Socio-economic considerations for rural aquaculture development of Singida tilapia, *Oreochromis esculentus* (Teleostei: Cichlidae, Graham 1928) in Uganda, East Africa

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Running Title: Socioeconomics of Singida tilapia rural aquaculture in Uganda

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ABSTRACT

Domestication and development of aquaculture of Singida tilapia (Oreochromis esculentus) is being promoted in Uganda as a means of conservation of the species threatened with extinction but also as a means of promoting improved supply of fish to poor communities living in remote fishing communities that cannot afford commercial feeds based aquaculture of current farmed fish species in Uganda. The cost of fish feeds is a big deterrent to rural aquaculture development. Singida tilapia predominantly herbivorous nature coupled with other attributes makes this species a prime candidate for rural aquaculture development. As such a socioeconomic was conducted to assess Singida tilapia suitability for rural aquaculture development between July 2014 and June 2016 as part of the national effort to conserve and restore this previous fisheries highlight as a key fish source for rural Uganda. Knowledge and experience in use of such a species, need to lure rural women and youth in aquaculture, and need for a low input system were assessed against the attributes of Singida tilapia including handling under pond conditions, use of natural feeds, simple hatchery system/processes, and appreciable growth performance under pond culture conditions. Singida tilapia was assessed to fit the rural farmers' cited attributes for its rural aquaculture development.

Key words: Singida tilapia, rural aquaculture, socioeconomics

INTRODUCTION

Oreochromis esculentus (Singida tilapia), together with the related *O. variabilis* (locally known as mpongo) formed the mainstay of fisheries in Lake Victoria Region (LVR), comprised o Lake Victoria and Lake Kyoga basins, right from the inspection of the commercial fishing in the early 1900s to the mid-1970s when these fisheries declined .The commercial fisheries based on these two LVR native tilapiine species that are also endemic to LVR's lakes Victoria, Nabugabo and

Kyoga, collapsed starting in the mid- late 1970s, and by the 1980s were biologically completely displaced from their native ranges (Mwanja, 2000; Goudswaard et al., 2002; Mwanja et al., 2012). The displacement of these two species, which are the only native tilapiine species in the LVR, was driven by fishing pressure, changed lake aquatic environment, and introduction of the comparatively more ecologically versatile tilapiine species (*Oreochromis niloticus*, *O. leucostictus*, and *Tilapia zillii*) and predation by the introduced Nile perch (*Lates niloticus*) (Mwanja et al., 2010; Hecky et al., 1994; Balirwa, 1992). However, the two native tilapiine species have remained as small stocks in small water bodies (often referred to as satellite lakes) in the basins of the larger lakes in LVR; the two species were stocked in these lakes starting in the early 1930s for purposes of increasing access to fish to the rural communities and protecting the two from increasing fishing pressure and from competition from the more ecologically versatile exotic tilapiine species (Mwanja et al., 2010). Following the displacement of Singida tilapia from its native range, and the questionable viability of the surviving remnant stocks in the satellite lakes, Singida tilapia was placed on the IUCN Red List of threatened species (Twongo et al., 2006). The collapse of the native tilapias with upsurge of the related sister species and the predatory Nile perch (Mwanja, 2000; Goudswaard et al., 2002) coupled with the relentless and growing fishing pressure, pointed to domestication and aquaculture of these species as a viable solution to ensuring that they are conserved and continue to constitute part of the LVR fish supply especially for rural fisheries dependent communities in Uganda.

The successful effort to domesticate and culture Singida tilapia under aquaculture conditions (Mwanja et al., 2017) presents Uganda with an opportunity to develop rural Singida tilapia aquaculture. The process of domestication of Singida tilapia and development of technologies for

its culture revealed attributes that make Singida tilapia a candidate species for rural aquaculture in Uganda including the predominantly herbivorous feeding ecology; the similarity in spawning and breeding behaviour to already established aquaculture species – the Nile tilapia; the ready assimilation to pond culture environment; and the good performance when cultured exclusively on algae in pond waters (Mwanja et al., accepted). These attributes were viewed as plausible solutions to of the most pressing challenges facing rural aquaculture development in Uganda including limited number of appropriate aquaculture species for rural aquaculture; the requirement for formulated feeds; the stuntedness for tilapia raised in ponds; and the marginalization of poor and vulnerable segments of rural communities without requisite resources for aquaculture (Mwanja & Mwanja, 2009; Mwanja et al., accepted). This study presents information on the socio-economic perceptions and desires of rural farmers for adopting Singida tilapia aquaculture as part of the national drive to conserve Singida tilapia and restore its previous role as a major source of fish supply, especially for the rural fishing communities.

Background to Singida tilapia fisheries

Singida tilapia (*O. esculentus*) is endemic to lakes Victoria and Kyoga found in East Africa, with Lake Victoria shared among three countries of East Africa; Kenya, Tanzania and Uganda, while lakes Nabugabo and Kyoga are exclusively found in Uganda (Fry & Iles, 1972). Singida tilapia, *Oreochromis esculentus*, is a cichlid and a cogener of Nile tilapia, *O. niloticus*. Nile tilapia was introduced into lakes Victoria and Kyoga from Lake Albert and Lake Turkuna starting in mid-1930s (Welcome, 1967; Lowe-McConnell, 1987). Singida tilapia together with mpongo, the two native and endemic LVR tilapiines, were both displaced from their native ranges and deliberately stocked in the minor water bodies (normally referred to as satellite lakes) around the three lakes

Victoria, Nabugabo and Kyoga (Fig. 1) (Welcome, 1966; Fry & Iles, 1972; Mwanja et al., 2010). The two LVR native tilapiine species are currently placed on the IUCN Red List as critically endangered (Twongo et al., 2006). Singida tilapia's preferred food is diatomous algae and is a predominantly herbivorous that feeds from the water column (Garrod, 1959; Lowe-Connell, 1958). Singida tilapia currently survives as separate and relatively small isolated stocks in the different satellite lakes, with a few cases of reportedly relatively sizeable viable stocks in satellite lakes Lemwa, Kawi, Gigatte Nawampasa, Nyaguo, Kimera and Namumbya around Lake Kyoga; Kijanebalola, Kachera and Mburo, part of the Kooki lakes complex found in South-western basin of Lake Victoria; lakes Kayugi, Manywa and Kayanja in the North western part of the Lake Victoria basin that form the Nabugabo lakes complex (Mwanja, et al. 2010) in Lake Kanyaboli in the north eastern part of Lake Victoria Basin in Kenya (Njiru, 2005); and in lakes Babati and Basotu in Tanzania, (Okedi et al., 1975).

In Uganda, Singida tilapia catches contributed over 70% by weight of the total annual fish catches until the late 1950s (Department of Fisheries Annual Reports, 1958/68). In Tanzanian lakes (Babati and Basotu), Singida tilapia constituted over 90% of the commercial fish landings but started to decline from a recorded 400 tons annual catch to 150 tons on Lake Babati; and from 700 tons in 1970 to about 100 tons in 1975 for Lake Basotu (Okedi et al., 1975).The decline continued through the late 1970s when the two species were displaced from their endemic ranges of lakes Victoria, Nabugabo and Kyoga, and relegated to mostly as non-viable stocks in the satellite lakes leading to being listed as a critically endangered on the IUCN Red List (Twongo et al., 2006). Currently Nile tilapia is the most commercially important tilapiine in LVR, a sharp contrast with the fisheries of LVR between early 1900s and the mid-1970s when Singida tilapia and mpongo formed the

mainstay (Balirwa. 1992; Mwanja, 2000; Njiru et al., 2005). A major option for saving Singida tilapia from extinction is its domestication and propagation through aquaculture development and stock enhancement of its remnant stocks in satellite lakes (Mwanja & Mwanja, 2009); Mwanja *et al*., 2012).

Why development of rural aquaculture based on Singida tilapia

As a herbivore that predominantly feeds on algae, Singida tilapia reduces the need for commercially formulated feed if raised in well managed earthen ponds, a major form production system in rural areas. Coupled with the ease of handling under captivity Singida tilapia may be a prime candidate for development of rural aquaculture in Uganda where the need for affordable dietary animal protein at household level is critical to ensuring food and nutrition security. Indeed it has been found to grow quite well in appropriately fertilized ponds with minimal or no artificial dry rations provided as feed (Mwanja et al., 2017). Singida tilapia rural aquaculture is also envisaged as a means of reducing and or eliminating fishing pressure on the remnant stocks of this species in the wild. The conservation and restoration project for Singida tilapia is meant to sensitize communities around satellite lakes where Singida tilapia continues to exist, as to its ecological and socioeconomic value to the ecosystem and their livelihoods, and to support such communities to find solutions other than fishing for the demand for fish. Farming of Singida tilapia therefore gives the project a very important tool in conservation and restoration of this species.

MATERIALS AND METHODS

Study area

This study focussed on satellite lakes with the most ecologically pronounced remnant stocks of Singida tilapia. These were lakes Nakivale, Misyera, Rwoma, Kashasha, and Kijanebalola in Isingiro and Rakai Districts; lakes Manywa, Kayugi, and Bilinzi of the Nabugabo lakes complex in Masaka District; and lakes Kawi, Lemwa, Gigatte, Nakuwa and Kimera of the Kyoga lakes

complex in Pallisa, Kaliro and Bugiri Districts respectively. Other communities involved in the study included those around lakes Mburo and Kachera that form part of the Kooki lakes complex in Kiruhura, Rakai and Lyantonde Districts (Figure 1). The fishing and indigenous knowledge of Singida tilapia coupled with fish farming interest formed the basis for choice of the study communities. As such, the study sampled farmers from five districts close to the satellites which still harbour pockets of Singida tilapia (Table 2), and in limited cases are still fished for mainly household consumption. The districts studied include Pallisa District in Eastern Uganda by Kyoga satellite lakes; Isingiro District in South western Uganda by Kooki satellite lakes; and Masaka District, Kalungu District and Bukomansimbi District in Central Uganda by Nabugabo satellite lakes (Table 3). Although the study population was wide, only those that expressed interest in farming Singida tilapia as alternative supply of household protein and for income generation were interviewed.

Desk review

The study explored the demand for development of rural aquaculture for Singida tilapia as part of the efforts of its conservation and restoration. We examined the status of the species, the strategies and plans for conservation and restoration of Singida tilapia species (Mwanja et al. unpubl). In-depth examination of the policy and legal framework for rural aquaculture practice and development in Uganda was made. The National Fisheries Policy (2004), the Fish Act (2000), the Development Strategy and Investment Plan for the Agriculture Sector of Uganda (2011-2014), the Statistical Abstracts for Uganda (2015), and the Department of Fisheries Annual Report (2012) were among key documents utilised.

The study also examined historical records detailing the production and contribution of Singida tilapia production, its decline, as well as eventual collapse and displacement from lakes Victoria and Kyoga in the period 1950s to 1980s. In addition, the study considered and analysed the increasing production trends and contribution of the introduced species and the Nile perch fisheries from early 1960s to 2016. Data sources included the yearly statistical books of the United Nations Food and Agriculture Organization (FAO), and the Department of Fisheries Resources records held at the National Fisheries Resources Research Institute (NaFIRRI) of the National Agricultural Research Organization (NARO). Secondary production data were examined for the historical importance of Singida tilapia to the fisheries industry and livelihoods of rural communities in the past.

Socioeconomic and sociological survey

Using interview schedules and field observations, this study collected data on the existing rural production systems; the fish farming practices; capture fisheries activities; other livelihood sources; means, influences and standards of living; and assessed the resource management and availability for adoption of Singida tilapia rural aquaculture systems. The study also assessed the capacity and the suitability of farming households to adopt and produce Singida tilapia under aquaculture conditions as a means of addressing some of the challenges for rural aquaculture. Three types of interviews (Key informant interviews, focus group discussions and individual household level interviews) were used in establishing the extent of involvement, challenges and needs of respective households in rural aquaculture. The key informant interviews were based on a common checklist and targeted community leaders, opinion leaders, public technical managers, resource managers, politicians, rural development experts, and aquaculture researchers. Focus group discussions were used to investigate farmers' understanding of tilapia farming needs, and

establish the need for farmers adopting Singida tilapia farming as a means of overcoming some of the challenges.

Sampling design

A sample of 90 households was targeted, 30 from each of the three lake complexes, Kooki lakes complex; Nabugabo lakes complex; and Kyoga lakes complex. In each lake complex the interviews were conducted with six key informants including the District Fisheries Officers or Managers (2), local communities' authorities (Village leaders) (2); a youth leader (1), and a women leader (1). We also held one focus group discussion with active fish farmers in each of three key districts involved including Pallisa of the Kyoga lakes complex, Isingiro of the Kooki lakes complex, and Masaka of Nabugabo lakes complex.

Data analysis

Survey data was coded, entered, cleaned and analysed with the aid of the Statistical Package for Social Sciences (SPSS, 2013).

RESULTS

Importance of Singida tilapia fisheries

The analysis shows that Singida tilapia remains critically marginalized with the remnant stocks still faced with environmental and fishing pressure. Generally, Table 1 shows that all key native fisheries species of LVR drastically reduced in their contribution to the fisheries production over the period while the introduced species, including Nile perch and Nile tilapia, were increasing in their contribution to the LVR fisheries. The results show that Singida tilapia remains extirpated from nearly all its native ranges save for a few of the Kyoga lakes and in satellite lakes where it was introduced (Table 2). Fortunately, in a few of the satellite lakes where the species was introduced the results show that Singida tilapia has become the dominant tilapiine species (Table

2). In all, eighty two (82) respondents were interviewed and were from three districts of Isingiro District by Kooki lakes complex in South-western Uganda, Masaka District by Nabugabo lakes complex in Central Uganda, and Pallisa District by Kyoga lakes complex in Eastern Uganda. Table 3 shows the number of interested farmers by county within the three districts, with Pallisa County in Pallisa District, Buddu County in Masaka District, and Isingiro North in Isingiro District being the counties with farmers that were most interested in taking up Singida tilapia farming. Singida tilapia remained popular within the communities close to the three lake complexes where the species still occurs. Tables 2 and 3, show that the species is more dominant in Masaka by Nabugabo lakes complex, but the most interest in Singida tilapia was registered in Pallisa District found by the Kyoga lakes complex, implying that the relative ecological dominance and abundance of Singida tilapia were not necessarily always matched with the fishers interest in Singida tilapia. It could also be interpreted that the high interest in Singida tilapia resulted in relative low abundance and low ecological dominance due to the higher fishing pressure. The respondents were equally split among youth and elderly, with males constituting 54.9%, and average household size being 4 persons. The results also show that only 8.6% of the respondents did not have any formal education, while the majority (50.6%) had only primary level education. This could explain why the majority (79.5%) of the respondents were self-employed peasants (Table 4). The results also show that although respondents were engaged in multiple agricultural production activities, the majority were involved in crop farming (85.4%) (Table 4). This was followed by fisheries and fish farming at 39.0%, and livestock farming at 37.8%. Respondents revealed that fisheries, fish farming and livestock farming only come second to crop farming as an economic livelihood activity. Only 7.3% of the respondents reported fisheries and fish farming as the most important economic livelihood activity. Men (13.2%) reported their most important economic activity was

fish farming compared to women (4.2%). However this cannot be attributed to culture as only 3% of the respondents (all men) reported cultural norms as a hindrance to fish farming.

Fish farming practices, Knowledge, production attributes, benefits and challenges

Respondents were asked if they had any knowledge and understanding of fish farming and what their source of information and guidance on fish farming was irrespective of if they were practicing or non-practising fish farmers, responses are given in Table 5. A very high percentage (95%) of the respondents had the basic knowledge in fish farming with their source of information as mainly from within fish farmers (73.1%). Among those involved with fish farming, the majority of the respondents were owners or managers of the fish farms. However, when asked about the time they engage in or spend on the fish farming activity, the majority (65.6%) reported spending very minimal time compared to the time they spend on other production enterprises, and that they only worked on the farm at irregular intervals. It should be noted that all the none of the male respondents had never heard about aquaculture whereas 8% of the female respondents had never heard about aquaculture. All respondents who had attained secondary level education and above had heard of aquaculture, while very few of those with primary education had knowledge or had heard of aquaculture practice. In other words, those who reported not having heard about aquaculture had not gone beyond primary education level. The unemployed (housewives and students) were not knowledgeable while the employed were highly knowledgeable about aquaculture

The main challenges faced by fish farmers included lack of farming inputs (seed and feed) reported by all fish farmers, recurrent floods (87.5%) and lack or unaffordable labour (75%). Other challenges included poor yield, predators and diseases. Despite the challenges faced by the farmers, there were some benefits that were registered from fish farming, mainly increased

household incomes (84.4%) followed by household animal protein supply (18.8%) (Table 5). However, 15.6% of the respondents reported that they did not get any benefits from fish farming. Table 6 indicates the level of knowledge, source of knowledge and willingness to take up Singida tilapia farming. A relatively good number (34%) of the respondents reported being knowledgeable about Singida tilapia and their source of information was mainly from other fish farmers (54.5%). When asked if they were willing to take up Singida tilapia farming, 96.2 % were ready to take it up, and they offered a number of reasons why they were not currently engaging in fish farming including lack of aquaculture know how and lack of land for aquaculture production enterprise.

Status of knowledge of fish farming and capacity needs for adoption of Singida tilapia aquaculture

Table 7 gives an indication of the capacity gaps for Singida tilapia culture with 44% of the respondents having received training in fish farming; 45% of them having received training in fish feeding and management, while only 36.7% were trained in pond construction and management. Ninety six Percent (96.3%) of the respondents felt that they still needed training in fish farming. The respondents pointed out the following areas for training: basic aquaculture (51.8%), pond construction (24.6%) and fish product handling, safety and marketing (12.3%).

Preferred traits and attributes for adopting and farming of Singida tilapia

Table 8 shows the desired traits in choice of species for rural aquaculture practice by the respondents. Leading traits include faster growth (77.6%), easier marketability (34.2%); environmental friendly species; and a species whose demand for feeding (use of artificially produced feed) is low (27.6%). This choice of traits is very much a reflection of the socioeconomic status of the targeted fishing communities, and the need for a species that addresses the challenges faced in rural aquaculture practice. Given that rural communities are engaged in several production

activities at any one time, it reflects the communities' desire to have a species that will ensure integrity of the environment or one which does not disrupt the agroecological and natural services that support other production activities just like the Singida tilapia. Table 9 shows the suggested ways and means by farmers for adopting and practice of Singida tilapia aquaculture. The two leading solutions pointed out were training and exposure of farmers to appropriate aquaculture practices and technologies (79.4%) and availing of financing for marginalized groups, especially youth and women interested in Singida tilapia farming (64.7%). It is therefore important that efforts to restore, domesticate and culture Singida tilapia as part of the conservation drive for this species includes opportunities for training and funding of targeted rural communities to engage in the aquaculture of Singida tilapia.

DISCUSSION

This study assessed the potential and choice of Singida tilapia as a candidate fish species for rural aquaculture development in Uganda, in terms of its capacity to meet the livelihoods and food security needs of the fish farming communities. The study also considered how farming of Singida tilapia fits in the communities' regular and more traditional production and livelihoods activities and ways. In particular the study sought to establish whether Singida tilapia domestication and culture provides answers to the challenges faced by the poor rural fish farmers including limited access to appropriate technologies and knowledge of aquaculture due to lack of or limited formal education; absence of the fish farming tradition and or limited experience in fish farming; inaccessibility to quality inputs and technical services for aquaculture due to the high poverty incidence; the limited involvement and participation of the largest segments of the population, in particular the youths and women, due to marginalization of both women and youth in rural

production economy; and the limited choice of species for rural aquaculture in Uganda. This study was part of a larger study aimed at rescuing Singida tilapia from extinction where rural aquaculture was investigated as one of the options for boosting Singida tilapia stocks (Mwanja et al2017)

Rural aquaculture of Singida tilapia was viewed as a means of diverting the fishing pressure on the remnant stocks to controlled production of this species under aquaculture conditions (Mwanja et al., 2014). Key to the success of this endeavour is the socioeconomic and sociological aspects and considerations for domesticating and use of Singida tilapia in rural aquaculture development, which is proposed as plausible and possible alternative to capture fisheries of this species remnant stocks and owing to the favourable rural aquaculture attributes (Mwanja et al. 1973).

The sociological research established high interest among communities around satellite lakes that still harbour Singida tilapia, communities considered to have living memory and knowledge of Singida tilapia as an excellent food fish species. Combining Singida tilapia restoration efforts with the efforts to provide rural households with ready supply of dietary animal protein will make the conservation undertaking socioeconomically viable and sustainable as this will reduce and in some instances eliminate the fishing pressure on the surviving remnant stocks of Singida tilapia in the wild. Rural aquaculture of Singida tilapia is in this regard seen as a means of allowing rejuvenation of withered stocks by reducing or removing the disruptive and or destructive fishing pressure.

Key attributes that made Singida tilapiaappealing to the rural fish farmers are the less dependence on formulated feeds owing to its predominantly herbivorous ecology, the appreciable growth performance under pond aquaculture; the ease of handling and culture in ponds and cages; and the high potential for commercial or market oriented production given the local taste preference when compared to other tilapiine species as well as the relatively lower cost of production due to the

much reduced need for formulated dry rations (feeds). Currently, Nile tilapia is the most consumed fish followed by Nile perch and Mukene. Substitutes to fish products are mostly beans, vegetables and lastly other meats (LVFRP, 1999). Therefore the adoption of Singida tilapia for rural aquaculture development is seen as critical to addressing the increasing gap between the increasing demand for fish and dwindling supply of fish faced in the rural communities, a situation attributed to the increasing value of currently produced fish from the wild given the increasing demand for the produced fish in urban, regional and international markets. The findings indicated high willingness by both fisher folk and fish farmers to take on culturing of this species once given ample information or training. This is a very good entry point in domestication and popularising the farming of Singida tilapia.

In addition, three key natural attributes of this species – appreciable growth performance, herbivorous feeding and preference by consumers, which were also considered as important factors in choice of aquaculture species by the respondents, make the species domestication and popularisation of Singida tilapia culture much easier. The historical role of Singida tilapia and its current preference among the studied communities provide a real opportunity for adoption of this species, especially if the adoption is based on efforts to address socio-economic challenges faced in rural aquaculture practice in Uganda. Among the key challenges faced by the rural poor communities is inability to use complex or intensive production systems and inaccessibility to quality inputs (seed and feed) due to poverty. Singida tilapia natural attributes such as herbivorous feeding habit and easy of handling under pond culture conditions make the species a prime candidate in addressing the challenges in rural aquaculture development in Uganda. These attributes take away the need for buying of commercially produced formulated feeds, and allows

the poor rural farmers to adopt and practice Singida tilapia farming. Also the easy of handling and low management requirement for pond based culture of Singida tilapia means that lack or low of education characteristic of targeted communities does not present a challenge to adoption of Singida tilapia aquaculture.

The natural attributes and easy of handling of Singida tilapia under aquaculture conditions have been proven in the field trials (Mwanja et al., 2017), and currently further research has commenced to economically evaluate the performance of Singida tilapia under the different production systems including ponds, cages and tanks with preliminary results indicating that Singida tilapia performs well in all production systems including both under extensive and intensive culture The study also showed that those in the communities who were knowledgeable and informed about basic fish farming practice were receptive to idea of being trained to adopt Singida tilapia aquaculture. The low or no cost nature of Singida tilapia extensive fish farming allows the marginalized segments of the communities, youths and women, to get involved and operate own Singida tilapia farming enterprises. The study findings also showed that the farmer to farmer knowledge sources are critical to successful adoption of rural aquaculture in Uganda. It is therefore the recommendation of this study that contact farmers be supported to serve as information sources for other farmers, and to demonstrate appropriate farming technologies for Singida tilapia that address the challenges and preferences indicated by the communities.

The findings show that the farmers' desires and needs for carrying out aquaculture are matched and can be met by Singida tilapia's attributes under aquaculture conditions. It is a conclusion of this study therefore, that Singida tilapia is a suitable and appropriate species for rural aquaculture

in Uganda, and presents a real opportunity to addressing the direly needed household dietary animal protein in the rural farming communities.

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Table 1 Contribution of Singida tilapia relative to other fish species to the fisheries production (tonnes) in Lake Victoria compared to other key fisheries species between 1960 and 2000 (‘000 tons) as per annual fisheries production reports (Department of Fisheries).

	Singida tilapia – Ngege	Bagrus sp. – Ssemutundu	Haplochromis species –Nkejje	Rastrineobola argentea – silver fishes	Protopterus victorianus – lung fish	Clarias gariepinus – Mmale	Synodontis victorianus – Nkorongo	Other non tilapia native species
1965	72	4	0	0	2	3	0	5
1966	59	10	3	0	3	6	0	4
1967	32	23	7	5	9	6	1	4
1968	8	15	19	0	39	9	0	3
1969	32	17	5	0	13	11	1	8
1970	26	27	3	0	17	8	1	1
1971	17	29	3	0	16	9	1	4
1972	9	31	5	0	17	9	2	5
1973	10	32	6	0	20	10	1	5
1974	6	35	7	0	13	11	1	3
1975	0	19	11	0	1	17	0	2
1979	1	39	9	0	8	18	15	3

1980	0	7	3	0	1	0	0	2
1981	0	3	2	12	1	4	0	2
1985	0	6	7	17	3	4	6	7
1988	0	0	0	22	0	0	0	0

Table 2. Occurrence of the ngege (*O. esculentus*) and the Nile tilapia (*O. niloticus*) in the LVR. The table includes information on the original status before the recorded introductions: N = native; I = introduced; and the current status: D = dominant; A = absent; E = extirpated or displaced; C = common but not the dominant tilapiine species; R = Rare

Lake/location	***O. esculentus***		***O. niloticus***	
	Original	**Current**	**Original**	**Current**
Napolean Gulf – Lake Victoria	N	E	I	D
Lake Kyoga	N	E	I	D
Lake Nabugabo	N	E	I	D
*Lake Kayanja – Nabugabo lakes	I	D	A	A
Lake Manywa – Nabugabo lakes	I	D	A	A
Lake Kayu	I	D	A	A
gi – Nabugabo lakes				
Lake Kachira – Kooki lakes	I	C	I	D
Lake Mburo – Kooki lakes	I	C	I	D
Lake Kijanebalola – Kooki lakes	I	C	I	C

Lake Nyaguo – Kyoga lakes	N	D	I	R
Lake Nawampasa – Kyoga lakes	N	C	I	C
Lake Lemwa – Kyoga lakes	N	C	I	R
Lake Kawi – Kyoga lakes	N	D	A	A
Lake Bisina – Kyoga lakes	N	R	I	R
Lake Edward – Edward/George basin	I	R	N	D
Lake Kanyaboli – Yala basin	I	D	I	C

Table 3: Number of rural prospective Singida tilapia farmers

Rural communities	Number of respondents	Percent
Pallisa	30	36.6
Isingiro	29	35.4
Masaka	20	24.4
Bunkomasimbi	1	1.2
Kalungu	2	2.4

Table 4: Characterisation of respondents by gender, age, education, size of household and livelihood or employment

Characteristic of respondents	Number	Percent of respondents
Gender of Respondents		
Male	45	54.9
Female	37	45.1
Age group/bracket of respondents		
18 to 30 years	39`	50.0
31 to 65 years	39	50.0
Level of literacy/education of respondents		
Illiterate	7	8.6
Primary education	41	50.6
Secondary education	29	35.8
Tertiary education	4	4.9
Size of households of respondents		
Up to 4 dependents	36	45.0
5 to 8 dependents	27	33.8
Over 8 dependents	17	21.2
Employment status of respondents		
Formally employed	6	7.7
Farmer/self employed	62	79.5
Housewife	7	9.0
Student	2	2.6

Unemployed	1	1.2
Engagement in agricultural production activity		
Crop farming	70	85.4
Livestock keeping	31	37.8
Fisheries and fish farming	32	39.0
Trader – produce dealer	4	4.9
Multi-enterprises	1	1.2
Most important Economic Livelihood Activity		
Crop farming	49	59.8
Livestock keeping	6	7.3
Fisheries and fish farming	6	7.3
Others	21	25.6

Table 5: Characterisation of existing fish farming practices, knowledge, production attributes, benefits and challenges

Attribute or challenge	Frequency	Percentage
Basic knowledge and understanding of fish farming		
Yes	78	95.1
No	4	4.9
Source of knowledge of fish farming in general		
Mass media	11	14.1
School	2	2.6
Local leaders	9	11.5
Extension worker	8	10.3
Fish farmer	57	73.1
Public Aquaculture Institute	1	1.3
Periodicity of engagement in activity		
Daily	10	31.3
Once a week	1	3.1
Irregular tending to fish farming	21	65.6
Benefits registered in fish farming		
Increase in household income	27	84.4
Household animal protein supply	6	18.8
Household maintenance	2	6.3
Fish farming knowledge & experience	2	6.3
None	5	15.6

Challenges to fish farming

Lack or unaffordable labour	24	75
Lack of farming inputs- seed, feed etc	32	100
Poor yield	15	46.9
Price fluctuations of the fish	3	9.4
Insufficient land for fish farming	7	21.9
Recurrent floods	28	87.5
Poor market system for fish	2	6.3
Predators and diseases	14	43.8
Aquatic weeds	2	6.3
Theft and human interference	6	18.8
Insufficient capital	5	15.6
Lack of information	1	3.1

Table 6: Knowledge, source of knowledge and willingness to take up Singida tilapia farming

Knowledgeable about Singida tilapia	**Number of respondents**	**Percentage**
Yes	28	34.1
No	54	65.9
Source of information about Singida tilapia		
Mass media	3	13.6
Local leaders	4	18.2
Fisheries officer	2	9.1
Fish farmers	12	54.5
Other	1	4.5
Willingness to take up Singida tilapia farming		
Yes	75	96.2
No	3	3.8
Reasons for not engaging in fish farming currently		
Lack of aquaculture know how	45	90.0
Lack of land for aquaculture	22	44.0
Inadequate water supply	4	8.0
Lack of feeds	1	2.0
Lack of capital	2	4.0
Envisage opportunities for women and youth joining fish farming		
None	16	20.5
Public support	60	'6.9
Networking	1	..3

Free labour and inputs	1	1.3
Cultural hindrances faced as a prospective fish farmer		
None	20	25.6
Considered bad omen	3	3.8
Not sure	55	70.6
Challenges faced as women or youth in fish farming		
Access to knowledge &training	10	23.3
Access to implements & inputs	18	41.9
Access to land and water	12	27.8
Access to fish markets	3	7.0

Table 7: Capacity gaps and development requirements for prospective Singida tilapia farmers

Capacity attributes (gaps and needs)	**Number**	**Percent**
Training and mode of training acquired		
Had hands-on site training	21	25.6
Trained away from fish farm	15	18.3
None	46	56.1
Types of fish farming training received		
Trained in fish feeding and management	27	75.0
Trained in Pond construction & management	22	61.1
Fish farm management	9	25.0
Trained in fish management	2	5.6
Interest in Fish farming training		
I am interested in training in fish farming	79	96.3
Not interested in training in fish farming	3	3.7
Areas of interest for fish farming training		
Basic Aquaculture	59	74.7
Pond construction and management	28	35.4
Group dynamics and leadership	3	3.8
Women and youth role in aquaculture	4	5.1
Planning and financing of smallholder rural aquaculture	6	7.6
Fish product handling, safety and marketing	14	17.7
Total cases	**79**	

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Interest in Fish farming training		
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Areas of interest for fish farming training		
Basic Aquaculture	59	51.8
Pond construction and management	28	24.6
Group dynamics and leadership	3	2.6
Women and youth role in aquaculture	4	3.5
Planning and financing of smallholder rural aquaculture	6	5.3
Fish product handling, safety and marketing	14	12.3
Total cases	**114**	**100.0**

Table 8: Farmers preferred traits for Singida tilapia as a candidate for rural aquaculture development

Preferred traits by farmers	Respondents (N)	Percentage (%)
Grows fast	59	77.6
Produces fast	6	7.9
Feeds little/easy to feed	21	27.6
Disease resistant	1	1.3
Fetch more money	5	6.6
Big in size (>0.5 kg) at harvest	7	9.2
Marketable	26	34.2
Environmentally friendly	1	1.3
Good quality fish	1	1.3
Easy to maintain	2	2.6
Easy to transport	1	1.3

Table 9: Suggested farmer solutions for improving adoption of Singida tilapia farming

Suggested solutions	Respondents (N)	Proportion (%)
Low cost funding for empowerment of women & youth	44	64.7
Training and exposure of farmers to appropriate aquaculture	54	79.4
Formation of women and youth associations for aquaculture	01	1.5
Provision of free inputs and technical support to women and youth	04	5.9
Availing both land and water for production to women and youth	04	5.9
Provision of no cost feeds to poor farmers	01	1.5
Having a model farmer that people can learn from	02	2.9

Figure Captions

Figure 1: General location of satellite lakes with Singida tilapia to Lake Victoria Basin Systems: