Status and Impact of Rural Aquaculture Practice on Lake Victoria Basin Wetlands

Wilson Waiswa MWANJA[1], Anne AKOL[2], Laila ABUBAKER[3], Matthew MWANJA[4] Scot Batman MSUKU[5] and Fred BUGENYI[2]

[1]Department of Fisheries Resources, Ministry of Agriculture, Animal Industry and Fisheries,
P.O. Box 4 Entebbe
[2]Department of Zoology, Makerere University, P.O. Box 7062, Kampala
[3]Department of Biochemistry, Nairobi University, Nairobi
[4]Department of Chemistry/Biochemistry, Kyambogo University, P.O. Box 1 Kyambogo
[5]Tanzania Fisheries Research Institute, Mwanza

Email addresses:
Wilson Waiswa Mwanja - wwmwanja@yahoo.com
Anne Akol - akol@mak.sc.co.ug
Laila Abubaker - abubaker@kenyanet.ke
Matthew Mwanja - mmtenywa@hotmail.com
Scot Batman Msuku - msuku@yahoo.com
Fred Bugenyi - fbugenyi@mak.co.ug

Key words: Rural Aquaculture, Wetlands, Lake Victoria

Abstract word count: 200

Full paper word count:

Corresponding Author: Wilson Waiswa Mwanja
Plot 29 Luggard Avenue Entebbe
Box 4 Entebbe, Uganda.
Email: wwmwanja@yahoo.com
Fax: +256 41 320496

Running title: Rural Aquaculture in Lake Victoria Wetlands

ABSTRACT

Growing rural poverty, explosive population growth, and underdeveloped 'water for production' infrastructure have combined to put pressure on Lake Victoria wetlands as a source of rural livelihoods. Among emerging non-traditional activities in the wetlands is rural aquaculture. In here the status of rural aquaculture in Lake Victoria basin and its impact on the ecological, physiochemical and socio-economic functions of the wetlands are reviewed. As part of this study a survey was conducted in Lake Victoria Basin among rural farmers to assess the status and impact of rural aquaculture in the basin. Aquaculture was found to be a minor component and a 'low input low output' production activity dominated by men. The practice was predominantly subsistence based on small ponds stocked mainly with free seed from government. There was no visible impact and little physiochemical changes on the wetlands used for aquaculture. Farmers reported occurrence of fish species similar to the cultured species in the wetlands in which they practiced aquaculture. This occurrence was attributed to flooding of ponds, inappropriate drainage screening and poor harvesting. With increasing rural aquaculture in the basin it's imperative that model rural aquaculture production systems and guidelines be developed for effective and non-detrimental utilization of wetlands.

INTRODUCTION

Wetlands benefit rural communities both directly (through harvest of natural products and agricultural production) and indirectly (through biogeochemical and physical functions and processes). With increased and Ineffective exploitation of the direct benefits the indirect benefits are fast eroded. Erosion of indirect benefits from wetlands is attributed to the environmentally degrading manner in which the direct benefits are increasingly being sought. Fish harvesting and fish farming in the three Lake Victoria riparian countries have become frequent activities especially within wetlands with the quest for food security, better rural livelihoods, and economic quest. The need for dietary animal protein and production for generation of income have been cited as the basis for this new wave of aquaculture in the East Africa (Mushi et al. 2005).

Aquaculture took root in the region as a subsistence activity for rural folk and was practiced in small ponds made using family labour. Farmers were supplied with fish seed and extension services free of charge by governments. With the changed government priorities and subsequent dilapidation of government hatcheries and extension delivery services the intended adoption of aquaculture by the rural farmers collapsed throughout the region of East Africa. However, with the increased demand and growing value of fish, farmers renewed their interest in aquaculture. New approaches were sought and old ones revised to address aquaculture development in the region. The renewed interest in aquaculture is though still faced with the same limitations 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). Given the poor or lack of 'water for production' infrastructure wetlands once again presented the only realistic potential for aquaculture practice and development especially for the rural farmers in Lake Victoria Basin.

However, as farmers rush to exploit wetlands for aquaculture and other agricultural related activities there is growing fear that such activity when not technically planned and conducted will have negative impacts on the ecological and environmental integrity of wetlands. For insistence to increase production at extensive level of aquaculture production farmers will need to clear large expanses of wetland for construction of larger ponds while for intensive fish culture the farmers will to have to adopt use of formulated feed, antibiotics and fertilisers, and utilisation of fast growing non-native and/or exotic species, as well as hybrid and selectively improved genetic forms of the native species. These attributes have a high potential of disrupting the ecology, and the natural and traditional socio-economic roles of wetlands. Therefore, given the call for improved aquaculture production as reflected in the National Fisheries Policy Documents for the three riparian states of Lake Victoria, and knowing that wetlands are currently the prime target areas for such aquaculture enterprises, there is need to assess the status and impact of current fish farming practices and production, and to design and develop model production systems and guidelines that lead to improved aquaculture with minimal or no disruption of the wetland ecological functions and traditional socio-economic roles.

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 assess the potential impact of rural aquaculture expansion on the ecological and natural functions of the Lake Victoria Basin wetlands. The socioeconomics of the existing rural aquaculture practices in the basin are discussed with reference to how rural aquaculture fits in with the rest of the traditional uses of wetlands for the inhabiting communities. In addition, existing rural aquaculture technologies are examined looking at the factors responsible for the current state. The results of this baseline data analysis informed the design of model rural aquaculture production systems for Lake Victoria Basin wetlands-based aquaculture.

MATERIALS AND METHODS

Study Area: Figure 1 shows the catchment of Lake Victoria in which wetlands studied are within the 124 administrative districts of the three riparian countries of East Africa. Efforts were made to cover all types of wetlands ranging from seasonal to permanent within the basin where aquaculture was being practiced. Many of the wetlands are flood plains of the numerous small streams and rivers that drain into the Lake Victoria and associated minor lakes in the basin.

Study design: The study targeted rural fish farmers in and near wetlands. Information about aquaculture was assessed using 4 methods: field and laboratory analysis of water within and out of the ponds; direct panel interview and discussion with the practicing farmer; use of questionnaire; and direct field observations around each of the pond surveyed. Issues of surveyed included physiochemical statistics, types of aquaculture practice, quality and quantity of production, systems of support for rural aquaculture, and comparative use of wetlands for aquaculture. To assess the impact of the rural aquaculture practices the following aspects were reviewed: flora and faunal species composition in area of practice, water retention, dissolved oxygen, conductivity, pH, temperature, siltation, and other water quality related parameters. In addition, data was collected on the socio-economic attributes of rural aquaculture pertaining to the utilization of Lake Victoria wetlands.

Data collection and analysis: Data was collected using a structured questionnaire, field discussion with farmers, sampling of farmers production systems for water quality and fish production parameters, and visual assessment of the fauna and flora in and around the production systems and the wetlands in general. Data was collected for the whole basin, and categorized, coded and analysed using EPINFO computer package. Data on physiochemical parameters was gathered through laboratory analysis of samples taken from and around the fishponds. Water samples were analysed for a few basic limnological parameters including dissolved oxygen, ammonia, nitrate and nitrite content, silica, turbidity, siltation, alkalinity, total phosphate, and chlorophyll a content. However, in-depth analysis of the findings on physiochemical parameters is presented and discussed in another manuscript ‘limnology of rural fishponds in wetlands of Lake Victoria’ that is under preparation.

RESULTS

Exploitation of wetlands for rural aquaculture: Fish farming in most of the wetlands was mentioned and observed to be a minor activity compared to other exploitative activities. Farmers were driven to set up fishponds in attempt to utilise the available waters that were otherwise not utilised for another activity. Most of the fishponds were on land owned by farmers followed by that regarded as communal (Table 1)

Characterisation of wetlands used for aquaculture: Wetlands within Lake Victoria were categorised by farmers in two major groups: permanent wetlands and seasonal wetlands. Most of the wetlands were aquaculture was being practised were characterised as permanent with little or no perceivable degradation as indicated in Table 2. Major activity around such areas was found to be crop husbandry of mainly small sized gardens for subsistence, followed by harvest of naturally occurring materials for household use and income generation (Table 1).

Characterisation of fish farmers and their fish farming practices in the wetlands: 122 rural fish farmers were visited throughout the Lake Victoria Basin and a total of 197 fishponds were sampled. The characteristics of the fish farmers are given in Table 3 including characteristics of the fish farms and their production, management, type and operation. 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. In 11.1% of the fish farms there was mixed farming with the different species reared in separate ponds but on the same farm. Among cultured species Carp was the most infrequent in occurrence while Nile tilapia was cultured virtually in all wetlands (Table 4). Most ponds in the wetlands ranged from small ($<500m^2$) to medium size ($1000m^2$) with only few above $1000m^2$. Most were sunken or excavated type ponds with no possibility for complete or proper drainage. Ponds depended largely on spring wells and underground water and with good portion also dependent on ran off during high rains. Over 50% of the ponds had constant flow water through the pond while half had stagnant water with appropriate drainage system.

Characterisation of fish culture practices and production attributes: Most fish farmers were subsistence producers with small sized fishponds, low stocking rate and with little or no management (Table 5). The majority of grow-out fish farmers had small to moderated sized ponds with fish reared for 6 to 12 months. Most farmers harvested fish using pond seining and completing draining while the most common, and for most farmers, the only input apart from seed was animal waste used as pond fertilizer. A few farmers applied lime as means of preparation (disinfecting) of the ponds, and public fisheries research institutes were the major providers of fish seed to rural farmers followed by the 'farmer to farmer' supply system. Selection and use of parental fish stock was random with no particular brood stock management regime, however, hatcheries used more females than males during spawning and fertilization.

Rural aquaculture socio-economic and physiochemical impact: Produced fish was mainly for generation of income followed by meeting household consumption (Table 6).

Farmers cited lack of capital, loss of fish through predation, lack of appropriate pond management and harvesting gears, lack of knowledge, and inadequate quality fish seed as some of the key challenges to rural aquaculture in decreasing order. The practice is based largely on family labour with some support from paid labourers using funds from family savings. For most farmers major water bodies attached to the attendant wetland served only as sink to the effluent from the ponds, with nearly 30% of farmers having knowledge of fish escapees into the wild. Flooding was the major cause of fish escapes followed by poor screening of the pond inlets and outlets. The only visible impact of pond effluents was increased plant growth in or around the areas of drainage.

DISCUSSION

Wetlands for Rural Aquaculture: The wetlands of Lake Victoria Basin are starting to show stress and erosion of their natural functions due to the increased exploitation and use by the rural communities. Large portions of the wetlands have been reclaimed for cultivation of crops and raising of livestock. Of increased significance also is the harvest of materials such as sand, fuel wood, building materials, water, and fruits for food from the wetlands. Though rural aquaculture has been practised for sometime in the Lake Victoria Basin it has remained relatively a minor activity in the wetlands. Rural aquaculture presents the most wetlands-friendly production activity compared to all others forms of wetlands' exploitation and production activities that were surveyed. 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 of pond comfortable or appropriate for fish culture. This design makes aquaculture very akin to wetlands, and to have an inherent interest to maintain the wetlands to support aquaculture especially in rural aquaculture, which is characterised by little or no inputs other than fish seed.

Fish farmers and their fish farming practices in the Lake Victoria Basin Wetlands
Existing rural aquaculture practice can be characterised as subsistence that currently occurs in all wetlands. Its pond based fish culture using mainly two species, Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*). It is still a minor component of the farmers' activities in the wetlands. Rural aquaculture is practised largely for food but with a good segment of the farmers intentioned on income generation. Most farmers involved were men with women's role largely limited to contribution of labour to the family pond. 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 has bearing on the type and content of extension materials and advisory services needed by the farmers.

Fish Culture Practices and Production Attributes in the Wetlands: The majority of the farmers had small ponds made for producing food to compliment the supply of animal protein to the families. However, this limitation is also due to the fact that for the majority of the fish farming families the family provides labour itself for aquaculture which is just one of the multitude of enterprises the families are engaged in. Making a reasonably sized fishpond requires extra labour which if such rural families are going to use they have to get

funds to pay for it. With poverty widespread in the basin very few farmers indeed reported using paid labour. Any meaningful adoption of aquaculture even at rural aquaculture level therefore will require either establishment of some revolving fund or credit or direct support for farmers to be able to use wetlands effectively for rural aquaculture.

The majority of the fish farmers were grow out fish farmers with a few producing fish seed. Since the majority depended on government supply for free seed, the ability to purchase fish seed by rural farmers should be a serious consideration for expansion and development of rural aquaculture in Lake Victoria Basin. In addition, most of the government centres are far removed from farmers, cannot deliver sufficient quantities of seed and in time, and quality supplied may not be guaranteed. This therefore implies that the system of supply of fish seed may also be greatly curtailing the effective utilisation of wetlands by the rural fish farmers. The emergence of private fish seed suppliers ought to be supported to bring quality fish seed nearer to the farmers. Caution though needs to be exercised as most of the recent fish movements in Uganda are largely attributed to aquaculture (Mwanja et al., 1997). A number of the species that have been moved easily interbreed with the native stocks and are likely to ecologically displace or genetically swamp in the native forms (Mwanja, 1996; Mwanja and Fuerst, 2003). Hence the need for care in promoting rural aquaculture as its practiced right in the wetlands that are the breeding grounds for many of the fishes in the major water bodies.

Social attributes of fish farming activities in Lake Victoria Basin Wetlands: Rural Aquaculture practice in Lake Victoria Basin Wetlands is largely a male domain and poverty ridden. It's a little or no input system with moderate or no management of production. Majority of the farmers are poor to manufacture or buy supplementary formulated feeds, acquire or use appropriate aquaculture gear, and pay for aquaculture advisory services without government or outside support. This situation especially blocks the involvement of women and youth who normally in such rural circumstances are not in control of even the little wealth that there is to support aquaculture, let alone have no land of their own. Indeed the majority of farmers reported practising aquaculture on their own plots or on rented land, which means you ought to have land or the ability to rent land in order to engage in rural aquaculture - a situation that limits women and the youth especially.

The majority of the farmers reported their wish to engage in income generating rural aquaculture practice, however, they seem to limited by circumstances. Its therefore important that model systems be developed that allow for farmers to engage in production that not only provides food but allows them to generate some income to fight poverty if the systems developed are going to appeal to the rural folk. Indeed it's likely that many can only involve themselves if they realise that they can produce and sell fish for income at the end of production cycle. Women and youth can especially be enticed if the design systems and guidelines have built within them ways and means of accessing support either in kind or financing/credit through which they can purchase the needed inputs.

Impact of rural aquaculture practices on to the wetlands and wetlands' functions: Though rural aquaculture currently does not yet seem to posse any threat to Lake Victoria

Basin Wetlands its important to note that there are already signs that if handled wrongly without clear guidelines expanded rural aquaculture can be a menace ecologically to the wetlands. For example a number of farmers reported escape of fish to the wild due to inadequate screening and/or poor control at harvesting. A majority of farmers release their effluents directly to natural watercourse without any form of treatment. This practice that loads nutrients into the natural waters will certainly cause eutrophication (Helminen & Honkanen, 2001), a situation that may negatively impact and change the functions of the wetlands. Chapman et al. (xxxx) argue that though 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 that has threatened the integrity of many African wetlands, precipitated local declines in indigenous wetland organisms, and altered ecosystem functions.

As a way of tracking the impacts on wetlands, studies are needed to establish and map out the genetic resources in these wetlands so as to be able to accurately assess the potential impact of any intervention made in the use of wetlands. 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. The importance of wetlands for both aquaculture and the lake fisheries is very vital, and any large-scale disruption of wetlands can also lead to loss of the wetlands natural functions. Another area of concern in utilization of wetlands is competition for resources for aquaculture and other traditional activities in the wetlands. 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.

Policy issues related to Rural Aquaculture Development: Our study didn't find any clear guidelines or agreed upon ways of doing aquaculture in wetlands in the Lake Victoria Basin. However, with increased interest in sustainability, effective utilization, and conservation of wetlands, there is throughout the region moves to develop standards, guidelines, regulations, and clear policies to manage wetlands better. Since preservation of wetlands is not achievable its important that guidelines and standards, as well as means be provided especially to the rural folk in utilization of wetlands (Bugenyi and Balirwa, 1998). It's very essential that the guidelines, standards and support given to farmers be based on tested systems and approaches so as not to put the farmers in a situation in which they revert to destructive and ecologically unsustainable practices.

As stated above, support to farmers including increasing access to quality inputs for rural aquaculture ought to be brought closer, and effective supply models developed to ensure sustainability of rural aquaculture. Policy for aquaculture should seek to work with existing fish farmers to train and support some of them to become producers and suppliers of the

required inputs for rural aquaculture. Policy should also seek more meaningful approaches for training of rural fish farmers. Though many farmers reported to have received some form of training in aquaculture the status of aquaculture in the field did not reflect that farmers were conversant with aquaculture practice. Demonstrations by successful farmers supported by aquaculture experts in all communities should be encouraged, and fish hatchery operators ought to be looked at as and developed into the primary source of aquaculture technical advise since all have to interact with fish seed suppliers.

Other than the farmers there is also need for review of existing policies, laws, regulations, standards or guidelines so as to make them more farmer supportive and friendly than acting as barriers to successful aquaculture development in the wetlands. For example there is need to explore ways and means that can facilitate aquaculture farmers to form viable associations and co-operatives through which individuals can acquire support from the associations. Group learning, block production, synchronised farming, and collective bargaining and marketing can be some of the means that can be enhanced by the right and appropriate policies to steer rural aquaculture in Lake Victoria Basin wetlands.

Countries in Asia that have made it had to come up with clear policies, management structures, guidelines, and regulatory framework for aquaculture development. In China aquaculture though practiced for several centuries only took off starting the early 1980s when a foundation for aquaculture policies was quest for self-sufficiency in food and economic growth had been clearly laid down within the foregoing aquaculture policies (FAO 2002).

REFERENCES

ABBAN, E.K (1999) Considerations for the conservation of African genetic resources for their sustainable exploitation. In: Towards policies for conservation and sustainable use of Aquatic Genetic Resources (Ed. RSV Pullin, DM Bartley & J Kooiman). ICLARM Contribution no. 1537, Manilla Philippines.

AMERICAN PUBLIC HEALTH ASSOCIATION, APHA (1980). Standard methods for the examination of water and waste water (Ed. Franson, M.A). APHA-AWWA-WPCF, Washington, D.C.

BALIRWA J. (1998). Lake Victoria wetlands and the ecology of the Nile Tilapia (*Oreochromis niloticus* Linné), Doctoral dissertation no. 2415 of Wageningen University, Netherlands

BUGENYI, F.W.B. & BALIRWA, J.S. (1998) East African species introductions and wetland Management: socio-political dimensions. In: *Science in Africa: Emerging water management issues* (Philadelphia, Pennsylvania 12-17 February 1998. American Association for the Advancement of Science 13-34.

BUGENYI, F.W.B. & BALIRWA, J.S. (2003) In: Crisman TL, Chapman LJ, Chapman CA and Kaufman LS (eds.) Conservation, Ecology, and Management of African Fresh Waters. Uiversity Press of Florida, Gainesville Florida pp 79 – 103.

CHAPMAN, L J., BALIRWA, J., BUGENYI, F.W.B., CHAPMAN, C. & CRISMAN, T.L. (xxxx) Wetlands of East Africa: biodiversity, exploitation, and policy perspectives

DE SILVA, S.S., MOEHL, J., SATIA, B., BARTLEY, D. & SUBASINGHE R. (2003) Inland fisheries and aquaculture: a synergy for sustainable fish production. In: Review of the State of World Aquaculture. FAO Fisheries Series 886. Rev. 2. Rome Italy.

FUERST, P.A., MWANJA, W.W. & KAUFMAN, L. (2000). The genetic history of the introduced Nile tilapia of Lake Victoria (Uganda, East Africa): The population structure of Oreochromis niloticus (Pisces: Cichlidae) revealed by DNA microsatellite markers. Proceedings of the Fifth International Symposium on Tilapia in Aquaculture (ISTA V) Brazil.

HELMINEN, H. & HONKANEN, T (2001) The role of aquaculture in eutrophication process of the Achipelago Sea, SW Finland. Verandlunen. Proceedings of Travaux 28th Congress, Melbourne.

MUSHI, V.E., OENGA, D.N. & MWANJA W.W. (in press - 2005) Meeting the increasing fish demand through development of aquaculture in the Lake Victoria Basin. Afr.J. Tropical Hydrobiolgy

MWANJA, W. (1996). Genetic variability and population structure of the tilapiine fauna of the Lake Victoria Basin (Uganda) in relation to exotic species introduction. MSc. thesis, Ohio State University, Columbus Ohio 102pp

MWANJA, W., BUGENYI, F.W.B., KAUFMAN, L., FUERST, P. (1997) Genetic characterization of tilapiine stocks in the Lake Victoria region, pp. 33-34. *In* R.S.V. Pullin, C.M.V. Casal, E.K. Abban and T.M. Falk (Eds.) *Characterisation of Ghanaian tilapia genetic resources for use in fisheries and aquaculture*. ICLARM Conference Proceedings, 58pp.

MWANJA, W.W. & FUERST, P. (2003). How issues of genetic diversity affect management of African inland water fisheries: the example of Lake Victoria Region. *In T.L. Crisman, L. Chapman, C.A. Chapman, & L. Kaufman, Conservation of Aquatic Biodiversity of Afric*a, pp 288-300. University Press of Florida Press, Gainesville, Florida.

MATAGI, S.V. (1986) The effect of pollution on benthic macro-invertebrates in a Ugandan stream. Arch. Hyrdobiol. 137: 537-549.

Table 1: Comparative land usage and ownership for aquaculture relative to traditional socio-economic uses of wetlands

Main production activity in wetland	**Percent Occurrence**
Harvesting natural resources	8.2% of wetlands
Crop production	81.1 % of the wetlands
Animal husbandry	8.2 % of wetlands
Brick making	1.6% of the wetlands
Settlement	0.8% of the wetlands
Ownership of wetland used	**Percent occurrence**
Farmer	72.1%
Rented from individual	1.6%
Rented/leased from govt	2.5%
Communal	23.8%
Donated by govt/inst./school	0%

Table 2. Limnological characterisation of the wetlands in which the surveyed fishponds occurred

Parameter	**Description**
Siltation	63% had no visible siltation, 28% had low siltation while 9% high siltation
Turbidity	64% absent, 26% low and 10% having high turbidity
Oxygenation	58% nearly devoid of oxygen, 32% low, and 10% with high oxygenation
Algal production	66% had no visible algae production, 26% low algal production, 8% high algal production
Coloration	68% had clear water, 20% brownish, 6% clear green, 7% dirty green
Stench	95.2% had no stench, 4.8% had moderate stench
Fish species occurrence	45% catfishes, 35% Tilapia, 15% Haplochromines, 5% cyprinids, 1% mormyrids,

Table 3. Characteristics of the fish farms / fishponds surveyed

Attribute	Description of attribute
Age	70% lie in age bracket of 30 – 60 years
Level formal education attained	95% with primary education & 50% with post primary
Training in aquaculture practice	80% had some kind of training in aquaculture practice
Ownership of farms along gender	77% were male owned, 17 female owned, 6% mixed
Trainer of farmers	82% were trained by field extension workers
Location of fish farms	95.5% were within permanent and 4.5% seasonal wetlands
Source of water for fishponds	51% underground wells, 23% rain fed, 24% from streams and rivers,
Purpose of fish farm	Percent per category
Fish breeding	22.3%
Seed propagation/producers	6.1%
Fingering raising	14.2%
Grow out	57.4%

Table 4. Different systems of rural aquaculture practices in Lake Victoria Basin wetlands including species combinations and types and sizes of fishponds

Farming system	Number of farms	Percent
A. Monoculture		**55.3**
Nile tilapia	56	77.8
Other tilapia species	3	4.2
African catfish	12	16.7
Carp	1	1.4
B. Polyculture		**44.7**
Different tilapia species	03	4.8
Nile tilapia and African catfish	54	87.1
Carp and African catfish	04	6.5
Carp and tilapia species	01	1.6
C. Mixed culture	**13**	**11.1%**
Nile tilapia & other tilapia species	2	14.3
Nile tilapia and African catfish	10	71.4
Nile tilapia and carp	2	14.3
African catfish and other tilapia species	0	0
African catfish, Nile tilapia and carp	0	0
Pond categorisation	**Number of ponds**	**Percent**
Barrage pond	9	8.1
Excavated/sunken	91	82.0
Diversion pond	11	8.9
Pond sizes	**Occurrence**	**Percent**
Small ponds < 500 m^2	65	65.7
Medium ponds > 500 < 1000m^2	31	31.3
Large ponds > 1000 m^2	03	3.0
Main source of water into ponds	**Number of farms**	**Percent**
Rain fed – ran off	38	19.4
Spring fed	61	31.1
Ground water	52	26.5
River/stream	44	22.5
Lake/dam	1	0.5
Swamp – flood waters	0	0
Well/dugout	0	0
Flow system through the pond during production	**Occurrence**	**Percent**
Stagnant water fish pond	59	50
Continuous water flow	59	50

Table 5. Source of material for brood stock, source of fish seed, practices used in production of fish seed, hatchery management practices, and attributes for grow out fishponds

Source of brood stock for hatchery operators	**Percent 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%
System for selection of parental stock	
Random choice of parents	67.7%
Following certain set criteria from experts	32.3%
Number of fish used for eggs and milt	
Equal number of males to females	0%
Usually more females than males	20%
More males than females	80%
Use of fry after hatching them	
Retain all for own use	9.1%
Retain some and sell/give out others	54.5%
Sell out all	36.4%
Is fish seed from farm purchased by other farmers in the wetland	
Yes	47%
No	53%
Size of production system	
<400 m^2	55.6
400 –1000m^2	38.4
>1000 m^2	6.1
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, fish baskets)	1.2
Type of inputs used in pond preparation	
Lime	21.8
Ash	2.7
Animal waste	72.1
Composite manure	3.4
Source and type of Fish feed used in fishponds	
On farm feed manufacture	31.5
On farm waste and house refuse	42.0
Purchased feed ingredients	26.5

Table 6. Socio-economic indices and physiochemical impact indicators or rural aquaculture

Importance of rural aquaculture practice to the farmer	**Number of farmers**	**Percent**
Supply of animal protein	50	36.8
Generation of income	60	44.1
Occupation	04	2.9
For both feeding and income generation	22	16.2
Constraints to rural aquaculture in the wetlands	**Occurrence**	**Percent**
Lack of capital	85	22.5
Lack of knowledge	48	12.7
Lack of appropriate technology	16	4.2
Lack of supply of quality and adequate fish seed	45	11.9
Theft and malice	24	6.4
Floods and excessive water flow into ponds	21	5.6
Predators	75	19.8
Lack of appropriate gears for management and harvesting	64	16.9
Source of labour on fish farm	**Number of farmers**	**Percent**
Solely family	073	57.0
Largely family supported by paid labour	017	13.3
Completely paid labourers	029	22.7
Group support	009	7.0
Source of capital used in fish farming		
Own savings	117	92.1
Credit from bank	001	0.8
Credit from microfinance institutions	001	0.8
Revolving fund from Government/NGO/CBO	008	6.3
Connection between fish pond and natural water body	**Occurrence**	**Percent**
Source of water	42	36.5
First destination of pond effluents	73	63.5
Reported escapes of farmed fish to the wild		
Knowledge of escapees from the farm	36	29.8
Absence of possibility for escape to the wild	85	70.2
Reasons for escape of fish into the wild		
No screens on inlet/outlet	12	30.8
Flooding	23	59.0
Poor handling and control at harvest	04	10.2
Destination of water from the pond		
Within adjoining swamp	52	41.9
Into nearby stream	58	46.8
Into nearby stream	10	8.1
Used for irrigation/fertiliser	04	3.2

Forest	-	-
Existence of any form of pre-treatment of effluent from pond	**Occurrence**	**Percent**
Present	0	0
Absent	119	100
Visible effect of the effluents to surrounding	**Occurrence**	**Percent**
Increased plant growth	48	42.5
No visible indication	65	57.5

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