COMMERCIALISATION OF AQUACULTURE INITIATIVE

A concept note for the Director General, NARO

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BACKGROUND

Fish is currently one of the two most important agricultural export commodities from Uganda with factory-processed fish exported mainly to Europe, South East Asia and the Middle East worth at least USD 100 m annually. Regional exports are probably of similar significance. All recorded fish exports rely heavily (95%) on factory-processed Nile perch with the Nile tilapia increasingly entering the export market chain. Regional fish exports are more diversified in terms of species and include Nile tilapia, Nile perch, "mukene", Tiger fish and "Angara", the last two fished from Lake Albert. Regional fish destinations include Kenya, Tanzania, Rwanda, Sudan, DR Congo and some parts of Central Africa. Internal consumption relies on subsistence to semi-commercial fishes for a variety and species dominated by Nile tilapia.

Annual fish harvested from production systems (lakes and rivers) in Uganda is about 300,000 mt. Fish production from aquaculture contributes about 0.02% (i.e. less than 100mt) of total fish production. Production for export is still below demand yet most production systems (lakes and rivers) are experiencing over-capacity and possibly close to diminishing returns on effort. Simultaneously the internal demand for fish within Uganda has increased tremendously as a result of fish exports and the emergence of new consumers (i.e. non-traditional fish eating communities). With reduced supplies due to exports and declining catches, and, a kilogram of fish on the open market fetching on average Ug. Shs 2,500/=, the per capita consumption of the once "the most readily available and affordable source of animal protein to the majority of Ugandans" has dropped to below 12kg except in fisher communities and within the immediate hinterland (<20km) of production systems. There are added concerns about the sustainability of Uganda's capture (wild stocks) fisheries. The priority issues addressed by FIRRI in capture fisheries research are:

a) Collapse in the native fisheries of lakes Victoria and Kyoga

b) The emergence of export- oriented fisheries based on the introduced Nile perch and Nile tilapia in these two lakes
c) Potential collapse in the current fishery based in the introduced fish species,
d) Declining biodiversity and its impact on productivity
e) Deterioration of the lake environment e.g. wetland degradation, water hyacinth proliferation, pollution etc
f) Declining socio-economic benefits
g) Inaccessibility of information

Other major issues are system specific (e.g. Lakes Albert, George, the numerous smaller lakes including Bisina, Wamala, Kijjanebalola, Opeta, Bugiri lakes, Kooki lakes) and of concern to District authorities but for which budget constraints have limited planned activities. Research in capture fisheries has advanced to a stage where for the larger production systems; the emphasis is on "monitoring core parameters and providing technical guidelines" and policy recommendations. With 20% of Uganda's surface area covered in lakes, rivers, streams and wetlands, and contributing 99.9% of the fish produced, capture fisheries research has to continue focusing on constraints to the outlined factors and monitoring the stocks, biodiversity and environment in the production systems with a view to ensuring the sustainability and profitability of the capture fisheries.

In aquaculture, the strategy is to supplement the over-stretched capture fisheries by increasing and diversifying fish farming and thereby catalyse transformation of the sector into viable commercial enterprises in line with PMA principles besides improving rural livelihoods and nutritional status.
There is a clear case for the promotion of aquaculture (fish farming) to bridge the large gap between capture fisheries production and production and demand.
Fish farming in Uganda is not new but needs aggressive promotion.

SITUATION ANALYSIS

Fish farming (aquaculture) was first established in Uganda in the 1950s and the Kajjansi Experimental Station was opened in 1952. By 1968, there were 11,000 ponds covering 420 ha and producing 800-900 mt of fish. By 1980, production had drastically declined to less than 100 mt, ponds had been abandoned, and it is only since 1988 that fish farming started picking up again. The 1968 peak production levels have not yet been realised, and fish farming in Uganda is still dominated (80%) by subsistence farmers owning on average one pond, with tilapia (the Nile tilapia, *Oreochromis niloticus*) as the most farmed fish. Over 50% of the ponds measure between 100-300 m^2 (i.e. 10 m X 10 m to 15m X 25 m) in size. Since the late 1990s (~1997), some farmers have taken up polyculture (Nile tilapia and catfish/mirror carp) with mirror carp in higher altitude areas as the target farmed fish. However large-scale fish farming comparable to what is practised in fish exporting countries of South East Asia (e.g. Vietnam and Malaysia) has not taken off. Thus although it is not exactly known, there are only about 5000-7000 fish farmers operating in the country.

Unlike many crop systems (coffee, cotton, beans, maize, etc), fish farming in Uganda is still practiced at subsistence levels with annual yields under 1000 $kg.ha^{-1}.yr^{-1}$ in comparison to crop yields in excess of 3000 $kg.ha^{-1}$ over a growing season of only three to six months. Pond construction, maintenance and harvest are manual and management is rudimentary. The very basic levels of management (proper fertilization, supplementary feeding, sorting seed, stocking densities, etc) are partly due to attitudes. It is likely that many farmers take to aquaculture as a hobby or a trial and error investment even though most (>60 %) express income generation as the main objective of the often one-pond (10 m X 15 m or less) enterprises. Markets, investment costs and thefts of farmed fish within communities are also frequently reported as the key disincentives.

CONSTRAINTS TO AQUACULTURE (FISH FARMING) DEVELOPMENT IN UGANDA

Although the aquaculture tradition has been in Uganda for over 50 years, still production is below 100mt annually. Apart from past political and economic decline, there are other factors that have hindered development of aquaculture in comparison to other sectors that picked up rapidly especially during the 1990s. For example, the formerly non-traditional cash crops e.g. maize, vanilla, fruits and fish from lakes have all entered the cash/export category but fish farming has not featured in any of these openings.

Vietnam has an intensive and aggressive fish marketing strategy based on fish farming. Still it is clear that without increased fish production, there will be an estimated deficit of 60,000 mt of fish on the export market orders within two-three years and an equal deficit to sustain local consumption within five years from 2002. Despite the potential for fish farming in most parts of Uganda (Fig. 1, attached), production is still at rudimentary and hobbyist levels. It is estimated that when promoted through the market, production from fish farming can increase from the present < 100 mt to 20,000 mt by 2006. In a concept paper of 2001 by FIRRI (Annex 1), the constraints identified to increasing aquaculture production to desirable levels are summarised and explained below:

1) **Inadequate supply of quality seed (fry) and, advice/uptake of reliable information**

   Fry are obtained from wild stocks, which include non-performing species (*Tilapia zillii*, *Oreochromis leucostictus*), that soon crowd the ponds

   a) No competent and trained seed producers.
      Private agents capture fish fry from lakes and sell to potential farmers mixtures of non-target species claiming they are supplying

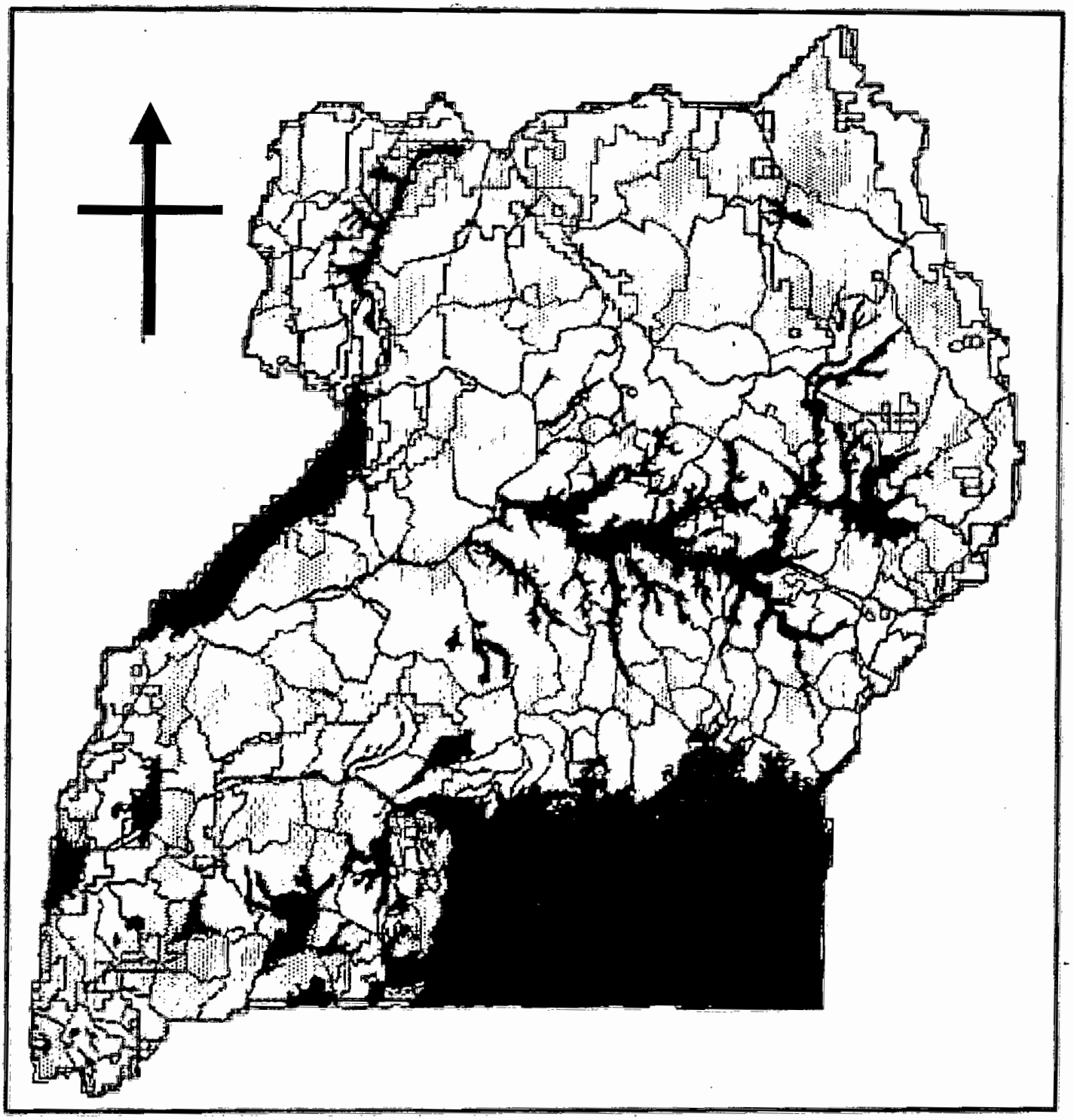

Fig. 1: A Map of Uganda Showing a Characterised Typical Tilapia growing zone (Shaded Orange)

Legend

A good Tilapia growing zone

quality fish. Many seed suppliers do not work closely with Kajjansi ARDC.

b) Lack of broodstock centres to supply quality seed (fry).

Broodstock (especially Nile tilapia) have to be isolated in screened-off breeding units; there are some of such centres in operation apart from Kajjansi ARDC. Fish farms are also often invaded by undesirable fishes from the wild e.g. from swamps and streams.

Kajjansi ARDC has been collecting broodstock from Lakes Victoria, Albert and George. These stocks held in Kajjansi ponds have not been multiplied and selected for quality strains in adequate quantities for release to private broodstock seed suppliers.

2) Nile tilapia prolific breeding resulting into stunted growth and poor pond yields, and abandonment of fish farming.

a) Congestion of the small (less than 10 X 10 m) ponds by fish due to prolific production.

When male and female fish are contained in one pond, reproduction results into over-crowding and stunting. The mono sex (male) technique which would also result into bigger fish, has not been adapted by farmers; in the case of polyculture ratios between the desirable density of tilapia (as prey and product) and catfish (with *Clarias* as predator and controller of proliferation) are not applied. Options for selecting all male stocks in ponds (sex reversal technique) are not well developed and multiplied among farmers.

3) Lack of adequate and appropriate fish feeds for fish farmers

Feeds are the most expensive pond input (60% of production costs) after construction (investment) costs. Poor feeding regimes reduce pond (farm) yields and profitability.

Farmers still rely on household wastes, brans (maize and rice), leaves of plants such as potato (*Ipomea*) and "dodo" (*Amaranthus*).

The young stages of fish (larvae and fry) depend on live feed especially zooplankton, ciliates, and bacteria. Such feeds can be developed through culture media manipulation to enhance survival of fry. Pellet feeds from formulated brans with mineral and vitamin bases can reduce waste and fouling as well as enhance growth. However due to the low level of fish farming, there are no established producers of quality fish feed. Food processing (chicken, cattle) industries produce by-products such as offals. Catfish have been shown to grow two to three times faster when fed on chicken offals in comparison to a diet made from brans.

4) Poor pond management practices

Management practices especially the application of recommended stocking densities, quality seed, polyculture, control of fouling (i.e. pond cleaning and liming) and fertilisation rates. Poor pond management is partly due to neglect (i.e. fish farming being regarded as a hobby) and inadequate information on pond management practices.

5) Limited variety of high value culture species

The number of endemic species for which there are established technologies for their reproduction and growth in Uganda is limited. There are the Nile tilapia, catfishes *Clarias gariepinus* and *Bagrus docmak*.

Nile perch and *Labeo victorianus* have ready market but their growing technologies are still under experimental development. The common/mirror carp (*Cyprinus carpio*), an exotic species originally imported from Israel is farmed on a small scale in the cooler parts in South-western Uganda.

6) Socio-economic constraints

Except for subsistence and hobby objectives, small-scale fish farming is not readily profitable. In terms of production per pond area per unit time, management (attention) and feeding costs, there is a minimum level of pond area and inputs below which fish farming as presently practised in Uganda is not of commercial value. The economic feasibility for sustainable small-scale aquaculture in Uganda has not been determined even though it may vary with geographical and market conditions. Large-scale commercial fish farming has not developed to its potential despite the sustainable environmental conditions for fish farming in most parts of Uganda. Major reasons for lack of development other than those cited above are socio-economic and cultural:

- Low pond yields (< 20 kg per $100m^2$ pond)
- Lack of markets
- Low prices for farmed fish
- Small-sized farmed tilapia and catfish,

Preference for larger-sized fish from lakes in comparison to pond production leads to:

- Absence of ready markets for small-sized farm fish in lake zones especially Lake Victoria
- Inadequate knowledge on economic feasibility (including costs and returns from fish farming per hectare in comparison to crops) due to inefficiencies in the production-to-market-to-consumption patterns.

7) Lack of investment credit schemes

On small scales, fish farming requires more capital (pond construction) than crops and returns from crops are faster. Combined with the enumerated constraints, fish farming ventures need to be on commercially viable scales in which the market has to be generated. The establishment

of large commercial farmers would provide markets for small-scale farmers who would act as out growers for the large farmers with ready markets.

8) Marketing Constraints

In areas around lakes especially the Lake Victoria crescent and the Kyoga region (Central Uganda), the limited market and low price structure for small-sized (<0.5 kg) fish from fish farms discourages commercial fish farming. Fish farming directly competes with the preferred larger sized (1 kg pieces) quantities from the lakes. However, it is not economical to farm fish beyond 0.5 kg per piece. Beyond this size (which requires more than six months culture) feeding expenses and management costs increase. The problem is compounded by the law, which prohibits the sale or handling of "immature" fish; basically all farmed tilapia (unless provided for in law and labelled or licensed) would not be allowed on the market.

Small sized processed (salted or sun-dried) tilapia (also known in fishery circles as "bambara", "bufingiri") are a delicacy for the regional markets in DRC, Kenya, Sudan and Rwanda. Therefore, if organised markets can be identified and farmed fish can be identified, fish traders could promote fish farming. There are many other countries exporting farmed tilapia with a demand market size of 350-500 g. These sources include South East Asia countries such as Vietnam and Malaysia where fish (tilapia) are major sources of foreign exchange earnings. Therefore, the marketing constraints are closely tied to other socio-economic constraints that would need to be addressed if large-scale fish farming in Uganda is to take off.

9) Geographical and environmental considerations

Studies have shown that the warmer parts of Uganda especially the West Nile-Acholi-Lango systems have a higher potential for fish farming. The

higher temperatures (25^0-30^0C) and their far removed geographical position in relation to the larger lakes makes Northern Uganda an area where fish farming can readily be adopted. In discussions with the District Fisheries officer (Gulu), the following observations were noted:

a) Opening up commercial aquaculture would be attractive as there is a perennial fish shortage in the area and a ready market is guaranteed.
b) There would be cheap labour to work on large farms
c) Individuals are keen to take advantage of possibilities such as supplying seed, trading in fish, etc
d) The Aswa River and its tributaries as well as several streams provide permanent sources of water
e) The Water for Production Project under DWD involves setting up 20 ha water schemes which could be coupled to commercial aquaculture
f) The Northern Uganda Rehabilitation Project could consider promoting large scale fish farming in the area
g) Land availability provides advantages to large scale investors

In other parts of Uganda, fish farming has been associated with wetland-dominated (swamps) areas. This explains why central and Eastern areas (around Lake Victoria and numerous Kyoga basin lakes and swamps) are favoured fish farming areas. These are also rice-growing areas but pisculture (rice- fish systems) is not practised. In addition, just like rice growing, large-scale fish farming in wetlands raises concerns about environmental suitability for such projects.

10)Nile perch

Contrary to previous assumptions, experiments at Kajjansi ARDC have shown that Nile perch can be cultured in earthen ponds, concrete tanks and

cages. The experiments have shown that a major input in growing Nile perch in ponds is feed. Nile perch are carnivorous feeding mostly on other fish and insects, a major cause of the species change in lakes Victoria and Kyoga where Nile perch were introduced.

11)Cage Fish farming

This culture system, which rears fish in captivity within lakes, rivers and streams, can achieve high fish production and economic efficiency. Various types of cages, feeding regimes and cage management are known technologies. In collaboration with DFR, it is intended to extend the Nile perch experiments into trial cage cultures in locations to be identified. A major consideration is the environmental aspect and suitability of introducing cage culture as a form of aquaculture commercialisation.

12)Farming ornamental Fish (Haplochromines)

The ornamental fish trade is based on remnants of the diverse haplochromine fauna found especially in satellite lakes and specific habitats in the large lakes and rivers. Although an international market exists for these fishes, it is not organised. Moreover, the large-scale dependence of an international ornamental fish trade on wild stocks could endanger unique species and would be subjected to appropriate conventions. This type of trade is therefore regulated but were categories of fish farms licensed to culture ornamental fish, it is likely that markets could open up. The farming for the small ornamental fish need not be on large scales envisaged for Nile tilapia, catfish, etc. For the small (<10 cm long) haplochromine fishes, concrete tanks and pumps could sustain commercially viable units once markets and sources of seed are identified.

13)Conclusion and the Way Forward

Alignment of aquaculture research to the MTP and PMA have involved discussions at various levels in the past. These culminated into the attached concept note developed towards the end of 2002. The on-farm-on-station research activities have attracted much attention but there is still along way to go to develop commercial aquaculture in Uganda. The summarised constraints should be ranked and time-framed for continuous monitoring.

Aquaculture production can increase from < 100 mt at present to at least 20,000 mt by 2006. The increase in production will meet only one-third of the estimated shortfall in fish production of 60,000 mt by that time. The expected increase will also only cover domestic demand. Moreover, the northern Uganda zone unless targeted will not substantially contribute to the sub-optimal increase in fish farm production. Therefore, the following activity-oriented objectives should be pursued in both research and development terms.

1. Improve strains of culture species especially tilapia and multiply quality broodstocks for wider dissemination.
2. Develop culture of high value species and strains (tilapia, Nile perch, catfish, *Labeo*, ornamental fish) and promote culture of mirror carp in cooler zones.
3. Develop quality feed especially pellet feeds
4. Develop technology for production of live feed (plankton, crustacea, ciliates, etc
5. Develop and promote mono-sex (all-male) technologies and culture
6. Test different culture systems (single species, polyculture, cage culture) and provide economic feasibility of the different systems
7. Build public-private sector partnerships in seed production, feed development and farm management
8. Promote for adoption polyculture systems

Clarias (Catfish) / tilapia

Labeo /tilapia/catfish

Tilapia/mirror carp/catfish

9. Develop simple guidelines for pond management (stoking densities, fertilisation regimes, thinning, fish health and water quality monitoring)
10. Establish economic feasibility of the different culture systems in different farming systems
11. Identify international markets with firm orders of farmed fish over specific time frames and aggressively promote commercial farms based in feasibility studies for investment analyses,
12. Promote small to medium scale fish farming co-operatives in northern Uganda and, if markets are , promote large scale aquaculture investments in the West Nile-Acholi-Lango systems.
13. Develop technologies for harvesting gear, post harvest handling including marketing

Focus for Kajjansi ARDC

Package available information by October 2003 as agreed in the Work Plan on:

1. Improvement of quality of cultured fish species and strains – A Guide for Practitioners
2. Development of high value species
3. Fish seed production
4. Technical Guidelines for:
    - Pond siting and construction
    - Culture of Tilapia
    - Culture of catfish
    - Culture of common carp
    - Fish feeds for fry, grow-out and broodstock

5. Elaborate on station experiments in comparison to field trials e.g. comparison of growth performance under different temperature, stocking density, feeding regimes etc
6. Perfect on-station catfish fry production

Annex 2

A record of farmers with interests/plans to develop commercial fish farming enterprises*

1. Hon. D. Migereko (Jinja)
2. Hon. M. Mutagambwa
3. Hon. S. Bbumba (Luwero)
4. Hon. J. Mukwaya (Mukono)
5. Hon. Kweronda- Ruhemba
6. Mr. A. Mubanda
7. Mr. D. Tugumisirize (Digo)
8. Mr. M. Tukundane (Mbarara)
9. Mr. Kazibwe (Lugazi)
10. Mr. C. Kassami
11. Mr. Nsubuga (Ranch on the lake)
12. Two foreign investors (enquiries)

* There is currently a Uganda Commercial Fish Farmers' Association

RESEARCH-EXTENSION-FARMER PARTICIPATORY RESEARCH TO IMPROVE AND INCREASE AQUACULTURE PRODUCTION IN UGANDA

Background

Fisheries are currently very important in the economy of Uganda with fish being among the two most important export commodities. The demand for fish in Uganda has increased tremendously due to increased fish exports and local demand by the increasing human population. There is therefore need to increase fish production to meet the increased demand. Aquaculture provides one of the avenues for increasing fish production.

The key constraints to increasing aquaculture production in Uganda have been identified as inadequate supply of quality fish fry and poor feeding and pond management practices. NARO recently developed a Medium Term Plan (MTP) to guide provision of its services to stakeholders. Under MTP, NARO is implementing two broad projects for the fisheries sub-sector. One project is focusing on capture fisheries and the other on aquaculture.

The project on aquaculture targets: "*Enhancement of Fish Farming through Improved Fry Production, Pond Management and Feeding*". Therefore, research in aquaculture focuses on improving production of quality fry and pond management especially feeding. The project is promoting culture of the two currently important aquaculture species, the Nile tilapia (*Oreochromis niloticus*) and the catfish (*Clarias gariepinus*). The project also targets introducing the originally popular species such as the Ningu (*Labeo victorianus*), the native Lake Victoria Ngege (*Oreochromis esculentus*), and the current economically important Nile perch, and ornamental fish into aquaculture.

The Kajjansi Aquaculture Research and Development Center is adopting a participatory approach whereby fish farmers and extension service providers will be involved in on-station and on-farm activities. The rationale of this approach is to promote exchange and cross fertilization of skills between researchers, extension service providers and fish farmers to improve and increase aquaculture production in Uganda.

The participatory process involves identifying, mobilizing, training and working with extension agents, fish farmers and fish fry producers from selected sub-counties within selected pilot districts in fish farming. The emphasis is on fish fry production of quality fry and improvement in pond management practices. This requires on-station activities at Kajjansi ARDC; and on-farm activities with fish farmers and fry producers in selected pilot districts.

On-station Activities

On-station activities include carrying out on-station research to generate or adopt technologies and preparing the station for training of extension service providers, fish farmers and fry producers. This involves:

1. Rehabilitation of ponds for holding brood stock, nursing fry;
2. Construction of concrete tanks for experimental work and for nursing fry;
3. Setting up a system for processing feeds;
4. Collection and improvement of brood stocks through selection;
5. Formulation of feeds;
6. Testing performance fry produced from broodstock aquatic systems under different feeds, fertilization and other pond management regimes;
7. Production of Tilapia (*Oreochromis*) and Male (*Clarias*) fry for stocking ponds from existing fry producers participating in the program;

8. Preparation of training materials (brochures, pamphlets, booklets, training manuals) for use by researchers, service providers, farmers and fry producers;
9. Organising training workshops for fish farmers, fry producers and aquaculture service providers in fish farming techniques and fry production;
10. Collection and propagation of Ningu and native Ngege.

These activities are undertaken by researchers.

On-farm Activities

On-farm activities take place on the fish farms of participating farmers and are in two stages: The first stage involves:

1. Identifying pilot districts and sub-counties within the districts to participate in the pilot program;
2. Assessing the state of aquaculture in selected districts and sub-counties within the districts;
3. Examining district and sub-county development plans and assessing the interest and potential for aquaculture;
4. Establishing the number of fish farmers, fry producers and the number of ponds in pilot sub-counties;
5. Selecting contact farmers within sub-counties (about 10 contact fish farmers are selected from each pilot sub-county);
6. Selecting up to two potential fry producers in each of the pilot districts;
7. Conducting a residential training course at Kajjansi ARDC for contact fish farmers and extension service providers from the selected districts;
8. Training the fry producers on-station at Kajjansi in fry production techniques including selection of quality brood stock, production and handling of fry;

9. Establishing baseline data on contact farmers ponds (area, pond conditions, etc).

These activities involve scientists from Kajjansi ARDC, sub-county and district leaders, extension service providers, and fish farmers and fry producers.

The second stage involves on-farm activities on the farmer's ponds. They depend on the level to which individual farmers have advanced in aquaculture.

The on-farm fish production activities include:

1. Guiding the farmers in methods of preparation of ponds;
2. Stocking the ponds;
3. Monitoring the performance of stocked fish including environmental parameters in the ponds through regular joint sampling by the researchers, extension service providers and farmers (An appropriate system of recording information during and between visits is developed during training and updated during visits);
4. Assisting farmers at sub-county level to organise themselves into fish farmer groups. The groups from sub-counties will then organize themselves into district fish farmer groups;
5. Provide the private fry producers with some basic fry production materials such as nets and hapas;
6. Collect, select and provide fry producers with quality brood stock;
7. Monitor the performance of brood stock and quality of fry produced regularly;
8. Inventory the number of fish farmers per fry producer;
9. Assess appropriateness of the technologies in terms of resource affordability and labour availability;
10. Assess benefits realised by farmers from aquaculture (By Socio-economists) in comparison to other activities (e.g. crops, poultry);

The main actors here will be fish farmers, fry producers, extension agents and researchers. This is a participatory process. The farmers, researchers and extension service providers are supposed to learn from each other's experience.

The Development partners supplementing government efforts include DFID (mainly in northern, central and western Uganda) and LVEMP in the Lake Victoria basin.

Attn: Director, FIRRI, Jinja

THE CONCEPT FOR COMMERCIALISATION OF AQUACULTURE

Background

Whereas subsistence aquaculture plays a very important role in terms of household nutrition, it has now been recognized worldwide that its economic contribution at whatever level is insignificant and it cannot lead to the development of aquaculture. The main driving force behind the development of this sub-sector to make it contribute to economic advancement is the earnings and profits that can accrue. Increased earnings and profits from the sub-sector will motivate people to make increasing investments into the sub-sector and that is how it can develop sustainably and this should be the goal for the promotion of the sub-sector.

The Goal

To contribute significantly towards improving the livelihood all Ugandans and the economy of the nation through aquaculture.

The **Vision** for aquaculture development is:

Market-driven, competitive, dynamic and profitable aquaculture

The definitions of the terms used in the vision are:

i. **Market-driven** = the forces of demand and supply to be the key driving force in investments
ii. **Competitive** = to win and sustain the market (ie. Continuously striving to be the best) amongst other players
iii. **Dynamic** = keep responding to changing market demand
iv. **Profitable** = striving to produce highest quality products and the lowest possible cost.

This vision is in line with the Government policy of **Modernization of Agriculture** to which all agricultural development plans must respond.

The research strategy to support commercialization of aquaculture

The following are the conceivable research strategies to achieve the vision and the goal.

1 The strategy of promoting large scale aquaculture

It has been realized worldwide that small-scale aquaculture is not economic. Profitability of aquaculture increases with increase in scale of operation and there is a minimum pond size at which the operation becomes economic. This minimum economic level of operation has not yet been established for Uganda. The lack of this information and the uncertainties that go with it have discouraged both potential investors and the finance

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institutions from investing in aquaculture. There is, therefore, an urgent need to determine the minimum economic level of aquaculture operation for Uganda.

2 Determination and demonstration of the profitability of aquaculture operation

It is not enough just to establish the minimum economic scale of aquaculture operation but the profitability is equally important. Investors and financiers would like to know what the rate of return to an aquaculture investment is and what are the potential risks in aquaculture operations. These are all economic studies.

There are few examples of a successful fish farmers in Uganda and this lack of examples poses a bit of uncertainty in aquaculture. Once the profitability of aquaculture is established, there is need to demonstrate to potential investors that it indeed works. The Aquaculture Research and Development Centre (ARDC) Kajjansi has several commercial size ponds the largest of which (0.8 – 1.5 ha each). Such ponds could be rehabilitated for purposes of studying and demonstrating the profitability of aquaculture in Uganda. The empirical data obtained would give more confidence to intending investors.

3 Development of alternative aquaculture production systems more akin to commercial aquaculture.

Earthen pond aquaculture has its own limitations, one of which is dependence on the availability of sufficient amount of water for large scale ponds. Alternative systems are known that offer more opportunity for commercial aquaculture operations. These include cage culture system which can be operated in small water bodies (eg. Minor lakes and valley tanks) and in lakes. Cages are being used in many countries with productions in hundreds of tons but have not yet been adopted in Uganda. The nearest example is in Zimbabwe where hundreds of tons of Tilapia are being produced for export market each year. There is an urgent need to adopt and adapt cage culture system in Uganda

The cage culture systems would particularly target high value species like Nile perch and Nile tilapia.

4 Targeting more profitable markets

At the moment aquaculture production, where fish is sold at all, is most suited and limited to pond-side sales, mainly because of the type of fish being cultured and the small- scale nature of production. It is not economic to transport the meager production to distant markets, which would offer higher prices.

What kinds of markets are available for aquaculture products? Production levels beyond the National requirements can immediately target the regional markets (Kenya, D.R. Congo, Rwanda and Sudan). Beyond this level, and as aquaculture develops in scale, the international markets over seas also offer opportunities. Each of these different markets demand slightly different fish species and different products, as explained below.

i Regional markets

Traditionally there has been a substantial amount of trade in fish and fish products in Rwanda, D.R. Congo, Sudan and other neighbouring countries from Uganda. The trade has been mainly in small size tilapia and Nile perch in sun-dried/salted form ("bambara"). However, the trade has largely been illegal because of the small immature fish from the lakes, which are in contravention of the fishery laws. Therefore the trade has always been interrupted by law enforcement agencies.

However, fish produced from aquaculture, whatever size, does not break any law. If the small size is what the market prefers, then aquaculture can target such markets. After all, aquaculture is more profitable with smaller size harvest than the very large fish. This kind of trade becomes more economic at a larger scale. This calls for either (a) the need for the present farmers coming together to pull together their productions into scale that make economic sense to transport to such larger markets or (b) for the creation of a middle man to be buying off productions from the small scale farmers an build the bulk for then market. Salted/sun-dried fish can be stored for months in good condition and this allows time to accumulate stock.

ii International markets

The major limit to penetrating the international markets for aquaculture products for sometime will be the small scale of production that does not make economic sense in export trade. Along side the demand for large scale production, the international markets demand very rigorous adherence to high standards of products.

The main products required in the international markets are Nile perch and Nile tilapia, mainly in the form of frozen fresh fillets. The markets will demand tens of tons of these products on weekly basis. Such production levels will be met when intensive cage culture systems have been developed, as is the case in Zimbabwe which exports tone of frozen fillets of tilapia to the UK.

5. Targeting high value fish (the Nile perch)

The Nile perch export has boosted significantly the economy of Uganda and its demand in international markets is on the increase. The white flesh of the Nile perch and Tilapia are the preferences of the international markets and these two fish species remain the target for these markets. Production of these fishes from the lakes can meet the demand and alternative sources, especially aquaculture, are urgently required.

Whereas production of tilapia through aquaculture is a familiar practice only requiring scaling up, production of the Nile perch has not been attempted yet in Uganda. Some initial observations of the Nile perch in ponds and tanks are going on at ARDC Kajjansi which are beginning to give some clues about the behaviour of the fish in captivity. Nile perch grows very well in ponds, increasing its weight by about 12% each week. The main limitations as yet is the shear amount of live fry required to feed Nile perch (up to 40

Tilapia fry of 0.2g per night for a 20g Nile perch). While Tilapia fry remains a profitable item, it does not make much economic sense to feed this amount to Nile perch. The main challenge is how to wean the Nile perch to dry diets.

The next two main challenges before the Nile perch can be cultured are i) to develop the technology for breeding the Nile perch in captivity to make the seed available for stocking, and ii) to develop proper production system for the fish. Cage culture seems to be the most feasible method.

6. Development of high value, cost-effective aquafeeds

Commercialisation of aquaculture will be directly linked to availability and the use of nutritious and cost-effective fish feeds. This will facilitate intensification of production. Attempts have been made at ARDC Kajjansi at developing fish feeds with very encouraging results with Nile tilapia and the Catfish. Another trial with a waste from a food processing industry (chicken offal) has also revealed that it is very effective in the production of Catfish. In these efforts there is a lot to benefit from stronger linkage and collaboration with the private sector, especially the food processing industries (fish processing, poultry processing oil processing, etc).

7. Adoption of technologies for intensification of production of fish seed

A pre-requisite for intensive aquaculture is methods for intensive production of fry for stocking. For example, production of 500 ton of tilapia fillet per month requires a continuous supply of 3.5 million fry per month. Such scales of fry production cannot be met by the current technologies in Uganda. These technologies exists in countries that have advanced in aquaculture, like Israel, Thailand, China, Belgium, etc. They only need to be adopted and adapted to Ugandan conditions.

Very closely linked to and to support mass fry production, is technologies for mass production of larval food which can also be adopted from countries with more advanced aquaculture. But equally important in fry production is the development of a rigorous fish genetics and breeding program to improve fish yields.

8. Develop mechanisms to facilitate quick adoption of technologies and acquisition of skills by the farmers

This can best be achieved through technology dissemination and training programs for farmers and extension staff. Built within dissemination are technology demonstration and farmer participatory research programs.

9. Developing mechanisms for supporting National planning and Policy

All development plans are achievable through good government policies, which are then translated into action plans. A good policy and national plan requires accurate and

reliable information/data from research. Therefore, there a strong need for close link research with policy for purposes of provision of information and receiving feed back.

10. Setting in place mechanisms for prompt response to the changing market demands

If the force of demand and supply is what should drive aquaculture research and development then there is an urgent need a mechanism for responding very quickly to the changing demands of the market. A scenario such as the demand for the Nile perch by the market being way ahead of research towards culturing the fish should not arise. This entails researchers being abreast with current market desires through market research and information.

11. Developing a research institution that produces high quality science and technologies and that is responsive to demands

The effectiveness of a research institution depends on both the personnel and the facilities, laboratory and equipment inclusive. The personnel need to be highly qualified and well informed. They need training, exchange of research findings with other research institutions through seminars, workshops and conferences; exchanging expertise through collaborations, etc.