Markets, Marketing and Production Issues for Aquaculture in East Africa: The Case of Uganda

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Abstract. Aquaculture is currently responsible for an insignificant proportion of total fish production in Uganda. However, given increasing demand for fresh fish in urban and peri-urban areas, and threats to the supply of fish from natural catch fisheries there seems to be a potentially strong market for fish and fish products produced by aquaculturalists. Small-scale fish farmers that are relatively close to markets or all season roads, and can supply consistent and high quality produce, will have the widest range of marketing opportunities, and will likely be within the scope of potential traders and intermediaries that deliver fish to markets. Fish farmers that are not close to roads, or produce unreliable quantities and quality of product may face high transactions costs of marketing their product, decreasing net returns to production. We also find that significant on-farm labor, and access to input markets are important factors leading to positive net returns to fish production. Areas with high population density and relatively low wage rates will be well suited to labor intense aquaculture. We conclude that aquaculture development has good potential in certain areas of Uganda and should therefore be pursued as a potential development pathway. However, policy makers should consider the importance of the price of fresh fish relative to the cost of labor, as well as other factors including the importance of smallholder credit and access to extension services when directing investments in aquaculture technology.

Keywords: aquaculture, Uganda, wetlands, fish farming, Lake Victoria, marketing

INTRODUCTION

Aquaculture is a non-traditional technology that has been adopted by smallholders in sub-Saharan Africa to a very limited extent. Despite considerable efforts by governments, national agricultural research organizations (NAROs), non-government organizations (NGOs) and donors to promote it as a sustainable technology that is easily integrated into farming systems, and has the potential to improve food security and incomes for rural populations, aquaculture has not taken hold. Although aquaculture technology adoption to date has been very poor in the region, increasing numbers of food insecure rural poor, persistent land degradation, and pollution and overuse of traditional fishery resources suggests that aquaculture should be revisited as a potential development pathway. The objectives of this paper are twofold. Taking Uganda as our case study we ask the question, does Uganda have sufficient demand to support an increase in the supply of fish produced using aquaculture technologies, and if it does, what are the potential marketing issues that smallholder fish farmers might face? We then consider the farm-level conditions under which aquaculture production will be most favorable, identifying socio-economic characteristics that will likely lead to positive returns to fish farming.

Uganda has a strong fish culture supported by natural catch fisheries throughout the country. The demand for fish is further supported by income and population growth in urban areas, and an increasing and food insecure rural population. As demand for fish and fish products are increasing – the supply of fish from Uganda's lakes and rivers is threatened by increasing pollution, unsustainable fishing practices and the proliferation of water hyacinth. This situation of increasing demand and decreasing supply from catch fisheries provides an opportunity for smallholders willing to invest in aquaculture technologies to capitalize on fish prices that are likely to increase in the short to medium term. However, there are several marketing issues and transactions costs that smallholders face with respect to getting their product to market, including issues of transportation and processing.

In addition to market signals and output prices, land use decisions hinge on relative profitability conditioned by endowments of farm level factors of production, as well as the institutions and services accessible to farmers. Integrating aquaculture into the production system of any small farm requires careful consideration of the opportunity cost of land, labor and material inputs, often influenced by factors such as access to credit, local institutions including land tenure, and the quality and availability of extension services. Population density and market access may have a significant impact on the factors affecting farm level fish production.

AQUACULTURE IN UGANDA – HISTORICAL CONTEXT AND PRESENT SITUATION

Aquaculture was introduced to Uganda as a non-traditional farm technology in the late 1950s (King, 1993). The Uganda Game and Fisheries Department constructed Kajansi Experimental Station, and Fisheries Extension Agents (known as fish guards) were trained and posted to rural areas to educate and train farmers on pond establishment and management. The initial push for fish farming in Uganda was quite successful, with over 5,000 ponds established by smallholders throughout the country by 1959 (FAO, 1984). During the 1960s fish farming gained popularity throughout the country, but was concentrated in only a few counties, peaking at approximately 11,000 ponds nation wide (MAAIF/DFID, 1998).[1] In addition to increased technology adoption by farmers during this period, government researchers at Kajansi were experimenting with carp culture, *Tilapia* hybridization, and predator control (Balarin, 1985). Due to political instability, constraints on transportation for Fishery Extension Agents, and lack of access to inputs including fry, the mid-1960s would be the last period of fish culture activity in Uganda until the mid 1980s when Museveni's administration came to power (Kigeya, 1995). During the 1970s and early 1980s the majority of fishponds were abandoned.

Renewed interest and investment in fish farming by the Ugandan government, donors and NGOs have lead to a modest resurgence of smallholder fish farming. Research activities at Kajansi have resumed, public radio broadcasts provide information and encouragement for fish farming, and the Ministry of Agriculture, Animal Husbandry and Fisheries (MAAIF) has a goal of integrating fish farming into the agricultural technology portfolio offered by extension officers (Kigeya, 1995). At present there are an estimated 7780 fishponds in Uganda with an average surface area of 200 m^2, totaling approximately 1,500,000 m^2 of pond area (NARO/FRI, 2000). Ponds are generally stocked with a mix of the local *tilapia* species, together with common carp and the indigenous African catfish. Relative to other countries in the region, aquaculture has maintained good rates of growth between 1990 and present (FAO, 1997).

Despite gains in aquaculture during the past decade, there still remains enormous untapped potential for fishpond development. However, the successful adoption and integration of this technology into smallholder farming systems will not be easily achieved. There are substantial constraints and significant potentials with respect to both marketing and production that are critical to the question of whether or not this technology should be strongly promoted for rural smallholders. Aguilar-Manjarrez *et al.* (1998), in an assessment of African fish farming potentials and constraints in Africa used geographic information systems to illustrate the potential for small-scale aquaculture development in Uganda. Table 1 provides a summary of their findings. Although the mainly biophysical criteria presented indicate that there is significant potential for aquaculture development in Uganda, a wide range of economic, social, cultural, institutional and environmental factors will also influence production and marketing potentials, and these factors are likely to be widely divergent throughout the country.

Table 1 – Constraints and Potential for Small-Scale Aquaculture in Uganda

Relative surface area with:	Very Suitable	Suitable	Moderately Suitable	Unsuitable
Net annual water requirement for shallow ponds	0%	98%	2%	0%
Soil and terrain suitability for ponds	71%	25%	4%	0%
Livestock wastes and agricultural by-products as feed and fertilizer inputs	29%	4%	47%	20%
Potential for farm-gate prices	12%	70%	15%	3%
Suitability for small-scale fish-farming	90%	8%	2%	0%

Source: Aguilar-Manjarrez and Nath, 1998.

[1] Between 1962 and 1966 approximately 90% of fishpond activities were concentrated in Kyadondo, Bulemezi, Singo and Busiro counties, which are situated close to Kampala and Lake Victoria (Kigeya, 1995).

Table 2 – Average household monthly expenditures on fish by urban vs. rural areas, Ugandan shillings

Region	Urban Areas		Rural Areas		Total	
	Mean hhd. expenditures on fish	% Mean hhd. expenditures	Mean hhd. expenditures on fish	% Mean hhd. expenditures	Mean hhd. expenditures on fish	% Mean hhd. expenditures
Central	1872	3.25	1445	3.96	1543	3.73
Eastern	2125	4.29	1076	4.54	1164	4.51
Western	687	1.38	570	1.59	576	1.59
Northern	2228	7.85	1119	5.07	1219	5.38
Uganda	1776	3.33	1037	3.28	1133	3.29

Source: MPED, 1991.

MARKETS AND MARKETING OF SMALLHOLDER AQUACULTURE PRODUCTS

Uganda's biophysical potential for aquaculture suggests that the supply of fish products could be significantly expanded under certain socio-economic conditions. However, the question of how much additional supply the market will bare, and how shifts in supply and demand will affect fish prices are important, and will have implications for the net returns of fish farming to smallholders. Information on the supply and demand for fish products produced using aquaculture technologies in Uganda is limited. However, there is considerable understanding of supply and consumer demand, and fish marketing for catch fisheries (for example, see Kirema-Makusa *et al.*, 1993). We extrapolate from knowledge about existing fish product markets to frame our discussion of likely future trends and how they might impact the adoption of aquaculture technologies for smallholder farmers. In addition to supply and demand, we consider existing marketing channels for fish and fish products and discuss the considerable constraints currently facing the development of aquaculture beyond the fringes of urban areas that are well served by good transportation networks and fish processing facilities.

Markets – Demand Side Factors

Perhaps one of the most important conditions for reliable consumer demand for fish products is a well-established culture of fish consumption in regions where fish are produced. Surprisingly, development agencies, NGOs and national agricultural research organizations in many countries in sub-Saharan Africa have tried to introduce aquaculture to regions where there is no tradition of fish consumption. These projects have almost always resulted in failed technology adoption. In Uganda, by contrast, there is a strong fish culture. Kigeya (1995) estimates that approximately 75% of Ugandans consider fish a traditional part of their diet. Average annual fish consumption of 12.7 kilograms per capita is estimated to be relatively stable, with higher fish consumption rates observed in regions that fall in close proximity to Uganda's large lakes. Low fish consumption rates in other parts of the country may be due to poor distribution, underdeveloped markets and preservation technologies, and unreliable transportation networks (*Ibid.)*, but may also be attributed to the incidence of pastoral communities that have clear preferences for livestock as their source of protein.

Consumer demand for fish products is variable depending upon whether or not urban or rural demand is considered.[2] Uganda's urban demand is centralized in the cities of Kampala and Jinja. Due to close proximity to Lake Victoria and the Nile River there has been a longstanding tradition of fish consumption in these cities, and markets for fish and fish products from catch fisheries are well developed. There are two factors that are likely to lead to increased demand for fish and fish products in urban centers: the rate of urban population growth, and increasing incomes in urban areas. Uganda's urban population more than doubled between 1970 and 1998 (a 251 % increase), reaching almost 3 million in 1998, and is presently growing at a rate of 5.3% per annum (World Bank, 2000). Data from the early 1990s indicate that average expenditures on fish by urban households are higher than for rural households due to higher incomes in urban areas, though urban households did not spend a higher proportion of their incomes on fish (Table 2). Thus, urbanization per se apparently will not increase fish demand.

What is more likely to have a profound effect on demand for aquaculture products in urban areas is income growth. Findings from the Ministry of Planning and Economic Development 1991 household and budget survey suggest that there is a relatively high income elasticity of demand for fish in Uganda. A breakdown of money spent on fish per month by monthly expenditure groups in municipal areas in Uganda suggests a strong positive correlation between income and expenditure on fish. For example, in Kampala average expenditures on fish for low-income

[2] One can also consider the demand for fish and fish products for export, however in the context of this analysis and in light of the transportation and processing constraints noted in the following section it seems unlikely that global demand for fish will greatly influence local fish production from ponds in Uganda in the near future.

groups (<50000 Ushs./month) were 1126 Ushs. or 3.76% of total household expenditures, whereas expenditures for the highest income group (>100000 Ushs./month) were 3502 Ushs (MPED, 1991). MAAIF/DFID (1998) suggest that a major factor contributing to the increase in fishponds in recent years has been rising demand in urban areas. Many smallholders have turned to fish farming to supply their own households or for local sale, and some farmers have been able to produce breeding stock for others.

Rural demand for fish produced in fishponds is also likely to be significant, particularly where catches from natural fisheries have been reduced (see discussion on sustainability in Uganda's catch fisheries in the following section). Fish consumption is expected to drop without alternative sources of fish, if the maximum sustained yield from natural fishery resources is being exceeded (Balarin, 1985). This has considerable implications for household level food security. Data indicate that between 1992 and 1997 the poorest 20% of Uganda's population became poorer – living on less than $1 US per month (APSEC, 1999). Further, in 1992, more than half of farmers reported that the productivity of their land was declining due to land exhaustion and poor management (FAO, 1999) making it harder to provide even at a subsistence level for their families. Diversification of farming systems into aquaculture technologies, driven by increased demand for fish and household food security needs may be a valuable opportunity for smallholders, allowing farmers to improve overall farm productivity as well as satisfy household level demand for fish and fish products.

Markets – Supply Side Factors

Although Uganda is well endowed with natural fishery resources, there is an increasing yet still inconclusive body of evidence indicating that the maximum sustained yield (MSY) of Uganda's primary catch fisheries is being surpassed (Wilson *et al.*, 1999), and that environmental problems are limiting fish health and smallholder access to fishery resources. Reliable data on current annual fish catches for the region are limited, but there is evidence to suggest that the major lakes are being over-fished. One recent estimate of the MSY for Nile perch was approximately 300,000 metric tons for the whole of Lake Victoria. Rough official statistics of annual catches on the Tanzanian side of the Lake fluctuated between 146,000 and 213,000 between 1988 and 1993 (CIFA, 1994).[3] On the Ugandan side of the Lake the total commercial catch of Nile perch in 1989 was estimated by the Uganda Department of Fisheries (UFD) to be around 67,500 metric tons (Kirema – Mukasa *et al.,* 1993). When considering these statistics in combination with the high volume fisheries and fish processing facilities on Lake Victoria's Kenyan shores it seems likely that yield from the Lake is far surpassing sustainable levels.[4] In addition, there is anecdotal evidence that the size of perch being caught and the presence of roe (fish eggs) is decreasing, further suggesting that the Lake may be over-fished (Pitcher *et al.,* 1995).

Other factors are reducing fishery resources and inhibiting artisanal fishers from accessing the resource that their livelihood depends upon. Water hyacinth has become an increasingly significant problem that threatens most of Uganda's waters. Water hyacinth in Lake Kyoga has made extensive areas of the lake no longer available as fishing grounds; the weed has seriously impeded navigation (Kirema – Mukasa *et al.,* 1993). Water hyacinth has also become a major problem on Lake Victoria, making fishing difficult particularly for small fishermen. Although several non-polluting methods have been proposed and experimented with (for example, the introduction of insect species that eat the weed), there are persistent rumors of the use of chemicals to destroy the weed. A number of recent poisonings and deaths related to the consumption of fish contaminated by chemicals suggests that chemicals are being used to destroy water hyacinth, and precipitated the European Union to impose a ban on fish exports from East Africa because of contamination fears (Ramadhan 2000). Agro-chemicals readily available in the region are also being used to kill fish that can no longer be caught using traditional methods due to the encroachment of the hyacinth (*Ibid.*).[5] Persistent problems of eutrophication from agricultural and waste run off, and the manufacture of soaps and cosmetics on Kenya's lakeshore have also contributed to pollution in Lake Victoria and decreases in the quantity and quality of fish caught.

Although the sustainability and pollution issues facing Uganda's natural fishery resources are in need of greater study, evidence indicates that Uganda may face limitations on natural fish supply, particularly as demand is increasing with population and income growth. Further, shifts in demand and supply are likely to increase prices for fish in the medium-term contributing to the profitability of fish farming. In recent years, resource poor farmers, with little or no encouragement have undertaking pond construction in areas close to natural

[3] The thirty-year presence of the predatory, non-native Nile perch, has reduced the Lake Victoria fishery to three commercially important species: Nile Perch (*Lates niloticus),* Nile tilapia (*Oreochromis niloticus)* and dagga (*Rastrineobola argentea).*

[4] Kenya, Tanzania and Uganda control 6,51 and 43 percent of Lake Victoria respectively.

[5] Alpha-Endosulfan, Beta-Endosulfan, Thiodan and Eddoder EC35 are being used by local fisherman.

catch fisheries. However, despite their efforts contributions to fish supply are so far minimal: production is estimated to be around 50 tons/year, insignificant compared to total fish catches from lakes and rivers of around 200,000 tons/year (MAAIF/DFID, 1998). There is however lots of room for growth, but aquaculturalists may face constraints with respect to their participation in fresh fish markets due to limitations in the existing fish marketing system.

Marketing

Fish marketing from natural catch fisheries as it exists in Uganda today is very complex involving transportation of fresh and processed products over a wide geographic range by a large number of traders and processors both formal and informal. Currently fish caught on lakes or rivers are channeled to consumers through a variety of conduits including the direct sale of fish to households at canoe landing points on lakes or rivers, sale to households via headload or bicycle traders that buy fish from fishermen at landing points, wholesalers that collect fish with pick up trucks in fairly large quantities delivering it to retailers, and processors that undertake basic processing such as salting and then sell to traders or consumers directly (Kirema-Mukasa, 1993). Larger commercial marketing channels also exist; however, the majority of wholesalers and large-scale producers cater to the export or high-end urban markets and generally do not deal with fishermen with small production levels. It is reasonable to assume aquculturalists could use the most basic marketing channels (i.e. landing point to consumer, or landing point to consumer via headload/bicycle). As long as distances are small, and there are reasonable profits to be made by intermediaries transporting fish and fish products to consumers, there is reason to believe that the role of traders and middlemen in Uganda's fish market will remain strong and adapt to a changing market structure.[6]

If small-scale aquaculturalists are going to gain access to urban and peri-urban markets, using the same, or a similar network of traders or intermediaries for the delivery of their goods to markets, minimizing transactions costs to traders and fish farmers will be important to relative profitability. Several factors may contribute to increased transactions costs for traders and/or aquaculturalists when ponds are in remote locations, or production levels are low or inconsistent. Fish is a highly perishable commodity, and strong consumer preferences for fresh fish make transportation a critical issue.[7] Farmers with fishponds close to main roads will have good access to potential traders and markets, whereas farmers in remote locations will have to spend time transporting perishable fish to pick up locations, or having traders come to them, increasing the transactions costs to traders and decreasing the farmers net returns.

Issues of reliability of production levels and quality of fish can also increase transactions costs for smallholders. Demand for fish is steady year round, so traders will be looking for farmers that can offer a reliable supply of fish, particularly if they have to travel significant distances to collect them from producers. Small farmers with variable production levels may not be able to meet the demands of traders. Issues of quality assurance can also increase transactions costs to traders. In order to compete with fish from natural catch fisheries, quality of fish, size of fish, and other characteristics may influence the willingness of traders to deal with small producers. Small scale fish producers that are remote from markets, or can not offer consistent supply or quality of fish may be able to overcome some of these constraints by using relatively low-cost preservation technologies such as salting, sun-drying and smoking that are commonly used by smallholders to preserve fish from catch fisheries.

The development of large-scale post harvest technologies and the improvement of transportation systems that can support the delivery of fish products to markets are essential if aquaculture is going to substitute for a significant proportion of fish from Uganda's catch fisheries. Currently the Kampala ice plant and the relatively new Uganda Fishing Enterprise Ltd. (UFL) in Jinga offer the most promising opportunities for smallholders to freeze, cold-smoke and process fish and fish products (Kigeya, 1995). However, without regular, reliable and fast methods of transporting fish to processing plants or large urban fish markets open to the aquaculture products, smallholders will not be able to actively participate in large markets.

SMALLHOLDER AQUCULTURE PRODUCTION

Demand and supply, in combination with the transactions costs of marketing influence the price that fish farmers can charge for their produce. Price however is only one half of the equations that determines net returns to

[6] It is interesting to note that Deininger *et al.*, (1999) found that in 1996 although 70% of crop producers were integrated into the market – they were only marginally integrated selling less than 20% of their total output. And approximately 25% of crop producers were not active in the market at all, being only subsistence producers. This has implications for the ability of small-scale aquaculturalists to integrate themselves into existing markets.

[7] Uganda's roads are in poor condition and in need of significant investment. Particularly poor are rural roads in the remote reaches of the country in regions that are likely to be inhabited by food insecure poor farmers.

production. Land use portfolios are generally based upon potential net benefits for a given set of environmental and economic resource endowments, taking into account the time frame in which benefits will be profitable. These factors include in addition to price, the availability and opportunity cost of land, labor and capital inputs, risk and access to credit, potential constraints or limitations imposed by land tenure arrangements, and the quality and accessibility of suitable extension services. We hypothesize that factors such as population density, proximity to towns, distance to tarmac roads, and natural resource endowments will affect these factors.

Land

The opportunity cost of land (i.e. the rental value of land in its most efficient alternative use) will likely be dependent upon three factors – how scarce land is, whether or not available land has high or low potential for other uses, and the extent of negative or positive environmental externalities associated with the land use. Scarcity is a serious factor in many areas of Uganda. Land fragmentation and decreasing farm size are common, with the average farm size being approximately 2 hectares. In some densely populated highland regions like Kabale, average farm sizes are much less than 2 hectares (Kasenge, 1998). In addition, land will be a significant cost of fish farming if it has high potential for crop production or livestock grazing. Conversely wasteland, or other lands with low or no opportunity cost, including gullies and ditches that can support fishponds may be appropriate for fish farming. Policy makers should also consider the potential short and long-term positive and negative environmental externalities associated with farmers' land use decisions when promoting new technologies.

The issue of aquaculture potential in land-constrained and/or high potential areas where the opportunity cost of land is high may be partially addressed by establishing chronic problem of draining and filling of wetlands for agriculture, industrial development or brick making, the government currently requires permits for these and other fishponds in the fringes of wetlands.[8] In response to a activities that might affect wetland sustainability and biodiversity,[9] and has chosen to actively promote small-scale fish farming as a sustainable use of wetlands. The potential of using wetlands for aquaculture may have significant implications for the land poor and landless – most in need of food security and alternative income sources. However, permits for fish farming and other aquaculture activities in wetlands are currently priced at 15,000 Ushs. – approximately $10 US per permit (MWLE, 2000), an amount of money beyond the means of many poor farmers. The issue of potential negative externalities also comes into play when wetlands are used for small-scale aquaculture. Concerns over hydrological disturbances that may occur when wetlands are altered to accommodate fishponds (i.e. management activities such as constructing embankments and/or drainage schemes, or importing water), the introduction of chemicals and pesticides that may enter the wetland as residue on fish feed, and biodiversity impacts on existing fish and wetland species should be considered carefully by policy makers before strongly advocating for the establishment of fishponds in wetlands.

Labor

Labor is a significant cost of production for aquaculture. Most smallholders converting farmland or wetlands to fish ponds will dig ponds themselves, and face ongoing management requirements such as the collection of feed, and the collection and application of manure and other fertilizers to improve fish yields on at least a weekly basis. In addition, labor costs associated with protection of ponds from theft or damage, harvesting, processing and marketing can be considerable and should not be overlooked when considering the costs of production. Data on labor inputs for fish farming in Uganda are scarce, but evidence from neighboring countries illustrates that labor is a high proportion of the total cost of production in this region. Small-scale aquaculture cooperatives and individual fish farms in Rwanda have very high labor requirements relative to other lands uses. For example, although fish farming was the most profitable activity in terms of income above variable costs and net returns to land, labor and capital for fish ponds of 1 hectare or less (US$2118/ha/year for fish as compared with $141/ha/year for cassava), when the opportunity cost of family labor was accounted for the in the analysis, fish farming became the least profitable of land uses (US$-1424/ha/year and US$-847/ha/year for fish and cassava respectively). Fish production required 6228 labor man-days/hectare as compared with 2265, 1810 and 1884 labor days per hectare per year for sweet potato, cassava and maize (Hishamunda *et al.*, 1998). Evidence from much smaller ponds (i.e. $1/10^{th}$ of a hectare) in the former Zaire indicates that labor in the first two years of fishpond production accounts for 75% of the total variable cost of production, and approximately 45% of the variable cost of production in years after establishment (Grover *et al.*, 1980).

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[8] Uganda currently has 240,000 square kilometers, or 13% of land area occupied by seasonal or permanent wetlands (NEMA, 1999), some of which have potential for small-scale, sustainable fishpond development.

[9] In Jinja district 76.2% of the 99.6 km^2 of wetlands have been converted to other uses, many of them allocated to private developers and filled for industrial development. In Iganga and Pallisa districts, seasonal wetlands are under direct pressure from agriculture. As much as 64% and 68% respectively of land area in the two districts has been converted to rice growing (NEMA, 1999).

How labor will be valued in farm-level analysis depends upon wage rates. Where wage rates are low and population densities high, labor intense technologies are likely to be adopted as long as returns on investment are positive. However, where wage rates are high and population densities low, high labor input technologies will generally be foregone. Factors other than population density may also influence the opportunity cost of labor including, the character of the labor market (for example, the availability of labor throughout the year), household demographics, and proximity to regions with off-farm labor opportunities. Due to low labor mobility, ethnic heterogeneity and limited awareness of wage rate differences across regions, rural Uganda lacks a well-developed labor market, making labor scarce and costly in some places, and relatively cheap and abundant in others (Sserunkumma *et al.*, 2000). In many areas, wage rates for hired labor have increased to the point where they are beyond the reach of most small scale farmers, forcing smallholders to rely entirely on family labor to carry out all farm activities.[10] It may also be the case that the opportunity cost of farmer's time may be highly variable during the course of the year (*Ibid.*). However, without household members to assume fishpond management requirements during times of the year when labor is scarce, fish farming is unlikely to succeed.

The composition of the household labor force is also likely to impact the viability of aquaculture technologies. Unlike capture fisheries, which are dominated by men, aquaculture is generally a gender-neutral technology. Women and children are generally responsible for pond management when ponds are part of integrated farming systems as the collection of feed and fertilizer for ponds can be incorporated into the management of livestock products and crop residues acting as fishpond inputs. Access to off-farm employment opportunities is likely to reduce aquaculture technology adoption by smallholders. Fishponds have fairly constant management requirements that are likely to preclude the primary manager of the pond from accepting off-farm employment. However, fish farming can be a lucrative supplement to off-farm employment income if sufficient family labor is available to manage the fish ponds while other family members work off farm.

Inputs

Primary material or capital inputs to production are fry, fish feed, fertilizer and equipment for harvesting. Fishponds cannot be established without sufficient fingerlings of reasonably good quality. However, there is currently a shortage of fish fry production centers in Uganda, which is seriously limiting the growth and development of aquaculture. To alleviate this problem the Fisheries Research Institute of the National Agricultural Research Organization (NARO) is presently trying to establish fry production centers throughout Uganda (Mbahinzireki, 2000)[11]. After local fry production and distribution centers are established, the goal will be to train established fish farmers in production and distribution, acting as small-scale local fry suppliers to other farmers (Kigeya, 1995).

Feed and fertilizer are also critical inputs to production; returns to these inputs are high. It is well documented that fish yields significantly improve when fishponds are appropriately fertilized and fed (Hazell *et al.*, 2000). The feed conversion rate of fish is higher than almost all common commercial livestock, and fish will consume feeds that are unpalatable or cannot be digested by most land animals (Pilley, 1993 as cited in Kigeya, 1995). Farmers without a household or local supply of fishmeal or seed will be dependent upon pellet and seed production centers that may be far from where they are producing. Currently between forty and fifty percent of Ugandan fish farmers fertilize or feed their fishponds (recall that there are approximately 7500 small-scale fish ponds in Uganda) (Kigeya, 1995). Smallholders with livestock, including small animals and poultry, have a source of organic fertilizer that encourages the growth of aquatic plants that fish can feed on. Finally, appropriate nets and other harvest technologies will be important to fish farm production. These can be costly and should be considered when evaluating the potential costs of production.

Institutions - Credit, Land Tenure and Extension

Availability of credit, land rights including security of tenure and rights of use, and access to appropriate extension support are integral components of introducing a non-traditional technology into smallholder farming systems. Although the most successful aquaculture technologies for smallholders are likely to involve relatively small ponds, high labor inputs, and cheap fertilizers and feed, short term credit may be necessary for the initial investment in pond construction, or for the purchase of harvesting equipment so that benefits can be realized. Poor farmers who lack collateral may not have access even to informal credit markets. Deininger *et al.*, (1999) found that between 1992 and 1993 only 42% of Uganda's rural communities had access to formal credit within 10 kilometers, and that where credit was available interest rates were very high (24% per annum). Further, lending that did occur was predominantly for trade and services, while loans for agriculture and livestock were a

[10] In the past decade, wage rates for casual, permanent and contract labor have increased between 21% and 29% throughout the country (MFPED, 1995 as cited in Sserunkumma *et al.*, 2000).

[11] Personal communication, Mr. Godfrey Mbahinzireki, National Agricultural Research Organization, Fisheries Research Institute, 9 May, 2000, Kajansi, Uganda.

relatively small proportion of total lending (15% and 11.5% respectively (*Ibid.)*. There is a tradition of small-scale traders offering credit to fishermen that do not have adequate capital to develop and maintain their operations (Kirema-Mukasa, 1993). If small-scale traders act as intermediaries for aquaculture products, there is potential for the development of an informal credit market.

Clarity of land rights and security of tenure are also required for fishponds to be successfully adopted by smallholders. A large share of smallholdings in Uganda (especially central Uganda), are characterized by *mailo* tenure, whereby occupants pay rent to *mailo* landowners.[12] However, unlike traditional landlord tenant relationships, tenants acquired legal protection against eviction in 1928, and rents were abolished in the 1975 land reform (Place *et al.*, 1997). However, farmers are required to get permission from landowners before undertaking land use changes such as the establishment of fishponds. Under this tenure system the majority of farmers report that they are relatively land secure and have few problems obtaining permission from landholders to invest in aquaculture (Sewankambo, 2000)[13]. The risk of displacement due to conflicts in Uganda and neighboring countries may be a factor affecting tenure security and investment in aquaculture in some regions of the country. If smallholders feel that farm production may be suspended or cease, they are unlikely to invest in labor intensive and semi-permanent structures such as fishponds.

One of the biggest constraints facing aquaculture development in Uganda is the lack of extension staff and infrastructure to deliver technical knowledge about aquaculture to rural smallholders. The technical aspects of constructing even small ponds of the appropriate size and depth, and ensuring that they will have suitable sources of water, filtration and aeration are complex, requiring significant education and extension support. Four features should be considered when developing aquaculture extension for smallholder farmers. First aquaculture offers the highest return to smallholders when it is implemented as part of an integrated farming system. Aquaculture should be part of the basic extension package that agricultural extension offers in areas where aquaculture is thought to have good potential. Second, given the current decentralization policy of the government and trends of decreasing budget allocations to agriculture, there should be a strong push to train private farmer extension agents.[14] This goal is compatible with the aim of establishing localized farmer-run fry distribution centers, where farmer distributors can also provide extension support. Third, aquaculture extension should be predicated on a simple extension message that involves information on pond siting and construction, information about the best feedstock, and how to feed and fertilize ponds. Several aquaculture experiments in sub-Saharan Africa and elsewhere have failed in large part due to the complexity of extension messages dealing with establishing and managing ponds. Finally, women should be integrated into the extension experience. Women are known to be active pond managers and should be involved in learning about establishment and harvesting practices (MAAIF/DFID, 1998).

CONCLUSION – AREAS OF COMPARATIVE ADVANTAGE FOR AQUACULTURE IN UGANDA

Available evidence on the current state of markets for fish products in Uganda indicates that the greatest potential for small-scale aquaculturalists will be the sale of fresh fish in the urban and peri-urban markets of Kampala and Jinja. In this region the demand for fish is increasing at the same time as supplies from traditional catch fisheries may be decreasing. Smallholders will likely be reliant upon traders or intermediaries to deliver their goods to market, and the transactions costs that accrue to either traders or smallholders for transportation, reliable supply, and monitoring quality is likely to have a significant impact on the prices that smallholders receive for fish. Smallholders with good market access and the ability to supply fresh fish of consistent quantity and quality are likely to command the highest prices and net returns. Increasing poverty among the rural poor is also leading to increased demand for fish and fish products. Food

[12] *Mailo* refers to former feudal ownership of land introduced by the British in 1900. Prior to the 1975 Land Reform Decree, *mailo* land was owned in perpetuity by individuals and by the government. Persons who lived on this land as well as new entrants with the consent of the landlords were legally protected to live on and use the land, but they were obliged to pay certain taxes. The 1975 Land Reform Decree abolished *mailo* land and the rights of customary tenants on such lands, but the decree has not been effectively implemented (Ogwang *et al.*, 2000).

[13] Personal communication, Mrs. Fortunate Sewankambo, Director Policy, Planning and Legal, National Environmental Management Authority, 9 May, 2000, Kampala, Uganda.

[14] The agriculture department, which includes extension, is receiving less priority in terms of budget allocation compared with other departments. In 1997/1998 3/32 districts whose budgets were analyzed by the Ministry of Agriculture (MAAIF) has allocated more than 3% of their budget to agriculture (Government of Uganda, 1998 as cited in Sserunkumma *et al.*, 2000).

insecurity and low farm productivity suggests that there is potential for fish farming to improve rural livelihoods. However, it is most likely that small-farmers producing fish in remote locations will be limited to subsistence production and very localized marketing opportunities given current constraints on transportation, access to small-scale processing facilities and a lack of intermediaries to market fish.

In addition to favorable markets and marketing opportunities, farm-level production that makes the most efficient use of land, labor and capital will be critical to smallholder diversification into aquaculture. Labor is likely the highest cost of production to fish farming. Areas where wage rates are low and population densities high are likely to have a comparative advantage due to the high labor requirements of successful fishpond investments. However, the price of fish relative to the opportunity cost of labor may be the key issue. We hypothesize that this price ratio is likely most favorable close to Kampala, but more information and data are needed on this issue. The cost and availability of inputs including fry and purchased feed are the other key factors defining the relative profitability of fish farming. In areas where fry production centers do exist, smallholder aquaculture has the potential to be profitable. For very small ponds land is unlikely to be a significant constraint, however if ponds displace other high value uses – the opportunity costs of establishment may be high. The establishment of ponds in the fringes of wetlands offers opportunity to aquaculturalists, however high permit costs and potential negative externalities may reduce the potential for this development pathway.

We have reviewed the characteristics that are likely to define comparative advantage for smallholders adopting aquaculture technologies in Uganda. We find that prices, which are likely to be high in areas close to large and growing urban markets with good access to transportation and fish traders, significant on-farm labor, and access to input markets are important factors leading to positive net returns to fish production. However, we stress that our findings are preliminary and would benefit greatly from a quantitative assessment of prices and the costs of production as they vary by population density, market access and natural resource endowment. That being said, it appears that aquaculture is a technology with good potential in certain areas of the country and should therefore be pursued as a potential development pathway for Uganda.

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