Approximately 1.2 billion people worldwide live on less than US$1 per day, a figure which is classified as absolute poverty. The majority of these people live in rural areas and are dependent upon agriculture for their livelihoods (World Bank, 2001). It is estimated that nearly half of the population in Sub-Saharan Africa fit into this category. According to the Poverty Reduction Strategy Paper (PRSP), 2001 and the Economic Recovery Strategy Paper, 2003 for the Government of Kenya, for which poverty alleviation is the over-arching goal, the poor constitute slightly over half of the population. Of these publications, the government underscores specific priority actions that must be taken to ensure poverty reduction, wealth and employment creation. All fisheries activities are classified as core poverty due to their direct impact on a large rural population. The strategy also identifies sustainable use of natural resources, of which fisheries is one, and the development of the same through judicious exploitation.

Agriculture provides the platform for poverty reduction and is the lifeline of 80% of Kenya's poor that live in rural areas, including farmers, workers and the informal sector. As 70% of Kenya's employment is agriculturally derived, creating jobs and increasing income in this sector is vitally important, and, if achieved, will have an important direct effect on poverty. Futhermore, agricultural growth can catalyse growth in other sectors, with an estimated growth multiplier of 1.64, compared to 1.23 in non-agriculturally related enterprises. There is, therefore, a strong case for the restoration and promotion of sustained agricultural sector growth to alleviate poverty (GOK 1999). In further elaborating the immediate priorities for development of the agricultural sector, it is recognized that the public and private sectors must come together to strategically enhance trade and marketing of agricultural produce**,** ultimately influencing poverty alleviation. To this end, the PRSP states the following as two of the immediate priorities.

- enhance of all physical infrastructure, particularly feeder roads, ports etc., (GoK 1999).

Aquaculture as a growth industry

Within the world wide agricultural sector, aquaculture's contribution to global supplies of fish, crustaceans and mollusks continues to grow, increasing from 3.9% of total production by weight in 1970 to 27.3% in 2000. Aquaculture is growing more rapidly than all other animal food producing sectors. Worldwide, the sector has increased at an average compounded rate of 9.2% compared with only 2.8% for terrestrial farmed meat products (FAO, 2002). At present, more than 90% of production of aquaculture fish products comes from Asia, although there is no inherent reason for aquaculture not to be a common, viable and sustainable activity outside Asia, and particularly in Africa. To-date, aquaculture in sub-Saharan Africa has been orientated to domestic markets and practices mainly by small-scale farmers at a near subsistence level. Based on GIS evaluation, the physical potential for expansion of production from aquaculture in Africa is enormous and, therefore, the need for governments and private sector to seriously put more effort into realizing the potential. What hinders production intensification; however, are the economic difficulties experienced by many countries in the region, relative lack of entrepreneurship skills, credit for aquaculture development and a conducive regulatory environment in which to tackle issues such as implementation of food safety measures and meeting export food safety standards (FAO, 1997). In order to allow small-scale producers to participate in commercial aquaculture production, and thereby create a pathway out of poverty, collaboration between the public and private sectors must take place.

The Value of Partnerships and Collaboration: The Case of China
In 2000, China was reported to have produced 71% of the total volume and 49.8% of the total value of aquaculture production. Major freshwater aquaculture systems include pond, cage, pen and paddy-fish culture in rice fields and indoor running water systems. Pond culture is the most popular and most important fish farming system in China. Ownership of aquaculture ventures in China comprises the state, corporate, individual, joint venture and independent foreign ventures. In some areas of the region, such as Wenzhou and Taizhou in Zhejian Province, joint ventures and cooperative farms account for 100% of aquaculture businesses.

Research institutes in China form an important constituent of aquaculture production. In 1999, there were 210 fisheries research institutes in China. National research institutions and universities, most of which are engaged in basic or applied research, are the major power for aquaculture research and technological development. Local institutions focus on solving the problems that affect local aquaculture development. They are more producer-oriented and are sometimes quicker to respond to farmers' needs than the more nationally based institutes. Often, they are also a step ahead in terms of practical technological advances. Non-fisheries commercial private companies also fund aquaculture research, especially in the areas of aquaculture feeds, chemicals (for the control of fish diseases) and breeding and culture technologies of high value species (FAO, 2002). These types of partnerships, between farmer and researcher and the private sector, form an important element of impact oriented research, and ultimately, increase in aquaculture production and economic improvement.

Challenges and Opportunities
In the past, attempts to transfer technologies and research to the rural poor have met with limited success due to lack of consideration of the demand-oriented market structures. Top-down approaches in the development and diffusion of technologies have resulted in limited and unsustainable adoption of available technologies. The involvement of a commercial partner ensures a demand-oriented, market led adoption of research innovations and provides a window for continuous feedback on appropriateness of research products.

The timing of this collaborative effort is opportune. Kenya has developed sound and progressive strategies and policies for agriculture-led development and requires innovative solutions to put these policies into practice.

This collaboration between the public and private sectors will enhance Kenya's comparative advantages and exploit hitherto under explored resources. Currently, under 1% of fish exports currently are derived from inland aquaculture and this is due in part to capital requirements, lack of credit facilities and access to markets (Abila, 2003), poor extension methods, lack of a comprehensive government policy on agriculture, poor information dissemination and technology transfer to farmers and low investment by the private sector, amongst others (fisheries Department. 2004). This type of commercial and pubic collaboration provides an excellent example of the complementary use of skills. Kenya will be better positioned to take advantage of trade opportunities and initiatives such as those mentioned in the African Growth and Opportunity Act (AGOA), and fulfill objectives such as those put out under the Bretton Woods' Institutes and the New Partnership for African Development (NEPAD).

New Approach to Aquaculture in Kenya; Although aquaculture has been known in Kenya for over a century, its performance as an economic activity leaves a lot to be desired. It has no significant impact on socio-economic growth as its contribution to food security, and fisheries resource base can be termed as insignificant. This poor sub-sector performance is attributed to poor extension service and inadequate research.

Despite the sub-sector's dismal performance, the country is endowed with favourable conditions suitable for commercial aquaculture. The government has taken cognizance of this and is focusing on developing strategies that will ensure growth of aquaculture is expedited. Such strategies include commercialization of small scale farming and public/private partnerships to develop commercial aquaculture enterprises.

New approach to aquaculture extension, would include demand-led research, training of farmers and extension staff, field days, contact farmers and development of Aquaculture Centres of Excellence as demonstration research and extension centres.

Aquaculture Production in Kenya; Aquaculture contributes only about 0.5% of the total national fish production. Approximately 1,000 m. tons are harvested from 10,371 small ponds owned by about 7,500 fish farmers. The current mean yield from small-scale fish farming is approximately 1,000 kg/ha/year. The production statistics may not be accurate due to poor data collection. Most farmers do not keep records of harvests or sales and do not also inform the Department when they are harvesting. The current low farmed fish production and inconsistent data collection notwithstanding, aquaculture has an enormous potential that the Government of Kenya plans to ensure it is realized for the benefit of Kenyans.

Aquaculture Potential in Kenya; Kenya is endowed with climatic diversity, natural features and resources that favor the culture of a wide variety of species. Currently, only about 0.014% of the 1.4 million hectares of potential sites are under aquaculture. The most common species cultured are tilapia, but there is a growing potential for profitable culture of the African catfish *Clarias gariepinus* for both bait and food. The most commonly farmed tilapia species include; *Oreochromis niloticus, Tilapia zilli, and Oreochromis mossambicus*. About 95% of fish farming in Kenya is small-scale. Only a few medium-scale intensive fish farms exist but there is room for growth of small, medium and large-scale farming for warm and cold fresh water and marine fish.

Government focus on aquaculture; The Government recognizes the constraints hindering aquaculture growth and development and realizes that the sub-sector could play an important role in poverty alleviation of rural population. It could also play a key role in provision of protein food and reduction of fishing pressure in capture fisheries. During the preparation of the Poverty Reduction Strategy Paper, aquaculture development was identified as a core activity for funding through the Medium Term Expenditure Framework (MTEF) budgeting system. Following this development in addition to the reorganization of the government functions, aquaculture has been prioritized and is now one of the four core functions of the Department of Fisheries. Given the fisheries potential, GoK has taken a keen interest and given aquaculture and fisheries in general the priority it deserves as demonstrated in the recent creation of a Ministry of Livestock and Fisheries Development. Clearly, small scale fish farming could be developed into a viable enterprise capable of supporting an enormous economic activity in rural Kenya and also increasing the fisheries resource base. This potential, however, is only realizable if GoK creates an enabling environment for investment in fish farming including facilitating availability of affordable credit facilities.

Major constraints inhibiting aquaculture growth in Kenya

- Poor extension methods which lack standardized packages
- A multi disciplinary and incoherent promotion of aquaculture through many institutions, which include Government, research institutions, Universities, NGOs, and Regional Authorities, among others, has not facilitated aquaculture growth. The farmer is left confused by many different extension officers who visit and give varying information.
- There is no comprehensive policy on aquaculture, including legislation and this is an indicator of the low priority the policy makers have accorded aquaculture as an socio-economic activity.
- Lack of certified quality seeds (fingerlings) and commercially produced feed.

- Weak training and research programmes which previously were not driven by farmers needs, though this is rapidly changing and more training programs are now demand-driven.
- Poor information dissemination and technology transfer to farmers. Many farmers with good land that can be put into profitable aquaculture are not even aware of this potential.
- Poor record keeping by farmers and inefficient statistical data collection has impeded information dissemination on viability of aquaculture.
- Low funding of the sub-sector activities by the Government and low investments by the private sector.
- Inadequate entrepreneurship skills by farmers and lack of credit.

Role of research in aquaculture development

An ongoing ACRSP program has helped change the approach to aquaculture in Kenya and has contributed to the rapidly changing attitude towards commercial fish farming in Kenya. The program has demonstrated that aquaculture can be a lucrative business opportunity, which can address the problems of poverty and food insecurity for the rural poor. The dramatic productivity improvement where collaborating farmers in an on-farm-trial, realized an increase of 350% in net average annualized production, has raised high hopes to both potential and existing farmers who have access to this information. The Sagana Aquaculture research and demonstration centre is being developed into a Centre of Excellence for Aquaculture in sub-Saharan Africa.

Revitalizing aquaculture in Kenya

Earlier Aquaculture Initiatives

Lake Basin Development Authority (LBDA) Programmes

1. FAO/UNDP Programme on fry production.
2. UNDP/BSF/FAO/GOK – From 1984-2000. LBDA coordinated implemented the "Development of Small Scale Fish Farming" in Western Kenya. The achievements included; Phase 1 – establishment of eight (8) fingerling production centres with a total capacity of 5,000,000 tilapia and 4,000,000 catfish fingerlings, *Clarias gariepinus* was introduced as a new culture species. Phase II – the project focused on increased fish production to reduce the reliance of farmers on the Government and create a more participatory approach of development through the establishment of sustainable fish farming systems. Several studies were done; PRA on socio-economics and marketing, Nutrition studies and cost benefit analysis. The impact of this activity has yet to be felt. Fingerling multiplication centres by LBDA were developed in to provide fingerlings to farmers as a way of promoting fish farming. Due to poor extension services and poor linkages between the authority and the Department of Fisheries to enhance extension services, these centres have had dismal performance, and have not significantly enhanced aquaculture development in Kenya.
3. UNDP/FAO 1983-1993 on training in hatchery design and construction and extension in the basin. Despite these initiatives, there has been no apparent impact on aquaculture growth in the area. Perhaps, the approach in the introduction of aquaculture to farmers is to blame for the dismal performance of an otherwise potentially viable economic activity. The attitude that aquaculture is only for subsistence has exacerbated its slow growth and development.

Shrimp Farming

The pilot mariculture project in Malindi, in Kenya's North Coast though showed good promise of spreading semi-intensive mariculture in the Kenyan Coast was riddled by ownership conflicts and, therefore, failed to deliver its objectives. This failure notwithstanding, the pilot project demonstrated viability of shrimp farming. The development of commercial shrimp farming at the Kenyan Coast is now being pursued through private/public partnership initiatives

Rationalization of Government activities

In late 1990 and early 2000, the government undertook an exercise to rationalize its functions to avoid overlaps and duplication inorder to maximize resource utilization. It is during this exercise that the aquaculture development was made a core function of Fisheries Department with other relevant institutions collaborating in aquaculture development.

Areas of focus for revitalizing aquaculture in Kenya

- Aquaculture inventory and establishment of an accurate baseline data.
- Survey of the potential aquaculture areas, documentation and mapping.
- Setting up of the Geographical information system (GIS) to monitor aquaculture development
- Publicize viability of aquaculture as a business through:- Documentaries, Feature stories, Field days; newsletters etc.
- Develop programs to show-case successful fish farmers, such as radio programmes, TV interviews etc.
- Develop Aquaculture Centres of Excellence in all potential regions to be used for research and technology development and transfer
- Promote private entrepreneurship in fish farming through facilitating access to affordable credit; enhancement of public/private partnerships in fish farming ventures; and capacity building in entrepreneurship skills for small scale farmers.
- Develop efficient extension packages and disseminate through public/private participation including use of contact farmers.
- Promote market access, enhance farmed fish quality and safety assurance, and facilitate development of cold chain and physical infrastructure.

References

Abila, R.O. (2003). "Food Safety in Food Security and Food Trade, Case Study: Kenyan Fish Exports." 2020 Vision For Food, Agriculture and the Environment: Focus 10 (Brief 8 of 17).

FAO (2002). The State of World Fisheries and Aquaculture. Rome, Food and Agriculture Organization of the United Nations: 150pp.

GOK (1999). Interim Poverty Reduction Strategy paper 2000-2003. Nairobi, Government of Kenya.

World Bank. (2001). World Development Report 2000 – 2001: Attacking Poverty. The World Bank.

ANNEX 3 OUTLINE DEVELOPMENT STRATEGY FRAMEWORK – UGANDA CASE STUDY

The following examples derive from a draft development strategy framework prepared in 2004 by one of the authors, at the request of DFID. This was developed primarily to illustrate how demand and supply sectors could be characterised, and information built up to guide further development. It does not intend to describe the sector or its markets with detailed accuracy, but enable such information to be fed in and the sector model to be built up more completely. Components of the approach are shown below, from which a series of sectoral and sub-sectoral projections could be made. The full document can be made available if required.

Approach adopted

The approach taken is:

- Firstly to consider features of current and emerging demand for aquaculture products, both domestically and internationally, and the possibilities this would hold out for volume, quality (size, species, product form) and price.
- This in turn can be used to consider supply options, and the ways in which these could be developed over a defined timescale. A simple spreadsheet-based structural model has been developed to describe these.
- From this can be assembled a perspective on the composite elements of the sector as a whole, the extent of its diversification, the upstream and downstream linkages, and the physical and institutional infrastructure required.
- From this also can be set out the key directions to be taken from the present stage of development of the sector, particularly as promoted and supported by the FISH project and its related initiatives.

This brief overview is developed from scenarios which are related to current perspectives, but is based on secondary data and indirect inferences from broadly recognised trends. As such it must be seen primarily as indicative, is open to interaction with other perspectives, and will require more targeted assessment to explore key features with greater definition and direction.

Demand

A number of points can be noted:

- The cost structures of capture fisheries and aquaculture supply are very different, and although similar species and products may be involved, they normally occupy separate market positions, with very different consumer expectations and price ranges. This is the case in Uganda as elsewhere, but with the gradual change in balance between capture and culture, and shifts in distribution and markets, longer-term trends may see a greater level of interconnection and cross-over.
- Uganda's markets are defined by interactions between domestic, regional and international demand. The first two of these are closely linked in terms of supplies, prices and distribution chains, while international markets are largely separate at this stage. Due to future interactions in exporting a wider range of product, and developing aquaculture feeds from lower-value fish, this may change.
- The overall perspective for meeting medium-term demands is that with export levels of 60,000t, domestic consumption levels of 10kg/cap/yr, a predicted population of 32 million by 2015, a total of 380,000t of food fish will be required, compared with an estimated catch of 220,000t, and an estimated potential capture fisheries output of 300,000t. Should a substantial fishmeal demand develop, this may easily account for a further 20-50,000t.

- These figures suggest a substantial shortfall, which may however be overstated due to potentially large amounts of unrecorded catch and consumption, though exports regionally may also be greater than reported. Much of the shortfall, particularly if a fish meal and oil sector develops, may be in the lowest price ranges.
- Apart from the export sector there is very little value-chain information available for the sector – ie what are the distribution structures, who is involved, where is the market power, what is the value added at each stage, and what are the investments and returns. This makes it difficult to define not just the current structures and values, but also the inherent dynamics and the potential impacts of change.

Domestic markets:

- In Uganda, the domestic market is defined by the wide availability of low-priced capture fishery products, together with a localised supply of export process by-products such as frames and trimmings. Except in more inaccessible areas, small fish such as *mukene*, and small tilapia, typically dried, are primary sources, and set price, product form and quantity.
- At local levels, while fish is appreciated, substitution with chicken, eggs and dairy products may be a factor limiting potential growth in consumption. Here, aquaculture production, whether consumed directly in households, forming part of social exchange, or marketed, is likely to represent an occasional rather than a staple food item. Evidence of new markets such as that for Nile perch frames, and arising from changing capture species distribution, would suggest that preferences and consumer responses at a range of levels will change.
- At average consumption levels of ~ 10 kg/cap/yr, and with relatively low prices, purchasing levels are not significant; at average prices of $0.25 per kg ($250/tonne), and a household size of say 6 people, this amounts to $15 per household annually. However, at a population level of 30 million, the gross annual value of the sector is $75 million.
- It is likely that most aquaculture production will enter markets in the price range of $0.50 per kg or above. As a very crude indicator, assuming consumption profiles as outlined in Table 1, an estimate can be made of the likely size and value of the domestic market. This can be refined with better demographic and income date, and with better understanding of purchasing power and preferences.

Table 1 Potential consumption profiles for aquaculture production in Uganda

Population sector	Number	Fish consumption	Local sourced	% aqua culture	Total aqua demand, t	Avge price$/kg	Total value, $ '000
Wealthy	10,000	20kg	30%	20%	12	2.00	24
Middle class	200,000	20kg	80%	30%	960	1.00	960
Upper poor	10,000,000	12kg	100%	10%	12,000	0.70	8,400
Lower poor	16,000,000	8kg	100%	5%	6,400	0.50	3,200
Total	26,210,000				19,372		12,584

Regional markets

- A considerable, yet poorly quantified amount of fish is distributed regionally, and there are varying reports of the relative buying power of bordering countries, and of the distances Ugandan fish are marketed. Though data is patchy, indications are that demand is strong and real prices are rising, with good opportunities for sales outside of Uganda.
- Links with population and income levels (eg elasticity features) are unclear, but with regional capture fisheries unlikely to increase, and with possibly increased export sales, growth in either or both of these – as anticipated if current health, governance and economic regeneration initiatives take place – would lead to an increase in real price.
- Currently there appears to be little appreciation of size and quality of fish products, domestically or regionally, but market information is very contradictory. There is already

evidence, particularly in more urban areas, of some change in consumption habit, but though widely consumed fish is rarely a food of great preference, and while better quality fish can still be supplied from capture fisheries, this may not remain a significant option.
- There is likely to be an increase in regional trade associated with aquaculture, as comparative advantages of some locations become clearer, and as urban centres develop a stronger demand.

International markets
- Where fisheries exports form a substantial part of the national economy (currently the case in Uganda) there may be a trade-off between increased export and foreign exchange earnings, and hence potential for local economic growth, but with reduced domestic supply of capture fishery products, and hence greater supply and price pressures.
- Aquaculture supply to international markets is of increasing interest – with huge potential for providing medium value white fish – tilapia, and valuable prospects for supply of higher value species such as Nile perch. Other options such as catfish and possibly macrobrachium may emerge, but these are likely to have more limited market potential.
- Major market sub-sectors could be of the order of 10s to 100s of thousands of tonnes annually, with typical first-hand sales values of $1,200-4,000 per tonne. Larger cost-driven markets tend to favour larger suppliers, or co-operative marketing agencies, and so options for small-medium enterprises to supply directly may be more constrained.
- Meeting international market demands will require well organised systems of production, with an increasing need for traceability and reliable food safety standards. Additional issues such as social and environmental accountability may also become important.
- A further niche market may be identified in the supply of organic and/or fair trade aquatic products. Criteria for the former have been developed and could be consistent with Uganda's potential supply methods. Concepts of fair trade in the sector are in early stages but may be applicable. Market sizes are so far relatively small – typically less than 5% of total in most food sectors, but margins can be good and production criteria may favour small-scale producers.

Supply options

Uganda has a number of distinct advantages in terms of supply, the most salient being water resources, particularly large water bodies, availability and suitability of endemic stocks, and a developing infrastructure and distribution capability for fish products, particularly for higher-value export products with exacting requirements for hygiene and traceability. For more intensive forms of aquaculture there is also the potential for relatively cheap feeding materials, though as with other animal feeds, there could be issues to address with respect to competition for direct human consumption. Several different areas of aquaculture could emerge. As an initial approach, eight subsectors are characterised – 2 involve fry and fingerling (seed) production, and 6 the ongrowing to market size. Others may develop or cluster round these, but they can serve as an immediately identifiable originating point, and a basis for scenario setting. These are outlined in Table 2.

Table 2 Summary of aquaculture sectors

Enterprise type	Features	Size	Production/sale	Employment	Annual returns
Small-scale hatchery/ nursery enterprise	Small farmer with higher skills and motivation, possible ext-ension role producing tilapia and possibly catfish in small ponds/ hapas, serving small-scale producers in local area.	Based on 1-4 small ponds and/ or hapas for broodstock , fry and/or nursing	Typically 10 to 200,000 fry or 5-50,000 fingerlings, using simple tech-niques, local feeds, etc	Farmer / direct family members – may link with local fry traders over time	$50 - $500 depending on species sold – may take share in production
Commercial	More enterprise-oriented	Will vary widely;	Typically 1-20	Farmer/manager	$500-$50,000

Enterprise type	Features	Size	Production/sale	Employment	Annual returns
hatchery	farmer or small business partnership supplying local farners and/or public sector stocking programmes and commercial ongrowers, wider supply range and better distribution methods	based on ponds or cages for broodstock, tanks, ponds, hapas for fry/ fingerling.	million fry or 20-20-500,00 finger-lings; possibly with selection, all-male production, market delivery to agents/ customers	and 1-10 staff, range of skills, plus transport/ distribution jobs.	depending on scale, specialis-ation, may link with ongrowing at a range of levels
Micro-scale subsistence production (normally ponds but small cages also possible)	Current small pond sector based on single households, some community or group ponds; low-input and low output, household consump-tion, tilapia, catfish, carp, small sales to local markets	Typically single ponds of 50-300m2 (cages 1-3m3)	5-15kg per 100m2, or 2.5-45kg per pond, some may be exchanged in community	Farmer/ direct family members, minimal use with surplus or un-costed labour ; some shared group labour	Negligible; per-haps $50 max; food security, social capital more important
Small-scale local market pond production	Developed from current small pond sector or as new enter-prise; improved tilapia/ optional catfish polyculture better fertilisers and possible simple feeds; farmer, family or co-operative, occasional external labour, may produce own fry/fingerlings	Typically based on 2-12 small ponds of 150-1000m2	Improved outputs 20-40kg/ 100m2 – 100-4000 kg per farm; small amount locally consumed, rest to markets, may be purchased at pond side	Farmer/manager small numbers of f/t and p/t staff	$50-$2000 depending on size, species mix; higher input costs – net return perhaps 20-40% of turnover.
Small –scale commercial cage	New enterprise, with individ-ual or group ownership, developed to make use of water bodies, tilapia, catfish, possible other such as Nile Perch, fed with wastes and/or prepared feeds	With perhaps 4-6 simple cages of 20-300m3 at 15-40 kg/m3/yr	Range from 1-60t/ farm annually, to local markets and/ or linked to larger commercial groups and/or processors	Farmer/manager small numbers of f/t and p/t staff	$500-90,000 depending on size, species mix; higher input costs – net return ~ 15-40% turnover.
Large commercial	Indigenous larger enterprise using cages, possibly vertic-ally integrated, with local fry supply, feeds, processing; prepared feeds and improved strains of tilapia, catfish, possibly Nile perch	6-12 larger cages of 300-1000m3 at 20-45 kg/m3/yr	From 40-500t/farm annually; to higher value regional and main export markets	Manager and teams of f/t and p/t staff; other inputs in linked enterprises	$20-750,000 depending on size, species mix; higher input costs – net return ~ 10-25% turnover.
Nucleus system	As above, indigenous or externally owned, but based on management centre, possibly with hatchery, feeds, processing, and range of smaller scale cage and pond producers in variety of contractual relationships.	Equivalent of large commercial unit as above, or larger, more diverse	Typically 300-2000t annually, to higher value regional and main export markets	Manager and teams of f/t and p/t staff; may be some specialists other inputs in linked enterprises	$150,000 to $3m annually, depending as above – net return ~ 8-20% turnover.
Major commercial	Externally owned or joint venture, probably vertically integrated, with local fry supply, feeds, processing; prepared feeds and improved strains of tilapia, catfish, possibly Nile perch	12-40 large cages of 1000-3000 m3 at 30-45 kg/m3/yr, plus fry and nursery units	Typically 360-4000t annually, to higher value regional and main export markets	Manager and teams of f/t and p/t staff; may be some specialists other inputs in linked enterprises	$200,000 to $6m annually, depending as above – net return ~ 5-15% turnover.

A further supply area, not addressed explicitly here, is based on stocking of water bodies. Though an ambitious programme is currently under way within the Government of Uganda's Strategic Export initiative, the value and potential of this is difficult to determine at this stage, nor are the longer term costs and benefits of stocking, the likely increases in total output or the implications for future seed stock quantities and price well explored. While the initiative is undoubtedly valuable for stimulating domestic hatchery production, it is very uncertain whether it can deliver an

economic return according to public sector expenditure criteria. However, should better quality information become available, potential costs and outputs can be factored in to the present profile.

Detailed projections

Further tables summarise scenario features for key selected sub-sectors. Based on estimated conditions at a defined start date (2004 for those with current or emerging production, later for those which may develop in the short-medium term), assumptions of growth/change rates are used to create future projections. In most cases, a simple continuous exponential is likely to overstate outcomes over longer periods of time (ie rates of change will tend to level off as the sector grows and as production and yields increase) – so a modified longer term target is used. In each of the examples, two tables are developed, the first outlining the number of units, area, production and gross value, and the second extending this to indicate impacts on food supply, income and employment. In the smaller scale and subsistence cases, the emphasis is on food supply, while in the more commercial sectors, income and employment[6] are identified.

[6] Expressed in FTE – Full-time equivalent units of employment

ANNEX 4 Key sources

Ahmed, M. and Delgado, C. 2000. Introduction to the issues and context of rapid changes in world demands for fish. Paper presented in the Biennial Meeting of the International Institute for Fisheries Economics and Trade (IIFET), 10-14 July 2000, Corvallis, Oregon, USA. Reprinted In: Fish to 2020: Implications of Global Fish Outlook for Developing Countries. WorldFish Center, Penang, Malaysia.

Ahmed, M. & Lorica, M.H. (2002) Improving developing country food security through aquaculture: lessons from Asia, *Food Policy*, 27(2): 125-141

Anonymous. 2001b. Sustainable commercial aquaculture development South of the Sahara. FAN (FAO Aquaculture Newsletter), 28:15-17.

Barlow, S and I Pike, 1997 Future world fish supplies should be enough for farm needs. Fish Farming International pp 14- 16, 1997

Bene, C, Cadren M and Lantz, F 2000 – Impact of cultured shrimp on wild shrimp fisheries; analysis of price determination mechanisms and market dynamics. Agricultural Economics 23: 55-68

Begum, A. and D'Costa, M. 2002. Small-scale aquaculture and aquatic resource management on poverty alleviation in Bangladesh: A Caritas participatory approach. Paper presented in the Regional Consultation on Focusing Small-scale Aquaculture and Aquatic Resource Management on Poverty Alleviation, 1214 February 2002. FAO, Bangkok, Thailand and NACA, Bangkok, Thailand.

Beveridge, M C M, L G Ross and L A Kelly 1994, Aquaculture and Biodiversity. Ambio Vol 23 No 8, pp 497-502.

Bruinsma, J. World agriculture towards 2015-2030: Chapter 7: Fisheries. Rome: FAO; 2003.

Costanza, R. Visions, values, valuation, and the need for an ecological economics. BioScience. 2001; 51(6):459468.

de Graaf, G. and Latif, A. 2002. Development of freshwater fish farming and poverty alleviation: A case study from Bangladesh. Aquaculture Asia, VII(2):5-7.

Delgado, C.L., Rosegrant, M.W, Meijer, S., Wada, N. and Ahmed, M. 2002. Fish as food: Projections to 2020. Reprinted In Fish to 2020: Implications of Global Fish Outlook for Developing Countries. WorldFish Center, Penang, Malaysia. 10 pp

Delgado, C. L.; Wada, N.; Rosegrant, M. W.; Meijer, S., and Ahmed, M. Fish to 2020: Supply and demand in a changing world. Washington DC: IFPRI; 2003.

Dolapsakis N.P. 1996. M.Res. Thesis 'Primary Resources and Aquaculture Development Beyond the Year 2000'. Institute of Aquaculture, University of Stirling.

Edwards, P. and Demaine, H. 1997. Rural aquaculture: Overview and framework for country reviews. FAO, Bangkok, Thailand. 61 pp.

Environmental Justice Foundation (2003): *Smash and grab: Conflict, corruption & human rights abuses in the shrimp farming industry*. London: Environmental Justice Foundation.

FAO. 1995. Code of Conduct for Responsible Fisheries. FAO, Rome, Italy. 41 pp.

FAO. 2001. Report of the FAO/Government of Australia Expert Consultation in Good Management Practices and Good Legal and Institutional arrangements for sustainable shrimp culture, Brisbane, Australia, 4-7 December 2000. FAO Fisheries Report. No. 659. FAO, Rome, Italy. 70 pp.

FAO. 2002a. Aquaculture development and management: Status, issues, and prospects. COFI:AQ/1/2002/2. FAO, Rome, Italy. 13 pp.

FAO. 2002b. The role of aquaculture in rural development. COFLAQ/1/2002/3. FAO, Rome, Italy. 12 pp.

Goss, J and J D Burch (2001): 'From agricultural modernisation to agri-food globalization: the waning of national development in Thailand'. *Third World Quarterly,* 22, 6: 969-986

Gujja, B. & Finger-Stich, A. (1996) What price prawn? Shrimp aquaculture's impact in Asia. *Environment*, **38**(7), 12-15.

Hardy, R.W. & Tacon, A.G.J. (2002). Fish meal: historical uses, production trends and future outlook for supplies, pp.311-325. In: Stickney, R.R. & MacVey, J.P. (Eds.), Responsible Marine Aquaculture. CABI Publishing, New York, 391pp.

Harrison, E.(1997) Options for small- scale aquaculture development. In *Report of the Expert Consultation on Small-Scale Rural Aquaculture* (eds M. Hinds, Martinez- Espinosa) pp.31-68 Fisheries Report No 548 FAO, Rome

Harrison E, Stewart JA, Stirrat RL, and Muir J (1994) *Fish Farming in Africa - What's the Catch?* University of Stirling, UK: Institute of Aquaculture and University of Sussex, UK: School of African and Asian Studies.

Howgate P, Bunting S, Beveridge M, and Reilly A (2002). Aquaculture associated public, animal and environmental health issues in non-industrialized countries. In: Jahncke M, Garrett S, Martin R, Cole E, and Reilly A (eds), *Public, Animal and Environmental Aquaculture Health*, Wiley.

Kautsky, N., Berg, H., Folke, C., Larsson, J. and Troell, M. 1997. Ecological footprint for assessment of resource use and development limitations in shrimp and tilapia aquaculture. Aquaculture Research, 28:753-766.

Michielsens, C.G.J., Lorenzen, K., Philips, M.J. & Gauthier, R. (2002), Asian carp farming systems: towards a typology and increased resource use efficiency, *Aquaculture Research*, 33: 403-413

Muir, J F (1995) Perspectives on Aquaculture. Aquaculture and food security. 224pp Mimeo. Study document commissioned for FAO, Rome.

Muir JF, Brugere C, Young JA, and Stewart JA (1999). The solution to pollution? The value and limitations of environmental economics in guiding aquaculture development. *Aquaculture Economics and Management* 3: 43-57.

NATS. 1997. Holmenkollen Guidelines for sustainable aquaculture. Norwegian Academy of Technological Sciences, Trondheim, Norway. 8 pp.

Naylor, R.L., Goldburg, R.J., Mooney, H., Beveridge, M.C., Clay, J., Folke, C., Kautsky, N., Lubchenco, J., Primavera, J. and Williams, M. 1998. Nature's subsidies to shrimp and salmon farming. Science, 282:883-884.

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell, M. 2000. Effect of aquaculture on world fish supplies. Nature, 405:10171024.

New, M.B. 1999. Global aquaculture: Current trends and challenges for the 21[5'] Century. World Aquaculture, 30(1):8-13, 63-79.

Prein, M and M Ahmed, 2000 Integration of aquaculture into smallholder farming systems for improved food security and household nutrition . Food and Nutrition Bulletin 21(4) 466-471

Thilsted SH, Roos N, and Hassan N (1997). The role of small indigenous fish species in food and nutrition security in Bangladesh. *Naga* 20(3-4): 82-84.

Wessells, C.R., Cochrane, K., Deere, C., Wallis, P. and Willmann, R. 2001. Product certification and ecolabelling for fisheries sustainability. FAO Fisheries Technical Paper No. 422. FAO, Rome, Italy. 83 pp.

Westland,L (1995) "Apparent historical consumption and future demand for fish and fishery products - exploratory calculations." Paper to International Conference on Sustainable Contribution of Fisheries to Food Security, Kyoto, Japan 4-9 December. FAO.

Williams, M. J. (1997) Aquaculture and sustainable food security in the developing world. In *Sustainable Aquaculture*, eds. J. E. Bardach, John Wiley & Sons Inc. New York

Young, J.A. and J.F. Muir. "Tilapia: Both fish and fowl?" *Journal of Marine Resource Economics* (2002):163-173