NATIONAL AGRICULTURAL RESEARCH ORGANISATION (NARO)




NATIONAL FISHERIES RESOURCES RESEARCH INSTITUTE (NaFIRRI)

ANNUAL REPORT 2015/2016

A Centre of Excellence for Fisheries innovations working in collaboration with SMART partnerships

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1.1 Mandate

To conduct basic and applied research of national and strategic importance in Aquaculture, Capture fisheries, Water environment, Socio-economics and Marketing and Information Communication Management and emerging issues in the fisheries sector.

1.2 Goal

To enhance the contribution of fisheries research to increased and sustainable fish production, economic growth, food security, and poverty eradication through generation and dissemination of appropriate technologies, knowledge and information.

1.3 Core functions

a) Generation of knowledge and technologies of strategic importance for the management, development and conservation of fisheries resources and water quality.
b) Establishment and management of the human, physical and financial resources of the National Fisheries Resources Research Institute.
c) Provision of technical backstopping and capacity building to the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Zonal Agricultural Research and Development Institutes (ZARDIs) and other agencies dealing in fisheries research and water quality.
d) Development and management of fisheries research information and ensuring collaboration with stakeholders.
e) Planning, monitoring and evaluation of all fisheries research programmes undertaken by the institute to ensure conformity with national research strategy.
f) Ensuring quality of knowledge and technologies developed, multiplied and disseminated through uptake pathways.
g) Generation of periodic reports on fisheries and water quality research programmes to National Agricultural Research Council (NARC) and other stakeholders.
h) Establishment of sustainable linkages and partnerships with local, regional and international research bodies.
i) Participation in problem identification and prioritization of fisheries research demands for the national research agenda

1.4 Research Projects implemented (Research Thrust) during the year

1.4.1 Fish Habitat Management

i) Sustainable utilization and management of natural fish food organisms and artificial feeds for Nile tilapia and African catfish.
ii) Determination of environmental and socio-economic factors that influence optimal fish production levels.
iii) Monitoring of environmental and fisheries parameters around established cage culture sites in Lake Victoria.
iv) Monitoring impacts of the Bujagali Energy Limited (BEL) project on the water environment of the upper Victoria Nile.
v) Map and monitor the prevalence and cover abundance of water hyacinth and other invasive aquatic weeds
vi) Backstopping LVEMP II Community Driven Development (CDD) projects on cage culture farming among communities in various districts
vii) Equipping small scale fishers with adaptation strategies to cope with impacts of climate variability and change on lakes Wamala and Kawi.

1.4.2 Capture Fisheries and Biodiversity Conservation

i) Assessment of commercial fish stocks and determination of appropriate harvesting technologies on major water bodies.
ii) Mapping distribution of *Mukene* fishing grounds and evaluation of appropriate gears for sustainable harvest of *Mukene* on Lake Victoria
iii) Improving light attraction technologies for enhanced harvest of *Mukene* on Lake Victoria.
iv) Identification, characterization and mapping of fish breeding and nursery areas for protection on major water bodies.
v) Development of appropriate cage culture technologies for cage culture and aqua parks.
vi) Actualizing the potential for fish production in small water bodies in South Western Uganda.

1.4.3 Aquaculture and Fish Bioscience

i) Genetic improvement of growth of Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) in Uganda.
ii) Sustainable utilization and management of natural fish food organisms and artificial feeds for Nile tilapia and African catfish.
iii) Development of diagnostic tools and control strategies for fish diseases in cultured fish.
iv) Development of low-cost captive breeding and hatching technologies for the Marbled lung fish (*Protopterus aethiopicus*) to improve livelihoods, nutrition, and income for vulnerable communities in Uganda

1.4.4 Innovations and Post-harvest Fisheries

i) Market and cost-benefit analyses of selected fisheries and aquaculture enterprises.
ii) Identification and prioritization of alternative livelihood options for fishers on Lake Edward and George.
iii) Investigation of bi-directional effects of HIV/AIDS, malaria and bilharzia on fish production on Lake Albert.
iv) Development of cost effective, energy efficient technologies, and marketing strategies for value added fisheries products.
v) Knowledge management, (information acquisition, processing, dissemination and archiving).

1.5 Staffing

The National Fisheries Resources Research Institute (NaFIRRI) obtained a new Director of Research. In this capacity, Dr. Anthony Taabu-Munyaho replaced the longest serving Dr. John Balirwa as the head of the institute. Other staffing levels were maintained. The total number of staff at the institute is 122, serving in different staffing categories including research scientists, technicians, and support staff. Females comprise of 31.1%) (Table 1). It is important to note that the total number of staff members included 46 volunteers (37.7%) distributed in all the staffing categories, indicating that they have continued to serve a very important role in the institute.

Table 1 Number of NaFIRRI staff in the different categories during 2015/16. The staffing levels for the year are maintained from 2014/2015.

	NARO payroll			Volunteers			All staff
Category	Male	Female	Sub Total	Male	Female	Sub total	
Research Scientists	18	7	25	3	5	8	33
Research Technicians	16	3	19	3	3	6	25
Support staff	23	9	32	21	11	32	64
Total	57	19	76	27	19	46	122

Of the 32 Research Scientists, 25 (78%) were on the NARO payroll while the rest were voluntees. (Table 2), with only 13 (39.4%) holding PhDs. More details on the staff can be obtained in Appendix 1.

Table 2 NaFIRRI Research Scientists by Qualification during 2015/16

Category	Qualification		
	PhD	Msc.	Bsc. or equivalent
NARO payroll	13	11	1
Volunteers	-	2	6
Total	13	12	7

1.6 Collaboration and Linkages

The National Fisheries Resources Research Institute has maintained collaborations with other institutions both in and out of NARO. The collaboration with the National Agricultural Research Laboratories (NaRL) in efforts to address concerns for post-harvest fisheries and identification of alternative livelihood activities for fishers has been maintained. Institutions including the Directorate of Fisheries Resources (DiFR), Lake Victoria Fisheries Organisation (LVFO), Makerere University, Directorate of Water Resources Management (DWRM), the National Water and Sewerage Corporation (NW&SC), the National Wetlands Inspection Department (NWID), National Environment Management Authority (NEMA), and Uganda Fish Processors and Exporters Association (UFPEA) have maintained collaboration through joint research, and information dissemination. NaFIRRI scientists also conducted joint research in collaboration with regional institutions such as the Kenya Marine Fisheries Research Institute (KMFRI), and the Tanzania Fisheries Research Institute (TAFIRI), Lake Victoria Basin Commission (LVBC), Egerton University as well as international institutions including the International Network for the Availability of Scientific Publications (INASP), McGill University (Canada), National Geographic, Toronto Zoo (Canada), University of Florida, University of Boston, Auburn University (USA) and World Fish Centre.

1.7 Funding

Funding for NaFIRRI activities has come from different sources including:

(i) Government of Uganda

(ii) The World Bank that funded the Lake Victoria Environmental Management Project (LVEMP II) and Agricultural Technology and Agribusiness Advisory Services (ATAAS).

Details of project specific funding information is provided in Table 3

Table 3 Details of funding information for projects at the National Fisheries Resources Research Institute (NaFIRRI) during 2015/2016

Project Name	End Date	Funding Agency	Balance as at 1st July 2015	Disbursements for the Period	Payments for the Period	Balance as at 30 June 2016
LVEMP 11	30/06/2017	IDA	36,633,626	289,000,000	25,608,713	24,913
			6,633,626	**289,000,000**	**25,608,713**	**24,913**
ATAAS JINJA	30/06/2017	IDA	27,195,322	429,155,841	454,160,030	2,191,133
ATAAS KAJJANSI	30/06/2017	IDA	43,480,812	376,560,971	358,002,662	62,039,121
			70,676,134	**805,716,812**	**812,162,692**	**64,230,254**
EMERGING A/C						
Environment & Social Impact Monitoring on Bujagali Dam	30/06/2018	BEL	1,330,326	84,009,437	85,254,455	85,308
			1,330,326	**84,009,437**	**85,254,455**	**85,308**
COLLABORATION A/C						
SON Fish	31/12/2017	SON Fish	3,466,410	24,592,458	26,034,504	2,024,364
Mc Gill University	31/12/2017	Mc Gill University	5,867,976	-	3,458,476	2,409,500
Aquatic Science Fisheries Abstract	30/06/2017	FAO	2,338,240	18,745,545	15,215,000	5,868,785
			11,672,626	**43,338,003**	**44,707,980**	**10,302,649**
Recurrent		**GOU**	**-**	149,141,618	149,141,618	-
Development		**GOU**	**-**	277,334,564	277,334,564	-
			-	**426,476,182**	**426,476,182**	**-**
RELU A/C						
RELU	30/06/2017	**MAAIF**	**6,820,682**	**15,495,000**	**21,548,366**	767,316
		NAROSEC		**16,726,000**	**16,726,000**	-
			6,820,682	**32,221,000**	**38,274,366**	**767,316**
KAAD	30/06/2018	**KAAD**	**1,147,981**	**234,338,159**	**233,504,140**	1,982,000
			1,147,981	**234,338,159**	**233,504,140**	**1,982,000**
			128,281,375	**1,915,099,593**	**1,965,988,528**	**77,392,440**

1.8 Status of Physical Resources

NaFIRRI has physical resources distributed at her two stations (Table 4) that facilitate a good working environment. These resources fall into categories including physical infrastructural, Office buildings and Office space, laboratory Space and transport.

Table 4 A list of structures, infrastructure and other facilities at NaFIRRI

Structures/facilities	Jinja	Kajjansi
Hatcheries	-	2
Feed mills	-	1
Ponds	-	25
Concrete tanks	-	46
Museum	1	-
Aquaria	2	1
Laboratories	3	3
Computer rooms	1	1
Board rooms	4	4
Conference rooms	1	1
Stores	13	1
Workshops	2	-
Staff houses	44	6
Scientific Laboratories/ offices	11	6
Hostels	1	1
Research Vessels	3	-
Research Canoes	7	-
Cars	20	6
Motor cycles	9	3
Tractor	-	1

1.9 Research achievements

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nakiyende

Project: Assessment of commercial fish stocks and determination of appropriate harvesting technologies on lakes Victoria, Albert, Kyoga, Edward and George.

Background

The fisheries of five major water bodies of Uganda, lakes Victoria, Kyoga, Albert, Edward and George are faced with unsustainable means of harvesting. This has led to reduced fishing opportunities, limiting the contribution of fisheries to food security, income, and employment. Stocks and catches of large sized fish species on these lakes have significantly reduced. As a result, there is a rapid increase in quantities of small pelagic fish species in fish catches of the lakes. Prominent among these are *Rastrineobola argentea* (locally known as Mukene), haplochromines (Nkejje), *Alestes baremose* (Angara) and *Hydrocynus forskahlii* (Ngassia). These are harvested by light attraction and undersized gillnets (< 3 inches) whose sustainability is unknown. The formulation of sustainable fisheries management options, including regulation of fishing capacity requires regular information on: number of fishing units; fish biomass, fish stock sizes, allowable catches; and interactions between fish species and biological cycles which is limited for both the exploited fish species and those with potential for exploitation in the lakes.

Objectives

The main objective is to generate the information required for formulation of sustainable fisheries management options and develop technologies to facilitate effective management and sustainable utilization of fish stocks in the five major lakes. The specific objectives are to determine:

i) quantities, value and trends of fish catches of the major commercial fish species (Nile perch, Nile tilapia, haplochromines, Mukene, Ragoogi, Muziri, and catfishes) on the five major lakes
ii) spatial and temporal distribution of fish stocks on Lake Victoria;
iii) magnitude and trends of fishing capacity on the five major lakes; and
iv) appropriate technologies for harvesting small pelagic fish species on lakes Victoria and Albert

Achievements

Outputs: The project established that the 76.2 mm (3 inch) mesh size gillnets are the most appropriate for sustainable harvest of two pelagic fish species; *Alestes baremose* and *Hydrocynus forskahlii* on Lake Albert where they should be operated in waters more than 10 meters deep after extensive study of impact of current harvesting technologies for the two species on the lake. Drawing from the previously determined sustainable harvest rates as 35% for Nile perch and 29% for Nile tilapia on Lake Victoria, the project provided policy advice on sustainable utilization and management of the Lake Victoria commercial fish stocks. This advice was strengthened by additional information that was generated on trends of annual fish production and beach revenue of commercial catch on Lake Victoria and information on fish species diversity in the riverine and sandy habitats on Lake Victoria and their conservation strategies.

Project Outcome:

Species specific management and development plans for the water bodies to improve fish catches and incomes through science based fisheries management.

Project Impact

Sustainable fishing practices have already been adopted by fishermen after awareness raising events. This if maintained is expected to conserve fish species biodiversity and facilitate fish stocks and species recovery in the water bodies. This will in turn lead to increased benefits from fisheries e.g. increased incomes, employment, nutrition and food security.

Technology/result dissemination

Project technical reports detailing the project findings and appropriate harvesting technologies and effective management options on lakes Victoria and Albert, have been updated and shared with stakeholders such as Directorate of Fisheries Resources (DiFR), Lake Victoria Fisheries Organisation (LVFO), and District Local Governments. The report has been updated by incorporating information on appropriate harvesting technologies for haplochromine fish species on lakes Edward and George. Other information dissemination packages (Posters, brochure and technical reports) for policy and management use have been developed. A MSc thesis ("Exploitation patterns and population structure of *Alestes baremose* (Joannis, 1835) and *Hydrocynus forskahlii* (Cuvier, 1819) on lake Albert, Uganda" that had been submitted to Makerere University for examination has been published.

Lessons learned

Unsustainable fishing practices, coupled with limited regulation of fishing effort and inadequate utilisation of evidence based advisory information have continued to limit the sustainable exploitation and management of the fisheries. There is need of concerted effort to restrict access to the fisheries resources through licensing, monitoring and effective enforcement of existing fisheries regulations. Given the decline in catches of large size fish species in the water bodies, fisher communities are turning to small size fish species including haplochromines and Mukene as alternatives to sustain their livelihoods.

Research activities in progress

The activities being undertaken under the project are determining:

(i) Appropriate gears for sustainable harvest of abundant haplochromine fishes on lakes Edward and George
(ii) Selectivity patterns of illegal hook sizes on Nile perch on Lake Victoria determined. Stock biomass and sustainable harvest levels for key commercial species on Lake Victoria
(iii) Effect of vertical joining of gill nets on Nile perch catches
(iv) The impact of illegal hook sizes on adherence to slot size of Nile perch on Lake Victoria and
(v) Appropriate gears for sustainable harvest of *Brycinus nurse* on Lake Albert

Cf
nakiyende
Project: Mapping distribution of *Mukene* fishing grounds and evaluation of appropriate gears for sustainable harvest of *Mukene* on Lake Victoria

Background

Lake Victoria, shared between Tanzania (51%), Uganda (43%), and Kenya (6%) is currently the most productive lake in Uganda with an annual yield of 300,000 metric tonnes (mt) of fish. Like in the other large lakes in the country, it is evident that stocks of fish species that grow to large sizes have reduced in Lake Victoria and are slowly being replaced by the small sizes species including the haplochromines and *Rastrineobola argentea* (Mukene). This observation points to the urgent need to formulate sustainable exploitation patterns of the emerging fisheries in order to avert a similar situation currently experienced in the large sized species. In order to achieve the above, current information is required on the available stock, current exploitation levels, breeding periodicities and the fishing grounds of the target species. The study "*Mapping distribution of Mukene fishing grounds and evaluation of appropriate gears for sustainable harvest of Mukene on Lake Victoria*" is aimed at mapping and geo-referencing Mukene fishing grounds on Victoria to guide their exploitation and management. A study by Taabu 2003 to establish the composition of by-catch in Mukene catches revealed that catches of Mukene from the inshore shallow waters less than 300 metres from the shoreline constituted the highest by-catch dominated by the juveniles of the non-target species. Recent trawl and hydro-acoustic surveys of 2011 and 2012 also indicated high biomass of Mukene in the deep open waters of the Lake. A mapping and geo-referencing study was piloted in four selected districts (Jinja, Buikwe, Buvuma and Mukono) on the Uganda part of Lake Victoria to establish fishing grounds for Mukene from the shoreline with a view of developing guidelines that would regulate sustainable utilization of Mukene on Lake Victoria.

Objectives of the study

The overall objective of the study is to establish the fishing grounds for Mukene on the Uganda sector of Lake Victoria to guide development of sustainable utilization strategies.
Specific objectives include;

1) Mapping out the Mukene fishing grounds in the sampled areas,
2) Determining distance of Mukene fishing grounds from the shoreline, to establish adherence by Mukene fishers to the 1km regulation
3) Developing a GIS database of Mukene fishing grounds on Lake Victoria for future management use

Achievements

Outputs

i) Updated technical guidelines for sustainable utilization of Mukene (appropriate fishing gear and methods) on Lake Victoria
ii) Updated a georeferenced map of distribution of Mukene fishing grounds on Lake Victoria
iii) Updated GIS database for Mukene fishing grounds on Lake Victoria

iv) Information dissemination packages (Posters, brochure and technical reports) for policy and management use

Outcome
The information on distribution of Mukene fishing grounds has been used as a basis for developing science based management decisions.

Impact
Fishermen are adopting the catamaran technology. The technology enables the fishers exploit Mukene stocks in deeper waters leading to increased catches.

Technology/result dissemination
Project technical reports detailing the project findings and appropriate harvesting technologies and effective management options for Mukene on lakes Victoria have been shared with the diverse stakeholders responsible for fisheries resources management such as Directorate of Fisheries Resources (DiFR) and District Local Governments.

Research activities in progress
Activities being undertaken and planned include:

1. Evaluating efficiency of a locally fabricated rig in shallow waters (< 20 m) and deep waters (>20m).
2. Developing a database of georeferenced Mukene fishing grounds.
3. Comparing the performance of locally fabricated fishing rig to the traditional encircling net (lampara).
4. Developing technical guidelines on appropriate fishing gear and methods for increased and sustainable harvest of Mukene developed.

Cf

Taabu

Project: Improving light attraction technologies for enhanced harvest of Mukene on Lake Victoria

Background

The Ugandan population (>39 million) is rapidly growing at a rate of 3.1% per annum, and this has resulted into increased demand for fish for both human consumption (595,000 tons) and animal feed industry (300,000 tons). The current production levels from capture fisheries (374,000 tons**)** and aquaculture (100,000 tons) are not sufficient to meet these demands. The per capita fish consumption which stands at 6 kg person^{-1} year^{-1} is far below the FAO-WHO recommended levels (17.5 kg person^{-1} year^{-1}). On Lake Victoria, biomass estimates indicate a reduction of 8% in Nile perch biomass from about 1.2 million tons to 1.1 million tons and a corresponding 8.5% increase in *Mukene* biomass from 1.3 million tons to 1.4 million tons between 2014 and 2015. With decline in large fishes (Nile perch and Nile tilapia), the highly nutritious *Mukene* remains the only viable option as it is considered to be relatively more affordable and accessible to the wider public. *Mukene* being a small fish with a lower regeneration time (3 - 9 months), stock assessment models suggest that it can be harvested to at least 60% of its biomass. The enhancement in the use of the improved technologies to attract and concentrate these fishes is expected to increase production to at least 60%, relieve pressure on other large fish stocks and improve local revenues, and the nutritional status of the poor *Mukene* fishing population.

Overall objective

To increase sustainable fisheries production of *Mukene* from Lake Victoria (Uganda) through increased and efficient light fishery production technologies.

Specific objectives

1) To investigate the appropriate light color to attract and concentrate *Mukene* on Lake Victoria.
2) To determine the appropriate source (lamps or bulbs) of light for sustainable harvest of *Mukene*
3) To compare the performance of surface, floating and submerged light sources in attraction and concentration of *Mukene*
4) To determine the appropriate light intensity (i.e. number of light sources; lamps, bulbs) for *Mukene* harvest
5) To investigate the effect of light source, color, and intensity on incidental harvest of non-target species (by-catch) during light fishing

3 **Achievements**

Project Outputs

The project established appropriate light colour, source and intensity for increased and sustainable harvest of Mukene. It also established the colour and intensity with least influence on by-catch. The solar powered bulbs (green and white colours) were found as the most effective at attracting and concentrating Mukene catch. The colours at an intensity of 9 watts for each colour type are the most appropriate light colours (Figure 1). Solar powered bulbs harvested higher catch rates compared to the traditional kerosene lamps.

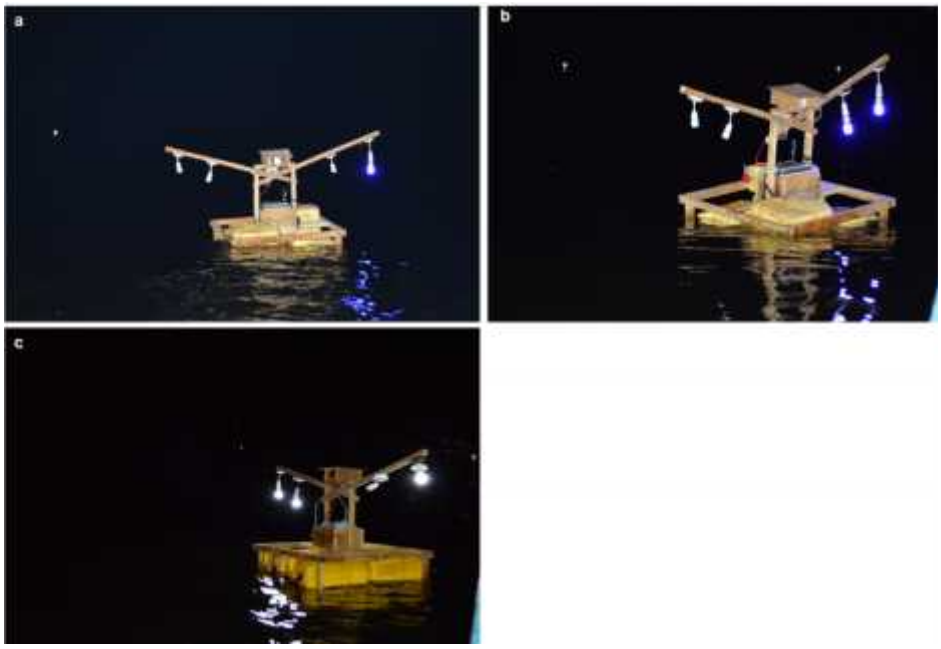

Figure 1 An illustration of white colour produced by solar powered bulbs at different light intensities of (a) 3 watts, (b) 6 watts and (c) 9 watts on a set up designed to attract and concentrate Mukene. The white colour, together with green were found to be the best colours to attract and concentrate Mukene.

Outcomes

The solar light technology has been adopted by fishermen, especially in the districts of Buikwe, Mukono, Buvuma and Mayuge.

Impact:

The adoption of the solar light technlgy is expected to increase catches of fishermen and ultimately their income.

Technology/result dissemination

The information generated from the project has been used extensively during conflict resolution events between Nile perch and Mukene fishers, emanating from perceptions that light used in Mukene fishing chases away Nile perch and enables Mukene fishers capture Nile perch juveniles and other fish types that are food for Nile perch.

Lessons learned

Fishing effort should be concentrated in the offshore and deep open waters of the Lake which have high densities of mature large Mukene.

Research activities in progress

The project is exploring the differences in performance of light when above the surface, floating and submerged on attraction and concentration of Mukene. To fully promote the already developed light technologies, the project is also examining the cost effectiveness of the Mukene fishing rig and its accessories.

Cf
Ogutu
Project: Development of appropriate cage culture technologies and Aqua parks
Background
The Government of the Republic of Uganda is making efforts to promote fish farming to bridge the gap in demand and supply of fish created by the rapidly growing human population, local, regional and international markets and the declining capture fisheries. Aquaculture ventures in the country have so far not been very successful because they have been fragmented, based on few small scale individual fish farms that are poorly planned, organized, managed and regulated. Consequently, the government is making efforts to promote cage culture aimed at bringing together aquaculture entrepreneurs, with common production targets into organized entities for commercial scale aquaculture production. This is being done through promoting establishment of Aquaculture Parks (APs) where zones are identified and allocated for aquaculture development to ensure proper planning, management and regulation to improve service delivery to the sub-sector. Setting up of cage culture facilities and APs requires technological and environmental, social and economic considerations.

Objectives
The specific objectives are:

1. Collecting geo-referenced physico-chemical, hydrological, topographical, biological, economic and sociological factors in the potential cage culture sites.
2. Identification, verification and mapping of potential Aquaculture parks (Aqua-parks)
3. Optimizing cage aquaculture production for highest production and income with minimal negative impacts on aquatic biodiversity and ecosystem services.
4. Developing guidelines, manuals for establishment and operation of cage fish farms and aquaculture parks.

Achievements
Project Outputs
The project developed guidelines for selection and zoning of sites for cage fish farming and aquaculture parks as well as a manual for operation of cage fish farms and aquaculture sites. The guidelines and manual are applicable in facilitating establishment and operation of cage fish farms in Uganda and other East Africa states sharing Lake Victoria. A cage fish farming site was established near NaFIRRI, Jinja to act as a site for research and demonstration of cage fish farming technologies (Figure 2). The sites that had been identified for cage fish farming and aquaculture parks in Busia, Mayuge, Jinja, Buikwe and Kalangala districts have been mapped out to provide information on the sizes of the operation area (Figure 3). In addition, information has been obtained on cage culture operation practices and is applicable for estimating capacity for the sites.

Figure 2 Scientists at NaFIRRI inspect a series of cages at the site established for demonstration of cage culture technologies (left panel while another looks on as fish feed at the site (right panel).

Outcomes

The development of the guidelines and manual have resulted into tools that can be used by prospective farmers and existing farmers, managers and other stakeholders to plan, operate and regulate cage fish farming enterprises. These tools have been absent for the sector. In a similar way, the establishment of the site for demonstration is a way to promote cage culture and good operation practices. The project also established a list of sites in different areas on Lake Victoria that are suitable for cage fish farming and aquaculture parks that can be taken up by prospective fish farmers and investors.

Figure 3 Suitable sites selected for cage fish farming in Busia district on Lake Victoria.

Impact
The guidelines and manual developed are expected to contribute to sustainable utilisation of water resources for cage fish farming. The utilization of proposed sites is expected to lead to enhanced practices of cage fish farming that will ultimately improve production from aquaculture.

Technology/result dissemination
The guidelines and manual have been printed into booklets that are available for stakeholders.

Lessons learned
During the project, it has been learned that the general public, including fishing communities are interested in undertaking cage fish farming although they face financial challenges of start-up capital. There is on-going establishment of many isolated small cage fish farms on the lake, contrary to the plans to group all farm interventions as APs.

Research activities in progress
The project is still engaged in efforts to identify more sites on water and land that are suitable sites for cage fish farming and aquaculture parks. Other activities include documenting impacts of existing fish cages on water environment and biota, consolidated existing information to improve guidelines and protocols on cage culture, maintain cage culture demonstration site.

Aqua and fish bio

Mwanja

Project: Genetic improvement of growth of Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus, Gervais*) in Uganda

Background

Increased growth rate for farmed fish by over 200-300% by selective breeding in countries such as Philippines, demonstrates the enormous potential to increase growth rate in farmed fish species through selective breeding. However, no such attempts have been made in Uganda yet there are many indigenous populations for two of the preferred farmed species– Nile tilapia and African catfish in many Ugandan water bodies. Above all, our farmers for a long time have continued to question the quality of seed they are using in their production systems without convincing answers from research. Despite many Ugandan wild tilapia and African catfish strains with good culture attributes, their comparative performance in common rearing conditions has never been evaluated to choose the best candidates for selective breeding. This project aims to develop fast growing strains based on local fish stocks of both the Nile tilapia and African catfish. The effects will be twofold: i) to address the questions of poor growth rates and low yields raised by farmers, ii) to reduce the production costs incurred by farmers due to poor growth rates, leading to long rearing period exhibited by the current fish seed.

Objectives

To produce genetically improved farmed fish seed/broodstock for Nile tilapia and African catfish species through selective breeding for better performing strains of fish species. The specific objectives are to:

a) Breed and select for fast growing strains of Nile tilapia and African catfish using wild stocks found in lakes Victoria, Kyoga, Albert and Edward based on their culture performance (breeding value).
b) Develop genetically improved strains to enhance productivity and competitiveness of Nile tilapia and African catfish farming in Uganda.
c) Improve the genetic resources and brood stock management practices of farmed Nile tilapia and African catfish by hatchery operators, extension service providers and farmers in Uganda.

Achievements

Project outputs

The prokect identified 5 strains of African catfish suitable for selective breeding from lakes Albert, Edward, Kyoga, Victoria and Wamala and produced specimes of purelines of African catfish from lakes Kyoga (700) and Wamala (547). The study selected 16 lines of 2 families (2 females x 1 male) for selected strains of Nile tilapia and and carried out on station growth performance evaluation of 4 identified pure strains of Nile tilapia (Albert, Edward, Kyoga & Victoria). The on-farm growth performance of Nile tilapia of the Kyoga strain was evaluated in Eastern Uganda (Tororo of District) and the Victoria strain in Western Uganda (Mbarara, Mitoma and Kasese districts). These evaluations led to development of three Nile tilapia strains with improved daily growth rates of 8.7%, 7.3% and 6.5%. The study also produced a F3 generation for the Victoria X Victoria strain.

Outcomes
The project is developing faster growing strains of Nile tilapia and African catfish.

Impacts–Innovations from this project have started demonstrating potential benefits for farmers. Strains with higher growth performance compared to strains that have been under culture are expected to result into improved production and benefits from fish farming in Uganda.

Lessons learned
Wild stocks distributed in different water bodies in Uganda are of higher genetic integrity, which is being exploited to improve growth performance of farmed fish through selective breeding.

Research activities in progress
Research actvies on going under this project involve continous selection of lines of Nile tilapia and African catfish that are improved and evalaution of growth perforrmance of Nile ttilapia and African catfish on station and on farms in different agro-ecological zones in Uganda inclding eastern, northern, south western and south western highlands.

Aqua and fish bio
Walakira
Project: Development of low-cost captive breeding and hatching technologies for the Marbled lung fish (*Protopterus aethiopicus*) to improve livelihoods, nutrition, and income for vulnerable communities in Uganda

Background
Marbled lungfish (*P. aethiopicus*) is native to Uganda waters but its natural stocks are declining mainly due to overexploitation and the large-scale conversion of wetlands to farm lands. Furthermore, climate change continues to influence regional rainfall patterns and temperature regimes, which directly affects aquaculture production. For example, seasonal water deficits caused by prolonged droughts usually constrain management of aquaculture systems. Rearing fish species that are tolerant to drought and stressful water quality conditions is a significant future for African aquaculture development. Air breathing fishes are suitable candidates in stressful conditions because of their ability to obtain and utilize atmospheric oxygen to meet all or part of their metabolic demands.

Marbled lungfish is an air breather that may offer some distinct advantages when water quality for fish growth is stressful like low-dissolved oxygen. Lungfish is valued in Uganda, and consumer acceptance seems high and widespread but appropriate aquaculture technologies are not available for fish farmers engaged its culture. Lungfish farmers currently collect seed from the wild environments and either raise them in earthen ponds or tanks. This is not sustainable ecologically as it can contribute to depletion of wild stocks. However, it is still undertaken since captive breeding technology is not known or documented for the species. The absence of breeding and production technologies limits possibilities to explore its potential to be cultured to generate income and improve nutrition for small-scale holders.

This study seeks to develop low-cost sustainable breeding and culture techniques for Marbled lungfish in the region.

Specific objectives

1. Determine the genetic diversity of the endemic Marbled lungfish (*Protopterus aethiopicus*) fingerlings sourced from four agro-ecological zones (East, North, South western and Central) of Uganda.
2. Domesticate the Marbled lungfish using simple, adoptable and productive captive breeding techniques that integrate indigenous knowledge.
3. Assess the reproductive performance of the A Marbled lungfish in captivity.
4. Evaluate the culture performance of Marbled lungfish raised to market size in small-scale fish ponds.

Achievements

Project Outputs

The study established that morphometric characteristics of lungfish populations from water bodies in Uganda are generally homogenous except populations from Lake Nawampasa that varied from others in gape size, snout length, orbital distance, dorsal fin length and anal fin length.

D-loop (mtDNA) diversity

The lungfish were clustered into three distinct groups that differ by approximately 9.8% sequence divergence. The genetic variation within lungfish populations (79.01%) is higher than variation between populations (20.91%) based on analysis of molecular variance (AMOVA). Conversely, rare haplotypes observed in populations are contributions from Lakes Bisina and Edward. The nucleotide (Pi) diversity values averaged 0.010 ± 0.001; indicating less diversified population between the six lakes.

SNP panel for genetic diversity of lungfish from six lakes in Uganda

A total of 12,085 putative high quality SNPs and 121 SNPs common to lakes Wamala, Kyoga, Nawampasa and Bisina were identified in the transcriptome.

Artificial and natural breeding of lungfish

Males reach maturity at 300g (37-57cm) compared to wild conditions, which mature between 65-85 cm. Lungfish weighing 300g responded to synthetic hormones (HCG and LRHa) but did not spawn. Fertilized eggs (28-46 mm) hatched at a rate of 74-87% when incubated in-doors under the following conditions: pH= 8.21; DO= 4.8 mg/L; Temp = 28.2^{o}C; TAN= 0.001mg/L; Nitrite= 0.0 mg/L.

Evaluating the indoor and outdoor performance of African lungfish

A survival rate of 74% was achieved when larvae were raised to fry size (> 270 mm) using a combination of Moina and formulated diet (crude proteins, 45%). In-door growth trials using wild-caught fingerlings revealed that they gradually accepted sinking fish pellets but marginally increased in average body weight. When fed on fish feeds with 45% crude proteins, the fish grew at a specific growth rate (SGR) of (0.50 ± 0.06%/d). The highest survival rate achieved was 57.50 ± 2.85%, which is higher than what has previously been attained.

Mortalities that occurred during trials were mainly due to cannibalism and pathogens (water moulds and bacteria). Common fish pathogens from experimental fish include bacteria (*Aeromonas sp. and Flavabacterium columnaris*), fungus (*Fusarium spp., Aspergilus sp and Saprolegnia sp*) and parasite (*Dactylogurus sp, Trichodina sp, Tetrahymena sp, Heterorchis sp* and cestodes).

Lungfish juveniles grew faster when raised in outdoor tanks and poly-cultured with Nile tilapia. Lungfish reached market size averaging 138 ± 42.46g in six months but size ranged from 50.2 to 512.9g, probably due to genetic variation within this species.

Outcomes

This project has generated preliminary information that will guide sustainable production of African lungfish, and directions to raise it profitability in captivity.

Impact

No impact has so far been realized but successful culture of the lungfish is expected to contribute to production from fish farming and avail to farmers a fish species that is resilient to water stress during drought.

Technology/result dissemination

A basic guidance on management of lungfish has been expressed in a farmer-oriented leaflet. In addition, a basic nutrition profile of lungfish grow out was developed in a technical report for extension

Lessons learned

Lungfish populations in Uganda are morphometrically homogenous but this requires more research to validate. Information from maternal DNA indicated variation within populations but hardly between populations. Identified putative SNPs revealed differences in lungfish populations. Lake Bisina is unique and more diverse than other lakes. Out-door tanks provide alternative aquaculture systems to raise lungfish if poly-cultured with Nile tilapia

Research activities in progress

The project is exploring technologies for mass seed production, low-cost feed management and improving lungfish survival to enhance success in domesticating the fish species to contribute on livelihoods of communities.

Aqua fish bio
Walakila
Project: Fish Health Surveillance and Control Strategies
Background
Despite the frequent disease outbreaks, information on fish pathogens to guide knowledge-based disease management is limited to parasitic infections. The scarcity of such information hampers the development of management schemes for disease control. With intensive promotion of commercial aquaculture in Uganda to achieve 200,000 tonnes from aquaculture by 2016, high fish stocking densities under commercial fish production will undoubtedly increase disease outbreaks. Preliminary observations indicate that although parasite induced mortalities occur, the intensity of parasites on diseased fish in most cases is too low or not detected at all, suggesting other infections such as bacteria, viruses or fungi. Preventing fish disease is one of the major routes through which fish loss can be mitigated. Knowledge on the occurrence, distribution, and potential risks of pathogens to farmed fish can help in designing management strategies for increased aquaculture productivity and sustainability. Therefore, this project intends to detect fish diseases, develop strategies of preventing and controlling fish disease outbreaks.

Research objectives
1. Determine the social-economic impacts of fish diseases in Uganda
2. Identify major fish diseases and parasites for farmed fish and wild fish.
3. Identify two control strategies for one major fish pathogen

Achievements
Outputs
The project identified infectious *Aeromonas* sp strain from commercial cage fish farms on lakes Victoria and Albert. Accordingly, four plant extracts (garlic, *Occimum* sp., *Bidens pilosa* and *Musa* sp.) were purified and profiled for *in situ* assays on infectious *Aeromonas* bacteria. The project also identified one probiotic *Aeromonas* sp through *in situ* assays and evaluated the effects of Azolla and duckweed on fish parasites.

Outcomes
The study continues to hold expectations to facilitate improved knowledge among farmers about major causes of diseases in farms and avail to them the most effective and affordable control measures.

Impacts:
The knowledge developed is expected to improve farm level management of diseases, leading to reduced losses of fish and ultimately improved yields.

Technology/result dissemination
1. A draft manual on Management of fish diseases in Uganda has been developed and awaits input from main stakeholders.
2. A brochure on controlling of fish predators affecting aquaculture was developed and published.

Lessons learned
1. Molecular approaches are required to identify unknown fish pathogens and parasites.

2. There is limited harmonization of fish disease information among aquaculture stakeholders including scientists in Uganda.
3. All hatcheries and grow-out fish farms lack biosecurity plans

Research activities in progress

1. Identification of major pathogens affecting cultured Nile tilapia and African catfish in Northern and Eastern Uganda
2. Undertaking on farm trials in the Western, Eastern and Central agroecological zones on the efficacy of two plant extracts and two biocontrol agents to control fish pathogens.

Fish habitat and aqua and fish bio

Egessa and owori

Project: Sustainable utilization and management of natural fish food organisms for Nile tilapia and African catfish

Background:
Understanding of natural feeding interactions in aquatic systems is crucial in explaining changes in fish stock performance. In aquatic systems, energy flow is from primary producers through various trophic levels up to fish production. Most fisheries studies have tended to focus on fish species of commercial value and little attention has been given to understanding factors that drive fish production. This project therefore examines the interrelations of lower trophic level organisms ((algae, zooplankton, macro-benthos and prey fishes) in our aquatic ecosystems and aims to explain the current status of fish stocks, and assess the performance of the Nile tilapia and African catfish in varying natural food environments of different study lakes. The specific objectives were to:

i) To ascertain the status and diversity of natural fish food resources
ii) To develop guidelines for management of natural fish food organisms in the wild
iii) To evaluate the potential of selected natural fish food organisms in development of artificial fish feed
iv) To formulate and develop cost-effective and feeding guidelines for Nile tilapia (Ngege) and African catfish (Mmale)

Achievements
Project outputs
The project analysed 10 local ingredients for nutritional quality so that they can be considered in formulation of fish feeds. From these ingredients, three formulations for Nile tilapia grower feed and three for African catfish grower feeds were formulated and tested for palatability and digestibility. The best two Nile tilapia grower feeds and best two African catfish grower feeds with best growth results were evaluated on-farm for growth performance and cost-effectiveness. In addition, growth performance of Nile tilapia fry fed on live and formulated dry feed was evaluated, with the live feed registering the better performance compared to dry feed.

The project established an inventory and status of natural fish food organisms. The natural fish food organisms identified were widely occurring and abundant and therefore constitute crucial natural foods for fish production in the northern and central sections of Lake Albert. The key algal groups such as blue-green algae and green algae occurred in generally low abundance values (< $5mm^3/L$), which may have limited their consumption by the Nile tilapia that instead overwhelmingly ingested higher plant materials.

Zooplankton fish food organisms were surprisingly not utilized by the fishes though high diversity and abundance were recorded. Most macro-benthos fish food organisms generally occurred in low abundances and were ingested in equally small proportions by the Nile tilapia, the African catfish and other fishes. Overall, the Nile tilapia from the northern section fed mainly on higher plant materials (72.4%) while algae (74%) was the more prominent food item in fish from central region of the lake. Diet for different sizes of the fish from the north indicated dominance of higher plant materials followed by algae across the size classes. Macro-

invertebrates (55.7%), higher plant materials (28.6%) and fish, particularly haplochromines (14.3%) were the food categories ingested by African catfish. Insects and fish were major food types for other fish species.

Outcomes:

1. Increased awareness of the need to sustain natural fish food organisms in the lake for optimal fish production
2. Increased knowledge in spatial variations in the role of natural fish food organisms as food for important fish species.
3. The role of riparian zones in providing suitable habitats for fish and fish food organisms and the need for its management well understood, enforced and appreciated among all stakeholders.

Impacts: The information on natural food organisms is expected to guide fishery management decisions to focus more efforts maintaining abundance of natural food organisms for fish and addressing overfishing thus potentially contributing to increased fish production. The development of formulated feeds, with ability to improve growth performance of farmed fish is expected to help farmers to increase their benefits from fish farming.

Technology/result dissemination:
A technical report has been prepared to convey information generated from the project activities to stakeholders.

Lessons learned: Low fish catch rates seem to be driven by other factors especially overfishing since water quality conditions and food resource base are conducive for fish production.

Research activities in progress:
The project is still being implemented on Lake Albert (northern, central and southern sections) to cover effects of seasons as well as the role of the riparian zone in occurrence, distribution, abundance and diversity of natural fish foods especially the invertebrates.

Fish habitat

Wanda

Project: Determination of the distribution patterns, cover abundance and seasonal dynamics of the Kariba Weed (*Salvinia molesta*) on Lakes Kwania

Background

Uganda is endowed with abundant water resources. Of the estimated total area of 243,038 km^2, about 42,383 km^2 (18%) is covered with water in form of lakes, rivers and swamps which are important fish production systems. The major water bodies include lakes Victoria, Albert, Kyoga, Edward, George and the River Nile complex. In 1991, fish production from Lakes Victoria, Kyoga and Albert was estimated at 180,000 metric tons valued at 35.6 billion Uganda shillings. By 2008, fish generated US$ 117 million in export earnings. Currently, fish export earnings are estimated at US$ 113 million from 18,558 tons. Locally, fish provides food security, income and employment opportunities. It is estimated that the fisheries sector also provides direct employment for over 1.2 million people, including fishermen, transporters and traders, but benefits more than 3 million people (DiFR, 2014). However, aquatic ecosystems and their associated resources have for the past few years been threatened by non-native aquatic weeds, notable among which is the Kariba Weed (*Salvinia molesta*). Preliminary data shows that much of the shorelines of Lakes Albert, Kyoga and Kwania are infested with *S. molesta*. A reconnaissance field data collection study was recommended to generate baseline data to determine the status of infestation by *S. molesta* on these lakes. The baseline data would be vital in the development of control strategies of the weed.

Objectives: The overall objective is to reduce the impact of *S. molesta* to manageable levels by 2016. Specific objectives include**:**

i. Establishment of the magnitude and distribution of *S. molesta* infestation on Lake Kwania;
ii. Development of the capacity and strategies for reducing the weed burden to manageable levels; and
iii. Development of policy recommendations that enhance weed management at local and national level.

Achievements

Project outputs:

The project documented the distribution and cover abundance of Kariba weed in the northern and central zones of Lake Albert (Figure 4). This is important information as it indicates continued spread of the weed in the water bodies of Uganda. Cover abundance of the weed in hotspots sites on the lake was estimated as follows: Bugoigo (214 ha), Panyimur (142 ha), Mugona (136 ha) and Toonya (45ha) (Figure 5). The study also extended the survey beyond Lake Kyoga, to the surrounding swamps and associated streams, with findings indicating presence of Kariba weed in some of these areas (Figure 6).

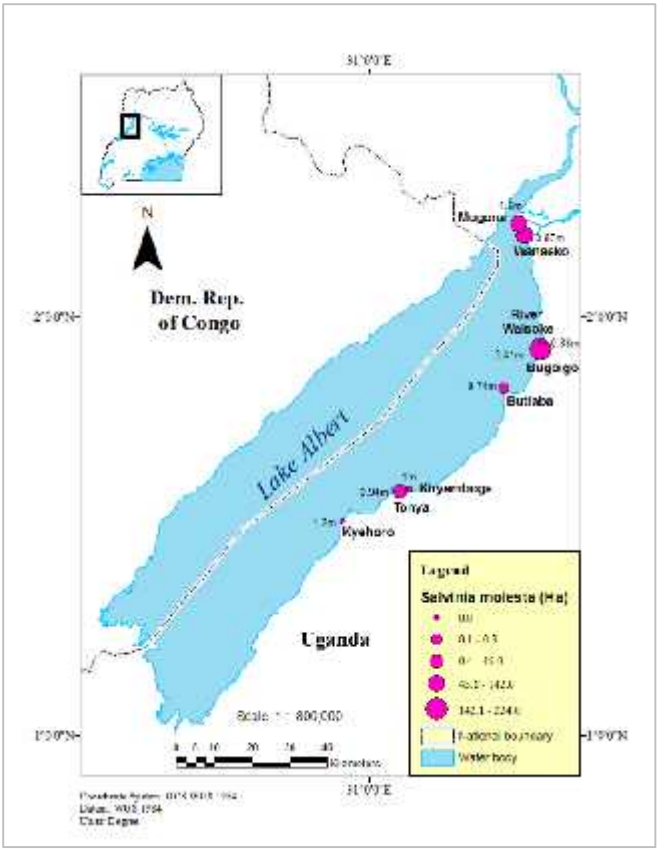

Figure 4 The distribution and abundance of *Salvinia molesta* (Kaliba weed) on Lake Albert.

Figure 5 Trend in cover abundance of Kariba weed in three sites with varying levels of coverage by the weed on Lake Albert. Mugina and Bugoigo (Figure 4) are hot spot areas with moderate to dense coverage (Photos taken in 2015)

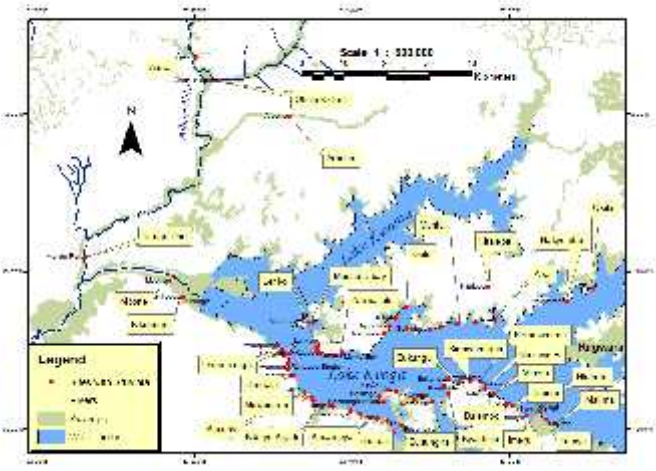

Figure 6 Sites along rivers and swamps beyond Lake Kyoga where *Salvinia molesta* was found.

Outcomes

Increased awareness of communities and other stakeholders through sensitization on the spread and impacts of Kariba weed and the urgent need for its control to non-nuisance levels on lakes Kyoga and Kwania and associated rivers and swamps. The information generated is also an important tool that can be based on to make decisions to control the continued spread of the weed.

Impacts

The information generated from this study has been utilised to develop a control strategy which will result into the control of the Kariba weed to manage its spread and levels if implemented. This will ultimately enhance fish production and livelihoods of communities who depend on the lakes.

Technology/result dissemination

a. A proposed control strategy (short and long term) and a policy brief have been availed to stakeholders including NAROSEC and MAAIF.
b. Other information packages including posters on "Kariba Weed, Giant Salvinia (*Salvinia molesta*) invades Lake Kyoga" are available to the public.

Lessons learned

Addressing the Kariba weed problem needs a collective effort involving a wide array of key stakeholders and availability of resources to facilitate the implementation of control strategies.

Research activities in progress

1. Updating infestation on cover abundance and distribution status of *S. molesta* on Lake Albert and the Kyoga Basin lakes.
2. Inventory of anthropogenic factors that influence proliferation of the Kariba weed
3. Determination of socio-economic impacts of Kariba weed infestation on livelihoods of fisher communities on Lake Kwania
4. Development of policy guidelines for Kariba Weed control

Fish habitat

Wanda

Project: Strengthen information base for the management of invasive aquatic weeds on Lake Victoria

Background

Water hyacinth *(Eichhornia crassipes)* has become a major invasive weed in Lake Victoria and its tributaries since the late 1980's, and a serious threat to aquatic ecosystems, affecting fish stocks and water quality. The Kagera River system is a major source of the invasive weed. In 1998, water hyacinth was estimated to cover approximately 17,000 ha of waters of the Lake Victoria. By February 2000, this weed infestation had been reduced by about 80%, to approximately 3,400 ha, mainly through biological control using two weevils – *Neochetina eichhorniae* and *N. bruchi*. In recent years the coverage of water hyacinths has remained stable in the range of 10 to 20% of the 1998 coverage, which is considered to be an ecologically optimal level, although some areas exhibit its resurgence. The continued nutrient and sediment loading from poorly managed catchments upstream are contributing to increased water hyacinth infestation, persistence, and resurgence of the weed in some hotspots. During LVEMP I, about 36 hotspots were identified and mapped in LVB, of which 13 were located in Uganda. Infested small water bodies and satellite lakes were also sources of the weed entering the main lake. Extensive, tightly packed water hyacinth mats along the shoreline impaired environmental quality for biodiversity maintenance, fish breeding grounds, nurseries of young fish, inshore feeding zones, and refugia for fishes. The interior of extensive mats were normally deoxygenated and/or had low levels of light and oxygen, and produced poisonous gases like ammonia and possibly hydrogen sulphide. Water hyacinth contaminates watering points for domestic supply, and livestock. Mobile mats obstruct access to landing beaches, fishing grounds and transport routes. Water hyacinth increases the cost of water treatment. Weed presence also increases the cost of hydropower generation at Nalubaale and Kiira dams in Uganda. Due to these negative impacts on the ecosystem, consistent data ought to be collected so as to identify weed hotspots and hence guide management based on informed decisions.

Research objectives:

i. To map and monitor the prevalence and cover abundance of water hyacinth and other invasive aquatic weeds in the Lake Victoria Basin (LVB)
ii. Identify water hyacinth hotspots; and
iii. Propose management decisions based on up-to-date data

Achievements:

Outputs:

The project established that water hyacinth continues to occupy various bays of Lake Victoria (Figure 7). Coverage in some bays was found to be as follows: Berkeley (2 ha); MacDonald (10 ha); Hannington (0.01 ha), Thruston (0.09 ha); Fielding (3 ha); Napoleon Gulf (3 ha); Murchison (19.3 ha); Grant (3.42 ha). Water hyacinth cover abundance is highest in the western zone of Lake Victoria in areas such as Nakiwogo to Sango Bay where coverage was found to be approximately 70 ha. This was distributed in major bays as follows: Bunjako Bay (55.4ha), Sango Bay (13ha) and Nakiwogo (0.02ha). The other sites together had minor infestations of less than 0.05 ha.

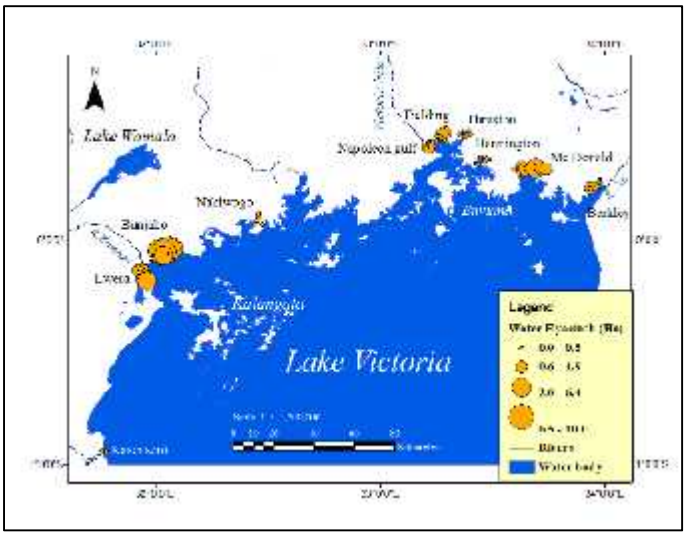

Figure 7 Distribution and cover abundance of water hyacinth in bays surveyed on Lake Victoria.

The study established the presence of Kariba weed in the Lake Victoria basin on Lake Kimira in Bugiri district (Figure 8). A total of 1 ha of Kariba Weed was recorded on the lake and its presence there predisposes Lake Victoria to the infestation by the weed.

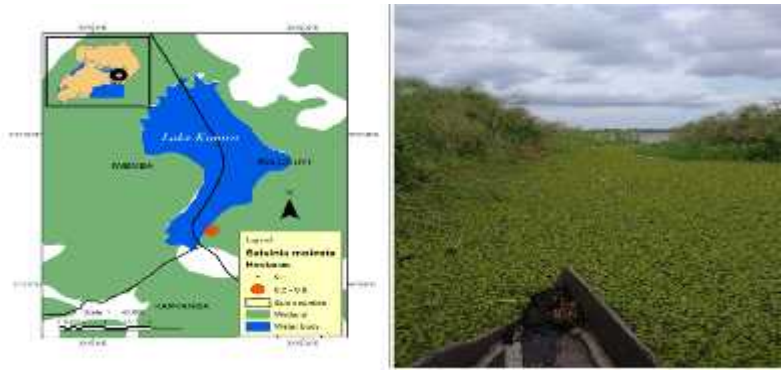

Figure 8 Lake Kimira in Bugiri district showing cover abundance of *Salvinia molesta* in a site where it was found (left panel) and a picture taken on the lake where the weed has spread (right panel). The lake is in the Lake Victoria basin near Lake Victoria

Outcomes

Information has been generated on areas that continue to harbour water hyacinth on Lake Victoria although the levels of the weed are declining. These areas can be targeted by measures aimed at total eradication.

Impacts

The information generated is expected to guide policy makers to strengthen efforts to implement strategies aimed at containing water hyacinth to levels that do not negatively affect fishing, navigation, recreation and water abstraction.

Technology/result dissemination

A journal publication (http://www.tandfonline.com/doi/abs/10.2989/16085914.2014.997181) with detailed information on water hyacinth management priorities was been published.

Lessons learned

i. Regular monitoring is vital in detecting any water hyacinth resurgence
ii. Regular monitoring will also document any new invasions e.g. Kariba Weed which is already a menace in the Kyoga-Albert aquatic systems with a possibility of infesting Lake Victoria.

Research activities in progress

1. Examining seasonal dynamics of major aquatic weeds and their hotspots in the Lake Victoria Basin.
2. Development of information packages including policy briefs, guidelines and National and Regional Monitoring, Surveillance and Control Strategy for water hyacinth and other aquatic weeds.

Fish habitat

Egessa

Project title: Strengthen the infrastructure for aquatic ecosystems health: Packaging and dissemination of information on heavy metal pollution and its impacts on the water environment and aquatic biota

Background:

Lake Victoria is a very important natural resource for the three riparian states of Uganda, Kenya and Tanzania. It is a source of fish and other aquatic resources used for generation of revenue, employment, navigation, trade and other purposes. However, the lake is faced with environmental problems that threaten the socio-economic benefits derived from it. Key among the threats is water contamination or pollution and over-fertilisation (eutrophication or excess nutrient loading). These threats originate largely from various development activities within the lake's catchment including agricultural activities/farmlands, industries and urbanization all of which generate wastes. In absence of proper disposal methods, wastes end up in the lake environment leading to deleterious effects such as deterioration of the water quality, which not only negatively affects the productivity processes but also reduces the multiple uses and benefits of the lake for the entire East African region. The existing environment laws and regulations are not strictly enforced leading to rampant poor water quality especially in bays adjacent to urban centres such as Murchison Bay near Kampala. Previous investigations have found such areas to have altered and lower diversity and abundance of key aquatic organisms i.e. algae, invertebrates and fish. Contaminants are known to bio-accumulate in organisms of the aquatic food chain, which may lead to low biosafety of the lake's food products.

Objective

To package the available information and data and produce information dissemination materials (pollution management guidelines, information brochures, a documentary, policy briefs and publications), sensitize stakeholders on the dangers of pollution in the environment, and develop a strategy to reduce pollution levels in the lake.

Specific objectives

1. To package and disseminate the generated information on heavy metals and nutrient pollution of Lake Victoria, to the stakeholders.
2. To develop a strategy for reducing pollution levels in the lake.
3. Sensitize stakeholders on the dangers of pollution in the environment

Achievements

Outputs

A video documentary on heavy metal and nutrient pollution, with recommendations for its management, in Lake Victoria, Uganda was developed. A monograph on pollution status of Lake Victoria was reviewed and completed.

Outcomes

The project has developed a video documentary and a monograph, which are important tools to increase awareness and initiate measures to control pollution and excessive nutrients in Lake Victoria.

Research activities in progress

1. Complete production of video documentary on aquatic pollution
2. Publish monograph on pollution in Lake Victoria
3. Disseminate generated and package information to stakeholders

Fish habitat

Egessa

Project: Monitoring of environmental and fisheries parameters around established cage culture sites in Lake Victoria

Background:

Source of the Nile (SON) Cage Fish farm is located at Bugungu in Napoleon Gulf, northern Lake Victoria, near the headwaters of the River Nile. NaFIRRI has, through a Public-Private collaborative partnership with SON management, undertaken regular monitoring of the cage fish farm since 2011. The agreed study areas cover selected physical-chemical parameters i.e. water depth, transparency, column temperature, dissolved oxygen, pH and conductivity; nutrient status; biological parameters i.e. algae, zooplankton, macro-benthos and fish communities. Results/observations made were presented in form of technical reports once every quarter; along with a scientific interpretation and discussion of the findings with reference to possible impacts of the cage facilities to the water environment and aquatic biota.

Research objectives: The objective of the environment monitoring is to track possible environment changes and impacts thereof as a result of fish cage operations in the area.

Achievements

Outputs:

The study noted significantly higher algal biomass (Figure 9), lower abundance of zooplankton, non-occurrence of pollution sensitive taxa and lower abundance of benthic macroinvertebrates at the site with fish cages indicating changes in water and sediment quality at the cage site. However, the physical chemical parameters (Table 5) (pH, dissolved oxygen, conductivity, water transparency and temperature) were within the acceptable and desirable levels for fish production.

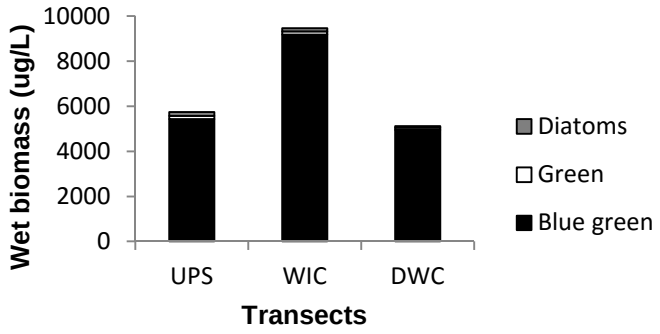

Figure 9 Variation of algal biomass across the three study sites, at SON 2015 (DSC = Downstream of fish cages; WIC = Within fish cages; USC = Upstream of fish cages)

Table 5 Summary record of physical-chemical parameters measured in-situ at SON fish farm, 2015 (DSC = Downstream of fish cages; WIC = Within fish cages; USC = Upstream of fish cages)

	DSC		WIC		USC	
	Mean	Range	Mean	Range	Mean	Range
T°C	26.4	23.2 – 26.7	26.7	26.5 – 26.9	26.8	26.5 – 26.9
pH	10.3	9.5–10.5	9.1	8.8 – 9.3	9.2	8.8 – 9.6
Turbidity (NTU)	2.1	0.5 – 3.3	3.7	0.6 – 4.9	2.4	1.9 – 3.5
DO (mg/L)	8.8	8.0 – 9.5	9.4	9.2 – 9.7	8.9	7.2 – 9.8
Cond. (μScm^{-1})	98	97 - 99	99	-	99.9	99– 102
BOD_5 (mg/L)	3.2	1.6 – 3.4	5.6	4.4 – 6.8	2.6	2.1 – 3.3

Outcomes: The generated technical reports give confidence to cage fish farmers in the area for cage-based fish production as long as best management practices are followed.

Impacts: The positive results contained in the reports confer undeterred long term potential for cage fish farmers to contribute to high and sustained fish production in the lake without compromising environmental quality.

Technology/result dissemination
Four quarterly technical reports and one consolidated technical report on levels of physico-chemical conditions, nutrients and biotic communities at cage and non-cage sites to assess possible impact were submitted to the stakeholder.

Lessons learned: It is important to share the generated technical reports with DiFR, the government agency responsible for managing fisheries resources in the country.

Research activities in progress:
Quarterly surveys will continue and the preparation of management guidelines and on-farm manuals on fish cages to guide management of areas with fish cages in the lake. Currently the team undertakes similar monitoring surveys in other areas with fish cages.

Post harvest inno

Joyce akumu
Project: Assessment of social, cultural and economic indicators of health, co-management and livelihood benefits.

Background
Fisheries and aquaculture significantly contribute to fishers' and fish farmers' incomes; nutrition, employment, and GDP. These benefits are directly threatened as a result of environmental degradation, invasive weeds and the slow growth in aquaculture production, which are linked to socio-cultural and economic activities in the catchments of aquatic ecosystems. However, there are limited research interventions that have been made to consider the interactions between water quality, fish productivity and the proliferation of aquatic weeds and other challenges with socio-cultural and economic indicators. This project therefore aims at contributing to the formulation of policy guidelines, management strategies and best practices that take into account these interactions to contribute to realizing increased and sustained fish production.

Objectives:
The main objective is to assess and quantify social, cultural and economic indicators of health, co-management and livelihood benefits based on bio-economic models and to develop management guidelines at different levels of fish production.

Specific objectives:
1. To assess the impacts of activities of lake side communities on water quality, and proliferation of aquatic weeds.
2. To determine the impacts of water quality, pollution and aquatic weeds on the livelihood of the lake side communities.
3. To strengthen the capacity of lake side communities in good water environment management.

Achievements
Outputs
The project established key socio-economic indicators of lake side communities favouring prolifiration of Kariba weed and other water weeds in the Northern part of Lake Albert and the impacts the proliferation of the weeds is having on the livelihoods of the fisher communities. According to local communities, the key human activities that adversely affect the prolification are fishing, oil exploration, road construction, and poor waste managment (Figure 10).

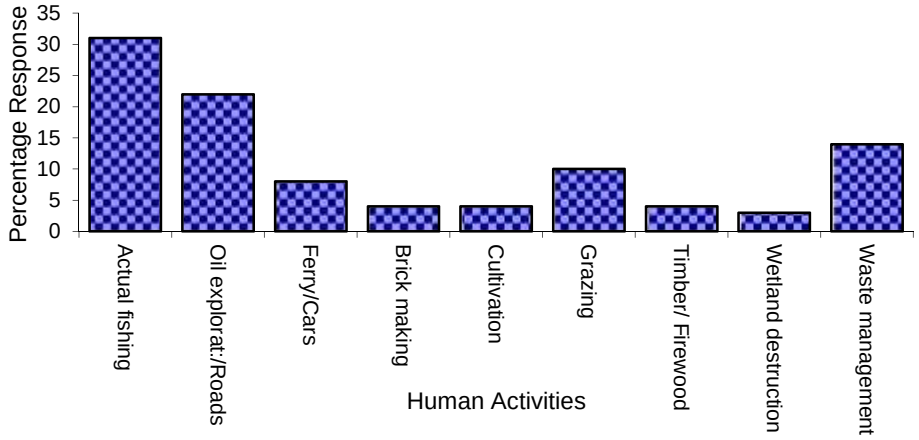

Figure 10 Human activities that are perceived by fishing communities as factors that adversely affect the water environment of L. Albert and accelerate the proliferation of Kaliba weed

The study established the many ways in which Kariba weed has affected local communities that are devastating for their livelihoods. Impacts include:

1. Coverage of fishing grounds and sensitive fish habitats by thick mats that have led to fish kills.
2. Loss of fishing opportunities as for example, inshore fisheries especially for *Brycinus nurse* (Ragoge) cannot be operated any more in some areas.
3. Increased expenses on fishing activities as most fishers (71%) have shifted to offshore waters that are more expensive to access. More fuel (average 5 litres) is needed to access fishing grounds that needed 10 litres to access before the infestation. Fishing costs have increased by about 50%.
4. Reduced fishing days and catch per unit of effort) as the average numbers of days fished has reduced from 6 to 3 days while average value for catch per canoe per day has reduced by 29.4%. This has affected many people including boat crew, boat owners, fish traders, processors and the consumers.
5. Reduced average daily income from fishing activities reportedly from 65,000/= per day before the emergence of kariba weed to 30,000/= Uganda shillings, indicating a 53.8% decrease.
6. Loss of fishing equipment including nets and boats worth an estimated 11,701,000 /= per month per landing site. The long roots of the weed entangle nets, rendering them inefficient to catch fish. This also reduces their lifespan which has reduced from about three months to two. More time is spent preparing nets for fishing trips, leading to loss of fishing days. Boats trapped within the weeds are exposed to faster depreciation as they become covered with water to the bream, which has reduced their lifespan from about 1 year to six months.
7. Interrupted transport as the weed impedes passage of transport boats, and canoes.
8. Migration of fishers where landing /docking areas have been blocked by the weed.
9. Reduced household fish consumption from an average of four meals per week to one.
10. Increased prevalence of diseases like malaria, bilharzia and skin rashes.
11. Limited access to water for domestic use whenever the weed covers landing sites. Water covered by the weed becomes unsuitable for any kind of household usage as color changes to dark coffee brown and has a foul smell.

12. Exposing people to dangerous animals such as snakes, crocodiles, pythons, and alligators that are harbored in the thick floating mats.

Outcomes: The project has generated information on the factors accelerating spread of Kariba weed and the impact of the weed on fishing communities, which should be used to guide and motivate measures to control the spread of the weed and mitigate the challenges faced by local communities.

Impacts

The project is expected to lead to the control of Kariba weed and result into sustainable fisheries resource conservation and management and improved livelihoods of the lake side communities.

Technology/result dissemination

Information communication packages including a poster paper, and a technical report have been prepared to disseminate information. The results have partly been disseminated to stakeholders during the NaFIRRI Annual stakeholder Review and Planning workshop.

Lessons learnt

i) Good agricultural practices using the right recommended quantities of herbicides/pesticides and cultivation far from shoreline areas will help in reducing the amount of nitrates in the soil and thereby lowers its content in the water, and will lower the dangers of abiotic consumption of harmful pesticides.

ii) There is urgent need to sensitize all stakeholders including private sector, communities, interest groups and individuals as well as governments so as to have the will to participate in tackling the water pollution problems in a curative but also in a preventive manner.

Research activities in progress

Research actvities in progress include evaluating socio-economic impacts of the Kariba weed and proposing appropriate mitigation measures.

Post hervest and inno

Joyce akumu

Project: Market and cost-benefit analyses of selected fisheries and aquaculture enterprises

Background

The fisheries sector in Uganda has enormous potential to contribute towards national development goals, yielding benefits to communities, private sector and the state through incomes, profits and public revenues. Uganda is striving for a competitive, profitable and sustainable fisheries sector envisaged in the National Fisheries Policy, in line with Development Strategic Investment Plan (DSIP). A major constraint to this development is limited understanding of profitability on investments in both capture fisheries and aquaculture and fish marketing systems.

Profitability research is necessary to facilitate transformation of aquaculture from subsistence to commercial production, necessary to attain the target production of 300,000 tonnes per annum set for Uganda under DSIP. With proper profitability information, investments would be attracted into fish farming. Widespread abandonment of ponds would be reduced with better understanding of profitability among fish farmers. Priority ranking of fish farming enterprises under Government programmes would be improved with higher profitability. Aquaculture projects would become more sustainable with improved economics of fish farming. Fish farmers would re-invest more of their earnings back into fish farming and not only on consumptive expenditures like paying school fees, building houses or buying clothes. Lastly, information on profitability and pay-back period would enable banks to lend more to fish farmers.

Research objectives:

The general objective is to examine market, costs and benefits of selected fisheries and aquaculture enterprises. The specific objectves include:

i) Determine the profitability indices, namely annual profits, break-even points and pay-back periods for fisheries enterprises for optimum exploitation of commercial fish species on Lakes Albert, Kyoga, Victoria, George and Edward.
ii) Estimate economic returns for aquaculture enterprise for optimum production of commercially farmed fish species.
iii) Develop strategies to improve market access for capture fisheries and farmed fish species locally, nationally and regionally.

Achievements

Project outputs:

The project established profitability indices for 8 districts in Mid and North- Western Sub-regions of Uganda. The indices revealed losses for most of the Nile tilapia and African catfish ponds (Table 6), which resulted in a high rate of pond abandonment. The average breakeven point (Table 7) per production cycle for a Nile tilapia pond was 3.9 tons and for 1.8 tons cat fish only and 1.1 tons for a polyculture (Nile tilapia and African catfish). Adoption studies conducted in the region revealed highest adoption rates for improved technologies, guidelines and best practices with respect to fish seed (66.2%) and lowest in harvesting and processing (35.4%). The major constraints to fish farming emerged as limited extension services, seed and feed and market for fish, and poor record keeping.

Table 6 Average revenues, costs and gross profits by species target of fish ponds per production cycle (Shs)

	Tilapia	Catfish	Tilapia & Catfish
Revenues			
Sale of fish	400,000	2,080,000	9,967,500
Total revenues	400,000	2,080,000	9,967,500
Costs			
Pond depreciation	107,143	72,500	275,862
Pond repair costs	175,000	300,000	180,000
Costs of fingerlings	524,317	875,000	531,126
Delivery of seed on farm	27,604	27,143	30,833
Packaging materials	9,947	10,950	16,333
Manufactured feeds	950,000	662,500	1,092,000
Delivery of feeds on farm	303,643	303,643	303,643
Labour costs	670000	822000	507500
Pond fertilisation	10,000	7,500	20,000
Harvesting nets	200000	400000	300000
Predator nets	66,000	66,000	66,000
Predator strings	40,000	40,000	40,000
Total costs	3,083,654	3,587,236	3,363,297
Annual gross profits	-2,683,654	-1,507,236	6,604,203

Table 7 Break-even points per pond by species stocked

	Nile tilapia	African cat fish	Nile tilapia/ African catfish
Total costs (Shs)	3,083,654	3,587,236	3,363,297
Prices of tilapia (Shs/kg)	800		1,250
Prices of catfish (Shs/kg)		2,000	4,800
Breakeven point for tilapia only ponds (kg) (1/2)	3,855		
Breakeven point for catfish only ponds (kg) (1/3)		1,794	
Breakeven point for mixed tilapia/ catfish ponds (kg) (1/2+3)			1,112

Outcomes

The project has generated information that can be used to iimprove enterprise selection among fish farmers, in terms of species or their combinations selected and levels of production that are profitable. The information can be used to raise awareness on the constraints limiting productivity of fish farming enterprises to inform decisions for mitigation measures.

Impacts

The study is expected to lead to:

i) Improved production and profitablity of fish farming enterprises.
ii) Increased returns on investments for fishing and fish farming enterprises.
iii) Improved incomes for fishers and fish farmers

Technology/result dissemination

Information dissemination materials have been prepared including a project technical report on technology adoption and performance of Pond Fish Farming in Western Uganda, a policy brief on strengthening adoption of improved technologies and guidelines and best practices along the fish farming value chain in Western Uganda and a fact sheet on profitability of fish farming in Eastern Uganda.

Lessons learnt

The poor economic performance of ponds is leading to abandonment of fish farming activities. However, if the challenges including high cost fish farming inputs such as feeds and fingerlings are mitigated, aquaculture production can increase.

Research activities in progress

On-going research includes examining profitability indices for aquaculture enterprises for pond and cage fish farming in various areas of the country, and evaluation of economic value of fisheries to national GDP.

Post hervest and inno

Bwambale

Project: Identification and prioritization of Alternative Livelihood Options for Fishers on lakes Edward and George

Background

Fisheries have been the main source of livelihood for the communities around Lake Edward, settled within the Queen Elizabeth Conservation Area (QECA). Studies carried out under this project between March, 2013 and June, 2014 indicated that most fishers in these communities derived up to 80% of their income from fishing with about 27% depending entirely on fisheries activities. However, their livelihoods have been threatened by the declining fish catches resulting from overfishing and catching of immature fish by the rapidly increasing population yet they cannot turn to activities such as crop growing that are prohibited in the QECA. There is, therefore, need for the fisher communities to engage in appropriate alternative livelihood sources with a view to reduce fishing pressure to enhance stock recovery for sustainable fisheries as well as for improved welfare. Against this background, two sanctuary-compliant livelihood options, that is: mushroom growing and bee keeping have been prioritised and the pilot for mushroom growing has been carried out at Kazinga, Katwe, Rwenshama and Kayanja landing sites around Lake Edward.

Objectives

The main objective of this project is to assess livelihoods, identify Queen Elizabeth National Park sanctuary-compliant livelihood options and pilot them among Lake Edward fisher communities.

The specific objectives are to:

i) assess the socio-demographic characteristics of Lake Edward fisher communities in relation to their livelihood capabilities

ii) assess livelihoods of Lake Edward fisher communities

iii) identify and pilot sanctuary-compliant alternative livelihood options for Lake Edward fisher communities.

Achievements

Project outputs

The project established three apiculture pilots involving a total of 89 members from three landing sites (Kazinga, Kayanja and Kishenyi) on Lake Edward. Each pilot was established with three different types of hives (langstroth, KTB and traditional hives) and their accessories including three protective gears, 6 catcher boxes, 6 kilograms of bees wax, 6 hive tools, 6 bee brushes, 6 airtight buckets, 6 bee smokers, 6 pieces of honey sieve cloth, 6 saucepans, 100 pieces of honey packing materials, 100 pieces of stickers, 6 pieces of candle moulds, and 10 litres of eucalyptus oil, distributed among the three pilots. The accessories were aimed at facilitating apiculture operations and value addition. The project also facilitated a farmer field school involving 61 members of the groups and developed their capacity in (i) bees' pests and diseases control and management and (ii) honey and bees wax harvesting, processing and quality control (Figure 11 & 12).

Figure 11 A cross section of members of a fishing community on one of the landing sites being trained on (a) how to establish bee hives establishment and management and (b) how to disinfect the bee hives

Figure 12 Female participants in one of the training sessions practicing how to boil wax used as a bait for bees in beehives.

Outcome

The pilots established can act as facilities from which others can learn from and adopt apiculture as an alternative livelihood source in the fishing communities. The fishers are now aware that there are livelihood options to which they turn to and diversify their livelihoods amidst the reducing fish stocks that are even friendly with conservation objectives of the national park in which the fishing communities involved are located. After the pilot establishment, training and capacity building events, the groups have bought more bee hives and added on the ones provided during the pilot. The group at Kazinga landing site has for example added more six traditional hives.

Impact

The outcomes of the project are expected to result into improved livelihoods options, income and food security for the fisher communities. It is expected that this will in turn reduce pressure on fish stocks through for example reduced time spent of fishing and fishing grounds.

Technology/result dissemination

1. The results of the mushroom pilot were presented at NaFIRRI Annual review and planning workshop in October, 2015.
2. Information materials including a technical report and a journal publication (http://www.fisheriesjournal.com/vol1issue5/88.1.html) have been prepared.

Lessons learned

1. Apiculture is a viable livelihood activity for fisher communities for the fishing communities.
2. Fisher communities need to be highly sensitised to embrace the available livelihood enhancement programmes such as Operation Wealth Creation (OWC), where they can acquire start-up capital that can help them to take off. Otherwise without such interventions and given their levels of income, adoption will continuously remain low.

Research activities in progress

The ongoing activities in the project include equipping fisher communities with knowledge and skills in value addition on hive products. The project targets to involve at least 60 members at the three landing sites of Lake Edward. The project also plans to determine adoption rates of the piloted alternative livelihood options, produce and inventory of socio-economic impacts of alternatives on livelihoods, and document changes in fishing activities in response to the adoption of the alternative livelihood options. In the long term, the prioritized alternative livelihood options will be up scaled to other lake systems.

3.0 NaFIRRI publications

A. Journals

Musinguzi, L., Efitre, J., Odongkara, O.K., Ogutu-Ohwayo, R., Muyodi, F.J., Natugonza, V., Olokotum, M., Namboowa, S., Naigaga, S., 2015. Fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hot spots: A case of Lake Wamala, Uganda. *Environ. Dev. Sustain*. http://dx.doi.org/10.1007/s10668-015-9690-6.

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Walakira, J., Molnar. J. J, Phelps R., and Terhune J. 2015. Culturing the African Lungfish in Uganda: Effects of exogenous fish feed on growth performance in tanks. Uganda Journal of Agricultural Sciences. 15 (2): 137 – 155.

Walakira, J., P. Akoll P., Engole, M., Sserwadda, M., Rutaisire J., Sserwadda M., Naigaga, I, Birungi, D. et al. 2015. Common fish diseases and parasites affecting wild and farmed Tilapia and Catfish in Central and Western Uganda. Uganda Journal of Agricultural Sciences. 15 (2): 113 – 125.

Wanda, F. M., , Namukose, M., & Matuha, M. 2015. Water hyacinth hotspots in the Ugandan waters of Lake Victoria in 1994–2012: implications for management, African Journal of Aquatic Science, 40(1), 101-106.

B. Books/ book chapters/ theses/special publications

Wacher, C., Okello W., Gitau, M.K. & Wolf, M. 2016. Participatory wetland management at the shoreline of Lake Victoria in Jinja, Uganda. The wetland user rights of an aquatic civilisation in a context of legal pluralism and modern environment law. Fountain Publishers, Kampala, Uganda

C. Technical reports/special papers

Akumu, J., K. Odongkara K., B. Mbilingi, R., Okura, D,. Namanya and A. Nasuuna

Bwambale M, K, Odongkara, J. Akumu., S, Namatovu., E, Naula and A, Nasuuna (2015) Livelihood Options for Fisher Communities to Relieve Fishing Pressure on Lake Edward. National Fisheries Resources Research Institute (NaFIRRI)

Bwambale M, K, Odongkara, J. Akumu., S, Namatovu., E, Naula and A, Nasuuna (2015). Water quality and pollution hot spots for optimal fish production and aquaculture in the Kyoga Basin (Lake Kwania). National Fisheries Resources Research Institute (NaFIRRI).

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Odongkara K., B. Mbilingi, Akumu. J, D. Mununuzi, R. Okura, G. Mutegeki and A. Nasuuna. 2016. Pond fish production system; promoting adoption of improved technologies, guidelines and best practices along the value chains for market-oriented fish farming in Uganda, Nafirri policy brief no 01 of 2016.

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D. Brochures

Profitability of fish farming in Eastern Uganda

E. Posters

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4.0 Challenges faced during the year

Challenges that were faced during the year are similar to the challenges faced in previous years, indicating that the challenges are persisting. These include:

a) In adequate and irregular flow of funding for research and information generation and dissemination. This is hindering research activities as well as other commitments of the institute for instance to cover facilitation for non-contract staff, yet they contribute to the institute's mandate. This is also making efforts to replace old and obsolete office, field and laboratory equipment difficult.
b) Slow procurement process especially for laboratory equipment and analytical chemicals.
c) Inadequate staffing is still a challenge and currently, the ratio of research technicians to research scientists has remained inappropriate for a research institution striving to be a Centre of Excellency.
d) Meeting the demand for technical backstopping of farmers especially emerging cage fish farmers has become a challenge. Their demands sometimes come when not expected and cannot be properly met when resources are inadequate.

e) Unclear foreign-driven research interventions for the Chinese based at NaFIRRI Kajjansi has hindered smooth access to research facilities and this is limiting the capacity for research and production of seed for farmers.

Appendix 1 NaFIRRI staffing by June 2015

SN	Name	Sex	Job Title	Qualification	Station
1	Taabu A. Munyaho	M	Director of Research	PhD	Jinja
2	Odongkara.O. Konstantine	M	Principal Res. Officer	PhD	Jinja
3	Mwebaza Ndawula Lucas	M	Sen. Res. Officer	PhD	Jinja
4	Wanda Fred Masifwa	M	Sen. Res. Officer	PhD	Jinja
5	Ogutu-Ohwayo Richard	M	Sen. Res. Officer	PhD	Jinja
6	Owori W. Akisoferi	M	Sen. Res. Officer	PhD	Kajjansi
7	Mbabazi Dismas	M	Principal Res. Officer	PhD	Kajjansi
8	Atukunda Gertrude	F	Research Officer	MSc	Kajjansi
9	Akumu Joyce	F	Research Officer	MSc	Jinja
10	Okello William	M	Sen. Res. Officer	PhD	Jinja
11	Nkalubo Winnie	F	Research Officer	PhD	Jinja
12	Bwambale Mbilingi	M	Research Officer	MSc	Jinja
13	Nkambo Mujib	M	Research Officer	MSc	Kajjansi
14	Cassius Aruho	M	Research Officer	MSc	Kajjansi
15	Aanyu Margaret	F	Research Officer	MSc	Kajjansi
16	Namulawa Victo	F	Research Officer	PhD	Kajjansi
17	Walakira K. John	M	Research Officer	PhD	Kajjansi
18	Komugisha B. Rose	F	Research Officer	MSc	Kajjansi
19	Mwanja T. Matthew	M	Research Officer	PhD	Kajjansi
20	Nakiyende Herbert	M	Research Assistant	MSc	Jinja
21	Musinguzi Laban	M	Research Officer	MSc	Jinja
22	Egessa Robert	M	Research Officer	MSc	Jinja
23	Nankabirwa Angela	F	Research Officer	MSc	Jinja
24	Amiina Robert	M	Principal Lab. Tech.	Dip	Jinja
25	Masaba F. Anthony	M	Sen. Lab. Tech.	Dip	Kajjansi
26	Kityo Godfrey	M	Sen. Lab. Tech.	Dip	Kajjansi
27	Kiggundu Vicent	M	Sen. Lab. Tech.	MSc	Jinja
28	Nsega Monica	F	Sen. Lab. Tech.	MSc	Jinja
29	Ocaya Henry	M	Sen. Lab. Tech.	BSc	Jinja
30	Bassa Samuel	M	Sen. Lab. Tech.	MSc	Jinja
31	Muhumuza Elias	M	Lab. Tech.	BSc	Jinja
32	Naluwayiro S. Janet	F	Lab. Tech.	Dip	Jinja
33	Pabire W. Gandhi	M	Lab. Tech.	Dip	Jinja
34	Ganda Egulance	M	Lab. Tech.	BSc	Kajjansi
35	Kasigwa Howard	M	Aquaculture Tech.		Kajjansi
36	Nakasiga V. Lydia	F	Lab. Tech.	BSc	Kajjansi
37	Ekwang Robert	M	Sen. Fin. Officer	ACCA	Jinja
38	Kyalimpa F. Batumbya	M	Sen. Internal Auditor	MMS, PGD &BCOM	Jinja
39	Mutalwa Edward	M	Marine Captain		Jinja
40	Asangai O. Timothy	M	HR & Admin Officer	MA, PGD-HRM	Jinja
41	Arinda Collins	M	Procurement Officer	BA	Jinja
42	Waigolo Saul	M	Info. Comm. Officer	BA	Jinja

SN	Name	Sex	Job Title	Qualification	Station
43	Endra Alice	F	Information Officer	MSc	Jinja
44	Wasukira W. James	M	Marine Engineer	MSc	Jinja
45	Sserwadda Martin	M	Farm Manager	MSc	Kajjansi
46	Bazanya Florence	F	Admin. Ass.	Dip	Kajjansi
47	Byaruhanga K. Godfrey	M	Aquaculture Eng.	MBA, BSc.	Kajjansi
48	Nabbumba M. Lillian	F	Admin. Ass.	BSES	Jinja
49	Opolot O. Stephen	M	Sen. Marine Tech.	Dip	Jinja
50	Bwire Patrick	M	Asst. Systems Admin.	Dip	Jinja
51	Omusana Gilbert	M	Maintenance Ass.	Dip	Jinja
52	Sevvume Hudson	M	Stores Ass.	Dip	Jinja
53	Rwabwera T. Kakuru	M	Records Ass.	Dip	Jinja
54	Twinomujuni N. Jessica	F	Admin. Ass.	Dip	Jinja
55	Mukiibi A. Caroline	F	Accounts Ass.	Dip	Kajjansi
56	Namukasa T. Zahara	F	Stores Ass.	Dip	Kajjansi
57	Nanyanzi S. Agnes	F	Accounts Ass.	Dip	Kajjansi
58	Okwakol Moses	M	Marine Tech.	Cert.	Jinja
59	Najjuma Marion	F	Accounts Ass.	BSc	Jinja
60	Ssentumbwe Francis	M	Accounts Ass.	MSc	Jinja
61	Byaruhanga Robert	M	Driver	UCE	Jinja
62	Bifamengo Moses	M	Driver	UCE	Jinja
63	Bagaga Vicent	M	Driver	UCE	Kajjansi
64	Mukasa M. Kosia	M	Driver	UCE	Jinja
65	Kalyowa Rogers	M	Driver	UCE	Kajjansi
66	Ddumba David	M	Driver	UCE	Jinja
67	Kajja Hannington	M	Driver	UCE	Jinja
68	Baliise Charles	M	Deckhand	Cert.	Jinja
69	Wanok W. Egino	M	Deckhand	Cert.	Jinja
70	Mukose Salim	M	Deckhand	Cert.	Jinja
71	Kabalinzi Rose	F	Office Ass.	Cert.	Jinja
72	Asonya Bonefance	M	Office Ass	Cert.	Jinja
73	Edaku Wilson	M	Security Guard	UCE	Jinja
74	Drakumah Tepheleson	M	Security Guard	Cert.	Kajjansi
75	Kasozi James	M	Research Officer	MSc	Kajjansi

Project staff

1.	Ochola Christine	F	Office Ass.	Cert.	Jinja
2.	Namayanja Justine	F	Proc. Ass.	Dip. Proc.	Jinja
3.	Babalanda Munilu	M	Deckhand	Cert.	Jinja
4.	Kiligoola Sande	M	Deckhand	Cert.	Jinja
5.	Madoi Muhammed	M	Deckhand	Cert.	Jinja
6.	Akol John Michael	M	Driver	Cert.	Jinja
7.	Semakula Henry	M	Driver	UCE	Jinja
8.	Akurut Hellen	F	Office Ass.	UACE	Jinja
9.	Oguti Milton	M	Office Ass.	UCE	Jinja
10.	Namusubo Faridah	F	Acc. Ass.	BBA	Jinja

11.	Nasuna Agnes	F		Dip. Acc.	Jinja
12.	Magezi Godfrey	M	Research Tech.	Cert. Lab.Tech.	Jinja
13.	Kyangwa Rogers	M	Driver	UCE	Jinja
14.	Nakaluba Maureen	F	Office Ass	Cert. Sec. Studies	Jinja
15.	Nimaro Joyce	F	Office Ass	UACE	Jinja
16.	Mugabe Hebert	M	Security guard	UCE	Jinja
17.	Kagoda Alamanzan	M	Security guard	Cert.	Jinja
18.	Tazibirwa Joshua	M	Research Ass.	Bsc Fisheries	Jinja
19.	Kamira Barry	M	Research Ass.	Bsc Biochemistry	Jinja
20.	Ocibo Emma	M	Ass. Systems Adm.	Bsc. IT	Jinja
21.	Sodagar Singh	M	Ass. Systems Adm.	Bsc. IT	Jinja
22.	Atiku Rajab	M	Security guard	Cert.	Jinja
23.	Mpomwenda Veronica	F	Research Ass.	Bsc.	Jinja
24.	Kagoya Esther	F	Research Ass.	Bsc.	Jinja
25.	Mudondo Felister	F	Research Tech.	Dip	Jinja
26.	Mulowooza Alex	M	Research Tech.	Dip	Jinja
27.	Nuwahereza Colleb	M	Research Tech.	Dip.	Jinja
28.	Amondito Brenda	F	Research Tech.	BSc	
29.	Amoding Leah	F	Library Ass.	BLIS	Jina
30.	Musubika Sarah	F	Research Ass	Bsc. Tech.	Jinja
31.	Turyashemererwa Martin	M	Ass. Systems Adm.	Bsc. IT	Kajjansi
32.	Nagawa Teddy	F		B.Com	Kajjansi
33.	Kabugo Fred	M	Driver	UCE	Kajjansi
34.	Wasirwa David	M	Driver	UCE	Kajjansi
35.	Katongole Frank	M	Driver	UCE	Kajjansi
36.	Sebutinde Paddy	M		UCE	Kajjansi
37.	Ssali Peter Kawuki	M	Ass. Systems Adm.	Bsc IT	Kajjansi
38.	Ddungu Richard	M		Bsc	Kajjansi
39.	Kimera Stephen	M		Bsc Aquaculture	Kajjansi
36.	Mutegeki Gad	M	Show Attendant	Bsc Env. Sc.	Jinja
37.	Vianny Natugonza	M	Research Ass.	Msc	Jinja
38.	Kauma Prossy	F	Library Ass.	BLIS	Jinja
39.	Matuha Maureen	F	Research Ass.	Msc.	Jinja
42	Nagayi Flavia	F	Office Ass.	UACE	Jinja
43	Namatovu Safina	F	Research Ass.	BVS	Kajjansi
45	Namulondo Benah	F	Acc. Ass	BBA	Kajjansi