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

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Project Duration: 2 years (April 2014 – March 2016)

Total Budget: USD $ 90,000

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Executive summary

The major source of fisheries in Uganda, Lake Victoria, is under severe pressure from the human population growth and subsequent fishing effort. Consequently, there has been a continuous decline in biomass and catches of larger sized fish (Nile perch and Tilapia) with exploitation rates of approximately 60% of the biomass. In addition, >80% of the harvested Nile perch is processed and exported to international markets leaving behind the small pelagic species *Rastrineobola argentea* (*Mukene*) as the only viable option for local revenues and consumption. Unlike Nile perch, the biomass of Mukene has increased but with lower proportional harvest (< 30%). The available technology for harvesting *Mukene* uses white light to attract and concentrate the fish. However, the role played by light intensity, alternative colours and source in determination of the amount of fish harvested is not known. The proposed project will determine the appropriate light colour, light intensity and suitable light sources to attract and concentrate larger quantities of *Mukene*. Along a transect from Napoleon Gulf, through Buvuma channel to the deeper offshore waters of Lake Victoria, experiments will be set up to involve the use of five different colours (white, blue, green, red, yellow) to concentrate and harvest *Mukene* using the appropriate fishing gears. Comparisons of time taken to concentrate fish and the resultant catches from each setup will be made. The appropriate source of light, number of light sources, and the effectiveness of using floating bulbs in comparison to submersible ones will also be determined. Efforts to construct small low cost rigs using locally available materials that can easily be adopted by poor *Mukene* fishers will be made. By improving the light attraction technologies for harvesting *Mukene*, the catches will increase and therefore the incomes, nutrition and livelihoods of the different stakeholders along the value chain will improve.

Background

Uganda's population (36 million) is growing rapidly (> 3.4% per annum) and so is the demand for fish for both human consumption (595,000 t) and animal feed industry (300,000 t). The current production levels from capture fisheries (374,000 t) and aquaculture (100,000 t) are not sufficient to meet this existing demand. This has created a large gap between the amount of fish consumed (≤ 6 kg person^{-1} year^{-1}) and that recommended by the World Health Organization (17.5 kg person^{-1} year^{-1}) *(2)*. Malnutrition rates especially in women and children are high in fishing villages *(1)*. It is therefore critical to close this protein gap for which approximately 160,000 tons of additional annual fish production is required *(7)*. This challenge is compounded by the fact that catches from the preferred natural fisheries stocks have declined as demand for fish protein grows. For example on the Ugandan portion of Lake Victoria, biomass estimates indicated a 14% reduction in Nile perch from 162,000 t to 139,000 t and a 17% increase in *Mukene* from 345,000 t to 403,000 t between 2009 and 2011 (*4*). Similarly on Lake Albert, > 80% of the catch is constituted by small fishes that are now increasingly demanded for human consumption as well as for use as a protein supplement by manufacturers of animal feeds. Whereas the large fishes Nile perch and tilapia are targets of the fish processing plants for export, the small fishes are considered to be relatively more affordable and accessible to the wider public and also very nutritive. They are processed using simple methods (sun drying) and provide employment especially to women who are the majority (60%) in the post-harvest sector. Most of these small fishes are harvested at night using the light attraction technology that was first introduced on Lake Victoria in the mid-1960s to harvest *Mukene*. However, this technology that eventually spread to Lake Kyoga and more recently to lakes Albert and Nabugabo has not been studied to determine the most effective light conditions and regimes for fish attraction and concentration. The production of the small pelagic fishes is currently below 30% of the exploitable standing stock in Uganda. Given the increase in biomass of small fishes in most Ugandan lakes, developing improved light attraction technologies is considered vital to enhance the sustainable harvest of these fishes and promote their contribution to food security, nutrition, and improved livelihoods especially of women who play a central role in household income projects.

Close to 95% of light currently used on most lakes to attract and concentrate *Mukene* is from pressure lamps powered by kerosene. However in 2006 industrial fishing rigs from Lake Kariba in Zimbabwe were introduced by Arrow Aquaculture Africa (AAA) firm operating at Kiyindi landing site in Buikwe district. The fishing rigs use light from electric bulbs supplied by a generator to attract and concentrate fish. The catches range from 280 – 4500 kg per rig per day according to season compared to 40 – 70 kg harvested by fishers using pressure lamps. For fishers using 1 - 7 pressure lamps per group, preliminary studies

have indicated a correlation between the number of lamps and *Mukene* catch. However, the optimal usage of lamps for sustainable harvest of these fishes in terms of the appropriate number lamps (light intensity), light colour and appropriate light source are still unknown. On the other hand, while the use of industrial rigs is very productive in comparison to the pressure lamps, the present rigs owned by AAA are ten times more expensive than the ordinary kerosene lamp units. This makes it essential to develop cost-effective technologies that will enable increased but sustainable exploitation of *Mukene*. The proposed project aims to increase sustainable fisheries production of *Mukene* by improving light attraction technologies through the determination of the most appropriate colour, intensity, and source of light for attraction and concentration of these small fishes. The enhancement in the use of the improved technologies to attract and concentrate these fishes will increase production to at least 50 – 60%, relieve pressure on other large fish stocks, and improve local revenues and the nutritional status of the poor *Mukene* fishing population.

Objectives of the research

The overall objective is to increase sustainable fisheries production of *Mukene* from Lake Victoria (Uganda) through increased and efficient light fishery production technologies.

Specific objectives include:

i. To investigate the appropriate light colour to attract and concentrate *Mukene* on Lake Victoria.
ii. To determine the appropriate source (lamps or bulbs) of light for sustainable harvest of *Mukene*
iii. To compare the performance of surface and submerged light sources in attraction and concentration of *Mukene*
iv. To determine the appropriate light intensity (i.e. number of light sources (lamps, bulbs)) for *Mukene* harvest
v. To investigate the effect of light source, colour, and intensity on incidental harvest of non-target species (by-catch) during light fishing

Research methodology

Proposed study area

Studies have shown that the size of *Mukene* in Lake Victoria is a factor of area of harvest. Smaller fishes are found inshore while large ones are far offshore. To cater for area effect, sampling will be conducted along a transect from shallow inshore areas in Napoleon Gulf around Kikondo landing site, through island zones around Nkembo to offshore station near Nkata Island (Figure 1).

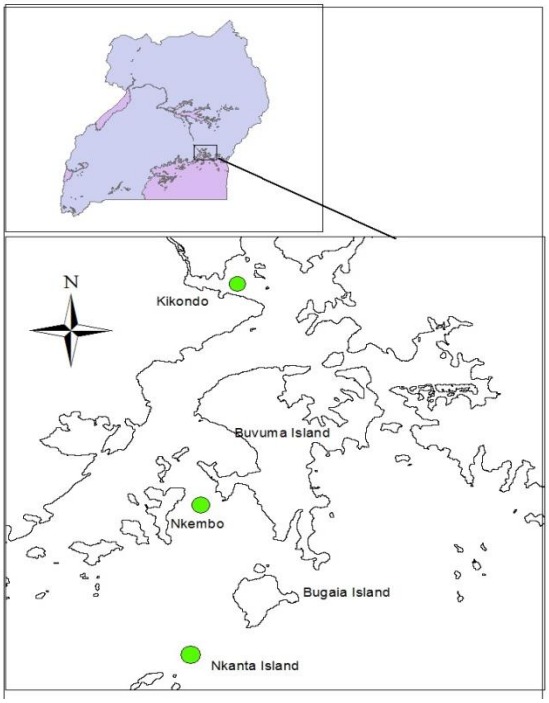

Figure 1: Map of the northern portion of Lake Victoria showing the location of the proposed study areas Kikondo, Nkembo and Nkata. Inset map of Uganda showing the expanded portion of the lake, the green circles show the actual fishing grounds for experimental light fishing.

Experiments will be set up to investigate each of the specific objectives as follows:

1. Effect of light colour on *Mukene* fishing

The current light fishing on Lake Victoria involves use of white light by artisanal fishers (using kerosene lamps) and industrial rigs (AAA) using generator powered bulbs. There are however, up to five colours of probable fishing lights that will be investigated (White, Blue, Green, Yellow and Red). The effect of colour will be studied through variation of light colours. Using both kerosene lamps and electric bulbs, performance of different colours will be evaluated. While for electric bulbs manufactured bulbs of different colours will be procured, the clear (colourless) glasses for kerosene lamps will be painted with the appropriate colours (white light source painted with a different colour emits the light with the colour painted on glass). Some of the white bulbs will also be painted to change their colours and their performance will be compared with manufactured coloured ones to check the effect of painting as used on kerosene lamps. For each colour setup, the time taken (minutes) for *Mukene* to concentrate around the lamp will be recorded and the quantity of fish hauled (retained by the net) will be weighed in kilograms. The five different coloured lamps or bulbs will be set in the same area giving each setup ample space and will be timed accordingly. The hauling will be done using available fishing methods (encircling or *lampara* net used by artisanal fishers and lift net as used on the AAA rigs). Fish yield from the different lamp settings and the time taken will be statistically modelled to evaluate effectiveness of each colour setting.

2. Appropriate source of light for *Mukene* fishing

Three primary types of light sources will be investigated (floating kerosene powered lamps, overhead electric bulbs powered by generators and floating electric lights powered by batteries). These light sources will be set up in similar design as in Experiment 1 above and their performance parameters (time taken to concentrate fish and quantity of *Mukene* harvested) evaluated as in the experiment above. Using the most appropriate light colour evaluated in Experiment 1 above, and the white light (if it not the former), the appropriate light sources will be determined. The white light is being emphasised since it is the one in current use. Battery-powered, 12-volt, LED and fluorescent light models that are available on the market will be evaluated, with appropriate light colours and intensities determined from Experiment 1 above. Trials into possibilities of cost effective and less hazardous sources such as solar batteries will be explored.

3. Effect of surface and submerged light

A significant fraction of the light shining on the surface of the water is lost by reflection and, thus, will not be available to attract fish and other aquatic organisms in the food chain (which in turn attract fish to feed on them). Surface floating lights have been the standard of night *Mukene* fishers for many years, but in addition to losing substantial quantities of light to surface scattering, the users of these lights often have to contend with annoying swarms of insects drawn to the lights along with fish. For this and other reasons, submersible lights that use fluorescent bulbs that slide beneath the surface and light up the water depths were developed. It is common knowledge that floating and submersible lights are used to attract fish and can be used separately or in combination. Experiments will be set up to compare floating and submersible lights separately through a similar experimental setup as in Experiment 1 above. Similar bulbs and same colours will be used in each comparison. For example a setting of white floating light bulb compared with a white submersible bulb. The measured parameters will be the time taken to concentrate fish and quantity hauled as described in the experiment above. In addition, trials such as combinations of a pair of floating lights positioned above submersible lights capable of lighting multiple levels of the water column to attract fish, while also providing more lighting above the water for fishers operations will be explored. In this experiment setup possibilities of fabrication of less cost rigs using locally available materials will be investigated.

4. Appropriate number of light sources (Light intensity)

After selection of the appropriate light colour and source the appropriate number of light sources will be determined. Currently on Lake Victoria different numbers of kerosene lamps are in use by different fishers in various areas of the lake. The number ranges from 2 – 9 lamps per team and mostly operating singly (one stand alone lamp per fishing operation). The impact of using single lamps as in the preceding case and possibilities of having two or three lamps together (an index of intensity) will be investigated. Light intensity will be studied by varying the number of lamps and the amount of light emitted measured as relative light intensity (RLI). RLI will be measured using simple light meters locally available on the market. Light intensity will be measured at the setting of the lamp and at the beginning of fishing (hauling). The rigs of AAA use overhead lights hanging above the water surface. The intensity of light emitted from such setting and quantity that actually illuminates the water layers will be evaluated through measurement of intensity at the different layers. To evaluate the effectiveness of the number of lamps used to harvest *Mukene*, the time taken to concentrate fish per setting (setup) will be recorded and the quantity of fish hauled weighed.

5. Effect of light source and intensity on harvest of non-target species (by-catch)

Fish and some members of their food chain have colour receptors in their eyes optimized for the light of their "space". The implication is that knowing the appropriate colour for fishing a particular species (*Mukene* in this case) can help reduce capture of other non-target species. During the set up in in the above experiments, sub-samples (plastic cup weighing 500 g) of hauled fish will be taken from each setting for analysis of proportions of non-target species. The samples will be immediately fixed in 5% formaldehyde solution and carefully sealed in plastic bags. The samples will be sorted in the laboratory by taxa and proportions of taxa obtained through counting and weighing. A few samples of pure *Mukene* (after removal of by catch) will be measured (standard length in mm) and heaped into 1 mm length intervals. 10 specimens from each group will be examined for maturity to estimate the proportion of immature *Mukene* being harvested by the different setups. The proportion of by catch (non-target species and immature *Mukene*) harvested by a given set up will be evaluated as a fraction of the total sample.

Expected outputs

i. The most appropriate colour of light for attraction, concentration and fishing *Mukene* on Lake Victoria determined.
ii. The most appropriate and cost effective source of light for attraction and fishing *Mukene* on Lake Victoria identified
iii. Appropriate setting of light (surface floating or submerged) determined
iv. Ecologically safe sources of light such as Electric from generators and batteries including solar batteries and their appropriate setting technologies determined and recommended for uptake pathways.
v. Public private partnership to produce cost effective rigs using flat stabilized platoons but with similar technology as used by AAA and encourage fishers to form groups and take it on.
vi. At least two MSc dissertations detailing appropriate light technologies and fishing grounds for *Mukene* produced

Research Team and partnerships

S/No	Name	Affiliation	Role on Project
01	Dr Taabu-Munyaho, Anthony	NaFIRRI	PI and Project coordination- Project design and implementation, data capture, analysis and reporting, resource management and monitoring and evaluation
02	Dr. Nkalubo Winnie	NaFIRRI	Assessment of the biology and ecology of the target and non-target species (by-catch) and evaluation of appropriate light fishing grounds, project monitoring and evaluation
03	Mr. Herbert Nakiyende	NaFIRRI	Catch Assessment and evaluation of appropriate *Mukene* fishing gears and

			methods, by-catch assessment, assessment of appropriate colours and intensity
04	Dr. Rhoda Tumwebaze	LVFO	Evaluation of floating and submersible light systems and technology evaluation and promotion, linkages with national and regional uptake pathways
05	Dr. Edward Rukunya	Department of Fisheries Resources	Improved post-harvest handling of *Mukene* for increased human consumption and treatment of by-catch
06	Engineer James Wasukira	NaFIRRI	Light systems fabrications, light intensity measurements, catamaran and rig designs and evaluation
07	Dr Kubiriza Godfrey	Department of Biological Sciences, MAK	Evaluation of appropriate light technologies and statistical analyses procedures
08	Mr. Keth Neville MD AAA	Private sector/Arrow Aquaculture Africa	Construction of rigs and partnership in fabrication of cost effective rigs and alternative light sources
09	Ms Kagoye Esther	Student	Evaluation of appropriate light colours and intensity for harvesting Mukene
10	Mr. Mangeni Richard Sande	Student	Assessment of proportions of by-catch and juvenile Mukene by light colours and intensity

To efficiently implement the project, the research team will among other activities:

i. Continue with a working relationship already established with AAA at Kiyindi in initial trials, and project appraisal phase. Members of the research team have worked with the proprietor (Director) of AAA in data collection of catches of rigs at different environmental conditions. This project will build on the already existing collaboration and tap on the experience gained using the current rigs that have grown from 1 rig to 11 rigs in just 5 years.
ii. Work closely with local artisans in fabrication of cost effective rigs, tapping of the skills gained by the Marine Engineer (member of the team) in the diverse activities he has worked with the private sector including Sekalala Enterprises Ltd.
iii. Plan to collaborate with Sekalala Enterprises Ltd on already started catamaran light fishery, to carry out experiments of light attraction and hauling using catamarans. Despite the fact that Sekalala Enterprises Ltd experimented on Catamaran fishing on Lake Victoria, the technology has not been appreciated on Ugandan part of Lake Victoria although it has been in use on the Tanzanian section for quite some time.
iv. In the areas of fabrication of simple mortars to power rigs we plan to partner with the National Agricultural Research Laboratories (NARL) particularly the Bio-system and Agricultural Engineering Research Programme
v. Work with local fishers at Kikondo, Kembo and Nkata fish landing sites on small single planked canoes using the *lampara* net with kerosene lamps. We have in the past worked with *Mukene* fishers at the Beach Management Units (BMUs) of Kikondo, Kembo and Nkata Island in studying selectivity of *Mukene* nets.
vi. Partner with Department of Fisheries Resources (DFR) particularly the project charged with responsibility of increasing *Mukene* for human consumption to increase on post-harvest handling of the catch. Particular interest will be in improved drying of the *Mukene* harvested during project experiments and utilization of by-catch species.
vii. Once a useful technology is developed it is important to have it adopted and taken to uptake pathways. But it often becomes difficult when a technology is developed without participation of the intended users (beneficiaries). The purpose is to ensure participation of fishers (intended users of the technologies being investigated) and utilize them to upscale the technologies into

their communities. During the implementation of the project, existing Mukene fishers will he hired and trained in handling the experimental setups, timing the concentration of fish, hauling and weighing the harvest, and taking samples and preservation for further laboratory analyses. Since fishers will be taking part in harvesting and weighing the catch, it will be easy for them to know which light intensity, source or setting technology is best suited for their operations. It will therefore become easy to partner with say NAADS and use these trained fishers as Trainers of Trainers (ToTs) and upscale the skills and developed technologies.

Anticipated impact

1. Increased and sustainable production of *Mukene* using recommended light attraction sources, colours and intensity and consequently annual fisheries production from the small fishes of the major lakes of Uganda.
2. Increased production of small fishes will lead to increased participation of women in fisheries production thereby promoting nutritional status for women and children.
3. Increased household incomes for the different stakeholders along the *Mukene* value chain particularly poor Mukene fishers, women who control the post-harvest sector, and boat owners
4. Improved nutrition from increased availability of properly handled *Mukene* for human consumption.
5. Increased utilization of costs effective, environmentally friendly light sources such as battery powered bulbs to harvest Mukene on the Uganda portion of Lake Victoria and possibly upscale it to other parts of the lake in the region and other water bodies in the country.

Internal Project Monitoring Plan/Project Governance

The project will be a research component under the Capture Fisheries and Biodiversity Management Programme of the host institute (NaFIRRI). It will be managed by the PI in close supervision of the office of the Programme Leader and the institute Director. Internal monitoring plan will be done at three levels:

1. **Activity implementation**: the internal Monitoring and Evaluation team led by Dr. Winnie Nkalubo will oversee implementation of activities of the project. The team will ensure that planned activities are according to the project work plan as captured in the Log frame and conform to the Standard Operating Procedures (SOPs) to be agreed on during the project appraisal period. The team will ensure that requisitions for diverse project activities are accompanied with reports of the previous activities and plans for the intended activities. They will ensure that plans are within the overall project work plan and budget. The team will prepare quarterly reports and submit to the PI and the host institute Director for further checks.
2. **Project progress**: Monitoring and evaluation of project progress will be done by the PI assisted by three of the team members. The team will periodically check on progress on the various project objectives through assessment of activity reports, project appraisal reports, and expenditure analyses. The team will make on spot assessment of progress through field visits to the activity/experimental setup and ensure adherence to the SOPs. The team will use the project Logical framework (Log frame) to ensure chronological implementation of the activities and realisation of key outputs. The team will convene monthly project meetings and share field experiences, discuss progress and self-evaluation reports, agree and document appropriate corrective actions during project implementation. The team will prepare and submit to the host institute, other participating institutions/firms, and the funder (NAROC) project progress reports and self-evaluation documents.
3. **Value for money audits**: This activity will be headed by the Director of the host institute assisted by the institute Internal Auditor. They will ensure proper accountability of the funds advanced to the project team, check and ensure quality from field and project progress reports, make on-spot assessment of project field activity implementation. Ensure adherence to PPDA guidelines in procurement of field and laboratory equipment for the project and generally ensure value for money along the project implementation chain. The team will periodically meet the PI with his project team and discuss short falls, suggest improvements and ensure delivery of quality research outputs.

Work Plan (1.0 pages)

		Year 1				Year 2			
S/no.	Activity	Qtr 1	2	3	4	1	2	3	4
01	Project appraisal and literature review								
02	Planning meetings, site inspections and sensitisation of key stakeholders								
03	Procurement of equipment								
04	Equipment testing								
05	Data collection yr1 (Quarter 1 and 2)								
06	Data analysis and report preparation								
07	Quarterly progress report								
08	Semi-annual project review meeting								
09	Data collection yr1 (Quarter 3 and 4)								
10	Annual project review meeting								
11	Annual progress report								
12	Monitoring and evaluation								
13	Data collection yr2 (Quarter 1 and 2)								
14	Data analysis and report preparation								
15	Semi-annual project review meeting								
16	Monitoring and evaluation								
17	Semi-annual progress reports								
18	Data collection yr2 (Quarter 3 and 4)								
19	Technology adoption trials								
20	Technology Dissemination								
21	Project completion meeting								
22	Final report preparation and submission								
23	Monitoring and evaluation reports								

Budget Template

Particulars	In puts	year 1	year 2	Amount	
A) Project planning meetings		UGX ('000)	UGX ('000)	UGX ('000)	USD
Facilitation to 12 team members (DSAs)	12x120x3	4,320		4,320	1,694
Transport refund	12x50x3	1,800		1,800	706
Hire of venue	1x400	400	-	400	157
Water and refreshments	12x25x3	900		900	353
B) Equipment costs					
Fabrication of cost effective rig	materials	48,000		48,000	18,824
Generator	Piece	3,825		3,825	1,500
Pressure lamps	12x60	360	360	720	282
Electric bulbs and cables	40x20	400	400	800	314
Mukene nets (2 lampara+2 scoop)	4x400	800	800	1,600	627
Fabrication of light stands (Rafts)	20x30	450	150	600	235
C) Field data collection					
DSAs for Team (12 members + 4 support staff)	16x120x4x8	30,720	38,400	69,120	27,106
Fuel (Diesel, petrol, Kerosene)	20x4x8x25	12,000	12,000	24,000	9,412
Field consumables/canoe rentals	8X500	1,600	1,600	3,200	1,255
D) Office expenses					
Office expenses & supplies	8X600	2,400	2,400	4,800	1,888
Information packaging & dissemination	4X1500	3,000	3,000	6,000	2,353
Preparation of project reports	8X1200	4,800	4,800	9,600	3,765
E) Project monitoring costs					
Project review meetings	4X7600	8,400	8,400	16,800	6,588
Project Monitoring & Evaluation	4X2000	4,000	6,000	10,000	3,922
F) Overhead costs					
Institutional overhead costs		9,000	9,000	18,000	7,059
Contingency costs		2,500	2,500	5,000	1,961
Total project Estimate		**139,675**	**89,810**	**229,485**	**90,000**

The conversion from UGX to USD had been done using the BOU rate of (1 USD = 2550 UGX)

Budget Narrative (0.25 pages)

The project is planned to run for 2 years (April 2014 – March 2016) divided into 8 three-month quarters. Depending on when the contract is approved and signed the first quarter can be anywhere between March and June 2014, the eight quarters will then be counted from that time. Most of the capital procurements and major fabrications are planned at the beginning of the project, hence higher annul budget for the first year. Operational activities will run quarterly throughout the two years. It is anticipated that each of the team members will have 4 working days in a quarter throughout the two years. Two annual project review meetings have been plan per year at a cost of 7,600,000 each (hence 4x7,600). Where an item is indicated as 8x1200 implies the expenditure will be per quarter (8 qtrs. in 2 years) at a rate of 1,200,000. For other materials like canoes, the project will use available institutional canoes in

additional to renting field canoes from local fishers. The total budget over the two year period is expected to be USD 90,000

Staff costs: Provision has been made for a salary for the two MSc students at US$ 200 per month for 2 years

Travel: (a) Field allowances at NARO rates for trips to the lake lasting 4 days each per quarter for 16 team members and support staff. Scientists, 5 Technicians, 6 Support Staff (5 Drivers, one coxswain and one fisherman), 2 representatives of stakeholders. (b) 2 vehicles will be used (one for NaFIRRI and the other for DFR). Provision has been made for the service of vehicles at an average cost of $200 per trip per vehicle; fuel for vehicles has been estimated at per vehicle $300 per trip.

Equipment: Equipment funds in Year 1 will be used to purchase construction materials (electric bulbs, generator, Mukene nets, pressure lamps, light stands) provision has been made for replacements such as pressure lamps, electric bulbs, nets and light stands in Year 2

Office costs: Provision has been made for consumables such as stationary, printer cartridges, maintenance of equipment. Provision has been made to meet the cost of internet connection for 2 Modems for 2 years at an estimated cost of $100 Per month.

Indirect costs: Indirect costs have been estimated at 10% of the project cost each year

Logical Framework

NARRATIVE	INDICATORS	M.O.V.s	ASSUMPTIONS
Goal: New knowledge applied to increasing sustainable harvest of *Mukene,* the resolution of which benefits poor *Mukene* fishers in the Lake Victoria region.	By 2016, (1) increased financial capital for poor households through: increased participation especially of women in fisheries production of *Mukene*; increased employment opportunities for different stakeholders along the *Mukene* value chain; reduced post harvest losses through improved efficiency & effectiveness in handling & processing technologies; increased availability of cost-effective technologies to harvest *Mukene*.(2) improved nutritional status through: increased per capita consumption; reduced malnutrition rates especially of women & children (3) improved information uptake pathways & the production of cost-effective harvesting gear.	(1) National & local adoption rate surveys. (2) Adoption & impact assessment reports. (3) National & local socio-economic surveys	Poor *Mukene* fishers invest benefits to improve choices & options for better livelihood strategies.
Purpose: Technologies for increased sustainable fisheries production of *Mukene* for improved food and nutrition security, incomes and livelihoods for poor fishers in the Lake Victoria region developed and promoted.	By 2016, improved light attraction technologies for enhanced *Mukene* harvest promoted.	Annual research programme reports.	*(1)F*ishers willing to adopt new technologies; (2) Enabling political environment
Outputs: (1) Appropriate colour, intensity, & source of light for attraction & concentration of *Mukene* documented. (2) Performance of different light attraction technologies for harvesting *Mukene* assessed. (3) Impact of appropriate technologies at household levels assessed (4)No. of *Mukene* fishers using recommended light harvesting technologies documented. (5) Decision support tool developed & disseminated	(1) Light attraction technologies (efficiency & effectiveness) tested, evaluated & documented.(2) Light attraction technologies compared & documented. (3) Impacts of appropriate technologies defined, quantified & documented. (4) 90% of target fishers sensitized and using recommended harvesting technologies by 2016. (5) Project findings & experiences synthesized to provide a basis for decision making relating to appropriate technologies for harvesting *Mukene* disseminated	(1) Quarterly reports (2) Published scientific papers. (3) Decision support tool	(1) Markets to allow fishers to benefit from technologies. (2) Target institutions use knowledge to enhance future impact.
Activities: (1) Review existing literature on *Mukene*. (2) Conduct surveys (3) Analyse & document survey results. (4) Conduct stakeholder workshops (5) Review & synthesise secondary data on impacts (economic, environmental, & social) Synthesize findings into a decision support tool . (6) Distribute booklet to extensionists (DFR, NAADS) (Year 2)	*Inputs/resources:* Summary budget (USD) *Training and meetings: 2,910* *salaries* 9,600 *Overheads:* 10,510 *Travel & subsistence:* 36,178 *Equipment:* 21,782 *Miscellaneous:* 9,020 *TOTAL:* 90,000	(1) Literature reviews. (2) Survey reports. (3) Stakeholder workshop reports. (4) Quarterly & annual progress reports. Final technical report	(1) Local field extension staff in place, & available to participate in project activities . (2) Collaborating institutions provide inputs on time (3) Fishers provide information in survey.

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11. **Professional CVs**

Principal Investigator (PI): Drs Anthony Taabu-Munyaho is a Ugandan Male Research Scientist of the National Agricultural Research Organization (NARO) attached to the National Fisheries Resources Research Institute (NaFIRRI), Jinja. He was born on 11th September 1967 from Lunyo sub-county, Busia district, Uganda. Taabu-Munyaho holds a Bachelor's degree in Zoology, Master of Science in Zoology with bias in fisheries and aquatic sciences. He has recently submitted his thesis for award of PhD in the area of fish population dynamics at the institute of Biology, School of Engineering and Natural Sciences University of Iceland. He has worked at NaFIRRI since 1999 and published 10 papers in referred journals in the area of fish stock assessment as per the details below. He is the reigning chairperson of the Hydro-acoustic working group comprising scientists from Kenya, Tanzania and Uganda, coordinated by a regional body; the Lake Victoria Fisheries Organization (LVFO) charged with the responsibility of regulating use and management of the Lake Victoria fisheries. Taabu-Munyaho is the current head of the fish stock assessment team at NaFIRRI and has recently been appointed Program Leader in charge of Aquatic Engineering and Gear Technology Research Programme.

The proposed PI has successfully led multi-sectorial research in the use of both fishery dependent (Catch Assessment and Effort or Frame surveys) and fishery independent (Trawl Hydro-acoustic and gillnet surveys). He has led diverse teams investigating some components of large Regional and National projects including LVEMP (fish biology and biodiversity sub-component), Implementation of a Fisheries Management Plan (IFMP) Hyrdo-acoustic working group, Bottom Trawl, Catch assessment and Frame survey working groups, and other short time projects such as Bujaghali Energy Limited (BEL). He has been a member of many consultancies including: Environmental Impact Assessment by Tullow oil Uganda, AES Nile power, Lake Victoria Basin Commission (LVBC) - Biodiversity Database and Ecologically Sensitive Areas (ESAs), and Total E and P biodiversity assessment of the Murchison Nile.

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Dr Rukuunya Edward is a male Ugandan born on 28th August, 1968 in Kabale district He holds a Bachelor's and Master of Science degree in Zoology (Fisheries and Aquatic Sciences) and a Post Graduate Diploma in Education from Makerere University, Kampala. He has been recommended for an award of a PhD in BioSciences of Makerere University and is on the graduation list for the forthcoming graduation in January 2014. In addition to the stated formal training, Rukuunya Edward has attended and gained skills from several specialised courses including Result Based Monitoring and Evaluation at the Uganda Management Institute (Kampala Uganda) , Digital Aerial/Geo-referenced Monitoring from Bath Spa University College, UK and Gender, and Climate Change in Fisheries and Environment from the University of Iceland.

He is a an Assistant Commissioner Fisheries Resources Management (Natural Stocks) in the Ministry of Agriculture Animal Industry and Fisheries and also a National Project Coordinator for a project on Increasing Mukene for Human Consumption supported by FAO and GoU. He has published one papers on fisheries in the Journal of Tropical Fisheries and hydrobiology and has 3 manuscripts getting ready for publication. He has also successfully completed an assignment as an international consultant in developing a Water Hyacinth Management Strategy for on Lake Tana, Ethiopia including development of a 5 year integrated project proposal for the Lake Tana basin. Dr. Rukunya has a 20 years working experience with the management of fisheries resources in Uganda

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Kubiriza K. Godfrey is a Ugandan Male born on the 7th day of August, 1979 in Mukono District (currently Buikwe) Uganda. Godfrey holds a Bachelors degree in Fisheries and Aquaculture from Makerere University, a Master of Science degree in Aquaculture and Fisheries Sciences, from the University of Malawi, Bunda College; a post graduate training in sustainable Aquaculture Management, from the United Nations University-Fisheries Training Programme, Iceland, a Certificate in multi-variable statistics from the University of Nairobi/Copenhagen.

Godfrey is finalizing his PhD degree in Biology (Bias in Fish Nutrition and effective experimental design in fish growth studies) at the Institute of Biology University of Iceland/Holar University College, Iceland. In addition, Godfrey has specialized training in Ecological modelling, GIS thru: Bunda College, Malawi and Sea food quality monitoring thru: United Nations University Fisheries Training Programme (UNU-FTP), Reykjavik, Iceland.

He is currently an assistant lecturer in the Department of Biological Science, Assistant field attachment coordinator and head of Aquaculture extension in the Department of Biological Sciences. He also heads the statistics and research methods service unit of the Department of Biological Sciences. Godfrey has published several papers related to Fisheries, Aquaculture and Aquatic Sciences in general.

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Dr. Winnie Nkalubo is a Research Scientist with the National Fisheries Resources Research Institute (NaFIRRI) in Jinja and joined the institute in 1999. She holds a Bachelor of Science degree in Botany and Zoology, a Masters degree in Environmental Science and Technology and a PhD in Science. She has also received specialized training in FishBase and Fish Taxonomy and the use of ArcGIS tools and applications in fisheries management. Her research interests include: Fisheries Biology and Ecology, Aquatic Ecology, Riverine Ecology, Biodiversity Conservation and Water Resources Management. Nkalubo's professional goals are to increase fisheries productivity in Lake Victoria and throughout Uganda using ecological and biological approaches. She is the team leader for the study on "Identification, characterization and mapping of fish breeding and nursery areas for protection in the five major water bodies of Uganda. Nkalubo also leads and coordinates research activities of projects under the Fish Biology and Ecology Section at NaFIRRI. Nkalubo is the Training Coordinator at NaFIRRI charged with overseeing all aspects of internship and training programmes (planning, implementation, evaluation) at NaFIRRI and has spearheaded GIS related activities at NaFIRRI since 2012. Nkalubo is also the Climate change champion tasked with mainstreaming the climate agenda into fisheries research activities.

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THE REPUBLIC OF UGANDA

OFFICE OF THE COMMISSIONER
DEPARTMENT OF FISHERIES RESOURCES
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UGANDA

19th December 2013

The Director General,
National Agricultural Research Organization
P. O. Box 265, Entebbe

Dear Madam,

LETTER OF SUPPORT FOR THE PROJECT "IMPROVING LIGHT ATTRACTION TECHNOLOGIES FOR ENHANCED HARVEST OF *MUKENE* ON LAKE VICTORIA"

I write to reaffirm and endorse my department's participation in the application for funding for the above-mentioned project to be submitted by the National Fisheries Resources Research Institute (NaFIRRI), Department of Fisheries Resources (DFR), Makerere University and Arrow Aquaculture Africa (AAA).

The collaborative research with NaFIRRI shall be particularly beneficial to the development of *Mukene* harvest in Uganda as we seek to improve food and livelihood security of millions of people. In the last few years, the biomass of *Mukene* on Lake Victoria has increased substantially yet the level of harvest is still low. Now, it is a critical time to develop technologies that will sustainably harvest this resource. Currently for individual fishers, it is becoming evidently more difficult to earn sufficient income from the declining wild fisheries with a disproportionate effect on the women who play a central role in the post-harvest process.

The Department of Fisheries Resources in collaboration with NaFIRRI under the MAAIF have been conducting joint research activities for several years to spur adoption of generated technologies and to ensure that the management of the country's fisheries resources is based on sound scientific information that is routinely updated through Standard Operating Procedures (SOPs). We therefore envisage that the funds we are requesting will contribute to this effort at such a critical time in the process. We are currently implementing a project for increasing *Mukene*

for human consumption and our focus has been on improving post harvest handling to increase its availability for human consumption. Clearly, the catamaran harvesting technology this project piloted between 2010 -2012 had several challenges and a lot is still required in the technology generation component which the proposed project will address.

I wish to affirm that DFR fully supports the proposed study and confirms that if the grant is offered, we will ensure dedicated implementation of research activities and finalization of the project and that the results will help both management and research to implement priority management goals to improve fisheries production in the country. On behalf of the DFR, I pledge support for the project and please do not hesitate to contact us on the above address in case of further information.

Yours sincerely,

Wadanya L D Jackson
Commissioner Fisheries Resource Management and Development