
Status and impact of rural aquaculture practice on Lake Victoria basin wetlands

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Abstract

Rural aquaculture in Lake Victoria basin is a fast increasing nontraditional farming activity which if not appropriately practised will lead to degradation of the wetlands. As part of a study to develop appropriate guidelines and model systems for *wetlands-based* rural aquaculture in the basin a survey was conducted to assess the status and the ecological and socioeconomic impact of rural aquaculture on wetlands and wetlands communities. Aquaculture practice was found to be common but not as a major activity. Aquaculture in the wetlands can be described as a *low input-low output* production activity and subsistence based on ponds under 400 m² using free seed from public agencies with hardly any supplementary feeding. Men owned most of the ponds and women only contributed to the management of the fishponds by feeding the fish. Poorly constructed ponds and loss during harvesting have led to the escape of cultured species into the wild. Introduction of nonnative species in the basin has already led to wide ranging ecological, environmental and socioeconomic changes whose impact and usefulness are still very much contentious. Repeat of such scenarios can be avoided if appropriate and science-based models for rural aquaculture farming are developed, tested and disseminated to the communities.

Key words: Lake Victoria, rural aquaculture, wetlands

Résumé

L'aquaculture rurale dans le bassin du lac Victoria est une activité fermière non traditionnelle en augmentation rap-

ide qui, si elle n'est pas pratiquée de façon appropriée, va conduire à la dégradation des zones humides. Dans le cadre d'une étude destinée à développer des directives et des modèles de systèmes adéquats pour une aquaculture rurale «basée sur les zones humides» dans le bassin, on a réalisé une recherche pour évaluer le statut et l'impact écologique et socioéconomique de l'aquaculture rurale sur les zones humides et les communautés qui y vivent. On a découvert que l'aquaculture était une pratique courante mais pas une activité majeure. L'aquaculture dans les zones humides peut être décrite comme une activité de production «*low input-low output*», et la subsistance basée sur des étangs de moins de 400 m² utilise des semences gratuites fournies par des agences publiques avec très peu de suppléments. Ce sont les hommes qui possèdent la plupart des étangs, et les femmes contribuent à la gestion des bassins uniquement en nourrissant le poisson. Des bassins mal construits et les pertes au moment de la récolte ont eu pour résultat que des poissons d'élevage se sont échappés dans la nature. L'introduction d'espèces non indigènes dans le bassin a déjà provoqué de grands changements écologiques, environnementaux et socioéconomiques dont l'impact et l'utilité sont encore très discutés. On pourrait éviter la répétition de tels scénarios en développant des modèles scientifiques appropriés pour l'aquaculture rurale, avant de les tester et de les propager dans les communautés.

Introduction

Lake Victoria has a catchment area of 194,200 km² with extensive wetlands of various types (Balirwa, 1998), supporting a rapidly growing human population that is currently estimated at 30 million (Mushi, Oenga & Mwanja, 2005). Before the concern for wetland degradation in the

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Lake basin, wetlands were largely regarded as 'wastelands' or marginal lands that were reclaimed for infrastructure development or converted into arable land. With the recognition of the importance of wetlands in the provision of a host of ecosystem services, the importance of wetlands has been brought to the fore and legislation put in place to protect wetlands. However most times this runs contrary to the sustainable and effective utilization of wetlands for better livelihoods especially among the rural poor who can only access such marginal lands. One way that such conflicts have been handled has been to identify production activities that are ecologically suitable to the wetlands environment and socioeconomically appropriate for the resident human communities. In the region one such activity that is gaining prominence is aquaculture.

Aquaculture was introduced in the East African sub-region between 1940s and the 1960s as a subsistence activity for rural communities (Mwanja, 1996). Support to this intervention then was considered as a part of the rural development drive by the national and international development agencies of the colonial times (Mwanja, 2006), and as such aquaculture has remained largely promoted for subsistence and rural livelihood rather than productive and income generating enterprise – as intended by the recent efforts in the region in revamping the sector. With the changed government priorities and subsequent dilapidation of government hatcheries and breakdown of extension delivery services the intended adoption of aquaculture by the rural farmers collapsed in the 1970s and 1980s throughout the sub-region of East Africa (Mushi *et al.*, 2005). The need for dietary animal protein and production for generation of income are cited as the basis for this new wave of rural aquaculture in the East African region (Mushi *et al.*, 2005). This renewed interest in aquaculture is however still faced with the same limitations that plagued it in earlier years, including underdeveloped 'water for production' infrastructure and the typical challenges to aquaculture of lack of quality fish seed, inadequate and poor extension services, inappropriate guidelines, and the fast changing development and economic policies (Mushi *et al.*, 2005; Mwanja, 2006). Given the raging poverty and poor or lack of 'water for production' infrastructure, wetlands present the only feasible source of water for rural aquaculture practice and development in the lake basin – and government role in provision of inputs is still looked at by farmers as the only means by which they can successfully be engaged in aquaculture practice.

Establishing the current status of aquaculture in the basin including socioeconomics of the practice will inform the design process of production systems suited for the basin wetlands. In this study we report on the findings of a baseline survey conducted to assess the existing rural wetlands-based aquaculture practices and production systems, and the impact of rural aquaculture on the ecological and natural functions of the wetlands. We also examine the social and economic indices such as gender, funding for aquaculture and level of education of farmers for those practising rural aquaculture, and also compare use of wetlands for rural aquaculture with the traditional uses of wetlands.

Materials and methods

Study area

Lake Victoria Catchment is a network of rivers, streams and patches of wetlands in the form of swamps and flood plains. This is punctuated with several satellite minor lakes. Fig. 1 shows the catchment of Lake Victoria containing the wetlands that were surveyed. Efforts were made to cover all types of wetlands ranging from seasonal to permanent forms within the basin. One hundred and twenty-two pond sites in 26 districts were studied. The selection of districts was at the recommendation of government fisheries officers who identified districts known to have significant (number of farmers and duration of farming) aquaculture activity.

Study design

The study targeted rural fish farmers in and near wetlands. A minimum of five rural farmers in each of 26 districts was sampled for this study. The study included interviewing of farmers, observation of pond site and wetlands, field measurements of limnological aspects of both the ponds and wetlands, and laboratory analysis of water samples of the ponds studied. To assess the impact of the rural aquaculture practices, the following aspects were assessed: flora and faunal species composition, surface water levels, dissolved oxygen, conductivity, pH, temperature, siltation and other water quality related parameters. In addition, data were collected on the socio-economic attributes such as gender roles, source of labour, source of funding, importance of production and use of wetlands for rural aquaculture relative to the traditional uses such crop and

animal husbandry. The criterion for farmer selection was a minimum of 1 year practice of fish farming by the farmer and the ponds had to have fish aged 6 months or more. The study was conducted simultaneously in the three East African countries (Uganda, Kenya and Tanzania) during February to March 2004.

Data collection and analysis

Data were collected using four methods: direct panel interview and discussion with the practicing farmer; use of a questionnaire; laboratory analysis of water within and out of the ponds; and visual assessment of the fauna and flora in and around the production systems and the wetlands in general. Issues investigated included type of aquaculture system, quantity of production, support systems for rural aquaculture, economic activities present in the wetlands other than aquaculture and the socio-economic attributes (pond ownership, funding sources, source and cost of inputs, type and source of advisory services and utilization of the produced fish) of rural aquaculture in the Lake Victoria basin wetlands. An electronic probe was used for onsite measurement of the pH, conductivity and the dissolved oxygen at the inlet, within the pond and at the site of discharge of the pond effluents. Categorical observations of algal content, turbidity, siltation, smell and colour were also made for the water. Water samples were taken from the inlet into the fishpond(s) and within the fishponds and analysed in the laboratory for selected nutrients (ammonia, nitrite, nitrate, phosphates, silica and chlorophyll *a* content). In-depth analysis of the findings on physiochemical parameters is presented and discussed in another paper. Data were categorized, coded and analysed using descriptive statistics with the aid of the EPINFO computer package.

Results

Characterization of fish farmers and their fish farming practices in the wetlands

One hundred and twenty-four rural fish farmers were interviewed and 197 fishponds were sampled. Table 1 presents selected attributes of the fish farmers in the wetlands surveyed. The majority of the farmers were male (81.2%). A one-third (30.1%) of fish farmers were in the 20–40 years age group while over 50% were between 41 and 60 years of age. Only 2.6% of the farmers interviewed

had no formal schooling, the bulk (52.1%) having attained secondary school education. Over 78% of the farmers had received specialized aquaculture training of at least 1 week duration. Training was mainly conducted under the national/public extension system that also was reported as the major source (81%) of technical support and knowledge for the farmers. Only 5% of the fish farmers operated ponds located on rented or government-leased land while the majority (71%) owned the land on which the ponds were located. The rest of the farmers (24%) had their ponds on land that was communally owned meaning that they were only 'part-owners' and subject to the decisions of the entire group that owned the land. Table 2 gives the description of the production systems. 65.7% of the ponds in the wetlands were under 500 m², 31.3% were between 500 and 1000 m² and only 3.0% were above 1000 m² in surface area. Eighty-two per cent of the ponds were sunken or excavated type ponds with no possibility for complete or proper drainage, 9.1% were barrage ponds with appropriate drainage system, and 8.9% were diversion type ponds set aside from the water source with water flowing into and out of the ponds. Ponds depended largely on spring wells and underground water and with a good portion also dependent on ran off during high rains. Over 50% of the ponds had constant flow of water through the pond while half had stagnant water with appropriate drainage system (Table 2).

Exploitation of wetlands for rural aquaculture

Fish farming in most of the wetlands was mentioned and observed to be a minor activity compared with other exploitative activities. Farmers were driven to set up fishponds in an attempt to utilize the available waters that were otherwise not utilized for another activity. Most of the fishponds were on land owned by farmers followed by land regarded as communal (Table 2). Farmers categorized wetlands in two major groups: permanent wetlands and seasonal wetlands. 95.5% of the fishponds were in permanent wetlands as opposed to 4.5% in seasonal wetlands. 81.1% of the farmers had crop husbandry as the major activity, followed by harvest of naturally occurring materials and animal husbandry at 8.2%, the other being brick making at 1.6% and wetlands reclaimed for settlement at 0.8% (Table 1). Fish farming was not a major production activity of any farmer, but was found to be the most important alternative or second option activity by the rural farmers (Table 2).

Attribute	Category	Per cent of respondents
Total number surveyed = 124	Rural farmers	–
Gender (n = 117)	Male	81.2
	Female	18.8
Age group (n = 113)	20–30 years old	7.1
	31–40 years old	23.0
	41–50 years old	32.7
	51–60 years old	23.0
	>60 years old	21.2
Education level attained (n = 115)	None	2.6
	Primary	45.2
	Secondary	30.4
	Tertiary	21.7
Source of training in aquaculture (n = 95)	Extension system	82.1
	Research station or college	9.5
	Peer farmer(s)	7.4
	NGO	1.0
Duration of training (n = 77)	1 week	68.8
	2–4 weeks	19.5
	>4 weeks	11.7
Ownership of land with ponds	Farmer owned	71.0
	Communally owned	24.0
	Leased from government	0.0
	Rented	5.0
Source of start up capital	Personal savings	92.1
	Bank credit	0.8
	Microfinance support	0.8
	Revolving fund from public agency	6.3
Source of labour	Family	57.0
	Family & paid labour	13.3
	Paid labour only	22.7
	Group labour	7.0

Table 1 Attributes of fish farmers in selected wetlands of the Lake Victoria basin

Characterization of fish culture practices and production attributes

55.3% of the grow out fish farms surveyed practiced monoculture of Nile tilapia or African catfish or common carp while 44.7 practiced polyculture of Nile tilapia with African catfish or common carp. 11.1% of the fish farms practised mixed farming with the different species reared in separate ponds. Among cultured species Carp was the most infrequent in occurrence while Nile tilapia was cultured virtually in all wetlands surveyed (Table 3). Under the monoculture system Nile tilapia was the main fish species farmed (77.8%) followed by those farming African catfish (16.7%). Other tilapia species were also farmed in monoculture system by 4.2% of farmers and carp under this system done by only 1.4%. Polyculture was practised by

44.7% of the farmers. Under the polyculture system the most common combination was Nile tilapia and African catfish at 87.1%, followed by carp and African catfish at 6.5%, different tilapia species at 4.8% and carp and tilapia species at 1.6%. In a few of the farms (11.1% of the surveyed farms) practiced both monoculture and polyculture. Grow out ponds were harvested after 6–12 months of rearing. Partial harvest using draining and seining was the most common method applied by 44.6% farmers. Complete harvesting through seining of the ponds was used by 28.9% and while 25.3% of the farmers also used complete harvesting using complete draining of the ponds.

72.1% of the reported using animal waste (cow dung or chicken droppings) as pond fertilizer. 21.8% reported using lime in pond preparation, while 2.7% used ash and 3.4% used composite manure. Forty-two per cent of the farmers

Table 2 Wetland use, including relative importance, production unit sizes, type of production systems, and source of water for fish farming

Attribute	Category	Per cent of respondents	
Wetland categorization/type	Permanent wetlands	95.5	
	Seasonal wetlands	4.5	
Major activity in wetland	Harvesting wild plants and animals	8.2	
	Crop production	81.1	
	Animal husbandry	8.2	
	Brick making	1.6	
	Settlement	0.8	
	Most important alternate activity for wetland use	Harvesting natural resources	5.9
		Domestic water supply	18.6
Crop production		10.7	
Animal husbandry		22.9	
Pond size	Fish farming	41.9	
	<500 m ²	65.7	
	500–1000 m ²	31.3	
Pond type	>1000 m ²	3.0	
	Excavated/sunken ponds	82.0	
	Barrage ponds	9.1	
Source of pond water	Diversion ponds	8.9	
	Rain fed – ran off	19.4	
	Spring fed	31.1	
	Ground water	26.5	
	River/stream	22.5	
	Lake/dam	0.5	
	Swamp – flood waters	0.0	
	Well/dugout	0.0	
Water flow system	Regulated and/or stagnant pond water	50.0	
	Continuous flow through pond	50.0	

used on farm waste and house refuse for feeding fish, 31.5% used feed made on the farm, while 26.5% indicated that they had purchased ingredients to supplement the natural fish feeds (Table 3). 76.9% were reported their source of fish seed to be public fisheries research institutes followed by the 'farmer to farmer' supply system reported by 11.5% (Table 4). Only 6.4% received their seed from certified private hatcheries, while 3.9% used seed from the wild or natural stocks (Table 4).

Rural aquaculture socio-economic attributes and ecological impact

44.1% of the farmers practised fish farming for generation of income while 36.8% used fish farming for supply of dietary animal protein for their families (Table 5). Farmers cited lack of capital (by 22.5% of the farmers), loss of fish through predation (19.8% of the farmers),

lack of appropriate pond management and harvesting gears (by 16.9%), lack of knowledge (12.7%) and inadequate quality fish seed (by 11.9%) as some of the key challenges to rural aquaculture. The practice is based largely on family labour (for 57% of the farmers) with some support from paid labourers using funds from family savings (for 13.3% of the farmers. Another 22.7% of the fish farms depended completely on paid labourers, while 7.0% depended on group support especially in construction of the ponds. Funds used to support fish farming were largely (92.1%) from own savings. The other only significant source was from Government and/or nongovernment organizations at 6.3%. 92.1 % of farmers reported using personal savings to fund their fish farming practice, and in only a minority had a grant, loan or revolving fund from some public organization been used. The latter case was found true for mainly women self-help groups. Table 5 shows the vis-

Farming system	Number of farms	Per cent
Purpose of farm	Fish breeding	22.3
	Seed propagation	6.1
	Fingering raising	14.2
	Grow out	57.4
Farming systems	Monoculture	55.3
	Polyculture	44.7
(a) Monoculture	Nile tilapia	77.8
	Other tilapiine species	4.2
	African catfish	16.7
(b) Polyculture	Carp	1.3
	Different tilapia species	4.8
	Nile tilapia & catfish	87.1
(c) Mixed culture	Carp & Catfish	6.5
	Carp & tilapia	1.6
	Nile tilapia & other tilapia species	14.3
Type of inputs used in pond preparation	Nile tilapia and catfish	71.4
	Nile tilapia and carp	14.3
	Lime	21.8
Source of fish feed used in fishponds	Ash	2.7
	Animal waste	72.1
	Composite manure	3.4
	On farm feed manufacture	31.5
Use of fry after hatching them	On farm waste & house refuse	42.0
	Purchased feed ingredients	26.5
	Retain all for own use	9.1
	Retain some and sell/give out part	54.5
	Sell out all	36.4

Table 3 Fish farming systems for rural aquaculture practice in Lake Victoria basin wetlands including species combinations

ual impacts of aquaculture observed in field on the wetlands.

Discussion

Fish farmers and their fish farming practices in the Lake Victoria basin wetlands

Existing rural aquaculture practice can be characterized as subsistence that occurs in wetlands. Its pond based fish culture used mainly two species, Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*). It is a minor component of the farmers' activities in the wetlands and is practised for food but with a good segment of the farmers the intention is on income generation. Production is extensive, both monoculture and polyculture, and of 'low input output' systems. Most of the fish is consumed at the points of production (farm family and neighbours) with very little sold in the local markets. Thus, despite the keen interest in the enterprize, the contribution of aquaculture

to the volumes of fish traded is negligible and farmers are unable to economically break even. The men because of issues of land tenure dominated the practice with women limited to contribution to the family labour in pond management. Although each district has an extension system, this survey showed that the frequency of contact between the extension officers and the farmers is inadequate. Most farmers fortunately have had some form of training conducted mainly by the fisheries extension workers and the majority has attained some level of formal education to primary school level. This allows for production and use of printed material and eases on the need of regular visits of extension workers.

Fish culture practices and production attributes in the wetlands

Field observations revealed that farmers had sufficient room to have ponds of over 1000 m² but the majority of farmers had ponds under 400 m². This limitation may result from the fact that for the majority of fish farmers

Table 4 Source of brood stock, source of fish seed and attributes for grow out fishponds

Source of brood stock for hatchery operators	Per cent of occurrence
Own farm	8.9%
Research station	67.9%
Farmer to farmer	17.9%
Wild stock	5.3%
Source of seed for grow out farmers	
Own farm	1.3%
Established hatchery	6.4%
Research station	76.9%
Farmer to farmer	11.5%
Wild stock	3.9%
Is fish seed from farm purchased by other farmers in the wetland	
Yes	47%
No	53%
Grow out period	
<6 months	12.7
6–12 months	73.3
12–18 months	7.0
18–24 months	3.5
>24 months	3.5
System of harvesting	
Partial	73.4
Total	26.6
Method of harvesting	
Complete harvest by draining of pond	25.3
Partial harvest by either draining and/or seining	44.6
Complete harvesting by seining without draining	28.9
Other (fish traps, hooks and fish baskets)	1.2

depend only on family for the labour, where the family is also engaged in other enterprises. Very few farmers reported using paid labour citing lack of means to pay for the hired labour. Similarly farmers were not able to feed the farmed fish due to lack of means to procure fish feed. As an alternative farmers used vegetable matter or maize bran (meant for poultry) for tilapia or waste animal products like offal for catfish and freshwater shrimp left behind as a by catch of the small minnow on Lake Victoria (locally known as mukene in Uganda, dagaa in Tanzania and omena in Kenya) for the catfish production that was not technically formulated and manufactured for the cultured species. Therefore to effectively utilize wetlands for productive aquaculture will require establishment of some revolving fund or credit scheme or direct support from public agencies.

Social and ecological attributes of rural aquaculture in Lake Victoria basin

The majority of the fish farmers were grow out fish farmers with a few producing fish seed. Farmers' dependence on government supply of free seed is untenable in the region because by policy governments have decided against government operated production facilities. Secondly, most of the government centres are far removed from farmers, cannot deliver sufficient quantities of seed as demanded by farmers and the quality supplied may not be guaranteed as the very institutions are responsible for certifying of the hatchery operations and management and hence cannot police themselves. The emergence of private fish seed suppliers ought to be supported so as to leave public institutions with the monitoring and regulation of the quality fish seed supplied to farmers. Caution although needs to be exercised to ensure that private hatchery operators do not lead to unwarranted species movement and introduction that may easily interbreed with the native key aquaculture species (Mwanja, 1996; Mwanja & Fuerst, 2003).

Although farmers gave generation of income as the reason for starting aquaculture they failed to realize this goal. Three key reasons were responsible for this farmers' predicament: poor fishpond management practices; use of the produced fish for household food fish; and the socio-cultural setting of the farmers where they feel compelled to give relatives and neighbours the harvested fish free of charge as a norm that cultivates good neighbourliness and fostering of relationships. To design models and guidelines for rural aquaculture in such settings therefore requires clear understanding of the sociocultural and economic attributes of rural aquaculture as well. Particular emphasis needs to be put on involvement of all beneficiaries in the production process to allow for cultural sharing and distribution of the harvest. Communal ponds or group ponds need to be considered as a way of getting the communities involved not only at harvest but also in the production.

The finding that farmers released their farm effluents directly into natural watercourse without any form of treatment raises ecological and general environmental concerns. It can lead to introduction of cultured species in non native ranges (Mwanja *et al.*, 1997; Mwanja, 2006) and may also lead to eutrophication through nutrient loading of the associated wetlands (Matagi, 1986; Helminen & Honkanen, 2001) especially as farmers adopt use of better performing species strains, increased stocking and use of formulated fish feed, a situation that may impact

Table 5 Socio-economic indicators and physical impact indicators of rural aquaculture

	Number of farmers	Per cent
Importance of rural aquaculture practice to the farmer	Supply of animal protein	36.8
	Generation of income	44.1
	Occupation	2.9
	Food & income generation	16.2
Constraints to rural aquaculture in the wetlands	Lack of capital	22.5
	Inadequate knowledge	12.7
	Limited technology	4.2
	Poor quality and inadequate fish seed	11.9
	Theft and malice	6.4
	Floods and uncontrolled water intake	5.6
	Predators	19.8
	Inappropriate tools	16.9
Connection between fish pond and natural water body	Source of water	36.5
	First destination of pond effluents	63.5
Reported escapes of farmed fish to the wild	Knowledge of escapees from the farm	29.8
	Absence of possibility for escape to the wild	70.2
Reasons for escape of fish into the wild	No screens on inlet/outlet	30.8
	Flooding	59.0
	Poor handling and control at harvest	10.2
	Within adjoining swamp	41.9
Destination of water from the pond	Into nearby stream	46.8
	Into nearby stream	8.1
	Used for irrigation/fertilizer	3.2
	Forest	–
	Increased plant growth	42.5
Visible effect of the effluents to surrounding	No visible indication	57.5

and change the integrity of the wetlands. Chapman *et al.* (2001) have found that although in East Africa humans have lived with and within wetlands throughout history, there has been since the 1950s large-scale swamp conversion and increased population pressure on small wetlands resulting in increased threat to the integrity of these wetlands, precipitated local declines in indigenous wetland organisms and altered ecosystem functions. Abban (1999) calls for involvement of benefiting communities in the management of their own resources through 'study and documentation of our fish genetic resources, and a gradual but sustained ecosystem-based approach to the use and management of natural resources, and support for development and sustainability of community-based management'. This has two advantages in that it allows for the community to make informed decisions on the utilization of their natural resources, and also allows for tracking of changes brought about by the use of these wetlands and contained resources. De Silva *et al.* (2003) emphasize the increasing importance of aquaculture as a fish food supply

but caution on the problem of competition for primary resources such as land and water as aquaculture development takes root especially in the developing countries.

Because of the population explosion in most of the areas around wetlands there will be an increased pressure brought about by the rush for materials such as sand, fuel wood, building materials, water and fruits for food from the wetlands (Bugenyi & Balirwa, 1998; 2003). Nontraditional production enterprises such as aquaculture will also become prominent and stand to pose a threat to wetlands functions if not done in an environmentally responsible manner, especially as the urge to expand production and adopt technically more productive technologies increases. The wetlands where rural aquaculture was being practised were found to be 'pristine' with little or no visible impact to the wetlands. By design aquaculture seeks to retain water and maintain the environment appropriately wet and comfortable for fish culture, hence by its nature aquaculture has to be done in an environmentally responsible manner. Rural aquaculture by default is 'low input low

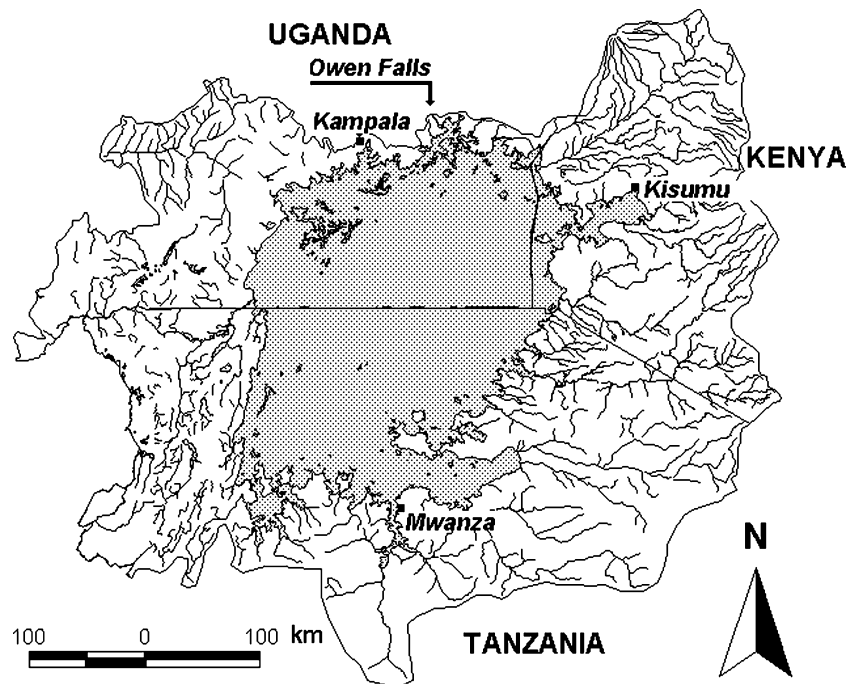


Fig 1 Showing Lake Victoria and its catchment as potential sites for aquaculture development

output' system that adds very little other than the fish seed to the pond water, and therefore for most times poses no real threat to the water quality in the wetlands. The ponds are also usually small in size because of the limited support and noncommercial nature of the undertakings. If appropriately integrated with other traditional production practices rural aquaculture can indeed enhance production per unit area of wetland used. However, this requires that ponds be well sited, constructed with a good drainage system and diversion channels to protect against floods and storm waters, and use of appropriate inputs including the right fish seed.

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