National Fisheries Resources Research Institute
(NaFIRRI)



African Union Centre of Excellence for Research and Training in Aquaculture, Inland Capture Fisheries, and Climate Change

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- Kikagati Power Company Limited
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Abbreviations

ACARE: African Centre for Research and Education
ACIAR: Australian Centre for International Agricultural Research
AFALU: ASSOCIATION OF FISHERS AND LAKE USERS OF UGANDA
ARDC: Agricultural Research and Development Centre
ASARECA: Association for Strengthening Agricultural Research in Eastern and Central Africa
BSFLM: Black Soldier Fly Larval Meal
CAADP: Comprehensive Africa Agricultural Development Programme
DiFR: Directorate of Fisheries Resources
DWRM: Directorate of Water Resources Management
FAO: The Food and Agriculture Organization of the United Nations
FCR: Feed Conversion Ratio
FPU: Fisheries Protection Unit
GIS - Geographic Information System
GoU: Government of Uganda
ICIPE: International Centre for Insect Physiology and Ecology
ICT: Information and Communication Technologies
IEC: Information, Education and Communication
KMFRI: Kenya Marine & Fisheries Research Institute-Kisumu
LVBC: East African Community Lake Victoria Basin Commission Secretariat
LVFO: The Lake Victoria Fisheries Organization
MAAIF: Ministry of Agriculture, Animal Industry and Fisheries
MT: Metric Tons
NAADS: National Agricultural Advisory Services
NaFIRRI: National Fisheries Resources Research Institute
NAR Act: National Agricultural Research Act
NARO: National Agricultural Research Organization
NARS: National Agricultural Research System
NEMA: National Environment Management Authority
NGO: Non-Governmental Organization
NWSC: National Water and Sewerage Corporation
PARI: Public Agricultural Research Institute
PESCA: Promoting Environmentally Sustainable Commercial Aquaculture
RMCA: Royal Museum for Central Africa.
SDGs: Sustainable Development Goals
TAFIRI: Tanzania Fisheries Research Institute
TIMPS: Technologies, Innovation, and Management Practices

UFFCA: Uganda Fisheries and fish Conservation Association
UFFRO: Uganda Freshwater Fisheries Research Organization
UFPEA: Uganda Fish Processors and Exporters Association
ZARDI - Zonal Agricultural Research Institute

Executive summary

NaFIRRI conducts aquaculture and fisheries research that is responsive to the national development needs. Research at NaFIRRI guides the management of fisheries resources for their sustainable exploitation and is responsible for the development of the fish farming sector in Uganda to increase fish production. This report is intended to present highlights of research interventions and activities in the financial year of 2023/2024. The research highlights are focused on fish habitat management; capture fisheries and biodiversity conservation; aquaculture and fish bioscience; and innovations and post-harvest fisheries.

NaFIRRI through the ARDC leads the research part of the PESCA (promoting environmentally sustainable commercial aquaculture in Uganda) project. In this period, this project registered tremendous achievements important in the development of aquaculture in Uganda. Among others, the project harnessed genetic tools to ensure faster growth of farmed fish. 20,000 parent stock of Nile tilapia from selective breeding were earmarked for distribution to seed multipliers across Uganda. The project also made strides in zoning areas with high potential for aquaculture and improving feed for farmed fish using locally available ingredients.

Through a project to enhance bulk production of quality Nile tilapia seed to increase production, scientists at ARDC worked hard to increase the capacity of Zonal Agricultural Research and Development Institutes (ZARDIs) to produce seed. This was through the supply of brood stock to 4 ZARDIs and refurbishment and equipping fish breeding facilities.

The ARDC is worked in irrigation schemes in the western, Eastern, and Northern regions of Uganda to empower rice farmers to adopt fish farming. 50 demonstration sites were established while 1,852 farmers were skilled in aquaculture management practices. These farmers in irrigation schemes were supported with seed, feed, and equipment such as feed pelletizers. This is a good example of efforts to diversify food systems to increase food security and resilience of farming households.

In capture fisheries, NaFIRRI is active in interventions to promote sustainable use of fisheries resources. To tackle the scourge of post-harvest losses, we accomplished community engagement in fishing communities on Lake Albert to promote good practices for post handling practices. Significant milestones were made in securing land to establish a solar tent drier as part of efforts to improve post-harvest infrastructure.

With support from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), catch assessment and frame surveys were accomplished for Lake Kyoga. These surveys are critical for evidence-based fisheries management, yet they were lacking for the lake

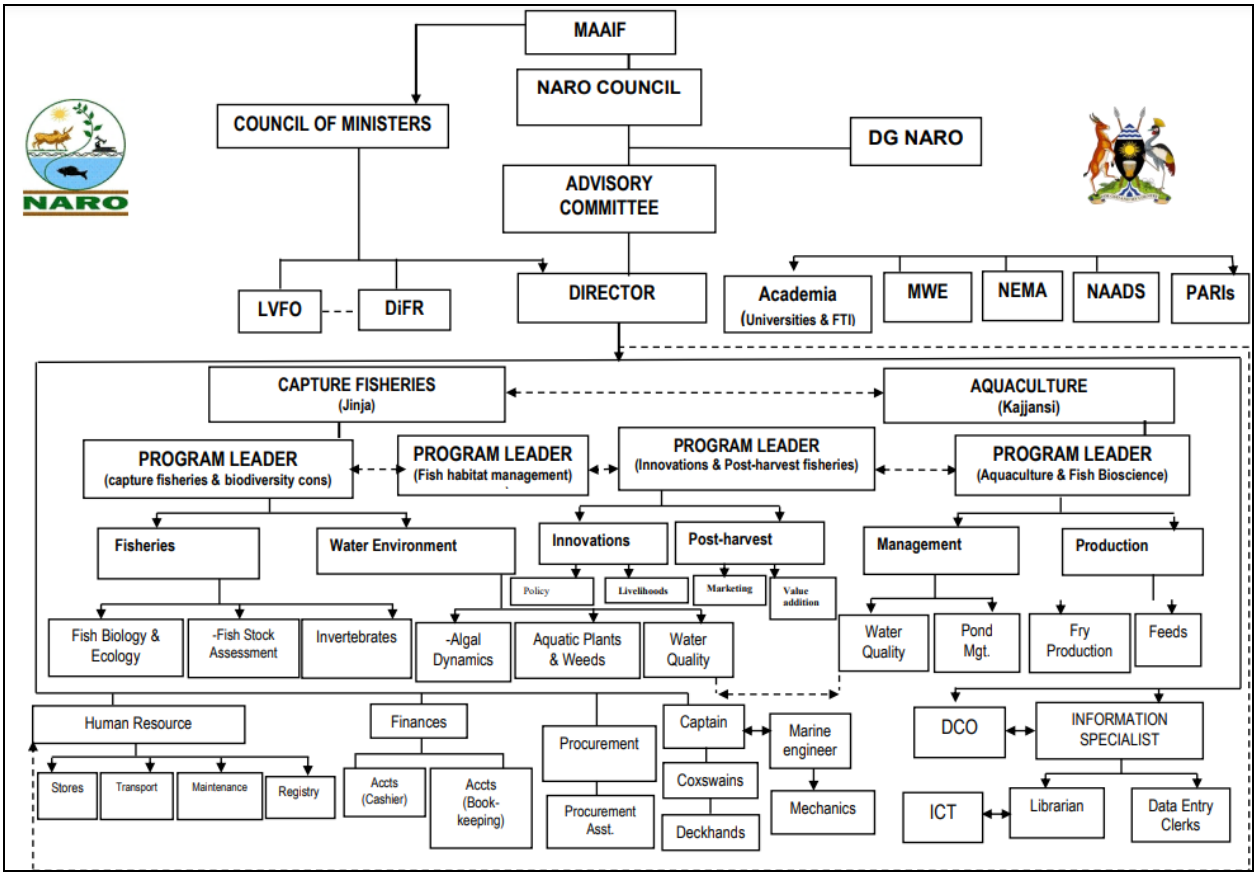
in the last decade. From these surveys, attributes of the fishery and fishing effort which are used in decision-making were determined. These include but are not limited to annual catches, value of fish, and number of fishers. The results from these surveys were used directly into the Kyoga Basin Lakes Fisheries and Aquaculture Management Plan I (KBL-FAMPI) (2024- 2028), validated in March 2024. Still on fishery assessment surveys, a major infrastructural advancement was made by the acquisition of a new research vessel, Angara, for Lake Albert. This vessel will enable NaFIRRI and partners acquire novel data on biomass of fish stocks this making fisheries management more effective.

We also made strides in advancing access to freshwater biodiversity data for conservation decision making. Building on achievements in the past, NaFIRRI continues to maintain and enrich the Freshwater Biodiversity Portal for Uganda. It is noteworthy that photographic atlases were accomplished for the fishes of Uganda in all the major national lake basins. Aggregating research conducted over several years, the atlases profile the fishes of Uganda. The atlases do not only provide a chance to understand the enormous diversity of the fishes of Uganda but also present vital information about the fishes such as conservation status, presence, and origin that is essential for conservation decision making, capacity building, and advocacy.

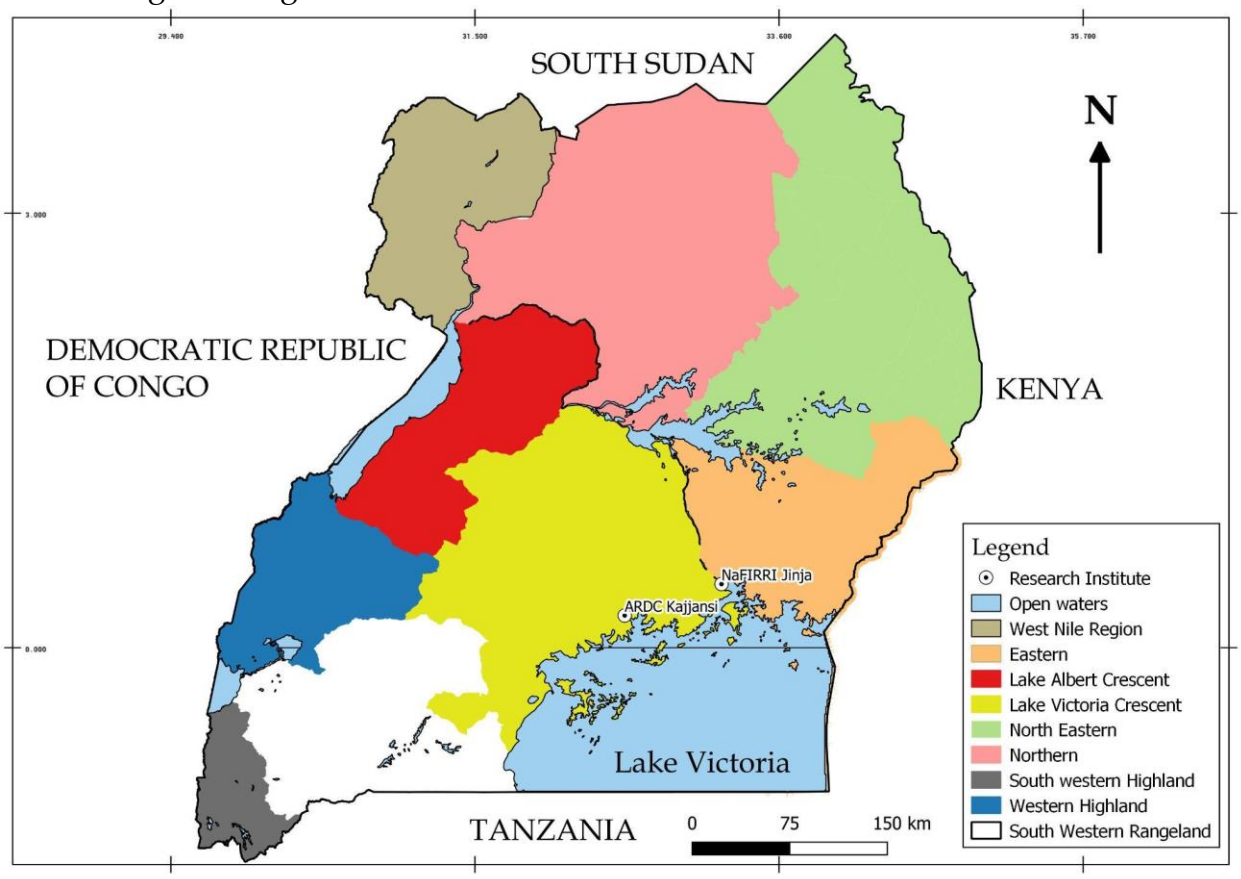
In this period, NaFIRRI was active in monitoring Bujagali Energy Limited (BEL) as part of its obligations to ensure that the operations of the dam are in line with International Financial Corporate (IFC) Performance Standard 6 (PS6) guidelines regarding biodiversity conservation. The monitoring was expanded to cover the area downstream the dam that is designated as the offset area of the dam. Data acquisition in this area was completed to examine the suitability of this area as a biodiversity offset, provide evidence to mitigate habitat degradation and overfishing, and facilitate more understanding of new fish species.

In all the endeavors over this period, numerous partnerships have been established for technological development and promotion. From the partnership with 15 other NARO National Research Institutes and ZARDIs to unlock the multipurpose potential of pigeon pea for food, feed and soil health enhancement in Uganda to a new partnership with University of Birmingham, Lilongwe University of Agriculture and Natural Resources, and the Institute for Poverty, Land and Agrarian Studies at the University of the Western to build adaptive fisheries governance capacity, these partnerships strengthen the capacity of NaFIRRI to effectively implement its mandate.

Organizational Structure, Governance and Management



National agro-ecological zones



Chapter 1: INTRODUCTION

1.1 About NaFIRRI

1.1.1 Brief background

The National Fisheries Resources Research Institute (NaFIRRI) is a semi-autonomous Public Agriculture Research Institute (PARI) of the National Agricultural Research Organization (NARO) established by the National Agriculture Research System (NARS). NaFIRRI's headquarters are located along plots 39-45, Nile Crescent & Plots 28-32, Oboja road in Jinja city.

NaFIRRI has a sub-station called the Aquaculture Research and Development Center (ARDC), located in Wakiso district, 13 km from Kampala, along Entebbe road, 1.5 km from Kajjansi town. The centre is responsible for aquaculture research and development in Uganda. The centre is equipped with research facilities such as ponds, outdoor concrete tanks, and indoor hatcheries and laboratories, a hostel, training rooms and library. These make it a convenient training hub in aquaculture best management practices. The centre operates a feed mill with capacity to produce two tonnes of sinking pellets per hour.

1.1.2 Mandate

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

1.1.3 Vision

A Centre of Excellence in Fisheries Innovations and Impact Creation in collaboration with SMART partnerships.

1.1.4 Mission

To generate the knowledge base, develop and disseminate fisheries technologies for increased but sustainable fish production, conservation of the fisheries genetic resources, water quality and fish habitat, and to develop and manage the fisheries and required linkages with stakeholders.

1.1.5 Goal

To enhance the contribution of fisheries research to increased and sustainable fish production and conservation of the natural resource base.

1.1.6 Objectives

i) Generation of knowledge and technologies of strategic importance for the management, development and conservation of fisheries resources and water quality.
ii) Establishment and management of the human, physical and financial resources of the National Fisheries Resources Research Institute.
iii) 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.
iv) Development and management of fisheries research information and ensuring collaboration with stakeholders.
v) Planning, monitoring and evaluation of all fisheries research programmes undertaken by the institute to ensure conformity with national research strategy.
vi) Ensuring quality of knowledge and technologies developed, multiplied and disseminated through uptake pathways.
vii) Generation of periodic reports on fisheries and water quality research programmes to National Agricultural Research Council (NARC) and other stakeholders.
viii) Establishment of sustainable linkages and partnerships with local, regional and international research bodies.
ix) Participation in problem identification and prioritization of fisheries research demands for the national research agenda

1.1.7 Core values

The core values of NaFIRRI are inclusivity, subsidiarity, transparency, integrity, accountability and excellence.

1.1.8 Research programmes

Research at NaFIRRI is organised into four programs i.e., Fish Habitat Management, Capture Fisheries and Biodiversity Conservation, Fish Bio-science and Aquaculture, and Innovations and Post- harvest fisheries.

1.1.8.1 Fish Habitat Management

Research in this program is implemented to meet the following objectives.

a) Integration of lake productivity processes into fisheries management, control of pollution and degradation of aquatic environment to support fisheries productivity
b) Understanding environmental (water quality) and socio-economic factors that facilitate fish production.
c) Management of invasive water weeds e.g., water hyacinth (*Eichhornia crassipes*) and Kariba (*Salvinia molesta*).

The Fish Habitat Management program has four thematic areas:

i) Water quality and pollution (organic & Inorganic, plastics; habitat degradation, sand minding).
ii) Aquatic productivity processes - Primary productivity (algal studies) & Secondary production (zooplankton and macro benthos).
iii) Invasive aquatic weeds; and
iv) Climate variability and change.

1.1.8.2 Capture Fisheries and Biodiversity Conservation

The research under this program focuses on fish stock dynamics and technologies for sustainable harvesting, management, and conservation of fish stocks and biodiversity.

1.1.8.3 Aquaculture and Fish Bioscience

This program is based at ARDC. Focus areas include:

a) Fish feeds (natural and formulated)
b) Cage culture technologies
c) Fish breeding.
d) Fish health

1.1.8.4 Innovations and Post-harvest Fisheries

This program focuses on:

a) Livelihood and innovations
b) Markets and cost benefits analysis of fisheries and aquaculture enterprises.
c) Technologies for value added fisheries products.
d) Dissemination through ICT and linkage to reduce cost of service delivery.

1.2 Key intervention areas and achievements
Part 1: Interventions in aquaculture



1. Applied research in seed, feed, production systems, and training with a commercial perspective

This intervention is under the project on promoting environmentally sustainable commercial aquaculture in Uganda (PESCA). The PESCA project is funded by the European Union and Government of Uganda with a major objective of contributing to a competitive, job-intensive, environmentally sustainable, and climate-resilient agriculture sector in Uganda. This intervention, implemented at the ARDC, leads the research portion for the project to achieve the major objective of the PESCA project. The intervention has registered tremendous achievements which are important milestones in the development of aquaculture in Uganda.

Using molecular genetic tools for enhancing first growth rates

Suitable sources of ideal brood stocks of Nile tilapia from lakes Victoria, Kyoga, Edward, and George were identified through molecular genetic tools for selective breeding programmes. This is key for enhancing first growth rates under captivity.

20,000 parent stock of Nile tilapia generated under the selective breeding programme were earmarked for distribution to seed multipliers in districts.

Potential aquaculture zones

High-potential aquaculture zones were identified in the six (06) agroecological zones for land-based aquaculture.

Building capacity for aquaculture research and development

Through national surveys of hatcheries, potential channels for improved access to quality seed and parent stocks as well as current seed demand and production levels, capacity needs, and challenges were identified. The current national production of seed is at 164,000,000 with a gap of 2.4 billion seeds required to reach the national target of one million metric tons of fish produced from aquaculture.

Aquaculture infrastructure at ARDC consisting of 40 earthen ponds, 55 concrete tanks, a fish hatchery, a training hall, two hostels and a feed-mill were renovated to enhance production of quality parent stock, feed and knowledge transfer to stakeholders.

1,500 fish farmers and other stakeholders were trained on aquaculture best management practices and production of feed and seed with a commercial perspective.

Advances in improving feed for fish

Eleven (11) local crop varieties appropriate for use in fish feed production were identified based on their nutritional composition, effect on enhancing fish performance, and producing cost-effective fish feed to boost commercial aquaculture in Uganda. The crop varieties include Maize (Long 5D, Long 5 OPM, and

Bazooka), Sunflower (AGSUN, Sunfola), Cotton (BPA2015 A, BPA 2022), Soya (Maksoy 3N, Maksoy 6N), and Simsim (Sesame 2, Sesame 3). Fifteen (15) fish feed producers have been trained on how to utilize these local crop varieties in fish feed production.

Four feed formulations for Nile tilapia and African catfish were developed using the local crop varieties and black soldier fly larval meal (BSFLM) for upscaling quality and cost-effective fish feed production in Uganda. BSFLM was used to substitute mukene at 0, 25, 50 and 75% respectively. Four fish feeds with 25%, 0%, 75% and 50% substitution levels of mukene, respectively were found to be the most effective in enhancing fish growth and cost effectiveness. The best feed conversion ratios of 1.6, 1.7, 1.5 and 1.4 respectively were achieved for Nile tilapia juveniles, Nile tilapia grow-out, African catfish juveniles, and African catfish grow-out fish respectively. The average feed conversion ratio (FCR) for all the feeds was 1.55.

Capacity building

One training manual on fish feed production and a fish feeding guide were developed. These are appropriate for use in all agro-ecological zones for big feed manufacturers as well as farm made feed, for commercial and subsistence farmers. This will guide farmers and feed manufacturers on production of better-quality fish feed and proper application of the feeds.

Standards for fish feed production and handling were also developed in consultation with stakeholders such as fish feed producers, fish farmers, and field extension staff.

One protocol for nutrient enrichment of the freshwater flea, *Moina micrura* developed for use as live feed for African catfish fry.





2: Adopting multi-disciplinary approaches in genetic improvements, nutritional enhancement and climate change adaptation for improved production of Nile tilapia in Uganda.

This aims at selective breeding of genetically different native Nile tilapia for fast growth, temperature resilience, and developing commercially competitive and environmentally safe feeds and feeding regimes for the Nile tilapia. To be implemented until 2027, the intervention will also build the capacity of scientists in fish breedinf

Achievements

- Two PhD and 3 MSc students are under-taking training in selective breeding for improved growth and tolerance to high temperature, and development of competitive and environmentally safe fish feed by applying nutrigenomics and circular economy principles.
- Genetics of farmed Nile tilapia in 8 agro-ecological zones (within the lake basins) in Uganda determined and used to design strategies for improving fish seed quality through selective breeding programmes using genomic tools.
- One MSc thesis on morphometric and genetic characterization of farmed and wild Nile tilapia in Uganda completed.

3: Bulking quality-declared Nile tilapia seed for increased aquaculture production in Uganda

Achievements

- Developed status report of fish production and holding facilities and equipment in all ZARDs and ARDC. Refurbished and renovated fish holding facilities and equipment (pond, tanks, hatcheries, pumps) at ARDC and Nine (09) ZARDIs to improve physical infrastructure.
    - Desilted two (02), 14 x 34m^2 grow-out ponds and three (03) 12 x 8 m^2 nursery ponds at Ngetta ZARDI.
    - Repaired three (03) multipurpose concrete tanks at ARDC.
    - Maintained, dredged, and de-silted three (03) ponds at ABI ZARDI.
    - Procured and installed one (01) water pump at ARDC.
    - Rehabilitated two ponds and constructed the drainage systems to improve the water supply at Buginyanya ZARDI.
    - Installed one new water pump at MuZARDI to improve the supply of quality water in the fish holding facilities.
- Established and equipped a basic fish molecular and genetics analysis laboratory at ARDC. The equipment includes assorted DNA extraction and amplification equipment and consumables, and fish tagging equipment.

- One thousand Nile tilapia broodstock (150 gm) collected from Lake Albert and transferred to Ngetta, MuZARDI, ABI, BuGIZARDI and ARDC for conditioning and genetic material extraction.

4: True-fish Project

This project is enhancing sustainable commercialization of aquaculture in the Lake Victoria basin, East Africa, through understanding the genetic structure and the diversity of tilapiines and strengthening their conservation.

Achievements

- Recommendations made from the genetic screening studies of the tilapiines from the Lake Victoria basin.
- Developed a scientific advisory statement on the use and conservation of tilapiines for sustainable commercial aquaculture in East Africa.

5: Foodland Project (Food systems Africa)

The objective of this intervention is to develop, implement and validate innovative technologies, nutrition performance of local food systems in Africa while strengthening agro-biodiversity and food diversity merged with diversity of diets.

Achievements

- Assessed dietary requirements for healthy nutritional foods and products (including fish).
- Developed protocols for fortification of some foods with fish products (noodles, crackers -formed with fish bones).
- Improved protocols for producing fish oil from *Labeobarbus altianalis*.
- Improved protocols for breeding and nursing *Labeo victorious* and *Labeobarbus altianalis.*
- Scaling up of integrated fish vegetable farming technologies and supporting demonstrations of 400 farmers for adoption of the technologies.
- Improvement of protocols for developing cassava biodegradable materials as packaging materials in collaboration with National Agricultural Research Laboratory (NARL).
- Developed a protocol for optimizing shelf life of smoked and filleted fish products.
- Established information from 50 fish farmers in Wakiso and Mukono districts to design an adoption study of integrated fish-crop culture systems.

6: Commercialization of African catfish pituitary products and cryopreservation of catfish milt

This projects aims at providing cheaper options for induced spawning and multiplication of African catfish.

Achievements

- Protocols for effective preservation of the African catfish pituitaries developed.
- Optimized the protocol for preservation of African catfish milt with Vitamin E supplementation (E=10iu).
- Protocol for the cryopreservation of African catfish semen developed.
- Supported research activities for two MSc. students. Student research focused on performance of Purified Pituitary Extracts on ovulation and spawning in African Catfish in Uganda and the effect of different antioxidants on the quality of the cryopreserved African Catfish (*Clarias gariepinus*) sperm.
- Facilitated short term training for two project staff and two students on reproductive biology and artificial spawning.

7: PrAEctiCe (Potentials of Agroecological Practices)

This intervention focuses on the development of a decision support tool to assess environmental and socio-economic impacts of aquaponic systems, with a particular focus on impacts on climate change mitigation and adaptation as well as financial viability.

Achievements

- Profiled existing aquaponic systems in Uganda and provided baseline information for the development of a decision support tool that will assess the environmental and socio-economic impacts of the system in Uganda. An aquaponics system to test the decision support tool was established at ARDC.

8 Knowledge and skills enhancement, adoption and utilization of Best Aquaculture Management Practices by fish farmers for improved livelihoods in five irrigation schemes (Doho, Ngenge, Tochi, Wadeli and Mubuku)

The project aims to empower smallholder fish farmers in irrigation schemes to acquire aquaculture best management practices through demonstration of technologies generated from research.

Achievements

- 50 demonstration sites were established with smallholder farmers to facilitate acquisition of skills and knowledge of farming technologies and best management practices in irrigation schemes.
- 1,852 farmers skilled in the best aquaculture management practices.

- Nine feed pelletizers with grinding mills distributed to support on-farm making of feed by the fish farmers in the irrigation schemes.
- 180,000 fingerlings distributed to support farmers in the irrigation schemes.
- 5,000 African catfish and Nile tilapia fingerlings distributed to five seed multiplication hatchery operators.
- Two tons of feed and feed ingredients distributed to support demonstration of on farm made feeds of demonstration ponds.
- 100 farmers from the districts of Kabarole, Kasese, Oyam and Kween trained in aquaculture best management practices, fish feed formulation and production, fish feeding management, aquatic health management, pond preparation and stocking.
- Demonstration materials (85000 assorted seed, feed, 10 feed-making machines, 4500 broodstock, 13,800 kg larval feed, 4 scoop nets, 4 seine nets) distributed to farmers.
- 30 seed producers in seed production and hatchery management trained.

9 Technology generation and promotion

This was an intervention implemented with support from recurrent and NTR.

- A technology for efficient water exchange in tanks used for fry production was tested. This will contribute to improved water quality management in production systems.
- 5.6 tons of quality fish feed were produced.
- 107,015 Nile tilapia seed, 13,550 mirror carp seed and 5,250 African catfish seed produced.

Part 2: Interventions in fish habitat management, capture fisheries and biodiversity Conservation



1 Efficient technologies for harvesting and management of post-harvest losses and waste in small pelagic fisheries in lakes Victoria and Albert

This project aims at increasing production of the small pelagic fishes, reducing postharvest losses and ensuring environmental protection. The project is working to improve technologies for sustainable harvesting, fish processing, management of light-fishery generated waste, and building human capacity to address post-harvest losses.

Achievements

a) Accomplished community engagement and secured land for constructing a solar tent drier in Kaiso, Lake Albert.
b) Trained women in fish handing and the use of the solar tent technology.
c) Formed two groups that will be trained in the solar tent technology for drying fish.

2 Improving the knowledge of status of fish stocks for effective fisheries management

Knowledge of the status of fish stocks is useful for effective fisheries management. For this purpose, we determined fisheries management reference points (FMRP), life-history traits for exploited fish species, and two ecopath models of lakes Edward and George. Extended to lakes Victoria and Kyoga, the FMRP show that the status of most of the fish stocks in Uganda is poor, classified as either collapsed, recruitment impaired, or overfished (Musinguzi, 2024; Figure 1). The poor status of the stocks can be attributed to persistent and increasing high fishing pressure. Rebuilding the biomass of the stocks to levels that support maximum sustainable yield (MSY) should be the immediate target for management, with increased catches as an incentive.

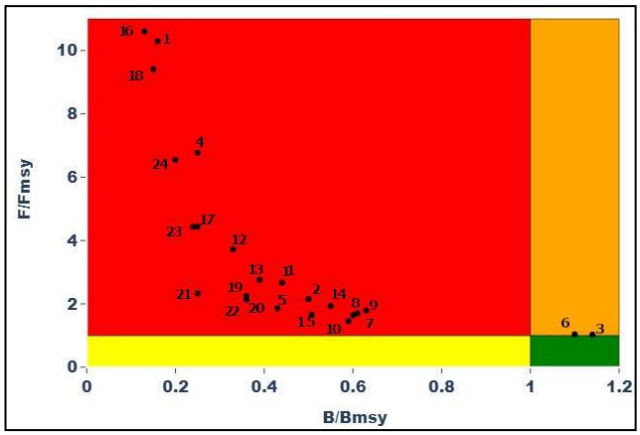


Figure 1 A Kobe plot for different stocks in lakes Victoria, Kyoga, Edward (Uganda), George and the Kazinga Channel relating exploitation level (F/Fmsy) with stock size (B/Bmsy) to classify fish stocks in exploitation categories: red (overfished, collapsed or recruitment impaired), yellow (reduced fishing pressure but low stock

Accomplished for lakes Edward and George, the life-history traits are consistent with those available in literature, indicating their reliability for fisheries decision making. The traits show evidence of unsustainable fishing despite the presence of the fisheries protection unit (FPU) in the waterbodies. For example, estimates of size at maturity (L_{m50}) for Nile tilapia *Oreochromis niloticus* and marbled lungfish *Protopterus aethiopicus* are currently lower than baseline estimates in the water bodies. In addition, no significant changes in the traits (fish size and size at maturity) could be attributed to the management changes involving the FPU. However, positive

signs attributable to the changes in management are apparent such as a high proportion of mature individuals in commercial catches for most of the stocks.

The ecopath models accomplished for lakes Edward and George (Musinguzi, 2024) show aspects of the ecosystems of the water bodies including functional groups, their biomass, energy flows, and the role of fishing. Biomass in the water bodies is dominated by phytoplankton, comprising 68.3% (Lake Edward) to 80.3% (Lake George) of total biomass. Based on the models, the two water bodies exhibit immature ecosystems, indicating high sensitivity to fishing pressure and environmental change. This observation suggests that the water bodies should be managed from an ecosystem perspective that accounts for all ecosystem elements and external threats such as agriculture that cause pollution and eutrophication.

An awareness raising workshop was facilitated to increase awareness of stakeholders involved in fisheries management of lakes Edward and George about the status of exploited fish species. Held on 1st September 2023 in Kasese district, the workshop brought together District Fisheries Officers from all the four local governments mandated with managing fisheries resources on the lakes, as well as the coordinator of the FPU (Figure 2).



Figure 2 Participants at the dissemination workshop (Top left).

3 Catch Assessment and Frame Surveys in the Kyoga basin lakes

This intervention was under the Responsible Fisheries Business Chains Project (RFBCP), supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The aim was to acquire data on estimates of the fisheries production, value and fishing effort in the Kyoga basin lakes to help fisheries management and restoration efforts.

Achievements.

a) Trained enumerators and fisheries administrators in the Kyoga basin lakes on how to collect data on fish catches and fishing effort.
a) Determined the catches and value in lakes Kyoga and Kwania. Overall catches were 106,000 t in 2023, valued at 0.121 bn$. Catches in the smaller lakes within the Lake Kyoga basin were 21,681t with a value of 0.021 bn$. Fishing effort on the Kyoga basin lakes indicated 6,574 fishing boats on the whole Kyoga basin lakes.

4 Enhancing sustainable fisheries management and aquaculture development in Africa

This intervention was aimed at (i) identifying sources of fisheries, aquaculture, socioeconomics and environmental related data (research and statistics) in East and Southern Africa, and (ii) promoting uptake and implementation of knowledge, innovations and best practices to inform policy change in fisheries management and aquaculture development at national and regional levels in Africa.

Achievements

- A full report on sources of fisheries, aquaculture, socioeconomics and environmental related data (research and statistics) in East and Southern Africa.
- A full report on Promote uptake and implementation of knowledge, innovations and best practices to inform policy change in fisheries management and aquaculture development at national and regional levels in Africa.

5 Advancing freshwater biodiversity data access, utility and relevance for conservation decision-making in Uganda

This builds on past accomplishments on biodiversity including the freshwater biodiversity portal for Uganda, the national red list for the fishes of Uganda, and distribution maps for all the fishes to create awareness on the fishes of Uganda and their challenges, address information gaps, and mainstream the biodiversity information into government decision making.

Achievements.

NaFIRRI has maintained the freshwater biodiversity portal for Uganda. Information communication and dissemination materials including 6 postcards (900 copies), photographic atlases of fish species, and a policy brief were developed to disseminate the Freshwater Biodiversity Portal for Uganda and its major modules (species records, species summary pages, the national red list for all the fishes of Uganda, fish distribution maps, and the gallery). The atlases are visual presentation of all the fishes of Uganda by major lake basin. The atlases are a tool to enlighten stakeholders on the importance of the waterbodies for aquatic biodiversity beyond the few species of commercial importance.

6 Baseline monitoring Critical Habitat-qualifying fish species of the Upper Victoria Nile (UVN)

NaFIRRI is working is to ensure that the operations of Bujagali Energy Limited (BEL) operations are in line with International Financial Corporate (IFC) Performance Standard 6 (PS6) guidelines as regards biodiversity conservation and maintenance of

critical habitats for realizing a Biodiversity Net Gain (BNG) or Net Positive Impact (NPI) in the Bujagali Hydropower Project Area of Influence. NaFIRRI is implementing a monitoring program as well as three Additional Conservation Actions (ACAs) which are:

i) To describe the Critical Habitat –qualifying species that are new to science.
ii) To address over-exploitation of Critical Habitat-qualifying species.
iii) To monitor biodiversity at the Busowoko- Kalagala Falls Site (BEL Biodiversity offset).

Achievements

One of the specific objectives of this intervention is to identify and characterize Critical Habitat-qualifying biodiversity. This was undertaken and yielded the following lessons and recommendations:

- Physico-chemical characteristics of water in the area indicate that the upper Victoria Nile (UVN) is not polluted.
- Zooplankton variation in abundance and species richness in upstream and downstream sites are an indication of the impacts of changing lotic to lentic conditions upstream due to damming, with increased water depth in the reservoir. Only one species of zooplankton (*Thermodiaptomus galeboides*) is of conservation importance because it is threatened on the IUCN Red List.



Figure 3 Participants at a dissemination seminar at BEL headquarters, February 2024.

- Occurrence of taxa of macro-invertebrate varied spatially and was highest at the upstream zones of Kalange (20 species) and Naava (16 species), while the reservoir of the dam had the lowest (10 species).
- At the downstream reaches of the dam, there was no obvious trend in the diversity of macro-invertebrates along the river since Buyala had 16 species, Busowoki with 11 and Kalagala with 15. In order of abundance, bivalves were the most dominant with 10 species, followed by Gastropods, Odonata and

Diptera each with 4 species, Ephemeroptera (3 species), Trichoptera (2 species) while the rest (Decapoda, Coleoptera, Hirudinea and Oligochaetes) had one species each. A dissemination seminar was held at BEL headquarters on 20th of February 2024 to disseminate the progress on the conservation actions (Figure 3).

7. Biannual Ecological monitoring of the Upper Victoria Nile (UVN)

Since 2006, NaFIRRI has been implementing bi-annual ecological monitoring studies on the UVN to investigate the impacts of Bujagali hydropower project on the fisheries, water environment, and ecosystem to recommend remedial measures to the developers. These ecological monitoring surveys are carried out twice a year in April, representing the peak of the rainy season, and September, depicting a dry-wet period of each year. This monitoring is supported by BEL to get insights on how the construction and operation of the Bujagali Hydropwer plant has affected water flow, aquatic habitats, and ecological functioning, and how these have favored or stressed the thriving biota.

Major observations

1. From this ecological monitoring, NaFIRRI has been able to establish the prevailing water quality determinants, biology and ecology of fishes and food webs, fish stock and fish catches including economic aspects of catches and sanitation/vector situation (bilharzias and river blindness). One of the impacts of dams is modification of fisheries in the area. In general, the stocks of Nile perch have declined while those of mukene (*Rastrienobola argentea*) especially in the reservoir have gone up over the monitoring periods. Thus, small seines are rampant for fishing of *mukene.*
2. Since July 2023, the recovery of *Labeobarbus altianalis* (Kisinja) has been noted but unfortunately, the fishery is targeted by undersize hooks. Additionally, hooks are used to target brooding females of cichlids such as O. *niloticus* from their breeding areas.
3. Longlines are prevalently used to target species of Nile perch, *Bagrus docmak*, and *L. altianalis* especially in shallower habitats because they are resilient to periodic changes in water velocities.
4. The overharvesting of juvenile *Mormyrus kannume* has gone unabated, whose main catch is sold as bait for Nile perch fishers in Lakes Kyoga and Victoria. These catches are the most lucrative to the fisher communities.
5. Trends in zooplankton composition, species richness and abundance estimates show that this assemblage is characterized by rotifer-driven species richness and copepod dominated numerical abundance and has been stable over the monitoring periods.

6. The high dominance of copepods, especially in the reservoir reaches of the dam, suggests high potential for fish production, especially for pelagic fishes in these areas relative to the downstream sites.
7. The abundance of macroinvertebrates and algae at the downstream of the dam is consistently lower compared to what is picked up in reservoir reaches. This could be a community response to prevailing water flow dynamics in this area probably created by the dam operations due to periodic opening and shutting of the radial gates.
8. In general, the prevalence of schistosomiasis across monitored sites has reduced, although it remains a significant public health issue due to increase in snail vectors that was noted. Kalange-Makwanzi, the upstream transect, has been consistently found for the last three consecutive monitoring to be a higher-risk area for bilharzia infections, demanding targeted measures. Low-intensity infections have been noted in the current and previous three monitoring periods, which should not lead to complacency as even low intensity levels of infection can cause significant morbidity over time. Water Contact activities such as fishing and bathing in the river are correlated with higher risk of bilharzia infections, requiring focused public health messaging to communities concerned.



8. Aquatic monitoring of Kikagati

From September 2022 to September 2023, The Kikagati Power Company Limited (KPCL) required the implementation of a fish sampling programme to monitor the natural movements of fish, both upstream and downstream, past the infrastructure at the Kikagati Hydropower Plant (KHPP) weir (Figure 4). The migratory species found in the affected reach of the Kagera River that naturally migrate past the weir and the reason for these migrations, were studied. The main species of concern was the then critically endangered migratory Ningu (*Labeo victorianus*). Adult Ningu (ca. 15 to 40cm in length) are known to migrate upstream to spawn among seasonally inundated floodplains and vegetated lateral pools during high flow periods in February to April, again in August, September and possibly October. The fry and juvenile Ningu (ca. 20 mm to 50 mm in length) were thought to move downstream about 3 to 6 weeks after spawning. The purpose of this monitoring was to establish whether adult fish could freely migrate upstream over the weir via the semi-natural fishway (or fishpass) constructed on the right riverbank. Of equal concern was that after spawning, juvenile *L. victorianus* could safely move downstream past the weir infrastructure.

This aquatic monitoring programme was implemented in partnership with ACER (Africa) Environmental Consultants, Anton Bok Aquatic Consultants, and Aquatic Ecosystem Services (AES). The Monitoring programme aimed to quantify both up- and down-stream movement of fish at different locations across the HPP infrastructure. It focused on monitoring the potential near-field and direct impacts of the project infrastructure on fish movement and not the broader ecosystem effects of the weir and water regulation. The monitoring programme was based on a spatial plan of the infrastructure and available and likely locations for movement of fish both upstream and downstream past the KHPP.



Figure 4 Sampling locations upstream and downstream Kikagati Hydropower weir, used in this monitoring

Major observations

1. On several occasions when the fishway was drained, the fish species captured included: *Labeo victorianus; Gnathonemus longibarbis; Mormyrus kannume; Hippopotamyrus grahami; Marcusenius victoriae; Oreochomis spp., Labeobarbus altianalis*, at least three *Enteromius* species, three to four *Haplochromis* species., *Clarias gariepinus* and two *Synodontis* species.
2. Between September 2022 and June 2023, 866 upstream migrating *L. victorianus* which included both adults and juveniles had been captured. A good number of those captured were ripe females and males (Figure 5).

3. Mortality rates from fish caught in the tailrace (Site 7) to those caught upstream at site 5 of the HPP, were compared in fish holding tanks. In 31 control trials undertaken, 605 fish from both sites were involved. Their size range was 21 mm – 154 mm in length. Fish species included in the control trials included: *Enteromius nyanzae, Enteromius kersteni, Labeobarbus altianalis, Enteromius jacksonii, Haplochromius nyererei, Synodotis afrofischeri* and smaller numbers of *L. victorianus*. The mortality rate at site 5 was 14.9% and it occurred very rarely. At site 7, the mortality rate ranged from 7 to 36%.

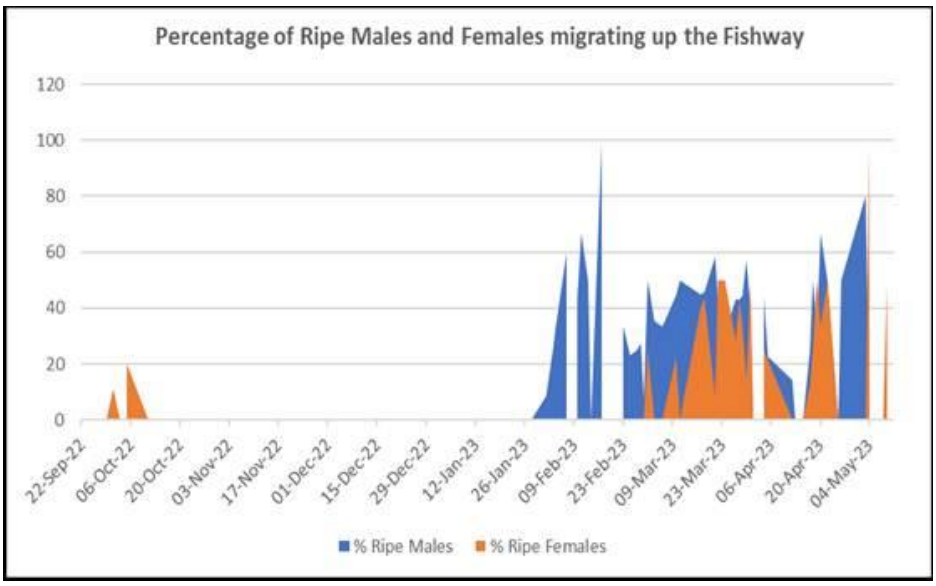


Figure 5 Percentage of ripe running male and female L. victorianus caught migrating up the fishway over the period 23/09/2022 to 11/05/2023.

9. Increasing the understanding of the generation of greenhouse gases from lakes

NaFIRRI is part of a global partnership that is striving to increase the understanding of the aquatic biogeochemical cycle of greenhouse gases in inland lakes. This effort has availed previously unavailable data on the contribution of inland waterbodies to greenhouse gas emissions (Borges et al., 2022; Humpage et al., 2023). There have been efforts to complete the knowledge on generation of greenhouse gases in lakes by conducting more filed work in Lake Albert and its affluent rivers, lakes Kyoga and Kwania, and satellite lakes of Lake Kyoga. A total of 93 samples at 75 sites were collected in 8 lakes (Albert, Kyoga, Nakivale, Mishera, Kachera, Karungi, Kijanebalola, Wamala), and 10 rivers (Bube, Sonsio, Waiga, Waki, Wambabya, Lutowa, Nkusi and Rwizi) as part of this effort. In addition to greenhouse gases (CO_2, CH_4 and N_2O), data has been collected on other biogeochemical indicators including conductivity, temperature, dissolved oxygen, 3C/14C ration of CH4, and inorganic nutrients. This information is key to include into plans for the management of inland lakes to mitigate climate change impact.



A portable spectrometer at NaFIRRI used to take observations on greenhouse gas emissions

Part 3: Interventions in post-harvest fisheries and innovations

1. Promotion of farmed *Clarias* as bait in the Lake Victoria Nile Perch fishery

The promotion of farmed bait such as African Catfish has the potential of reducing the negative impacts of catching bait from ecologically vulnerable areas and reducing pressure on the population of hapchromine which despite being the main food for Nile Perch, is also being over-targeted for use as a bait in Lake Victoria Nile Perch fishery. This initiative also has the potential for creating a substantial segment of niche markets for farmed fish, especially for fish farmers that are not usually in position to feed the fish to a table size which usually takes close to a year while raising those meant for bait would generally take less than two months. Under the coordination of Lake Victoria Fisheries Organization (LVFO), National Fisheries Resources Research Institute (NaFIRRI) in partnership with Heidenbery University (Germany) embarked on initiatives for promoting African Catfish as bait by carrying out a preliminary study in March 2024. The results indicated that fishers used wild-based baits mainly dominated by haplochromine, followed by ***Clarias liocephalus (locally known as Ensonzi)*** and *Momyrus kannume* ***(Kasulu***). Majority of the fishers that were involved in the preliminary study were willing to explore into the use of farmed African Catfish as bait. The plan for financial year 2024/25 is to implement an experimental activity with fishers using purely farmed African Catfish to ascertain the catchability and other traits that are expected to form a basis for promoting farmed it as bait.

2: **Baseline survey for small fish production and processing interventions on Lake Victoria, Uganda**

The objective of the study was to provide baseline information that would form the basis for measuring outcomes resulting from monitoring and evaluation of interventions of solar lights for fishing, solar dryers for processing and improved fish quality for the overall Lake Victoria small fish project (LVSF). The baseline survey captured the project results framework indicators and any relevant data for monitoring project progress and performance against which the project performance will be evaluated. The study results also guided the identification and selection of 6,000 beneficiaries along the value chain (3,000 - fishers who are currently using kerosene powered lights for their fishing activities to adopt more sustainable practices based on solar energy and 3,000 at the post-harvest level, mostly women fish processors and traders with improved technologies for fish preservation, value addition and marketing strategies to access higher value markets. The project is planning to install solar driven mukene drying technologies as pilots at Dimo landing site in Masaka district that will be in position to process up to 2 tonnes of mukene in a day to reduce post-harvest loses

during rainy weather and to produce high grade mukene. Solar light experiments and net panelling have been undertaken at Bwondha landing site as a pilot.

3 Investigating the Effect of Solar Light and Net Panelling in the Mukene Fishery on Lake Victoria

The Lake Victoria Small Fish Project (LVSFP), funded by IFAD and implemented by NaFIRRI through the LVFO, has the primary objective of supporting environmentally friendly and sustainable technologies in the harvesting of mukene. To achieve this, the project advocates for the adoption of solar lamps instead of kerosene lamps. This shift aims to mitigate the negative impact of kerosene lamps on the environment and reduce greenhouse gas emissions associated with their use. The project aims to minimize conflicts and increase the acceptance of solar lamps in the Lake Victoria region. This broader acceptance of solar lamps is expected to improve catch efficiency, decrease carbon emissions, reduce environmental pollution, and lower operational costs in the area. The experiments conducted at Bwondha landing site under the small fish project indicated that bycatches in mukene fishery were dominated by Nile perch, haplochromine cichlids (locally called Nkejje), and *Caridina* (locally called Ochonga). Light source and intensity did not have any significant effect on bycatch in all habitats, although by-catch was higher inshore than offshore. Secondly, increasing light intensity did not have any significant effect on catch rates across all fishing grounds (inshore and offshore). For panel 10, increasing number of solar lamps significantly increases the catch rates. Thirdly, light source (solar lamps vs Kerosene lamps) had no statistically significant effect on catch rates in the inshore fishing grounds. In solar lights, increasing the number of panels in the offshore increased the catch rates although catch rates were significantly higher when in 10 panels.

4. Consumption patterns and factors leading to under-consumption of mukene within the Lake Victoria region, Uganda

This study was aimed at gaining an understanding of the consumption patterns, consumer's perceptions, attitudes and beliefs and the level of knowledge of the community on health benefits associated with consumption of mukene, as well as generating evidence (micronutrients composition) that would help to positively transform consumer's perceptions, attitudes and beliefs. Results indicated that mukene consumption is widespread among the households around Lake Victoria and is rated as very important in their diet with an average consumption of three days a week. This is because of the knowledge about nutritional benefits and its being easily available, accessible and affordable since it is usually measured in relatively affordable quantities. The main factors hindering consumption of mukene were unhygienic processing often contaminated with other unwanted materials, handling, storage, bad smell, bitter taste, small size, considered food for animals by some, and lack of awareness on its

nutritional values. The recommendations made include the need to improve processing, improving quality as well as value to mukene, and enhancing knowledge about its nutritional value.

5 Evaluation of value chain mapping of fish flows, price changes and climate risk of the small fishes of Lake Victoria

Catches of "small fish", particularly the mukene (*Rastrineobola argentea*) in Lake Victoria, increased from 190,000 t in 1999 to over 900,000 t in 2021. Despite dominating the lake-wide catch (62%), the economic contribution remained low. In 2021, it was only 23% of the estimated total value of landing of USD 1,139,300. This situation is due to low appreciation of its nutritional value, poor post-harvest handling, packaging, and marketing.

Low technical capacity and poor adoption of improved practices and technologies by supply chain actors affect the availability and quality of mukene in the market. Poor harvesting, handling, and processing practices contribute to an estimated 50% of post-harvest losses. Losses take place at every level of the value chain: delayed landing of the catch and poor handling and storage of fish on the boat, processing by drying on sandy beaches, grass, old nets, or mats; burning by overheating during drying; re-drying after rain etc. To enable an assessment of the impacts of volume flows of small fish along the value chain, including the associated aggregated value, employment, and climate risks around these flows, a mass balance approach was undertaken to better appreciate the opportunities and bottlenecks in the value chain. The current work focused on the mukene value chains starting from the landings of fish in the three riparian countries of Lake Victoria. However, more vital analysis is still ongoing and the results of which will be availed.

1.3 Alignment with relevant strategies, policies, regulations and mandates (national, regional, global).

Our research interventions are aligned with Sustainable Development Goals (SDGs): SDG 2: (end hunger, achieve food security and improved nutrition and promote sustainable agriculture); SDG 1: End poverty in all its forms everywhere; SDG 12: Ensure sustainable consumption and production patterns; SDG 13: Take action to combat climate change and its impacts; and SDG 14: Conserve and sustainable use the oceans, seas and marine resources for sustainable development. These SDGs have been localized through several reginal and national development policies that our work is aligned with.

The interventions are in line with the National Development Plan (NDP) Programme III specifically programme 1 (Agro-industrialization) and V (Natural Resources, Environment, Climate Change, Land and Water Management) as defined in NDPIII as SDG accelerators.

The interventions are also in line with the Vision and Mission of the National Agriculture Policy (2013), being "A Competitive, Profitable and Sustainable Agricultural Sector" and "Transform subsistence farming to sustainable commercial agriculture" respectively. Our research aims to fulfill the following Comprehensive African Agricultural Development Project (CAADP) priority areas: extending the area under sustainable land management and reliable water control systems; improving agriculture research, technology dissemination and adoption; and malabo commitment No. 1 to pursue agriculture-led growth strategy to achieve targets on food and nutrition security to achieve targets on food and nutrition security.

The interventions in fish habitat management and capture fisheries and biodiversity conservation contribute to the provision of the constitution of Uganda (section XIII) to support the state to 'protect important natural resources, including land, water, wetlands, oil, fauna and flora on behalf of the people of Uganda'. Relatedly, all the interventions of NaFIRRI strive to support the research needs necessary to achieve the goal of the national fisheries and aquaculture policy (MAAIF, 2017). The goal of the policy is 'to increase fisheries and aquaculture production to 1.7 million tonnes annually so as to contribute to food security, nutrition and economic growth'.

1.4 Technology Generation

A summary of major technologies generated with their attributes and comments from early adopters or beneficiaries where applicable

Technology Generation	Number	Attributes
Market-oriented products generated	4	New fish feed formulations for Nile tilapia and African catfish developed from local crop varieties and the black soldier fly larval meal
Improved agricultural technologies and innovations developed and adopted	2	• A method for mitigating heat-stable antinutritional factors in fish feed ingredients using a commercial multienzyme complex (at 0.5% inclusion in feed) was developed. This will permit better utilization (digestion) of plant feed ingredients by fish • Efficient water exchange system in ponds and tanks (not adopted)
Products and services suitable for industry developed	1	Black soldier fly larval meal, eggs and pupae at the ARDC insectary to produce cheaper protein sources for fish and livestock feed
Products and services for food and nutritional security generated	3	• 5000 Broodstock for Nile tilapia, African catfish, Mirror carp, • Improved fish products (noodles, crackers, smoked fish products) • Integrated fish vegetable farming practices
Genetic resources are conserved for sustainable utilization (including mother gardens).	1	F1 generation of Nile tilapia with improved growth

1.5 Technology promotion

A summary of major technologies promoted with their attributes and comments from early adopters or beneficiaries where applicable

Technology promotion	Number	Attributes
Agricultural research innovations commercialized	1	Nile tilapia fish feed
Agricultural research innovations patented	1	Nile perch fish oil
Improved technology demonstrations established at the PARIs	1	Demonstration unit for optimizing black soldier fly production
Stakeholders (groups) empowered on improved agricultural technologies, innovation, information, management practices (TIMPS)	6	• fish farmers, extension staff and entrepreneurs empowered with best aquaculture management practices • Geneal public during agricultural shows and exhibitions • Policy makers through dissemination workshops and materials • Fisher managers
Market led demand driven technologies promoted to engage the youth in business	1	Fish feed production
Scientific publications in peer reviewed journals	18	See publications
High-level bulletins to update policy makers	6	
Conference papers/presentations	7	• ARBEC II, Kisumu, Kenya 17-21June 2024 (six presentations) • 7th PAFFA conference (one presentation)
Fisheries research innovations promoted		• Fisheries management reference points for effective fisheries management • Solar tent dryer technology • Freshwater biodiversity portal for Uganda • The national red list for the fishes of Uganda

1.6 Research Partnerships

A summary of major partnership with their attributes

Technology promotion	Number	Description
Multi-stakeholder's agricultural research innovation platforms established	2	• Working Group on fish breeding, genetics, and biodiversity management in aquaculture of the True-fish project • Collaborative training in fisheries and aquaculture in East, Central and Southern Africa (COTRA)
Functional Public-Private Partnerships established for technology development and promotion	2	• Partnership with GIZ on fisheries data collection • Partnership with Nugsoft technologies on maintenance, development and promotion of the freshwater biodiversity portal for Uganda
New or existing or going research partnerships for technology generation and promotion	9	• A partnership with 15 NARO National Research Institutes and ZARDIs to unlock the Multipurpose Potential of pigeon pea for Food, Feed and Soil Health Enhancement in Uganda • A partnership with Makerere University, School of Food Technology, Nutrition and Bioengineering; International Centre for Insect Physiology and Ecology (ICIPE) under the PROTEINAFRICA project to promote insect-based feed in Uganda • A collaboration with 16 universities or research institutions in Potentials of Agroecological Practices -PrAEctiCe project in Kenya, Uganda and Tanzania. • A consortium of 28 partners from Europe and Africa with funding from the European Union on a multi-commodity project (Foodland project) to address the organizational, technological, and nutritional needs of the local African food systems in Tunisia, Morocco, Ethiopia, Kenya, Tanzania and Uganda. • Collaboration with Lake Victoria fisheries

		Organization on the Vacuum pump technology for drying Mukene. A technology which is still undergoing research. • Collaborate with AU-IBAR on consultancies and reports produced. • Collaborate with IGAD on the Blue economy in the fisheries. • NaFIRRI has created a partnership with University of Birmingham, Lilongwe University of Agriculture and Natural Resources, and the Institute for Poverty, Land and Agrarian Studies at the University of the Western to build adaptive fisheries governance capacity. The project will also involve the departments of fisheries in Uganda and Malawi, fishing communities and non-governmental organizations working in the fisheries sector in assessing the existing capacity for adaptative fisheries governance and how that capacity can be strengthened. • Collaboration with the Royal Museum for central Africa for increasing knowledge of fisheries and fish diversity of Uganda • Working Group (WG) on fish breeding, genetics, and biodiversity management in aquaculture (under LVFO-True fish). True fish project Aims at addressing the key risks to the long-term development and sustainability of the aquaculture sector, by minimizing the risk of accidental or intentional introduction of genetic material which can threaten native species. The working group reviews the studies and

		recommendations related development and conservation of the tilapiine used in aquaculture • A partnership with Makerere University School of Food Technology, Nutrition and Bioengineering under the PROTEINAFRICA project to assess growth performance, egg production and carcass quality in farmed fish fed with insect-based feed in Uganda. The partnership is funded by the Australian Centre for International Agricultural Research (ACIAR) through the International Centre for Insect Physiology and Ecology (ICIPE).
Research partnerships (new or existing or going) for on farm trials	2	• Integrated vegetable farming innovations with farmers in Mukono, Lwengo, Masaka and Wakiso under the FOODLAND project. The project aims at enhancing the diversity of food production and consumption in six African countries including Uganda. It is a consortium of 28 partners from Europe and Africa with funding the European Union. It is led by Alma Mater Studiorum - University di Bologna (UNIBO). The project is multi-commodity project. Under the fish component, NaFIRRI will work to advance aquaculture technologies with simple, low investment methods to achieve a breakthrough in rural and peri-urban fish farming. • Collaboration with other 16 universities and research institutions in PrAEctiCe project being implemented in Kenya, Uganda and Tanzania to provide a novel

		agro-ecology indicator set for East Africa with an aim of helping smallholder farmers in their agro-ecological transition. The focus is to develop a decision support tool for agro-ecology advisors supporting the selection of the best suited combination of agro-ecological practices in a local context. The tool will be tested and validated in aquaponics systems that have been set up at ARDC - Kajjansi.

1.7 Strengthening Agricultural Research Capacity

1.7.1 Infrastructure development and Management

Infrastructure development and Management	Number	Description
Infrastructure established	1	A new vessel, Angara acquired for Lake Albert
Demonstration facilities constructed	1	One aquaponics system established at KARDC
Laboratories rehabilitated	1	Renovations were made to the floating fish feed mill premises
Laboratories/fields/farms/offices equipped	2	• The fish feed nutrition laboratory was equipped with a new fume hood • Construction of the recirculating aquaponics systems at ARDC for integrated fish and irrigated crops.

1.7.2 Facilities and equipment management

- Renovations were made to the floating fish feed mill premises at ARDC. The work done includes upgrading the power supply system, raising parts of the roof, repairing roofs and walls, construction of a walkway and installation of a new floating feed production line that is still ongoing. The line has a capacity to produce up to 5,000 metric tons of fish feed per year. This will contribute to the realization of the government's target of producing 1 million metric tons of farmed fish per year by 2030
- The fish feed nutrition laboratory was equipped with a new fume hood. The fume hood provides a healthier and more conducive working environment for laboratory staff
- Construction of the recirculating aquaponics systems at ARDC for integrated fish and irrigated crops.

1.7.3 Human resources management

Staff promotions

Name & position	Promotion
Dr. Aruho Cassius; Senior Research Scientist	Program Leader; Aquaculture and Fish Bioscience
Dr. TibihikaPapius Diaz, Senior Research Scientist	In-charge ARDC
Dr. Aanyu Margaret, Senior Research Scientist	Program Leader; Innovations and post-harvest fisheries
Dr. Olokotum Mark, Senior Research Scientist	Promoted to Senior Research Officer and appointed Program Leader, Fish Habitat Management
Dr William Okello, Senior Research Scientist	Promoted to Principal Research Officer
Dr. Bassa Samuel, Research Officer	Senior Research Scientist & Program Leader; Capture Fisheries and Biodiversity Conservation

Staff capacity and capabilities by qualification

Qualification	**Scientists**	**Technicians**	**Support staff**
PhD	11	00	01
Masters	12	02	02
Degree	01	04	05
Diploma	-	02	03
Certificate	-		03
Other	-		12
Total	**24**	**08**	**26**

Staff (scientists) capacity and capabilities by discipline

Discipline	PhD	MSc	BSc	Dip	cert
Fish breeding	2	1			
Fish nutrition	2	1			
Aquatic Animal Health		1			
Socio-economist	1	1			
Engineer (Aquaculture Production Systems)					
Technicians (Aquaculture)			2		
Fish stock Assessment	1	1			
Fish Biology and Ecology	1				
Technicians (fish stock assessment & fish biology)		1	1		
Engineer (Marine)		1			
Marine Captain		1			
Marine Technician				1	
Marine Deckhand					1
Limnology and Pollution Studies	2				
Aquatic weeds and Plants	1				

Ecology					
Phytoplankton Ecology		1			
Zooplankton Ecology					
Macroinvertebrates Ecology	1	1			
Technicians		1	1	1	
Volunteer/Collaborators		1	1	2	
Total	11	12	5	4	1

Staff training

Name(s)	Training name or qualification	Training type	status	Institution
	PhD	Long-term	Underway	Makerere University
Two (02) project staff and two (02) students	Reproductive biology and artificial spawning issues.	Short term		
Namatovu Aziidah	MSc.		Completed	
Juliet Nakasolya	MSc.			
Nakiyende Hebert	PhD	Long term	Underway	Makerere University
Laban Musinguzi	PhD	Long term	Completed	KU Leuven
Lujja Jessy	Aquaculture spatial planning	Short term - June, 2024	Completed	N/A
Nansereko Frank	Aquaculture spatial planning	Short term June, 2024	Completed	N/A
Laban Musinguzi	Training on the UNECA Blue Economy Valuation Toolkit (BEVTK) (15th to 17th May 2023), Nairobi, Kenya	Short term	Completed	IGAD
Mr. Egessa Robert	PhD	Long term	Underway	Hungarian University. of Agriculture and Life Sciences, Hungary
Ms. Angela Nankabirwa	PhD	Long term	Underway	Cornel University, USA
Ms. Racheal Nabwire	Msc	Long term	Underway	Addis Ababa University, Ethiopia
Endra Alice	PhD	Long term	Underway	
Richard Dungu	PhD	Long term	Underway	

Staff departures

NAME	DESIGNATION	REASON FOR DEPARTURE
Dr. Kasozi Nasser	SRO	Appointed Director of Research
Dr. Mujib Nkambo	SRO	Death
Birungi Namuyiga Dorothy	RO	Resigned
Dr. Sserwada Martin	Farm Manager	Resigned
Kiggundu Vincent	Sen. Lab. Technician	Mandatory retirement
Masaba Anthony	Sen. Lab. Technician	Mandatory retirement
Opolot Oula	Sen. Lab. Technician	Mandatory retirement
Namara Jesca Turinomujuni	Administrative Assistant	Mandatory retirement
Bifamengo Musa	Driver	Mandatory retirement
Asonya Bonifance	Office Attendant	Mandatory retirement
Anthony Masaba	technician	Mandatory retirement
Godfrey Kityo	technicians	Mandatory retirement

1.8 Financial resources

Table 1 Summary of the resources acquired and used by projects during the year (both GoU and off-budget projects)

Project Name	Balance as of 1st July 2023	Disbursements for the Period 1st July 2023 to 30th June 2024	Payments for the Period 1st July 2023 to 30th June 2024
GoU Recurrent	0	175,000,000	175,000,000
GoU Development	0	0	0
Competitive Grant Scheme	0	409,070,008	409,070,008
Non-Tax Revenue	0	480,052,384	480,052,384
Potentials of Agroecological practices in East Africa with a focus on Circular water-energy-nutrient systems (PrAEctiCe)	117,355,359	317,304,755	212,424,804
Adopting multi-disciplinary approaches in genetic improvements, nutritional enhancement and climate change adaptation for improved production of Nile tilapia in Uganda (ARISE)	215,557,680	390,000,000	246,414,989
Upscaling the benefits of insect-based animal feed technologies for sustainable agricultural intensification in Africa (PROTein Africa)		18,000,000	17,404,900
Improved protection of biodiversity, in relation to conservation of native species of tilapias in the EAC region (TRUE-FISH)	36,278,525	21,036,768	57,315,293
FOOD and Local, Agricultural, and Nutritional Diversity (FOODLAND)	5,777,199	294,579,766	91,372,457
Farm Income Enhancement and Forestry Conservation (FIEFOC II)	1,469,466	579,416,017	580,845,590
Au-aibah strengthening stakeholders-consultancy	35,840,754	700,000	34,151,280
Au-aibah improved capacities consultancy	387,000	29,680,000	25,795,000
Environment and Social Impact Monitoring on Bujagali Dam	4,180,925	128,733,180	129,321,733
Securing a Global Freshwater Hotspot	14,952,609	0	0
Harnessing Dietary Nutrients of Underutilized Fish and Fish-based products in Uganda	3,776,152	318,115,000	289,787,475
Small Fish and Food Security: Towards innovative integration of fish in African food systems to improve nutrition.	10,559,093	0	10,037,475
Expanding spatial coverage of freshwater biodiversity monitoring indicators in the Lake Edward system	10,585,000	0	10,464,001
Advancing freshwater biodiversity data and information access, utility and relevance for conservation decision making in Uganda	1,924,201	0	1,924,201

Food security and Health for East Africa- Reducing human Schistosomiasis	29,343,200	0	15,440,450
The biodiversity biogeography and evolutionary history of the northern basins of the great African lakes: the enigmatic fish faunas of LakeS Kivu, Edward and Albert revisited.	17,885,000	0	17,389,100
Biodiversity Action Plan (BAP)baseline and monitoring activities of Critical Habitat-qualifying fish species of the Upper Victoria Nile	38,515,374	240,879,475	94,094,075
Kikagati Power Company Limited-Sampling programme for monitoring migratory fish at the Kikagati HPP Weir	46,191,775	18,429,264	64,621,039
Identify sources of fisheries aquaculture, socioeconomics, and environmental related data (research and statistics) in the East and Southern Africa	0	209,747,000	111,652,450
Total			

Table 2: Budget and releases for the year in relation to the previous year

Budget item	Previous year (2022/2023)		Current year (2023/20240	
	Approved Budget (Shs)	Released Budget (Shs)	Approved Budget (Shs)	Released Budget (Shs)
1. GoU Recurrent	120,000,000	168,134,300	273,000,000	175,000,000
2. GoU Development	90,000,000	68,616,249	250,000,000	0
3. Competitive Grant Scheme	548,112,750	162,632,000	475,729,000	409,070,008
4. Non-Tax Revenue	656,400,000	179,606,069	530,830,000	480,052,384
1. GoU Devt. Internal Audit		3,988,482		3,446,039
2. GoU Rec. Internal Audit		1,494,368		0
Potentials of Agroecological practices in East Africa with a focus on Circular water-energy-nutrient systems (PrAEctiCe)	576,000,000	154,050,859	576,000,000	317,304,755
Adopting multi-disciplinary approaches in genetic improvements, nutritional enhancement and climate change adaptation for improved production of Nile tilapia in Uganda (ARISE)	220,204,600	269,461,500	499,056,250	390,000,000
Upscaling the benefits of insect-based animal feed technologies for sustainable agricultural intensification in Africa (Protein Africa)			32,000,000	18,000,000
Improved protection of biodiversity, in relation to conservation of native species of tilapias in the EAC region (TRUE-FISH)	215,700,000	80,681,884	215,700,000	19,496,768
FOOD and Local, Agricultural, and Nutritional Diversity (FOODLAND)	300,000,000	186,339,205	300,000,000	294,288,767
Farm Income Enhancement and Forestry Conservation (FIEFOC II)	317,500,000	50,435,339	579,640,000	579,416,017
Au-IBAR strengthening stakeholders-consultancy	183,414,000	147,573,246	35,840,754	
Au-IBAR improved capacities consultancy	126,305,000	125,918,000		
Environment and Social Impact Monitoring on Bujjagali Dam	133,533,000	133,533,000	133,533,000	133,533,000
Harnessing Dietary Nutrients of Underutilized Fish and Fish-based products in Uganda	3,977,500,000		3,977,500,000	316,475,208
Small Fish and Food Security: Towards innovative integration of fish in African food systems to improve nutrition.	769,126,800	314,557,543	769,126,800	
Expanding spatial coverage of freshwater biodiversity	22,971,000	11,463,660	22,971,000	

monitoring indicators in the Lake Edward system				
The biodiversity biogeography and evolutionary history of the northern basins of the great African lakes: the enigmatic fish faunas of Lakes Kivu, Edward and Albert revisited.	21,785,600	18,170,885	21,785,600	
Biodiversity Action Plan (BAP)baseline and monitoring activities of Critical Habitat-qualifying fish species of the Upper Victoria Nile	481,000,000	466,592,300	481,0000,000	
Kikagati Power Company Limited-Sampling programme for monitoring migratory fish at the Kikagati HPP Weir	155,400,000	48,332,567	155,400,000	71,853,036
Identify sources of fisheries aquaculture, socioeconomics, and environmental related data (research and statistics) in East and Southern Africa	222,000,000	74,000,000	222,000,000	148,000,000
Total	9,136,952,750	2,665,581,456	13,880,112,404	3,355,935,982

1.8.1 Financial statutory requirements.

- Pay As You Earn (PAYE)
- National Social Security Fund (NSSF)
- Withholding Tax (WHT), and
- Value Added Tax (VAT).

1.8.2 Budget and releases for the year

Approximately 3.35B was released in the year compared to approximately 2.7B in the previous year (Table 2).

1.8.3 Funding gap

The development budget for the FY 2023/24 was not financed.

1.8.4 New funding sources and resource mobilization strategy.

The scientists are writing research project proposals for funding. The institute is also focusing on enhancing NTR generating activities. The institute is focusing on writing research project proposals for funding as well as generating revenue from the research products and services.

Knowledge and Information resources

Publications

Journal articles

1. **Bassa S.**, Massa H., Bogere S., Owour G., **Nakiyende H**., Nyaundi J., Taabu-Munyaho A., Ochieng Ogello E., **Balirwa J. S**., **Nalukenge Nkalubo W**. and Getabu A. (2024). Sustainability of Fish-Hydropower Dam Interaction: A Case Study of River Nyamugasani ecosystem, Albertine Graben. Uganda Journal of **Agricultural Sciences,** Volume 22 Number 1 (2024) pp. 55 – 73.
2. **Musinguzi, L**., Vranken, N., Natugonza, V., **Okello, W.**, van Steenberge, M., and Snoeks, J., (2024) State of knowledge of aquatic ecosystem and fisheries of the Lake Edward System, East Africa. Aquaculture, Fish and Fisheries. https://doi.org/10.1002/aff2.140.
3. Nyaundi, Joseph, Omasaki, Babu, Jared, Simon, Mwirigi, Naphtali, Omondi, Reuben, Mwayuli, Genevive and Bassa Samuel, (2023). Dissipation of environmental Dichlorodiphenyltrichloroethane (DDT) metabolites concentrations in selected rivers in South-West Kenya Journal: ID AJAS-2021-0174.R3African Journal of Aquatic Science.
4. Okito, G.M., Matunguru, J.M., Uvon, J.J., Hamulonge, G.T., Rugadya, R., Nakiyende, H., Kubiriza, G.K., Akoll, P., Mulongaibalu, M., Lina, A., Nshombo, V.M., Micha, J.C. and Ntakimazi, G. (2023). Length-Weight Relationship and Condition Factor of Bagrus bayad (Fabricius, 1775, Bagridae) from Lake Albert, DR Congo. Open Access Library Journal, 10: e9614. https://doi.org/10.4236/oalib.110961.
5. Kwikiriza G, Vijayan T, **Tibihika PD**, Curto M, Winkler G, Nattabi JK, Kariuki J, Meimberg H (2023) Introgressive hybridization levels of Tilapiine species in Lake Victoria basin, Kenya inferred from microsatellite and mitochondrial DNA genotyping based on next-generation sequencing. **Conservation Genetics**:1-14. doi:https://doi.org/10.1007/s10592-023-01570-x
6. **Tibihika PD**, Curto M, Meimberg H, Aruho C, Muganga G, Lugumira JS, **Namulawa VT, Aanyu M, Ddungu R,** Ondhoro CC (2023) Exploring the morphological dynamics of Nile tilapia (Oreochromis niloticus Linn. 1758) in Victoria Nile as depicted from geometric morphometrics. **BMC Zoology** 8 (1):28. doi:https://doi.org/10.1186/s40850-023-00190-9
7. **Tibihika PD, Aruho C, Namulawa V, Ddungu R, Atukunda G, Aanyu M, Nkambo** M, Vijayan T, Kwikiriza G, Curto C, Meimberg H (2024) Unlocking Nile tilapia (*Oreochromis niloticus,* Linn. 1758) selective breeding programs in Uganda through geographical genetic structure mapping. Aquaculture, Fish and Fisheries (*in press*).

8. Yang Yang, Gastauer S., Proud R., **Mangeni-Sande R.**, Inigo Everson, Kayanda R. J., and Brierley A. S. (2023). Modelling and in situ observation of broadband acoustic scattering from the Silver cyprinid (*Rastrineobola argentea*) in Lake Victoria, East Africa. ICES Journal of Marine Science, 2023, 1–14 DOI: 10.1093/icesjms/fsad137
9. Kouamé Yao, E., Koffi Ahoutou M., **Olokotum M.**, Sahima Hamlaoui · Emilie Lance, Marie, B., Bernard, C., Rosine Yao Djeha, Quiblier C., Jean-François (2023). Assessment of cyanotoxins in water and fish in an African freshwater lagoon (Lagoon Aghien, Ivory Coast) and the application of WHO guidelines. Humbert. Vol.:(0123456789), Environmental Science and Pollution Research https://doi.org/10.1007/s11356-023-29025-3
10. Nyamweya, C., Lawrence, T. J., Migeni Z. Ajode , Smith, S., Alfred O. Achieng ,James E. Barasa, Frank O. Masese, Taabu-Munyaho A., Mahongo S., Kayanda, R., Rukunya, E., Kisaka, L., Manyala, J., Medard, M., Otoung, S., Mrosso, H., Sekadende, B., Walakira J., Mbabazi, S., Kishe, M., Amon Shoko, Tallent Dadi, Gemmell, A., **Nkalubo, W.,** (2023). Lake Victoria: Overview of research needs and the way forward. Journal of Great Lakes Research 49, Issue 6.
11. Vlasceanu M., Doell K. C., Bak-Coleman J.B., Todorova B., Berkebile-Weinberg M. M., Samantha J. Grayson‡, Yash Patel1, D. Goldwert**, Bwambale Mbilingi, Okura R. (2024).** Addressing climate change with behavioral science: A global intervention tournament in 63 countries. Science Advances. **10**, eadj5778, issue 7
12. Humpage, N., Boesch, H., **Okello, W**, Chen, J., Dietrich, F., Lunt, M.F., Feng, L., Palmer, P.I., and Hase, F., (2023) Greenhouse gas column observations from a portable spectrometer in Uganda. Atmospheric Measurement Techniques Discussions. https://doi.org/10.5194/amt-2023-234.
13. Plisnier, P-D., Kayanda, R., MacIntyre, S., Obiero, K., **Okello, W.,** Vodacek, A., Cocquyt, C., Abegaz, H., Achieng, A., and Akonkwa, B., (2023) Need for harmonized long-term multi-lake monitoring of African Great Lakes. Journal of Great Lakes Research. https://doi.org/10.1016/j.jglr.2022.01.016
14. **Nakiyende, H., Basooma, A**., Nyeko, J.I., **Okello, W.,** Rugadya, R.,Albrecht, C., Lawrence, T., Van Steenberge, M., Smith, S., Muderhwa, N., Matunguru, J., Mulongaibalu, M., and Ajode, M.Z. (2023) Limitations for informed decision making and better management of the transboundary Lake Albert fisheries resources. Journal of Great Lakes Research. DOI: 10.1016/j.jglr.2023.02.006
15. Borges, A.V., **Okello, W**., Bouillon. S., Deirmendjian, L., **Nankabirwa, A**., Nabafu, E.,Lambert, T., Descy, J-P., Morana, C. (2023) Spatial and temporal variations of dissolved CO_2, CH_4 and N_2O in Lakes Edward and George (East Africa). Journal of Great Lakes Research. DOI: 10.1016/j.jglr.2022.11.010

16. **Nankabirwa, A., Egessa, R., Naluwairo, J., Magezi, G., Kiggundu, V., Pabire, G.W., Ocaya, H., Okello, W.** (2023) Horizontal differentiation in water chemistry, phytoplankton, zooplankton and macrozoobenthic communities in Lake Kwania. African Journal of Ecology. DOI: 10.1111/aje.13120
17. Ted J. Lawrence, Alfred O. Achieng, Geoffrey Chavula, Lloyd Haninga Haambiya, Jacob Iteba, Robert Kayanda, Emmanuel Kaunda, Migeni Z. Ajode, Fabrice A. Muvundja, **Nakiyende H.**, Chrisphine Nyamweya, Kevin Obiero, Pierre Denis Plisnier, Harris Phiri, Claver Sibomana, Stephanie Smith (2023). Future success and ways forward for scientific approaches on the African Great Lakes, Journal of Great Lakes Research, 102242, ISSN 0380-1330, https://doi.org/10.1016/j.jglr.2023.102242.
18. Vlasceanu, M., Doell K.C., Bak-Coleman J B., Todorova B., Berkebile-Weinberg M. M., Grayson S. J.**, Bwambale M., Okura** Rita et al (2023). Addressing climate change with behavioral science: A global intervention tournament in 63 countries. *Sci. Adv.* **10**, eadj5778 (2024)

Technical and Working papers

1. **Bwambale M., Akumu, J., and Odongkara K.O., 2024:** Commmunity perceptions towards the protection of critical habitats in the upper Victoria Nile. The Biodiversity Action Plan (BAP) project, National Fisheries Resources Research Institute, NaFIRRI.
2. **Akumu, J., B. Mbilingi and K.O. Odongkara, 2023: Market Survey of Lake Victoria Small Fish, Uganda. National Fisheries Resources Research Institute. Jinja, Uganda.**
3. **Akumu, J. K, B. Mbilingi, K.O. Odongkara, R. Okura and M Musobya, 2023**: Baseline Survey for Small Fish Production and Processing Interventions on Lake Victoria, Uganda. National Fisheries Resources Research Institute. Jinja, Uganda.
4. **Akumu, J. K, K.O. Odongkara and M. Musobya, 2024:** Investigating the Effect of Solar Light and Net Panelling in the Mukene Fishery on Lake Victoria, Uganda. National Fisheries Resources Research Institute. Jinja, Uganda.
5. **Akumu, J. K, K.O. Odongkara, and M. Musobya, 2024:** Assessment of consumption patterns and factors leading to under-consumption of mukene within the Lake Victoria region, Uganda. National Fisheries Resources Research Institute. Jinja, Uganda.
6. **Aanyu M, Atukunda G, Tibihika P, Byaruhanga E, Bassa S, Aruho C, Wanda F, Endra A, Guma J, Muhumuza , Tushimirera M, Opio D, Agoe C, Ddungu R,** Kakembo T, **Namulawa V. and Nkalubo W. (2023).** Cost effective mechanism

for stakeholder's participation and consultation, and recommendations based on best practices, National Fisheries Resources Research Institute, Uganda. A consultancy funded by: AU-IBAR.

7. **Aanyu M, Atukunda G, Tibihika P, Byaruhanga E, Bassa S, Aruho C, Wanda F, Endra A, Guma J, Muhumuza, Tushimirera M, Opio D, Agoe C, Ddungu R, Kakembo T, Namulawa V. and Nkalubo W. (2023).** Proposed mechanisms for rationalization of existing fisheries and aquaculture platforms and networks and a framework for anchorage with Regional Economic Communities and relevant Regional Fisheries Organizations, and Inventory of Non-state Actors in the fisheries and aquaculture sector Africa. National Fisheries Resources Research Institute, Uganda. A consultancy funded by: AU-IBAR.
8. **Aanyu M., Opio D., Atukunda G. and Namulawa V. (2023).** Nutritional profiles of local crop varieties with potential for use in fish feed formulation and production in Uganda. (2023), Funded by PESCA Project.
9. **Aanyu M., Opio D., Atukunda G. and Namulawa V. (2023)**. Standards for Fish Feed Production, Handling and Management in Uganda. By Funded : PESCA Project.
10. **Opio D., Aanyu M., Atukunda, M, Owori Wadunde, and V Namulawa, M. (2023).**Training manual on Fish Feed Production and Feeding Management. By Funded by: PESCA Project.
11. **Okello, W., Olukotum M.,** Ejobi F. (2023). Status of Water Quality and Phytoplankton Community of Awoja stream and Wetland system, Soroti District.
12. **National Fisheries Resources Research Institute, NaFIRRI** (2024). Policy guidelines on fishing lights and net panneling in the small pelagic species fishery in Uganda, 7 pp.
13. **National Fisheries Resources Research Institute, NaFIRRI (2024**). Policy brief: 01/2024 conservation and control measures for managing the fisheries of mormyrus kannume in the upper Victoria nile, Uganda
14. **National Fisheries Resources Research Institute, NaFIRRI (2023).** Aquatic Ecology Monitoring: Water quality, fish composition and abundance, fish catch, fishing effort, catch beach revenue, sanitation and disease vectors. Monitoring No. 32.
15. **National Fisheries Resources Research Institute, NaFIRRI (2023).** Aquatic Ecology Monitoring: Water quality, fish composition and abundance, fish catch, fishing effort, catch beach revenue, sanitation and disease vectors. Monitoring No. 33.

16. **National Fisheries Resources Research Institute, NaFIRRI (2024).** AU-IBAR (2024). Technical report of a consultancy on promotes uptake and implementation of knowledge, innovations and best practices to inform policy change in fisheries management and aquaculture development at national and regional levels in Africa prepared by the National Fisheries Resources Research Institute. Pp 92.
17. **National Fisheries Resources Research Institute, NaFIRRI (2024.** AU-IBAR (2024). Technical report of a consultancy on sources of fisheries, aquaculture, socio-economics, and environmental related data (research and statistics) in East and Southern Africa prepared by the National Fisheries Resources Research Institute. Pp 83.
18. Shechonge HA, Aruho C, Obiero K, **Tibihika PD**, Basiita RK, Wismen B, Benzie JAH, Ciezarek A, Haerty W (2024). Genetics screening research of tilapiines in the Lake Victoria Basin. Distribution and potential threats of farmed species. (TRUEFISH project report 2024)

Policy briefs

1. **Aanyu M, Atukunda G, Tibihika P, Byaruhanga E, Bassa S, Aruho C, Wanda F, Endra A, Guma J, Muhumuza, Tushimirera M, Opio D, Agoe C, Ddungu R,** Kakembo, T**, Namulawa V. and Nkalubo W. (2023):** Mechanisms for Rationalization of Fisheries and Aquaculture Platforms and Networks in Africa and Anchoring them to Regional Economic Communities and Regional Fisheries Organizations. National Fisheries Resources Research Institute, Uganda. Funded by: AU-IBAR.
2. **Aanyu M, Atukunda G, Tibihika P, Byaruhanga E, Bassa S, Aruho C, Wanda F, Endra A, Guma J, Muhumuza, Tushimirera M, Opio D, Agoe C, Ddungu R,** Kakembo, T**, Namulawa V. and Nkalubo W.** (2023). Cost Effective Mechanism for Stakeholder's Participation and Consultation at National and Regional Level in the Fisheries and Aquaculture Sector in Africa. National Fisheries Resources Research Institute, Uganda. Funded by: AU-IBAR.
3. **Opio D., Aanyu M., Atukunda G. and Namulawa V.** (2023): Utilization of local grain varieties selected according to protein and amino acid composition for production of nutritionally balanced aquafeeds in Uganda. By Funded by: PESCA Project.
4. Policy Brief on small pelagic fishes (Lake Victoria, Albert, Kyoga, Nabugabo).

5. POLICY BRIEF: 01/2024 Conservation and Control Measures for Managing the Fisheries of *Mormyrus Kannume* in The Upper Victoria Nile, Uganda.

Fisheries and aquaculture information materials

1. **National Fisheries Resources Research Institute, NaFIRRI** (2023). Fishes of the Lake Edward System.
2. **Mangeni-Sande R**., **Basooma A., Magezi G. and Bassa S.** (2024). Acoustic estimation of biomass of major commercial fish stocks in Lake Victoria, Uganda.Issue 1, Vol 1.
3. **Mangeni-Sande R., Nakiyende H.**, Natugonza V., **Basooma A., Olokotum M.,** Taabu-Munyaho A., Ogutu-Ohwayo R., **Musinguzi L.**, **Bassa S.**, Kayanda R., Nyamweya C. S., Proud R., **Nkalubo W.**, and Brierley A. (2024). The influence of light fishing technologies on catch dynamics of mukene fishery in Lake Victoria, Uganda.
4. **National Fisheries Resources Research Institute, NaFIRRI** (2024). The Fisheries Potential of the Lake Kyoga Complex and its Implications for Management. Issue 1 Vol 1, 2024.
5. **Ocaya H., Musinguzi L., and Egesa R.,** (2024). Heavy metal pollutants in sediments of seven Lakes of Uganda: Implications for management
6. 41**. Mangeni-Sande R.,** Proud R., Smout S., Nyamweya C. S., Yang Yang, Kayanda R. J., Taabu-Munyaho A., and Brierley A. S. (2024). Improving Accuracy of Dagaa Acoustic Biomass Estimation using Random Forest and Geostatistical Methods for Ecosystem-based Fisheries Management in Lake Victoria.
7. **Bassa S**., Dheyongera G., **Nakiyende H.., Olokotum M., Balirwa J. S., Muhumuza** E., **Mangeni-Sande R**., Nyaundi J., Ochieng Ogello E., **Lugya J.**, Byamukama P., Omolo A., **Nsega M**. and **Nalukenge Nkalubo W.** (2024). Will the Marine protected areas in the Kyoga basin lakes provide a future prospect for the fisheries? A case to answer. Issue 1 Vol 1 2024
8. **Bwambale M.,** KarlijnV., FondaJ., Luomba J., **Okura R., Musobya M, Akumu J.** (2023). Climate change perceptions in the Lake Victoria Basin.
9. **Wanda FM &** R. Nabwire, (2024). *Spirulina*: A potential resource for biodiesel production and fish feeds ingredient.

Books (Theses)

Olokotum M. (2023). The dynamics of cyanobacteria and potential threats of cyanotoxins in Uganda: A case of Murchison Bay and Napoleon Gulf, Northern Lake Victoria, Makerere University, Uganda.

Musinguzi L. (2024). Towards Ecosystem-Based Fisheries Management in the Lake Edward System. A Reappraisal of the Fisheries and Aquatic Ecosystem Status, Ku Leuven University, Belgium.

Integration of ICT in Research

NaFIRRI has a commitment to strategic integration of Information and Communication Technology (ICT) into research to enhance the efficiency of data acquisition and dissemination.

A cornerstone of NaFIRRI's ICT integration is the development and management of the Freshwater Biodiversity Portal for Uganda (https://freshwaterbiodiversity.go.ug/). This online platform serves as a centralized repository for data and information on aquatic biodiversity including species distribution and water quality parameters. By digitizing this information, NaFIRRI has facilitated easier access by researchers, policymakers, and other stakeholders.

NaFIRRI also maintains an application for cage aquaculture on Google Store. The app is in place to help prospective farmers get started with cage aquaculture. It also provides basic information pertaining to the management of fish farming enterprises.

NaFIRRI has also, in partnership with others, developed the electronic Catch Assessment Survey (e-CAS), an application to capture data from catch assessment surveys including catch quantity, type of fishing nets and boats used, and how much money the fishers expect to earn. With the potential to accommodate an unlimited number of data sets, including fisheries surveys, aquaculture, socio-economics and marketing, the system is an invaluable resource for the sustainable development of fisheries for wealth creation, employment and food security.

Chapter 6: Challenges

6.1 Challenges

- Inadequate human resource capacity (personnel), including scientists, laboratory technicians, and feed mill operators.
- Insufficient funds to pay support staff to maintain facilities and acquire raw materials for the feed mill at ARDC.
- Limited financial support from the government for fisheries research.
- Inadequate water supply to the ARDC hatchery is impacting catfish seed production capacity.
- Widespread encroachment on and degradation of the surroundings of the natural stream (River Kajjansi) that supplies ARDC ponds with water has contributed to a decline in the volumes of water received in our ponds and hatchery and a severe deterioration in water quality.
- Lack of equipment for research in disease diagnostics and management.
- Lack of accredited laboratories.
- Long and unclear process of approving research protocols which delay publishing manuscripts in high impact journals.

6.2 Emerging issues

- Emerging and re-emerging aquatic animal diseases.
- Needs of rapid diagnostic kits for early disease detection.
- An early warning system for aquatic animal health emergencies.
- Explore the use of alternatives to antibiotics such as probiotics, bacteriophages, vaccines, medicinal plants for prophylaxis and growth enhancement.
- Incorporate selection of disease resistant traits in breeding programs
- Utilize ICT tools to monitor water quality at farm level and water bodies.
- Investigating nutritional requirements and development of formulated feed for candidate fish species for domestication. These include Ningu (*Labeovictorianus*) and the Ripon barbel (*Barbus altinialis*).
- Investigating the potential of microalgae as a sustainable protein replacement or supplement to Mukene for fish feed, a source of bioactive compounds and Omega-3 fatty acids. This includes utilization of algae from highly enriched environments (including areas around fish cages) along the shores of Lake Victoria
- Investigating the potential of brewer's spent yeast (BSY) as a sustainable protein replacement or supplement of Mukene in fish feeds.
- Replacing fish oil with algal oils in fish feed.
- The effect of diets on fish immune system and gut microbiota.
- The effect of diets on epigenetics in fish and expression of heat tolerant genes.

References

Borges, A. V., Deirmendjian, L., Bouillon, S., Okello, W., Lambert, T., Roland, F. A., ... & Morana, C. (2022). Greenhouse gas emissions from African lakes are no longer a blind spot. *Science Advances*, *8*(25), eabi8716.

Humpage, N., Boesch, H., Okello, W., Chen, J., Dietrich, F., Lunt, M. F., ... & Hase, F. (2023). Greenhouse gas column observations from a portable spectrometer in Uganda. *Atmospheric Measurement Techniques Discussions*, *2023*, 1-34.

MAAIF, 2017. National fisheries and aquaculture policy: optimising benefits from fisheries and aquaculture resources for socio-economic transformation. Entebbe, Uganda.

Musinguzi, L. (2024). Towards Ecosystem-Based Fisheries Management in the Lake Edward System: A Reappraisal of the Fisheries and Aquatic Ecosystem Status.

Gallery



A solar tent drier undegoing construction in Kaiso landing site, Hoima district, Uganda under a CGS project





Aquaponics System developed at ARDC



Rice – Fish Integration under SCCP Phase III



Floating fish feed production line



Facilities for fish breeding at ARDC



School study tours at ARDC



Word Food Day exhibition in Kituza, Mukono