



MINISTRY FOR AGRICULTURE,
ANIMAL INDUSTRY AND FISHERIES



NATIONAL AGRICULTURAL
RESEARCH ORGANIZATION



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2018/2019

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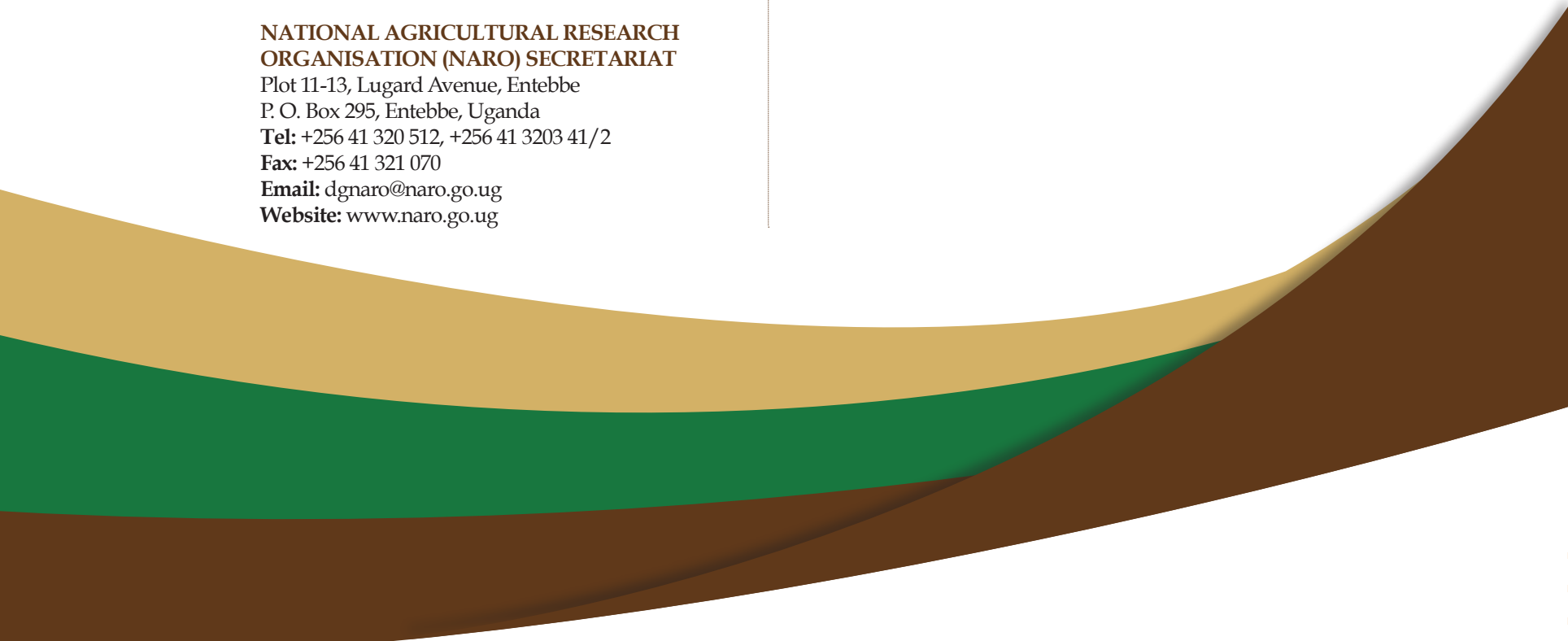
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NATIONAL AGRICULTURAL RESEARCH ORGANISATION

Co-ordinating, Overseeing and Guiding Agricultural Research

National Agricultural Research Organisation (NARO) is the apex body for guidance and coordination of all agricultural research activities in Uganda. It is composed of 16 public agricultural research institutes spread all over Uganda, both at national and zonal levels. NARO is committed to generating and disseminating appropriate, safe, and cost effective technologies for sustainable agricultural productivity, economic growth, food security and poverty eradication.



Vision

A competitive society supported by a dynamic agricultural research innovation system



Mission

To innovate for sustainable agricultural transformation

For more information visit;
www.naro.go.ug

**Prof. Joseph Obua**

Chairman, National Agricultural Research
Organisation Governing Council

Message from Chairman, NARO Governing Council

NARO is a Centre of Excellence for agricultural research in East Africa and globally. As such, it achieved a great deal in FY 2018/2019. One of the remarkable achievements was the development of the NARO Strategic Plan 2018/19 – 2027/28 which provides a new direction for investments in agricultural research in the next ten years.

The Strategic Plan responds to the development aspirations of Uganda as outlined in Vision 2040 to transform agriculture into a profitable, competitive and sustainable sector of the economy. In an era where knowledge-based economies are driven by science, technology and innovation, the role of agricultural research in this transformation process is paramount.

I thank the members of the NARO Governing Council for guidance during the development of this Plan and approving it. In the same vein, I would like to thank NARO top management and the entire staff for their efforts and support in developing the Plan.

This report presents a number of breakthroughs made including the release of improved crop varieties that are high yielding, drought tolerant and early maturing. Other breakthroughs include the development of three specific anti-tick vaccines, agro-machinery prototypes and other equipment and machinery for value addition.

The aforementioned achievements provide the impetus for NARO to innovate further and significantly contribute to the growth of the agriculture sector and the national economy for the benefit of our citizens. Together we can do and achieve more in the future. To all our staff and supporters, I would like to say “the sky is the limit” as we trudge on to the next financial year and achieve our targets.

Lastly, I would like to thank the government of Uganda, the development partners and stakeholders for their support which ensured that we delivered on what we promised.



Prof. Joseph Obua
Chairman, NARO Governing Council

National Agricultural Research Organisation Governing Council

Name	Title/Position
Prof. Joseph Obua	Chairman and Eminent Scientist
Mr. Pius Wakabi Kasajja	Permanent Secretary, Ministry for Agriculture, Animal industry and Fisheries
Mr. Titus Kajura	Representative of the Permanent Secretary of the Ministry for Finance, Planning & Economic Dev't
Mr. Haruna Mawanda	Representative nominated by Uganda Local Authorities Association
Capt. Tisasira Esau	Vice President, Uganda National Farmers Federation, Representative of Farmers
Mrs. Monica Kabatooro	Chairperson, Hoima District Farmers Association Representative of Farmers
Mr. Patrick Cheborion	Chairperson Farmers Forum, Kapchorwa, Representative of Farmers
Mrs. Margaret Ebuu	Uganda National Farmers Federation, Representative of Farmers (disabilities)
Hon. Idah Mehangye	Representative of Uganda National Non-Governmental Organizations Forum
Dr. William Wagoire	Director NaCORI, Representative of Public Agricultural Research Institutes
Dr. Sengooba Theresa	International Food Policy Research Institute, Representative of private agricultural research providers
Dr. Gudula Naiga	Vice Chairperson, Private Sector Foundation Uganda
Prof. John D. Kabasa	Principal, College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University - Representative of Universities
Dr. Peter Ndemere	Executive Secretary Uganda National Council of Science and Technology (Ex-Officio)
Dr. Samuel K. Mugasi	Executive Director, National Agriculture Advisory Services (Ex-officio)
Dr. Ambrose Agona	Director General, National Agricultural Research Organisation (Ex-officio)

Foreword by the Director General, NARO

In line with Uganda's Vision 2040, the National Development Plan II (NDPII) and the Sustainable Development Goals (SDGs), among others, NARO's emphasis in the FY 2018/19 was placed on research thrusts which have the potential to transform the agricultural sector significantly as the country gears towards agro-industrialization.

A total of 23 candidate crop varieties were submitted to the National Variety Release Committee of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). Upon release, the crop varieties will contribute to economic growth, food and nutrition security, and poverty reduction because of their peculiar attributes of resistance to pests and disease, better yields, increased nutrient densities and adaptation to drought-prone environments. As I write, am aware that some of these varieties have already been released and others are still being vetted for possible release.

Significant achievements were also made in the areas of agro mechanization, forestry, livestock and fisheries.

To make NARO more responsive to stakeholder needs, a new strategic plan (2018/19 – 2027/28) has been developed. The 10-year plan is impelled by the shift in focus from simply increasing agricultural production and productivity to causing real sector

and socio-economic transformation. It is envisaged that the actions arising from this plan will go a long way in increasing niche markets, agricultural research products and services suited for the industry.

NARO continued to engage with stakeholders and strategic partners to enhance access to agricultural research products and services. The NARO Compendium (2012-2017) that provides information about technologies generated by NARO in the last five years was published.

Also, an online NARO info hub was operationalized as an open-source of agricultural data, information and knowledge to support self-learning, information access, as well as feedback. The hub is available and operational at www.naroinfohub.org.

The Biannual NARO-MAK Scientific Conference was also held and used to disseminate research results and agricultural knowledge to over 350 participants from 10 different countries.



Dr. Ambrose Agona

Director General, National Agricultural
Research Organisation

The staff in all directorates and PARIs continued to deliver services to fulfill our mandate.

Their efforts, hard work and dedication are much appreciated.

We also appreciate the financial support from GOU, donors and development partners. I am thankful to the NARO governing council and all other stakeholders for their support during the reporting year.

Lastly, I urge everyone to read the Annual Report as a reference to the contribution of NARO to agricultural productivity, economic growth, food and nutrition security and poverty eradication.



Dr. Ambrose Agona
Director General, National Agricultural Research Organisation

National Agricultural Research Organisation Top Management

Name	Title/Position
Dr. Ambrose Agona	Director General, NARO
Dr. Yona Baguma	Deputy Director General - Research Coordination
Dr. Imelda N. Kashaija	Deputy Director General - Agricultural Technology Promotion
Prof. Justus Rutaisire	Director Corporate Services
CPA Mary Kigunddu	Director Finance
Mr. Robert Bagonza	Director Human Resource
CPA Denis Owor	Head Internal Audit



The President of Uganda, His Excellency Yoweri Kaguta Museveni inspecting a NARO- Kawanda stall displaying the NAROBAN5 at an event in Namalere –Behind him is the Minister of MAAIF Hon Vincent Ssempijja and other government officials.

CHAPTER 01

Achievements against performance indicators

NARO is mandated to undertake research in all aspects of agriculture. The organization's Vote Function Outputs emphasize; generation of agricultural technologies, strengthening of agricultural research-extension interface and strengthening agricultural research capacity.

Summary of Key Performance indicators

NARO undertakes periodic identification of research areas through demand articula-

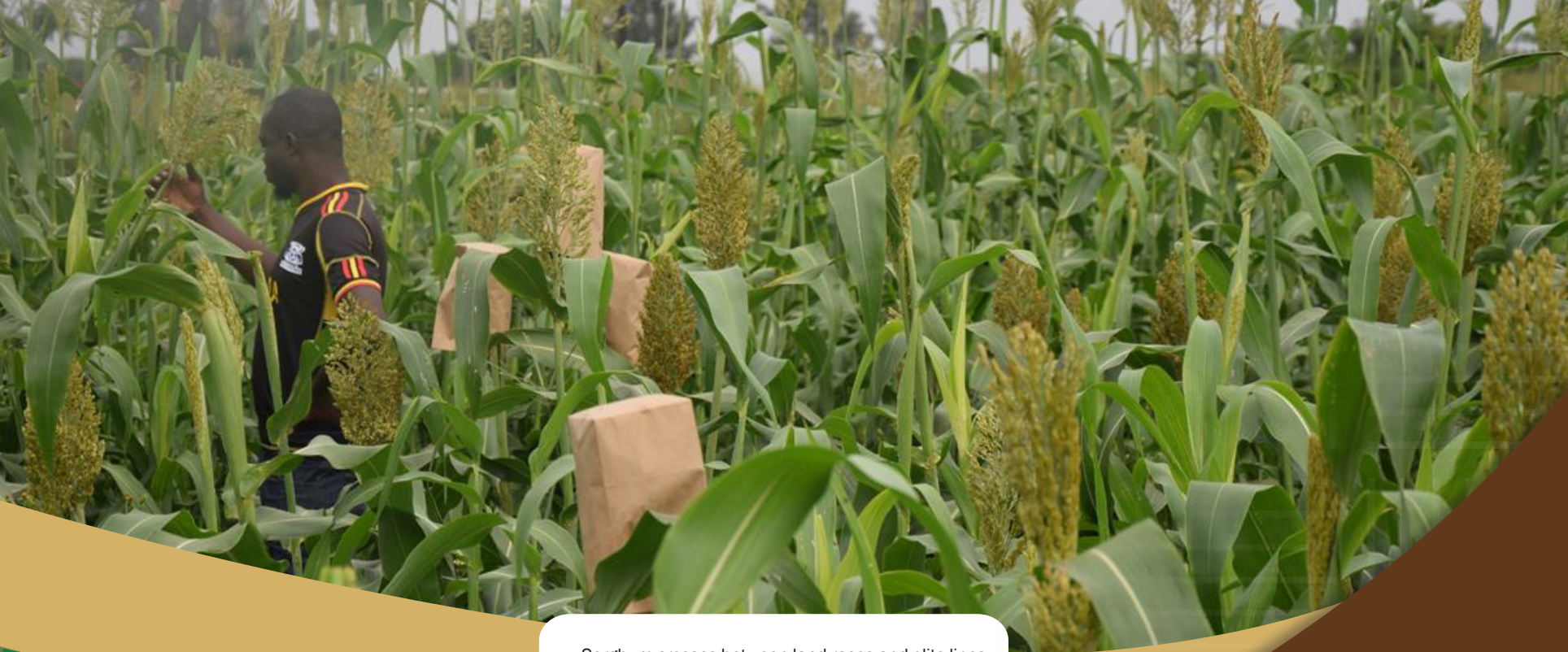
tion and priority setting of agricultural production and productivity constraints and opportunities.

In addition, socio-economic, gender, mar-

ket potential, consumer preference, environmental and social safeguards concerns are considered. Table 1 presents a summary of the Key Performance Indicators for the FY 2018/2019.

Table 1: Summary of NARO Performance as per the Key Performance Indicators

NARO Key Performance Indicators	Planned Targets	Actual Achievement	Reasons for variation in 2018/2019
Generation of agricultural technologies			
Number of new varieties/ prototypes submitted to Variety Release Committee for release	20	23	- Timely release of funds for activities and off-budget contributions - Technologies directly proportional to actual demands
Number of production technologies generated	70	70	
Number of research studies under competitive grants scheme (CGS)	40	16	Not enough resources to support all the targeted projects
Research extension interface promoted and strengthened			
Number of technological innovation platforms established/ supported	10	22	- Increased enthusiasm by farmers, processors and other groups in the value chain - Contribution of off-budget support
Number of technological innovations delivered to uptake pathways	40	77	- Contribution of off-budget support - Increased density of on-farm trials and demonstrations - Improving Research -Extension linkages



Sorghum crosses between land races and elite lines
at ABI ZARDI

CHAPTER 02

Generation of Agricultural Technologies

NARO has the mandate to conduct and promote agricultural research in all aspects of crops, livestock, fisheries, forestry, soil, water and natural resources. This chapter is a summary of the key achievements registered during the reporting period.

Crop Sub-sector

NARO has been undertaking the development of Technologies, Innovations and Management Practices (TIMPs) in national priority crops and other national strategic crops. The following has been achieved under variety improvement and development;

A total of 23 candidate varieties were submitted to the National Variety Release Committee (NVRC) of MAAIF as shown in Table 2. These included five (5) out of eighteen (18) newly introduced Dutch potato varieties with capacity to yield over 30T/ha which were found to be adaptable to Ugandan conditions.

As shown in Table 3, five (5) other varieties have been released and these are; two bean varieties, two groundnut varieties and one banana variety. The varieties have superior attributes over the current existing varieties with respect to yield advantage, pest and disease resistance, increased nutrient densities, adaptation to drought prone environments and culinary attributes.

Table 2: Candidate crop varieties submitted for release during the FY 2018/2019

Commodity	No. of varieties submitted for release	Key Attributes of the submitted varieties*
Cotton	2	- High fibre quality (>30 mm) and strength - High yielding
Maize	4	- Drought tolerance - Good grain type (shape, texture, colour, etc)
Rice	2	- High yield - Aromatic
Potatoes	6	- Crispy and suitable for fast foods - Resistant to late blight disease
Highland sorghum	3	- High yield - Drought tolerance

Table 3: Crop varieties released during the FY 2018/2019

Commodity	Varieties released	Key Attributes of the submitted varieties*
Groundnuts	2 (NARONUT1T, NARONUT2R)	- Drought tolerance - Early maturity (75 – 80 DAP**)
Beans	2 (NAROBAN6, NAROBAN7)	Drought tolerance, increased nutrient densities
Bananas	1 (NAROBAN5)	- High fruit quality comparable to land races - Resistant to weevils and Black Sigatoka

*The candidate varieties present a yield advantage over the existing reference varieties, for each commodity.

**DAP= Days After Planting

Two bean varieties released

Under beans research, two (2) drought tolerant, nutritionally enhanced with multiple pathogen resistance varieties (NAROBAN 6 and NAROBAN 7) were released. A total of 6.8 MT of foundation seed (including NAROBAN 4C and 5C) was released and distributed to 14 farmer groups in south western Uganda.



NAROBAN 6 (l) and its close relative NAROBAN 7(r) are Uganda's answer to drought as well as essential nutrient deficiencies

Introducing pre-cooked beans for greater food and income security

Many People who love to eat beans especially in the urban centres of Uganda often forfeit the consumption of their delicacy due to their long cooking time and high fuel requirements.

Bean researchers in Uganda are therefore making interventions to improve this state of affairs. Researchers at NARO are part of a national effort to commercialize a pre-cooked bean product whereby dried beans are pre-cooked under pressure, dried, packed and stored.

Consumers will now cook beans for only 15 minutes, as opposed to hours, before serving. This pre-cooked bean product is envisaged to save almost 80% of cooking fuel. Other products under development include fortified bean flour which is nutritionally enhanced with calcium, iron, and folic acid to aid in the fight against malnutrition.

The Food and Agricultural Organisation of the UN recognizes malnutrition as one of the indicators of food insecurity. In addition, a “Ready-to-eat” bean snack has also been developed and is currently under shelf-life testing stage. All these products are being developed under the ultimate objective of increasing bean consumption, improving diets, reducing on cooking time and fuel and creating a more lucrative



A farmer from Kiziba Community Seed Bank in Sheema District displaying common bean diversity during the Diversity Fair held in Rubaya, Kabale District.

market for bean growers while improving and diets and nutrition of the consumers.

To realize this, farmers have been organised in groups to multiply and supply specially selected bean varieties to pre-cooked bean processing plants, thereby generating income and

enhancing the capacity for bean production in the country.

A total of 76 farmer groups with a membership of 3,092 farmers have already been profiled from 10 districts.

Novel hybrid banana variety released as NAROBAN5

In the FY2018/2019, the Ministry of Agriculture Animal Industries and Fisheries through the national variety release committee released a pest and disease resistant innovative hybrid banana variety from NARO called NAROBAN5.

This latest variety is the 7th matooke hybrid to be released from NARO's banana research programme, contributing to government efforts to transform the agriculture sector by increasing land and labour productivity through the delivery of improved seed to the farming communities.

According to Dr Jerome Kubiriba (Programme leader Banana), NAROBAN5 is resistant to diseases that are responsible for the disappearance of banana plantations from Buganda, Busoga and Bunyoro regions. "Black Sigatoka, weevils and nematode pressure is what forced farmers in these regions to abandon banana farming. In this new variety, there is an opportunity to revive plantations", he says.

Ten million people in central Uganda depend on bananas for both food and income. And if adopted by many farmers, the new variety has the potential to revive central

Uganda's glory as a matooke hub and contribute significantly to ending hunger in Uganda.

Dr Rabooni Tumuhimbise, a banana breeder behind the development of this hybrid banana says, this is good news to banana farmers and consumers alike because NAROBAN5 tastes and looks as good as traditional varieties dispelling the myth that hybrid bananas do not taste nice. If you are a banana farmer interested in accessing this hybrid do not hesitate to get in touch with NARO Kawanda, banana program office.

Attributes of NAROBAN5

- Bunch weight of 45kg in well managed plots at Kawanda.
- Resistant to black Sigatoka disease
- Resistant to weevils and nematodes
- Tastes as good as local varieties (soft, aromatic and yellow in colour).



Two groundnut varieties released

Low on-farm yields of groundnuts are often attributed to factors such as outbreak of pests and diseases, use of low-yielding seed varieties and rudimentary farming practices with little mechanization.

Over the years, research efforts have endeavoured to breed varieties that are high-yielding, resistant to major pests and diseases, tolerant to drought, and have a short to medium maturity period.

In order to add onto the farmers' choice of preference / list, two (2) high-yielding groundnut varieties - NARONUT 1R and NARONUT 2T - resistant to major pests and diseases, tolerant to drought, high in oil

content and shorter maturity period (75 to 80 days) were released. These varieties are also drought resistant which mitigate the current erratic rainfalls

NARONUT 1R



Special Attributes

Maturity: Extra early (75 days)
Resistant to: Rosette virus, Drought and Heat
Germination: 4 days (50%)
Shelling: Very Easy
Taste: Sweet
Seed colour: Deep attractive red
Seed size: Medium to large
Seed Shape: Oval
Thin White Seed cushion: Present
Use: For butter and condiment
Spacing : 45 x 7.5/10cm
Yields: 2500-2700Kg/ha
Target production areas: Warmer areas, Cattle Corridor with short rains; Red soils give heavier less shrivel seeds



NARONUT 2T



Special Attributes

Maturity: Extra early maturing (80-85 days)
Resistant to: Rosette virus, Drought & Heat
50% Germination: 4 days
Shelling: Very Easy
Taste: Sweet
Seed colour: Attractive tan colour
Seed size: Medium to large
Seed Shape: Oval
Thin White Seed cushion: present
Use: For butter and condiment
Spacing : 45 x 7.5/10cm
Yields: 2500-2700Kg/ha
Target production areas: Warmer areas, Cattle Corridor with short rains, Red soils give heavier plump less shrivel seeds

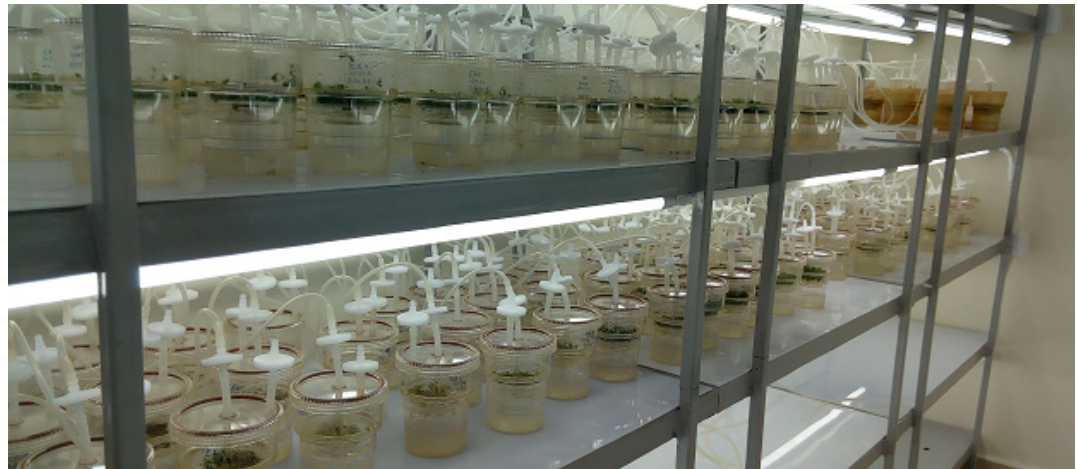


Coffee production boosted through tissue culture

In the FY2018/2019, NARO operationalized the tissue culture (TC) laboratory at the National Coffee Research Institute to enhance the availability of coffee planting materials to coffee farmers.

The lab operational level has since increased from 40 to 80% with Callus induction and embryo germination efficiency from 10 to 80%.

The tissue culture laboratory produced 96,764 clones, 33,382 rooted-cuttings weaned and 21,943 rooted-cuttings availed to farmers.



New RITA bio-reactors deployed



New RITA bio-reactors deployed



Newly installed Preparation chamber (Left) and Laminar flow-hood



Cassava MandiPlus technology for Africa farmers validated

National Agricultural Research Organization (NARO) through the National Crops Resources Research Institute (NaCRRI) in collaboration with The Brazilian Agricultural Research Corporation (Embrapa) and the Syngenta Foundation for Sustainable Agriculture for the past three years have been testing and validating the suitability of a cassava seed treatment technology called MandiPlus for African farmers.

MandiPlus technology involves coating every seed piece with a combination of protectants and stimulants to increase the quality of cassava seed by staving off pathogen, mite and insect attacks. This technology enables producers to cut much shorter seed stakes, and thus significantly increasing multiplication rates with an aim of developing a commercially sustainable delivery system for quality declared cassava planting materials.

Conventionally cassava in Uganda is propagated by 25 – 30cm long stem cuttings which are bulky, wasteful and results in low seed multiplication ratio, a key constraint to cassava seed systems.

Under the MandiPlus technology, short, treated (12cm) stem pieces have showed the same or better plant density, sprouting and plant height compared with long (24cm) untreated stem pieces. Seed treatment increase plant vigour, plant height, improved



A marked difference in vigour and plant density between treated and untreated 12cm stem pieces

sprouting percentage and reduced termite incidence; early indicators of increased seed yield, thus doubling or tripling the seed multiplication rate.

MandiPlus increases seed yield by two-fold and root yield by 8 tons per hectare in the case of NASE-14, NASE-19 and NARO-

CASS-1 cassava varieties. Although using MandiPlus Technology increases the production costs by 1/10th of the conventional cassava production method, the returns are double. The technology is cost-effective, superior to other local protectants and is more effective in white-fly control.

New cotton bio-pesticides in the offing

NARO has been undertaking research, promoting and education on the use of bio-control agents. Efforts were expended to produce an effective commercial formulation of cotton bio pesticides which can be patented for upscaling to commercial level. Two bio-pesticides were developed and evaluated for their effectiveness in management of major cotton pests mainly cotton boll-worms, fall army-worms and stem borers.

The total crop loss of 80%-100% can be obtained on farm if no control is put in place and at national levels high levels of poverty and food insecurity. The two bio-pesticides are stable prototypes of *Metharizium spp* (one litre), *Trichoderma* (2 kg) and neem seed extract (2 litres) produced for further testing in the field. These are naturally occurring products in nature and easily biodegradable compared to synthetic pesticides. These bio-pesticides are applied to the crop during the production cycle normally three times during the whole crop growing season. Application is either as a flowable powder (*Trichoderma*), or as liquid formulations (Neem seed extract and *Metharizium*).

These cotton bio pesticides will reduce drastically on synthetic pesticide use, increase on availability of highly nutritious and healthy products as well as conserving biodiversity hence contributing towards poverty eradication and improved nutrition in Uganda. Whereas most bio-pesticides products are



not stable in the environment, by producing stable prototypes of efficient products, these are considered break-throughs. These are naturally occurring living organisms in nature continuously destroyed by synthetic pesticides often used, therefore by multiplying them and using them back in the field means boosting ecosystems function while conserving nature.

This research is a collaboration between

NARO, Government of Uganda, Uganda Cotton Development Organization (CDO) and Government of India. One of our major objectives is promoting research and education on the use of bio-control agents (this will change farmers mind set that the only golden alternative to synthetics is bio pesticides, then also shall consider exploiting both the local and export market potential for bio-pesticides in Eastern, Central and Western Africa.

Agro-machinery

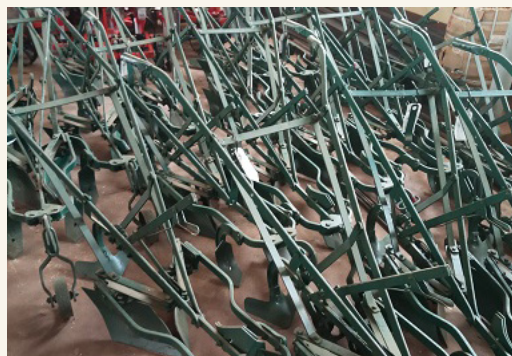
Increasing access to agro-machinery

As a long-term strategy to contribute to agricultural mechanisation in the country, NARO is evaluating new approaches to impress the farming communities to adopt the use of agro-machinery to enhance technological innovations.

For example, the Agricultural Engineering and Appropriate Technology Research Centre - Namalere is implementing a model in which equipment fabricated at the Centre are hired out to service scheme enterprises managed by entrepreneurs among local communities.

However, in other areas where hire of equipment may not be feasible, other approaches are being used including supporting farmers with essential equipment free of charge like the case at Abi ZARDI where four cassava chippers were handed over to beneficiary farmer groups.

It is envisaged that equipment hire service entrepreneurs will ensure sustainable access of these equipment to farmers; the entrepreneurs will earn additional income, create jobs for the youth who are the operators of these equipment, rural mechanics/artisans earn additional income by providing maintenance



Some of the ox-weeders and cassava chippers ready for hire

services, and the equipment support farmers will deliver quality and timely products to markets.

In the FY2018/2019, establishment of equipment hire service entrepreneurs was initiated for six (6) agro-machinery innovations among the farming communities in Acholi sub-region and Adjuman district.

A total of 25 trailers, 25 planters, 25 NARO



lightweight rice threshers, 23 food grade cassava chippers, 25 maize shellers, and 50 animal drawn carts were fabricated. In addition 75 ox-weeders were distributed to 25 sub counties and 23 cassava chippers distributed to 14 sub counties.

These efforts will later be followed by a series of appropriate skills enhancement programs for the beneficiary entrepreneurs.

Livestock Sub-sector

NARO gets ultramodern livestock bio-security diagnostic laboratory

A state-of-the-art regional diagnostic laboratory was constructed at the National Livestock Resources Research Institute (NaLIRRI) at Nakyesasa, Wakiso District. The laboratory is a Bio-security Level two (BSL-2) constructed and equipped to international standards with the support of the United States Department of Defence, through its Defence Threat Reduction Agency (DETRA). The construction and equipping of the laboratory was as a result of a cooperative biological engagement program in Uganda being implemented by DETRA.

This laboratory will support vaccine research by empowering detection and molecular characterization of pathogens, antibodies elicited by hosts due to pathogens and antigens. The facility will enhance bio-safety and bio-security standards and strengthen Uganda's ability to detect, diagnose, conduct surveillance and enable reporting of current, emerging and re-emerging diseases of national and international concern such as foot and mouth, Ebola and zoonotic diseases (transmitted from animal to man) like Anthrax.

The laboratory will also facilitate quick diagnosis and containment of disease and epidemics. The lab will not only serve Uganda, Congo,



R-L: Major Michael Miller from the US Embassy Kampala, Dr. Ambrose Agona, Director General - NARO, Dr Fredrick Kabi, Head Livestock Health Research.

South Sudan and other countries, but will enable NaLIRRI to attract and conduct high qual-

ity collaborative research and boost capacity building in livestock research.

Relocation and operationalization of the national livestock resources research institute (NALIRRI) from Tororo to Maruzi

The Government of Uganda identified the processing of rocks rich in phosphorus fertilizers to be having positive benefits especially for the agricultural sector to drive economic growth.

The development of the fertilizer industry in Tororo, would reduce the cost of mineral fertilizer and boost agriculture productivity. Government decided to exploit mineral deposits at Osukuru hills in Tororo.

Guangzhou Dongsong Energy Company Limited that is undertaking the project plans to setup energy and mineral development through phosphate fertiliser, steel mills, sulphuric acid, glass making and power plants. The Uganda Land Commission (ULC) leased the land currently hosting NaLIRRI to Guangzhou Dongsong Energy Group Company to undertake mineral development in 2015.

The Identification process for a suitable site to host NaLIRRI was guided by availability of supportive natural resources, conducive

natural and socio-economic environments for livestock research and production. The Maruzi ranch located in Akokoro and Ibuje sub-counties of Apac District was the site selected as suitable for Livestock research. NaLIRRI was allocated 10 square miles by ULC.

The National Livestock Resources Research Institute (NaLIRRI) developed and presented a project to guide the relocation of NaLIRRI and operationalisation of the institute at Maruzi. The project involves establishment of long-term infrastructure such as construction of buildings and hence its life span is fifteen (15) years.

The total budget comprises of capital development and operating costs consolidated from the relocation and operationalisation components.

The process of hosting the institute in a new site will have two phases. A transient settlement at Nakyessasa in Wakiso district and a final and complete transfer to Maruzi. Maruzi ranch currently lacks basic infrastructure for staff accommodation, offices and laboratories, animal houses, experimental fields, paddocks and other feeds, basic utilities like water, ICT and electricity.

Office and laboratory assets and livestock as well as staff will be hosted at Nakyessasa for at least two years. During this period works on research and research support infrastructure, and the necessary utilities to make Maruzi a full-fledged livestock research and development modern institute will be established.

NARO governing Council in its seating on



An artistic impression of the new NaLIRRI headquarters in Maruzi

the 6th April 2018 approved the relocation of NaLIRRI and operationalisation of the institute at Maruzi.

NARO presented the project for inclusion in the Public Investment Projects plan (PIP)

through the Development Committee (DC) of Ministry of Finance Planning and Economic Development (MFPED).

To date the Project Concept, Profile and Pre-feasibility studies have been approved.

Ministry of Finance, of Finance Planning and Economic Development has included the project in the PIP.

NARO will start receiving funding for this project in the FY 2019/2020.

Fisheries Sub-sector

Assessment of impacts of cages on the water environment of Lake Victoria

Cage fish farming can lead to the aggregation of wild fishes at the cages due to excess food available to them. Farmed fish may also escape from the cages and interact with wild fish resulting into spread of diseases and parasites, as well as dilute the genetic diversity of wild fish.

While outbreak of diseases among cultured fishes may be controlled through treatment, wild fishes cannot undergo such treatment and may thus spread diseases to other fishes hence affecting yields from capture fisheries.

These and other possible impacts of cages on the water environment may consequently result into conflicts with other resource users affecting growth of cage aquaculture industry.

Studies were conducted to evaluate the status of water physico-chemical conditions, nutrients and biological communities (algae, invertebrates and fish) around northern Napoleon Gulf, Lake Victoria called the source of the Nile (SON) where a cage fish farm has been established on Lake Victoria;



Status of the physical conditions

The key water conditions (temperature, dissolved oxygen, pH, conductivity and water transparency) indicated no major differences among the sites and were within the ranges suitable for production of aquatic fauna.

At all sites, temperature varied within the range of 25.6-28.3°C, while dissolved oxygen concentration was in the range of 5.3-9.4 mg/l. The conductivity and pH varied within the ranges of 95.6-107.1 $\mu\text{S}/\text{cm}$ and 6.3-8.0 respectively.

Status of nutrient concentrations

On average, Cage and Downstream sites exhibited higher concentration of nitrites, nitrates, total nitrogen, and total phosphorus than the references. On the other hand, the reference site presented a higher concentration of soluble reactive phosphorus, a readily available form of phosphorus, than recorded in the rest of the other sites.

For ammonium nitrogen, the concentration was slightly lowest in the Cage category and highest at the downstream.

Status of algae, invertebrates and fish

Chlorophyll, an indicator of algal biomass



was highest downstream of the cages and lowest at the reference, with a pattern similar to that observed for the soluble forms of nitrogen. The zooplankton community, a resident of the water column and therefore impacted by changes in water quality variables of the water column was still characterized by rotifer-driven species richness and copepod-dominated numerical abundance at all stations, typical of Lake Victoria.

On average, the abundance and number of taxa/species of total zooplankton, macro invertebrates, and fish were highest at the reference and lowest downstream of the cages.

The variation in number of fish species caught at the reference, cages and downstream of cages also indicated that wild fish were not aggregating at the cage site which would be caused by excess food available to them, and therefore cage fish farming had not modified the feeding behavior of wild fish in the vicinity.

Moreover, the absence of large parasites on wild fish specimens examined indicated that cages had not deteriorated water quality to a level that would favour high fish-parasite interaction.

Source of the Nile (SON) cage fish farm in Napoleon Gulf, northern Lake Victoria has therefore exhibited increased adherence to set standards and regulations.

There has also been a demonstration of good working relations between SON fish farm management and other lake users.

The operation of the SON farm has continued to expand, resulting into increased and sustained fish production by the farm. The best management practices had led to sustained fish production at the cage farm area.

Fish breeding and nursery areas identified, characterised and mapped on Lakes Albert and Edward

Lakes Albert and Edward provide water for agriculture, domestic use, and navigation. The fisheries are an important source of food, livelihood and income to the riparian communities within the lake basins and contribute significantly to the economies of respective countries sharing the lake.

However, the fisheries face critical challenges of dwindling fish stocks due to overfishing, use of inappropriate gears and vessels, pollution, land degradation and proliferation of invasive aquatic weeds which affect water quality, fishing activities, fish ecosystems and navigation. Activities (e.g. excavation, drilling, infrastructure such as roads and settlements) related to the recent discovery of oil and gas on the shores of Lake Albert are a potential threat to the well-being of the lake and its biodiversity.

The wetlands around these lakes are being converted to other uses thus reducing the ecosystem functions and the goods and services which they provide such as being biodiversity havens for many fauna and flora. The major concerns in the lakes include loss of biodiversity, environmental degradation and loss of ecosystem integrity as they impact on the sustainability and beneficial uses of the lake's ecosystem for the pres-

ent and future generations. The concept of marine protected areas (MPAs) has been widely used as an effective fisheries management tool. The aquatic resources of lakes Edward and Albert require scientific information to guide the process to gazette and protect critical fish habitats. This undertaking thus provided insight into the spatial spread of Fish Breeding Areas (FBAs) and their associated geographical features to guide appropriate fishing technologies, management measures and practices.

A total of 20 FBAs were mapped on Lake Edward (Figure 1), including 2 proposed by stakeholders during national consultations. The total area of the delineated FBAs was 16,000 hectares which is 0.07% of the lake surface area. On Lake Albert (Figure 2), a total of 26 FBAs were mapped including 7 from stakeholders. The total area of the delineated FBAs was 13,500 hectares which is 0.03% of the lake surface area.

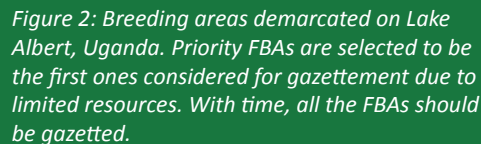
A set of actionable recommendations that fall under five key areas: Governance, Capacity building, scientific monitoring, legal and policy interventions, and sustainable utilisation of the FBAs were developed to guide the management of the FBAs. The recommended actions are given time frames ranging from short term (one-to-two years) to long term (through five years and beyond).

The recommended actions range from implementation of national, regional and international policies, protocols and conventions in addition to practical steps towards increased capacity building/sensitisation at grass roots, local and national levels as well as scientific monitoring.

Well-articulated guidelines and requirements for demarcation, gazettelement and management of the FBAs on lakes Albert and Edward were put in place. Step by step



The study provided an estimated cost of USD 60 per hectare of FBA (depending on the shape of the FBA polygon) for demarcation gazettelement, management and com-



This cost is distributed in proportions 51% for demarcation and marking, 42% management and protection and 7% compliance

Closed areas are a good tool for rebuilding fisheries. The completion of the FBAs adds lakes Albert and Edward to Lake Victoria as Ugandan water bodies with specified FBAs. This is an important step in ensuring better management practices for fisheries of Uganda.

Annual Report 2018/2019

Securing a global freshwater fish hotspot on Lake Nyaguo

Freshwater ecosystems are under-represented in the protected area network. Lake Nyaguo is one of the satellite lakes of Lake Kyoga basin, homing threatened native and endemic fishes which have disappeared or become extinct from major lakes like Victoria and Kyoga.

The catchment areas of this lake have been identified as spawning and nursery areas for fish, birds nesting areas, thus needing further protection to maintain its ecological values and integrity.

Although Lake Nyaguo functions as contemporary refugia habitats for the survival of many threatened aquatic wildlife such as fishes, water birds, reptiles, and mammals, unsustainable human activities like habitat destruction, modification and fragmentation, have continued to jeopardize the integrity of this lake to support these vital aquatic resources.

This lake is outside protected areas, and thus suffers from direct human impacts as communities over exploit these resources. NaFIRRI is facilitating the recovery of the populations of threatened aquatic wildlife in Lake Nyaguo and the surrounding catchment areas through creation of community protected areas.



This undertaking is of National Fisheries Resources Research Institute in partnership with Rainforest Trust and all stakeholders units at National, District, County, Sub-county and Village levels of the administration. The overall objective of this undertaking is to create Lake Nyaguo fish and wildlife reserve to better manage, protect and conserve threatened aquatic wildlife and their habitats. This undertaking also seeks to create awareness about threatened aquatic wildlife and their habitats among all stakeholders; to zone and designate critical habitats of threatened aquatic wildlife in Lake Nyaguo and promote

local communities' involvement in management of the newly created protected areas.

NaFIRRI has engaged stakeholders necessary to support the formation and management of the protected area. Key stakeholders include MDAs such as NEMA, UWA, DiFR, MWE-WMD, Local Governments of Kumi, Ngora and Pallisa districts, and non-governmental organizations such as Northern Uganda Social Action Fund, Vision Teso Rural Development Organization. Primary stakeholders comprises fishers in the lake, crop farmers, livestock grazers,

papyrus harvesters, domestic water users, land tenants and landlords. A management plan for the envisaged protected areas was developed. Ten community conservation committees were established in 14 fishing villages around Lake Nyaguo (4 Pallisa, 4 Ngora and 2 Kumi). For each community, a committee of 9 to 10 people was established, following the TORs for the committee with approval by community members. Training was conducted for the committees about the general conservation aspects, conservation agreements and the importance of a management plan. The committees were equipped with skills to interpret rules and regulations prior to their registration. A

resource mapping exercise was conducted to identify key biodiversity areas that need special protection and other resources that can act as keystone resources whose protection can guarantee the protection of other elements of the ecosystem. Key biodiversity resources included birds such as the crested crane, nesting places, fish breeding grounds, grazing lands, farmlands, sand mining areas, key spots with reptiles and mammals including crocodiles, hippos, aquaculture, papyrus harvesting, and cultural sites. Baseline abundance and composition levels of these resources were established to act as a basis for monitoring the importance of the protected area. Alternative livelihood

options that can be supported to reduce pressure on fisheries were identified. These included aquaculture dams for watering animals, small scale businesses and provision of acceptable fishing nets.

NARO has engaged relevant stakeholders, local leaders and communities around the lake Nyaguo through workshop and quarterly meetings. This undertaking has increased awareness of local communities about the importance of having the stewardship over their own resources and they have more awareness of the values of biodiversity and the steps they can take to conserve and use it sustainably.

Strategic Mechanisms to Advance Resilient Tilapia (SMART) in Uganda: developing diagnostic tools for emerging diseases

NARO is undertaking work to strengthen fish health management practices in Uganda using evidence-based information and technologies. Previous studies have identified Aeromonas pathogens as the common pathogens affecting farmed tilapia and catfish.

Furthermore, in vitro trials on selected Plant extract-N showed positive results in controlling common fish pathogens. Studies under the SMART project is a follow-up using in vivo experiments to develop bio-control agents for

emerging aquatic pathogens.

The plant extract was infused into fish feed at concentrations of 0, 0.1, 0.5 and 1% to determine the best concentration in stimulating the

growth, immunity, and prophylaxis against pathogenic *Aeromonas hydrophila* in Nile tilapia.

Furthermore, Mugimba et al. 2018 reported the first detection of TiLV using PCR in farmed

and wild Nile tilapia from Lake Victoria in Uganda in which SMART has collaborated with FAO to screen *Oreochromis niloticus* in the Lake Victoria Crescent to ascertain its absence/presence and pathological effects of fish. The SMART project seeks for quick, low-cost but effective innovations to foster and protect the economic food basket for Uganda through sustainable tilapia production. The capacity of fisheries authorities will be enhanced in preparedness to emergencies or emerging aquatic diseases especially the aquaculture industry and protecting biodiversity. A national surveillance and bio-control capacity to contain emerging aquatic diseases was conducted in one Agro-Ecological Zones.

Surveillance for virulent *Aeromonas hydrophilla* was conducted in 15 fish farms in Wakiso, Mukono and Buikwe districts with a total of 255 fish screened for virulent *Aeromonas hydrophilla*. Out of 255 fish samples, 67 plates produced presumptive colonies on MacConkey agar from which seven (7) virulent *Aeromonas hydrophilla* isolates were identified using conventional biochemical tests.

All the isolates were the gram negative and microscopic examination of the wet mounts showing short motile rods that measured 0.5



by 1µm. Surveillance on TiLV was done in ten districts of Mukono, Kyotera, Kalungu, Lwengo, Masaka, Gomba, Buikwe, Wakiso, Luwero, and Mpigi within the Lake Victoria Basin. Samples (255 samples) were collected from 30 farms and stored in RNAlater for further TiLV testing.

NARO has strengthened the capacity for fish health management. An assessment was conducted for four local medicinal plants as prophylactic agents for fish diseases in Uganda.

One local medicinal plant code-named plant (N) with high concentration of flavonoids

and antioxidants was identified. Plant N selected and evaluated as a growth promoter, immune-stimulant, and prophylaxis agent against pathogenic *Aeromonas Hydrophila* in Nile tilapia. Plant N packaged in powder, liquid and infused in feed for tank trials.

An architectural design of a fish health Laboratory was completed. The construction was extended to as to when funds will be available. One member of staff was trained in diagnostic of TiLV by FAO in Kisumu, Kenya. A surveillance team (multidisciplinary) for TiLV surveys has been established. Fish farmers sensitized on fish disease management.

Investigating micro-plastics in water, sediment and fish

Micro-plastics present a potential risk for fisheries production. Lake Victoria being surrounded by major towns, recreational beaches and over 800 fish landing beaches on Ugandan shoreline, it is vulnerable to micro-plastic pollution.

Proper mitigation of micro-plastic pollution in the lake requires knowledge of the nature of micro-plastics occurring in the lake, abundance, distribution and sources. The National Fisheries Resources Research Institute (Na-FIRRI) conducted a study to investigate the occurrence, abundance and distribution of micro-plastic debris along shoreline and sediment of Lake Victoria to generate knowledge to guide mitigation of pollution by plastics. Using four fish landing beaches (Masese, Kasenyi, Ggaba, Bwondha) and two recreation

beaches (Aero, Lido), the study established presence of micro-plastics in the shoreline and lake sediments.

Types of micro-plastics in shoreline and Lake sediment

The microplastics found in the shoreline and lake sediments comprise plastic films, filaments, fragments, foam and pellet. The sources of these plastics of concern include plastic basins, dolls, and polythene bags.

Abundance of the micro-plastics in shoreline and lake sediment

Abundance of micro-plastics was highest in shoreline sediment that ranged from 0.9 to 239.8 particles/kg dry sediment and lowest in lake sediment (0 to 14.5 particles/kg dry). The finding indicate that fish landing beaches had higher micro-plastic abundance than recreational beaches. At Masese, Gaba, Kasenyi and Lido beach areas, the abundance of micro-plastics decreased with increasing distance from



Aging plastic bottles at Masese fish landing beach and plastic debris in water at Kasenyi fish landing beach



Photos of micro-plastics (top) recovered from shore and lake sediment and their likely sources (bottom).

the shoreline into water. Films are the most abundant form of plastic particles in shoreline sediment while filaments are the most abundant in lake sediment. Polyethylene is the

most dominant polymer in the plastic materials (Table 4).

The polymers come from plastic materials

used in the community and therefore, the most polluting materials are container cups, water bottle caps, toys, household utensils, consumer bags, fishing nets and lines.

Table 4: Major plastic polymers identified from Lake Victoria

Major polymers in samples	%	Sources
Polyethylene (PE)	54.2	Container cups, water bottle caps, toys, household utensils, consumer bags, fishing nets and lines.
Polypropylene (PP)	23.3	Floor coverings, carpets, rugs, pipes, sportswear, fishing nets, and milk containers.
Polyvinyl chloride (PVC)	11.7	Packaging containers, pipes, electric cable insulators and clothing fabric.
Polyethylene Terephthalate (PET)	4.2	Drinking water and soda bottles, fruit containers
Polyamide (PA)	2.5	Clothing, thermoplastics, luggage, parachutes, backpacks.

Forestry Sub-sector

Biological control agent of eucalyptus pests released

Eucalyptus plantations in Uganda are under attack by two devastating exotic insect pests; the Red gum lerp psyllid and Bronze bug. These pests are causing enormous damage to plantations and financial loss to tree growers, estimated at UGX 1,768,650 per acre, while at the same time depriving human communities of wood and other benefits that accrue from Eucalyptus plantations.

In efforts to address this, NARO released a biological control agent *Psyllaephagus bliteus*, in western and south western Uganda to control the pest (Red gum Lerp psyllid). NARO also imported and is rearing a parasitoid *Cleruchoides nockae* for control of Bronze bug. We noted *P. bliteus* establishing well and registering high dispersal, of over 150 km from release sites within just one year. At the same time, parasitism levels ranging from 30%-65% were observed.

The population of the pest also declined from 45% to 15% as a result of the control agent. This comes as good news to tree growers, many of whom are now working with NARO scientists in using *P. bliteus* to cost-effectively manage the red gum lerp psyllid in their eucalyptus plantations.



Red gum Lerp psyllid (left) and its symptoms



P. bliteus parasitizing lerp



Bronze bug (left) and its symptoms



Parasitised Lerps. *P. bliteus* has emerged

Novel energy saving technologies developed

There are numerous cook stoves on the Ugandan market today, being presented to users under the pretext of being “energy-saving”. Many of these stoves, however, are not specifically designed to reduce production of dangerous combustion gases and therefore put households at the risk of respiratory diseases, especially in women and children.

Wary of this, NARO this year, developed a new design of a wood fuel cook stove prototype that outperforms the stoves on the market, in more ways than one:

- Reduces biomass fuel consumption by over 60% cf. conventional stoves (8%-12%) due to maximum heat insulation incorporated in the new design.
- Reduces on average expenditure on charcoal per household by over 50% (from UGX 3,500 to UGX 1,500 per day)



Cook stove prototype

- Incorporated ash tray at the bottom of the stove for safe ash disposal
- Is fast and clean in cooking with minimum smoke and heat loss to the surrounding, and less burning accidents.
- Significantly reduces the amount of carbon-monoxide (CO) liberated.

Improved fuel lighters developed

About half of wood resources invested in the tree product value chain is lost as waste during processing. Saw dust is one of the main wood wastes generated. It is often burnt or let to rot in the field, emitting dangerous gases into the atmosphere.

NARO has, since 2016 explored innovative ways of putting sawdust to productive use, one of these being sawdust-based fuel lighters. Improvements on the earlier version of lighters now has 5% increase in combustibility as a result of improved hydrocarbon-sawdust blending. The current version thus lights faster (2 to 3 minutes) and emits minimum smoke, making it environmentally friendly and safer to humans, when compared to common practices of

lighting such as using kerosene and polythene material (kaveera).

NARO also developed a fuel lighter press machine prototype with production capacity of 600 fuel lighter pieces per hour. The machine is manually operated under hydraulic system, portable (60kg in weight), operation is convenient for both men and women, easy to assemble and has estimated durability of 30 years.



Improved fuel lighters



Fuel lighter press machine



NARO staff during a photo opportunity at the 26th National Agricultural & Trade Show in Jinja. The Show under the theme; Fostering agricultural value chains innovation for farmer led food security, household income and job creation, ran from 13th to 22nd July 2018.

CHAPTER 03

Research Extension Interface

To create a closer alliance between agricultural research and extension, and enhance partnerships with other stakeholders, NARO continually promotes and strengthens research-extension linkages by coordinating and undertaking programmes in technology promotion, multiplication, dissemination, incubation and commercialization to ensure that improved technologies are availed to different uptake pathways for increased adoption and socio-economic transformation of communities. This chapter presents some of the key activities and events in the FY2018/2019.

Tripartite conference held on innovative Agrifood systems

The second National Agricultural Research Organisation and Makerere University (NARO-Mak) Joint Scientific Conference and 1st Feed the Future Innovation Lab for Nutrition Annual Scientific Symposium, 12 to 15th November 2018, held at Speke Resort and Conference Centre Munyonyo, Kampala, Uganda.

NARO and Makerere University are in a collaborative arrangement to provide a platform for regularly sharing knowledge generated from research both at national, regional and global levels. The platform, the biennial NARO-Mak Joint Scientific Conference, in partnership with the first feed the future Innovation Lab for Nutrition Annual Scientific Symposium (hereafter ‘the Conference’) was conducted on 12 to 15th November 2018 at Speke Resort and Conference Centre Munyonyo, Kampala, Uganda.

The overall objective of the conference was to provide a platform for all key stakeholders in agriculture to dialogue on important issues to guide Uganda’s agricultural sector into the future, taking into consideration important

challenges of climate change and malnutrition. The conference theme was, “Research for Innovative AgriFood Systems and Nutrition”.

The knowledge sharing was organized under five sub-themes namely; 1) Advances in Agri-preneurship and value chains; 2) Innovations in post-harvest, nutrition and food safety management; 3) Climate-smart agriculture, resilience and the environment; 4) Enhancing plant and livestock production systems and 5) Mainstreaming Gender in agricultural research and development agenda.

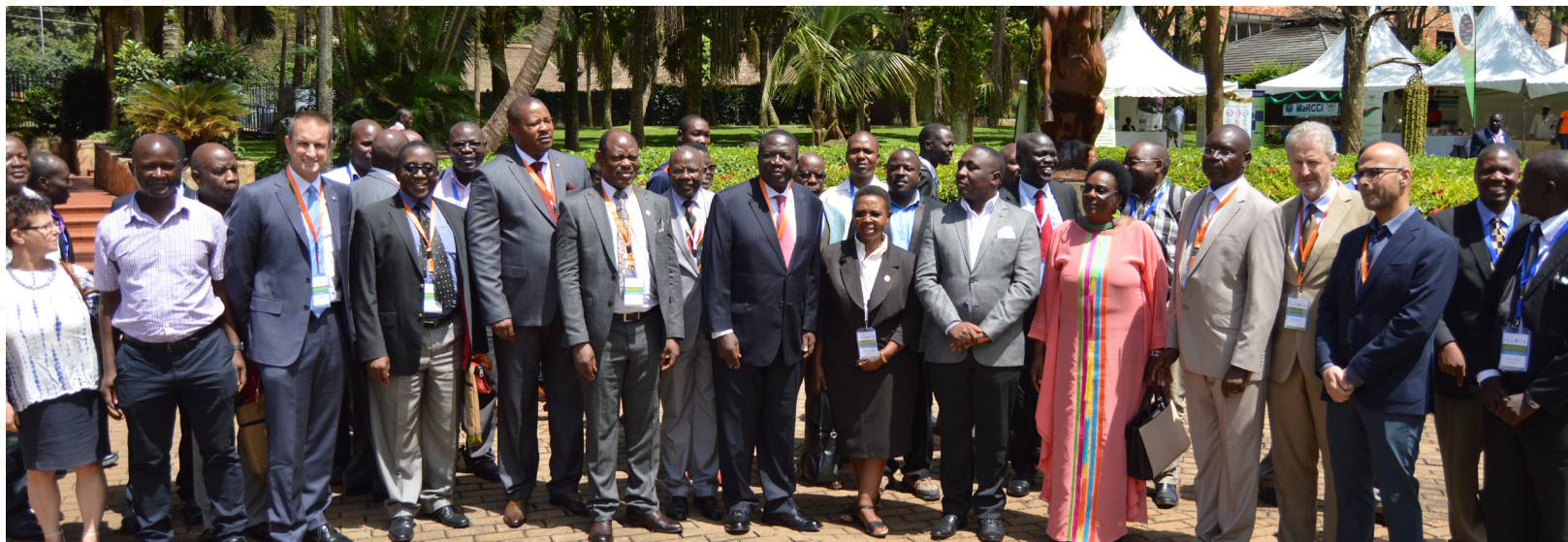
The conference discussed how agricultural scientists can work with policy makers and other stakeholders to improve the livelihoods

of farmers through the identification of good practices from both the traditional and modern concepts of agriculture and develop a model suitable for Sub-Saharan Africa.

The highlights of presentations and discussions of both keynote and technical papers made at this conference were summarized in the conference communiqué, indicating areas that require collective actions by stakeholders in the agricultural sector;

1. Advances in Agri-preneurship and Value Chains

Presentations under this thematic area spanned 11 key enterprises including indigenous vegetables, beans and bean-based prod-



Officials from NARO, Makerere University and Feed the Future Nutrition Innovations Lab during the joint conference.

ucts, fish, cassava, cattle, maize, groundnut, chicken, banana, tomato and calliandra. The following cross-cutting issues were examined: profitability of indigenous vegetables, assessment of market structure and performance on common bean products, valuation of fish disease incidence in aquaculture production, consumer preferences and market potential for farmed fish; the potential of cage fish farming, market access and food security.

Others included evaluation of food value

chains, disease evaluation in livestock, cassava-based bio-ethanol production, the profitability of indigenous chicken, processing of banana-based soups and various methods of contract marketing and product enrichment. The overarching observation was that there are notable advances in agribusiness value chain research that should be immediately piloted and scaled up but aspects of agri-preneurship are not adequately researched. The latter needs to be addressed to promote agro-based employment opportunities in Uganda.

The conference identified and flagged key issues that require policy and research attention. Regarding advances in agri-preneurship and value chains, there is need to:

1. Develop and enact mind-frame change programs for the transformation of the youth to actively engage in agri-entrepreneurship.
2. Develop and implement policy and strategies for enabling the transiting of agricultural research results into industrial

products via incubation and industrial parks

3. Institute policy measures to encourage the agro-based private sector to support the government in funding agricultural research especially for the development of processes and products for industrial application, uptake and multiplication.

2. Innovations in Post-Harvest, Nutrition and Food Safety Management

Presentations under this thematic area spanned six key enterprises including cocoa, African eleme (*Canarium schweinfurthii*), milk, cowpea, sweet potato and potato. Research issues investigated focused on post-harvest handling, aflatoxin exposure and infant birth outcomes, integrated agricultural and health interventions, cattle ownership, water and sanitation, nutrition outcomes, the nutritional food value of selected crops, health and hygiene across the milk value chain, economic benefits of small-holder dairy production, evaluation of cooking quality and preferences of selected foods, storage root dry matter, starch and sugar content, evaluation of improved harvesting technologies and creative capacity building approaches for improved welfare and incomes. We noted adequate research focus on the impact of nutrition-sensitive agriculture and post-harvest management practices on selected nutritional outcomes.

However, there was an inadequate focus on enterprise-specific interventions to address nutrition and food safety.

The conference identified and flagged key issues that require policy and research attention. Regarding Innovations in Post-Harvest, Nutrition and Food Safety Management, there is a need to:

1. Develop policies and strategies for enhancing the consumption of quality and safe food and feed, with emphasis on formulation and/or implementation of appropriate standards and regulations.
2. Develop and implement supportive policy frameworks for comprehensive nutrition education of both the urban and rural consumers of agriculture-based and other foods and food products.
3. Prioritize investments that improve the quality of people through nutrition and healthy diets.
4. Strengthen implementation of strategies for reducing post-harvest losses and waste along the entire food value chain beyond losses at harvest and storage levels.

3. Climate Smart Agriculture, Resilience and Environment

Research papers in this theme examined enterprises like sorghum, groundnut and rice.

Issues examined included cropping and conservation methods to mitigate the impacts of climate change and global warming, wetland and forest degradation, drought and cold stress tolerance.

The identified key issues that require policy and research attention for climate-smart agriculture, resilience and environment included:

1. Provide and/or improve incentives for encouraging private forest owners to conserve their trees.
2. Strengthen enforcement of the 200m buffer zone of water bodies in order to control external nutrient loading in the water systems.

4. Enhancing Plant and Livestock Production Systems Plant Breeding

Research papers under this sub-theme examined a number of enterprises including cowpea, maize, barley, rice, soybean, groundnut, coffee, cassava, sesame, beans, bananas, sorghum and sweet potato. They focused on various areas including evaluation and selection breeding for adaptability, drought tolerance under multiple environments and agro-ecologies; glyphosate tolerance, pest/ disease resistance, evaluation of crops for grain yield and agronomic traits, striga resistance, grain quality, yield stability, varietal characterization; per-

ceptions towards biotechnology and bio-safety. Advances in breeding tools/ methods presented included low-density markers, line profiling and heat treatment, among others.

Agronomy and Soil science

Enterprises examined under this sub-theme included cassava, fodder, giant bamboo, maize, beans, coffee, sorghum and cowpea. Research issues included evaluation of new treatment technology for accelerating germination and productivity, management practices to enhance fodder yield and carbon sequestration, optimal treatment for crop propagation, hybrid evaluation across striga infested environments, treatments for improved soil fertility, mulches from soil/ water management, evaluation of organic and mineral fertilizers, yield response in improved crop lines, disease prevalence and farmer knowledge to control them, agroforestry systems and crop yield evaluation of multipurpose trees, yield stability of advanced crop lines in diverse environments. Crop residue management, evaluation of striga suppressive capacity of cowpea, evaluation of agroforestry systems for productivity and profitability were also examined.

Fisheries

Research papers presented under this sub-theme focused on aquaculture and capture fisheries. Issues investigated included tank culture and cage aquaculture, effluent water



re-use, development of vaccines to prevent disease in fish, evaluation of potential fish feeds, evaluation of plant extracts as prophylactic agents for fish diseases and alternative livelihood sources as a tool for managing fisheries resources.

More focus was on production aspects but less focus on basic research and post-harvest management aspects of fisheries research.

Entomology and Pathology

Research under this sub-theme examined various enterprises including beans, sheep, goats and cattle, coffee, rice, maize, cassava, sesame, and sweet potato. The entomological and pathological issues investigated included sources of resistance to bean anthracnose, disease severity prevalence among ruminants, disease/pest prevalence and severity, the introduction of resistant varieties, comparison of foot and mouth disease viruses across borders, integrated fruit fly management, the impact of plant diseases/pests on yield, identification of disease-causing pathogens in crops, crop disease and pest resistance detection methods, field sources of pest mortality, crop morphological traits; temperature, rainfall and relative humidity on pest population dynamics, and varietal evaluation for pest/disease resistance.

Land use and management

Papers under this sub-theme focused on the following: Macronutrient evaluation for yield and economic returns, land degradation in areas adjacent to water bodies, diatomaceous earth (DE) and agricultural land use, tenure security and land improvement, adoption patterns and adoption intensity. There was inadequate research attention to aspects of soil science and soil fertility management. The important aspects of water for production and irrigation technology were also not addressed.

Livestock

Research papers in this sub-theme focused on goats, small ruminants, cattle, chicken, honey bee and piggery. Issues examined included characterization of goat management systems, disease and pest control methods in small ruminants, feed supplements in ruminant feeding, evaluation of feed and feeding regimes, growth assessment of crossbreeds/new lines, assessment of breeding efficiency, the impact of improved breeds on household welfare and child nutrition. There was an inadequate focus on modern tools like use of molecular techniques in livestock research. There was also little focus on post-harvest management and value addition to livestock products.

The identified key issues that require policy and research attention concerning enhancing plant and livestock production systems were the is need to:

1. Reconstruct our (national) extension system so that it is organic, holistic, equitable and transformative.
2. Strengthen existing institutions to effectively protect the agricultural sector against counterfeits including inputs, especially seed.

5. Mainstreaming Gender in Agricultural Research and Development

There were a few papers that examined gender issues. Enterprises focused on were beans and cassava.

Issues rotated around gender and household decision making. Important gender aspects such as in breeding, crop and livestock management, value chains, value addition, marketing and nutrition were missing.

The identified key issues that require policy and research attention concerning mainstreaming gender in agricultural research and development. These included the need for leadership in every relevant sector to keep an eye on the evolution of gender and extension concepts and provide for adjustments as society needs change.

6. Cross-cutting issues recommendations included

The conference identified and flagged key issues that require policy and research attention regarding cross-cutting research and development issues: The following were the recommendations:

1. The need for a model of agriculture that is sensitive to and suitable to the Africa situ-

ations. It should take cognizance of differences in economics, food security, ecology and social issues, in addition to ability to combine both traditional and modern concepts of agriculture; since no one size fit all. For example, large-scale farming may not be appropriate for everybody.

2. A call for the integration of information and communication Technology (ICT), such as the use of drones, in agricultural value chains for detection and management of pests and diseases, and assessment and manipulation of soil characteristics, for appropriate crop management.
3. Need for embracing the spirit of multi-sectoral planning and implementation of government development programs along the agricultural value chain
4. Provision of adequate and reliable funding to research, to enable timely delivery of technological solutions for the continuously growing and dynamic society needs, including science communication and user education, required for the effective conveyance of results to intended beneficiaries.
5. Need for a paradigm shift in methods of delivering information to farmers and related value chain actors; use of ICT to be strengthened.

NARO technologies at agricultural shows

NARO participated in a number of agricultural shows to showcase technologies, notably the national celebrations to commemorate World Food Day celebrations and the National Agricultural show in Jinja.

The two events gave opportunity to exhibit NARO technologies to thousands of show goers.

Celebrations to commemorate the World Food Day were held on 16 October 2018 at Nabuin Zonal Agricultural Research and Development Institute (Nabuin ZARDI) in Nabilatuk District, Karamoja sub-region, North-eastern Uganda under the theme: *Our actions are our future. A zero hunger world by 2030 is possible.*

Meanwhile the Jinja Agricultural Show, the biggest agricultural show in the country, also known as the Source of the Nile Show, the 26th in the series, was held on 13th to 22nd July 2018 under the theme; *Fostering agricultural value chains innovations for farmer-led food security, household income and job creation.*

Details on other agricultural shows such as farmer field days and training of stakeholders can be found in respective institute technical reports.



The Minister of Agriculture Animal Industry and Fisheries, Hon. Vincent Bamulangaki Ssempijja interacting with NARO staff during national celebrations to mark World Food Day on 16th October 2018, at Nabuin ZARDI

NARO Research products and potential to trigger agro-industrialization, a perspective of Operation Wealth Creation

If the research-industry linkages and partnerships through private sector, the cornerstone of Operation Wealth Creation's (OWC) new strategy towards Local Economic Development are to be successfully implemented, NARO needs to position herself as a lead partner in this initiative.

Over the years NARO has developed a number of technologies that have potential to trigger agro-industrialization in all areas of the sector including crop resources, livestock, fisheries, forestry and appropriate labor saving and agro-machinery.

Under the crop subsector for example, cassava-based products have been developed including; the Ngule brand of beer which is already being bottled by Uganda Breweries, industrial ethanol and high quality cassava flour suitable for confectionary industry.

Other cassava products under incubation are starch for pharmaceuticals and textile industries, biodegradable packaging paper and bio-diesel.

Other Prototypes of value addition have also been developed in sweet potato whose flour



The OWC Liason Officer to NARO, Major Peter Murara Rwego admiring briquetting machine developed by NARO. The machine can make 49 bricks per minute from saw dust.

can substitute wheat in confectionery industry; maize and rice for food and animal feed and as well as beer making.

As for beans, a pre-cooked bean snack has been developed, and NABE 12C variety has been identified to be having canning qualities. Body lotions for cosmetic industry have also been developed from coffee and cocoa; as well as coffee powder of premium quality standard.

In the livestock research sector, three candidate anti-tick vaccines have been identified and are undergoing clinical trials. If successful these vaccines will alleviate economic losses of over UGX 3.8 trillion incurred by livestock sector annually due to tick borne related diseases, mortalities and reduction in cattle production. Others include aflatoxin binder prototypes, a rapid diagnostic kit for African swine fever, dewormers, various feed formulations and

concentrates for different types of livestock and fish. In the fisheries sector, value addition on fish products to make sausages, powder, dried, salted and packaged particularly for the Angara fish delicacy have been accomplished.

In the forest subsector products of interest have been developed, some of which are undergoing patenting procedure. These are Biomass cooking stove, briquetting machine, fuel lighters, Caris body lotion produced from some shrubs occurring in forests and dry areas. This lotion cures bacterial infection of the skin.

Lastly, a number of appropriate labor saving and value addition machinery have been de-



veloped and require massive production for their visibility and affordability. These include rice hullers, maize threshers, cassava chippers, forage choppers, treadle water pumps, among others.

A synergy should be built between NARO and OWC to have potential technologies that can trigger agro-industrialization exposed to would be industrialists for the benefit of local economic development agenda.

Multi-stakeholder Innovation Platforms supported

Use of a Multi-stakeholder Innovation Platforms (MSIPs) is relevant for learning and enhancing technology uptake by end-users. NARO institutes have continued to support existing MSIPs and also supporting development of new ones under different agricultural commodities. During this reporting period, monitoring of MSIPs was conducted to track performance of already existing ones in order to provide further technical support and improve their functionality.

A total of 22 MSIPs were supported and their capacities strengthened through a number of activities including coordinating actor meetings, providing quality seed of different commodities, trainings in agro-economic practices, facilitating market linkag-

es and synergies between actor's partners as well as capturing feedback on technologies among others.

Plans are underway to profile all the individual MSIPs and continue to provide them

with support based on specific functionality gaps. Annex 1 provides more information on a total of 49 MSIPs that have remained active over the years and the support provided to them by NARO.

Case 01

The Rakai innovation platform

Lwankoni bean production and market innovation platform also known as “Rakai Innovation Platform” was established in 2014, the platform started experiencing a decline in its contribution to the community (smallholder farmers) in 2016 which led to the loss of member groups and a decline in quantities produced and sold, this trend continued through to 2017. In May 2017 NARO and the Community Enterprise Development Organization (CEDO) set out to strengthen this platform.

Contribution of NARO

NARO has strengthened the platform through numerous ways which include offering management trainings to the newly elected platform leaders, reviewing, re-enacting and translating the platform constitution into local language, encouraging smallholder farmer groups to join and those that had left to rejoin the platform and offering production, post-harvest and business (record keeping) trainings to the platform members.

In all the trainings offered to the platform, a total of 55 farmer representatives (25 women and 30 men) were trained, these have the mandate to offer the same or similar trainings to the farmers in the groups from which they come. The effect of trainings is measured by platform

leaders during group visits and quality of produce delivered for sell.

Platform leadership now has a committee of 10 individuals 4 women and 6 men (a youth and disabled persons’ representative) from different farmer groups. These are supported by a team of co-opted members from input dealers, local administrators, NGOs and research organizations.

The platform currently has a total of 22 farmer groups dealing in different bean varieties each with an average of 20 farmers. The groups are represented on the platform by 2 or 3 elected representatives from whom the platform leaders are elected.

Immediate outcomes

During 2018A season the platforms’ production increased in terms of quantity sold and quality of the produce. The platform sold 4,045 kg of beans to CEDO. According to CEDO officials, the quality of grain bought from the Rakai platform was very good. “Despite having grown different bean varieties, the quality of the beans provided by platform farmer groups was similar and extremely good compared to groups in other areas” said Mr. Katabarwa. It was reported by the platform chairperson, Mr. Nkongwe that the produce was however exceeding 6 tons, some of the farmer groups sold to other local bean grain buyers and more was kept for seed.

Apart from producing bean grain, some of the groups on the platform opted to produce seed for the season 2018B.

The acreage for bean production has increased from approximately 3.6 Ha in 2017A to 7.2 Ha in 2018A according to the platform secretary. Not all farmer groups registered their acreage under bean production however, it is estimated that the average acreage under bean production for all platform farmer groups is 14 Ha.

Partners, collaborators and their contribution

Apart from farmers, there are a number of other partners on the platform these include financial institution, local administrators (chiefs), NGOs, extension workers, research organizations and local leaders.

The partners offer support in terms of financial advice, market access for produce, coordinate trainings, solicit better equipment and farm inputs, product quality inspection and act as referees in case of funding.

The platform currently has 2 major collaborators. Makerere University department of agricultural extension and the Uganda government through the public administrator in the area (District Chairperson). These have collaborated with the plat-



form from its inception in 2014 and even in their non-attendance; partners on the platform still consider them key collaborators. They offer extension services such as soil testing, arbitrating of platform activities to the public and educating potential platform partners and also carry out trainings.

Evolving stories around the platform

The platform is currently seeking to change their medium of communication from quarterly meetings and phone calls alone to involve social media exchanges with the advancements in technology. These will ease data collection for production quantities, monitoring and improve communication on the platform.

The increase in platform membership has since seen an increase in volumes produced and sold, the number of farmer groups joining this platform in Kyotera district has increased and this will lead to better production and good quality grain and seed in the area. The platform is now used as a model in establishing and training other innovation platforms. A study carried out by Makerere University in 2018 (results not yet published) showed that Rakai innovation platform performs better than their counter parts of Masaka innovation platform in a number of aspects including meetings, production, training farmers and meeting all the intended objectives of the platform. This shows a great improvement from the previous years.

Case 02

Development of Cottage Industry for Enhancement of Ghee Production; the case of Kiruhura Women groups

In Uganda, 70% of the milk produced by both smallholder and commercial farmers was sold and the remaining 30% kept for home consumption (drinking, turn into yoghurt and ghee) and for calf rearing (Agriterra 2012). Of the 70% milk sold, 80-90% was sold informally in unprocessed form. As such, only 160 million litres (8.4%) of the 1.9 billion litres of milk annually produced was purchased by processors.

Since ghee and other products were being processed in traditional settings in Uganda, the products remained poor and small in quality and quantity that could not access lucrative markets.

For example, in 2018 a farmer at a milk collection center was paid UGX 500 or UGX 1000/litre of Ankole cow milk during the rainy or dry season, respectively. Thus, a farmer earned UGX 50,000 or UGX 100,000, respectively, from 100 litres of milk produced and taken for marketing. But, 100 litres of Ankole cow milk purchased by a woman and processed for ghee, produces about 20 kg of ghee.

At UGX 20,000 per kg, the same quantity

of milk would fetch UGX 400,000, 40 litres of fat free yoghurt (*Amacuunda*) worth UGX 80,000 (UGX 2,000 x 40 litres) and jelly (*Obutahe*). Uganda shillings 480,000 could only be obtained from 960 litres (48 Friesian cows) or 480 litres (24 Friesian cows) per day in the wet and dry season, respectively.

Comparatively, this quantity (100 litres) of milk could per day be obtained from 50 Ankole cows that generally consume less quantity of pasture/forage per animal and are maintained at a lower cost.

Yet, ghee produced in the Ankole sub region was of poor quality and produced in small quantities, not suitable for lucrative markets even though the quantity of milk

available in the households, if well-handled and appropriately processed, was adequate to spur production of ghee of better quality and can sustain good markets.

It is for this reason that Mbarara ZARDI in collaboration with Kiruhura Women in Development (K-WIDE); a women-led organisation based in Kiruhura district and Makerere University College of Veterinary Medicine, Animal Resources and Bio-security (COVAB) formed a consortium called Kiruhura Women Entrepreneurs in Ghee Processing (KWEG) aimed at improving the competitiveness, profitability and safety of traditionally processed ghee in the project area.

The National Agricultural Research Organisation (NARO) through the competitive Grants scheme funded the project and KWEK has since developed a cottage industry for enhancement of ghee production located in Nyakashashara Trading Centre, Kiruhura Town Council, Kiruhura district, specializing in the production of ghee from the local Ankole cow milk.

Before the KWEK project

Before the project ghee production faced the following outstanding challenges;

1. The women were using traditional methods (used water and milk of different quality and used different methods of water treatment) and hence the product lacked uniformity.
2. Rudimentary equipment (calabashes) and poor skills were used in the processing and packaging of the ghee produced by the organization.
3. Use of small containers limited the quantity of ghee produced by the organization.
4. Packaging was in traditional contain-

ers which were neither safe nor carry marketing information. This made it impossible to define the quality of the product or to standardize the product.

5. The starter culture technologies (fermenting of the bacteria) used in culturing of the milk were largely unknown.
6. Lack of appropriate cleaning equipment, the ghee produced was vulnerable to frequent microbial contamination that could raise public health concerns.
7. Whereas the women were greatly interested in expanding their production capacity, they had limited capital and inadequate access to market information.
8. Due to lack of appropriate preservation equipment, the shelf life of their ghee was low.

Project implementation

During project implementation, more women were mobilized into groups. Modern ghee processing equipment, procured and installed for improving processing, testing

of water, milk and ghee. The women were trained in improved ghee processing, testing of raw materials, milk and ghee preservation, packaging, savings, financial management, pricing, market identification and marketing dynamics.

Members capacity was built in leadership, group dynamics, product label design and product advertisement. Radio talk shows about ghee production/value addition were held at the regional level. KWEK established 5 kiosks as sale points. Additionally, starter culture that is essential for improving ghee yields from fermented milk was developed for use in the area. Since, the profitability of traditionally produced ghee was influenced by the gourds used for packaging, gourd performance in south western Uganda was evaluated and information availed.

Unlike before, gourds can now easily be locally grown by K-WIDE and other ghee processing women groups. The regularly conducted board and management meetings have been able to build the capacity of K-WIDE in undertaking ghee processing as a profitable economic activity with sustainability, and increased employment opportunity for young girl.



Visit to the project site by Director General NAROSEC and the NARO governing council



Women leaders receive certificates of attendance after a two weeks training in ghee production and handling by DDA



KWEG Board members pose for a photo after a workshop at NaLIRRI

Successes registered

Attitude and perceptions of the women has changed from traditional to modern methods of ghee processing, preservation and packaging. Quality of ghee produced has improved. More women are now involved in ghee production than before. While only 100 women used to process ghee, the number has increased to over 500 across the district. More products are produced from milk, which include family jelly, low fat yoghurt, white sauce, eye/ear drop and cooking oil. Monthly ghee production has increased from 200-500 to 500-800 kg, all done

with improved quality, packaging, labeling and storage. This has increased market coverage and sales. Based on the sales, about UGX 100,000,000 has been saved and this has enabled the group to purchase 3 plots of land each measuring 50 feet x 100 feet.

The land hosts the major part of the cottage industry. So far, the average household income of members has improved by at least 5% and if the product economic viability is maintained, conservation of Ankole long-horn cattle will be fully achieved.

The project has successfully improved the quality/quantity of ghee made by women groups in Kiruhura district. The ghee currently produced by K-WIDE and other women groups can meet 78% of the target characteristics. The commercial viability of ghee making by the women groups has been increased. The employment of young people and women in ghee making has increased by 20% and the capacity of K-WIDE in improved ghee processing, institutional management, financial management and marketing has increased by over 65% and it is able to create sustainability.



Chairpersons of women groups pose for a photo with KWEK board members after a review meeting Rushere



KWEK members on a study tour in Rukungiri for purposes of bechmanrking



Demonstrations on milk handling, ghee storage and packing at Nyakasharara

Table 5. KWEK Project results chain

Objectives	Key activity	Results	Outcome
Objective 1: To improve the quality and quantity of ghee by at least 20%	Train members in improved ghee processing, testing of raw materials (water and milk) and ghee preservation	Ghee quantity increased by 435%	Group monthly income increased by UGX 4 million
	Equip KWEK with improved machinery used in processing and testing of water, milk and ghee.	Ghee microbial contamination has reduced by more than 90% and is keeping forever, with losses reduced by 95%	Regular and consistent supplies achieved
Objective 2: To increase the commercial viability of ghee in Kiruhura district by at least 30%	Sensitize key stakeholders about ghee production and its importance	150 participants in 10 groups trained in group leadership and dynamics, record keeping, financial management, ghee processing, and ghee preservation	Groups have leadership, have bank accounts, keep financial and other records, contamination has reduced, ghee quantity increased, and ghee uniformity improved

Objectives	Key activity	Results	Outcome
	Conduct radio talk shows about ghee production/value addition	12 radio talkshows have been held on radio 5 Spot messages were ran for one year on radio 5 concerning making ghee for business	The community has been sensitized about ghee production ad its importance, KWEG activities have been popularized widely amongst the populace
	Develop and distribute IEC materials	We have a logo, stickers, headed paper, T-shirts, brochures and banners	The IEC materials have helped in advertising KWEG and its products both locally and nationally.
	Training women in boiling, packaging and preserving milk	200 participants trained in ghee boiling, packaging and preservation 100 farmers trained on milk handling and hygiene 15 staff members including board members trained in packaging and preservation 06 women groups trained in product packaging and labeling	Groups are now aware of the need to boil, preserve and pack the product, farmers are aware of milk handling process as well as hygienic practices, women groups have packed products with labels
Objective 3: To create employment for young girls and women by gainfully engaging them in ghee processing and marketing.	Establishing kiosks as sale points	06 selling points established in Kampala, Mbarara, Ibanda and Lyatonde 06 youth /kiosk attendants hired, and trained 02 youth hired as drivers for the delivery van 02 youths hired as turn boys	There is job creation for the youth who have been employed as kiosk attendants, drivers and turn boys. Sustainability is assured with involvement of youth in training and day to day work

Objectives	Key activity	Results	Outcome
Objective 4: To build the capacity of women in institutional management and agri-business	Procure and install equipment	Machines procured	The capacity of KWEK in terms of production and marketing has been enhanced
	Train members in product pricing, market identification and marketing dynamics	150 participants in 10 groups trained in product pricing, market identification and marketing dynamics, 8 kiosk attendants trained in marketing skills	Improved market coverage, improved skills in market identification, customer care and satisfaction.
	Train members in product label design, product advertisement methods	200 participants trained in product labeling, and advertisement including board members and kiosk attendants	Improved product labeling, design and advertisements. KWEK has attended a number of trade shows to increase market coverage
Objective 5: To improve research in ghee processing	Develop local starter cultures	Starter culture locally developed using bacterial from the Ankole cattle	Milk fermenting bacteria are now easy to get and have improved ghee yield from fermented milk
	Demonstrate gourd performance in the zone.	Knowledge on growing of gourds and their performance in the zone is known	Cheaper source of gourds now available
Objective 4: To strengthen collaboration and coordination in ghee processing	Conducting board and management meetings	A KWEK board has held 12 meetings	Collaboration of the consortium membership strengthened, capacity of K-WIDE built and joint decision-making being enjoyed

Workshops and trainings attended/organized

Institution	Topics/Purpose	Location	Participation
NARO-SEC	- Review workshop - Financial and progress review.	NARLI at Kawanda.	All PI's to present on progress of their respective projects.
COVAB-MAK	Transforming traditional ghee processing into an economically viable business in Uganda (TPEB)	Kiruhura –Rushere mother's Union Hall.	All women groups in the district engaged in ghee processing as well as production.
	Development of SOPS	Kiruhura district headquarters.	Women groups and farmers involved in milk production.
	- Training workshop on Group dynamics, - Ghee packaging and labeling	Kazo, mbaba, kyabagyenyi as well as Nyakasharara.	Women groups and their spouses.
Mbarara -ZARDI	- Milk handling. - Development of starter-cultures. - Testing and growing of performance guards. - Milk testing and handling	Mbarara -ZARDI	KWEG Staff and Board members Farmers
Bishop Stuart University	Enhancing the production and utilization of aromatic crops through establishment of commercial medicinal gardens	BSU-Mbarara	KWEG Staff and Board members, Farmers, Women group Chairpersons



Under the infrastructure development component ATAAS several units were erected and old ones refurbished across PARIs. An administrative block with a conference room at Ngetta ZARDI is an example.

CHAPTER 03

Agricultural Technology and Agribusiness Advisory Services (ATAAS) Project

The Agricultural Technology and Agribusiness Advisory Services (ATAAS): Exit of NARO's splendid project

The Agricultural Technology and Agribusiness Advisory Services (ATAAS) was a development project implemented in the agricultural sector, supervised by the Ministry of Agriculture, Animal Industry and Fisheries executed through NARO and NAADS in conjunction with the district local governments.

It was funded by Government of Uganda and the World Bank. ATAAS was approved by the World Bank Board on June 22, 2010 and became effective on December 20, 2011 after approvals by Cabinet and Parliament of Uganda and was implemented till 2018.

The ATAAS was indeed a game-changer, bolstering most of NARO's activities resulting into significant outputs and impacts in the agricultural sector. Most of these achievements have been reported in the previous Annual Re-

ports including construction and refurbishing of several office buildings, laboratories, farm and field infrastructure; acquisition of laboratory equipment and transport facilities. Above all ATAAS was the main engine in funding core research activities.

Achievements of ATAAS

Achievement of Objectives (Efficacy) Excerpt of the Independent Evaluation Group (IEG) Implementation Completion Report (ICR) Review UG-ATAAS (P109224). Report Number:

ICRR0021593. From the overarching Project Development Objective (PDO) statement three objectives are derived which are:

- i. to increase agricultural productivity of participating households;
- ii. to increase incomes of participating households;
- iii. the GEO objective 'to enhance the environmental sustainability and resilience of agricultural production to land degradation and climate risks'.

Objective 1:

To increase agricultural productivity and incomes of participating households

ATAAS project's outputs and outcomes serve to achieve all three objectives. The following were achieved for the first objective

Outputs:

- 91 innovative research projects were supported under the Competitive Grant Scheme; the recipients were 16

agricultural research institutes, 4 universities and 18 private sector enterprises.

- 81 new technologies were developed for five tracked market-oriented commodities (varieties of maize, rice, beans, cassava plant, and dairy).

- 216 on-station adaptive trials, 11,771 on-farm demonstrations, and 186 SLM community-level interventions were conducted nationwide by the Zonal Agricultural Research Development Institute (ZARDIs) District Adaptive Research Support Teams (DARSTs), and district-level extension officers, covering 12

locally prioritized commodities (including bananas, coffee, and fish). Through these activities, 327,059 new direct beneficiaries were reached.

- Foundation seeds and multiplication training to 14 private seed companies, several entrepreneurs, and three community producers were provided.
- 78 Multi-Stakeholder Innovation Platforms (MSIPs) covering all nine Agro-Ecological Zones were given training and financial support to operationalize, and engage in diverse commercial activities such as rice seed multiplication, maize flour processing, banana wine production, honey production, ghee making, fish farming, and other productive undertakings.
- The project overall covered 1.68 million households (25 percent of all rural households) through different means (slightly less than the target of 1.7 million).

Intermediate Outcomes

- Agricultural technologies generated by the National Agricultural Research Organization (NARO) system grew from

600 to 888 between appraisal and closing, a 48 percent increase, exceeding the target of 20 percent.

- In terms of access to extension services and adoption of technologies, the ICR reported that (para 34), during the earlier implementation design of the project (between 2011–2013), the share of beneficiaries with direct access to extension services grew from 47.8 percent to 59.0 percent; the share of beneficiaries trained by NAADS grew from 46.8 percent to 67.5 percent; and the adoption of technologies disseminated by NAADS grew from 36.1 percent to 49.2 percent.
- According to the ICR, (para. 35), after the reforms, extension outreach coordinated through NARO, Ministry of Agriculture Animal Industry and Fisheries (MAAIF), and the Local Governments (LGs) led to greater availability and adoption of technologies. The adoption rate at the end of project by project beneficiaries was 78 percent, (specifically 95.3 percent by crop enterprises, 63.3 percent by livestock enterprises, and 31.7 percent by SLM farmers, respectively). However, the ICR

did not provide evidence as to how sadoption was defined, covered which technologies, and how it was measured under the project.

- The project covered 20,930 ha of land with SLM practices, significantly exceeding the target of 11,000 ha. Highlands terracing and rehabilitation of degraded watersheds was adopted by a large share of communities, with their final coverage of 3,391 ha and 3,337 ha (771 percent and 556 percent of respective targets). The technologies selected for promotion and scaling-up were terraces, contour bunds, grass bunds, conservation agriculture (low-till), rehabilitation/ reclamation of degraded watersheds, agroforestry woodlots, agronomic/ vegetative SLM practices (mulching, intercropping, rotations, integrated nutrient management, grassland improvement, and so on), small-scale irrigation, and water harvesting. The ICR also noted that (para. 44) SLM interventions benefited not only the tracked commodities, but others such as coffee and banana plantations for which project interventions helped to control soil erosion that helped to improve yields and income.

Outcomes

At closing, yield growth for maize (80.5 percent), rice (180.4 percent), cassava (126.3 percent), beans (47.6 percent), and milk (120 percent) exceeded the targeted increases of 15 percent and 20 percent for crops and milk, among project beneficiaries as opposed to the baseline (2013).

However, the ICR noted that (para. 36), the baseline figures used country-level yields and did not reflect the project beneficiaries' actual yields per se. According to the Impact Evaluation results, at project closing project benefi-

ciary yields were measured for two seasons: (i) for season A, based on crop-cut method project beneficiary yields in 2017 were higher than the non-beneficiaries' (125 percent higher for maize, 154 percent higher for rice, 96 percent higher for cassava and 200 percent higher for beans); (ii) for season B, yield differences were lower but less reliable as the data was based on beneficiary recall of the figures (yield difference between beneficiaries and non-beneficiaries were 13 percent for maize, 38 percent for rice, 2.5 percent for cassava, 129 percent for beans) (ICR page 64).

Nevertheless, due to an absence of an M&E system systematically tracking beneficiary and non-beneficiary data from the beginning of the project, yield assessment was not robust.

Yet the ICR argued that even though fall army worm disease impacted particularly maize and beans in 2016-2017 season, yield increases reflected full recovery among project beneficiaries. It is worth noting that cassava yields were particularly attributable to promotion and dissemination of improved seed varieties under the project.

Objective 2:

To increase incomes of participating households

The outputs and intermediate outcomes outlined above for Objective 1 apply to the achievements of second objective.

Outcomes

Net agricultural incomes of project beneficia-

ries grew about 200 percent over the duration of the project significantly exceeding the targets (20 percent for men and 15 percent for women). At project closing, project beneficiaries had higher incomes compared to non-project beneficiaries. The impact evaluation (2018)

shows that net agricultural incomes for beneficiaries were higher than non-beneficiaries operating maize, rice, cassava, beans, and dairy enterprises with results of 57.8 percent, 39.5 percent, 27.8 percent, 400.5 percent, and 1,387.5 percent, respectively (ICR page 21).

Objective 3:

To increase incomes of participating households

The project covered 20,930 ha of land with Sustainable Land Management (SLM) practices, significantly exceeding the target of 11,000 ha. Highlands terracing and rehabilitation of degraded watersheds was adopted by a large

share of communities, with their final coverage of 3,391 ha and 3,337 ha (771 percent and 556 percent of respective targets).

The technologies selected for promotion and

scaling-up were terraces, contour bunds, grass bunds, conservation agriculture (low-till), rehabilitation /reclamation of degraded watersheds, agroforestry woodlots, agronomic/vegetative SLM practices (mulching, inter-

cropping, rotations, integrated nutrient management, grassland improvement, and so on), small-scale irrigation, and water harvesting.

Outcomes

The ICR noted that (p. 23) using the Ex Ante Carbon-Balance Tool, it was calculated that in aggregate, SLM interventions have sequestered 1,964,831 tons of carbon over the lifetime of the project (US\$151.3 million in 2018 prices).

Economic Efficiency: The ex-ante economic and financial analysis covered all project activities and assumed three main benefit streams: increase in yields as a result of technologies developed and disseminated; diversification to more profitable crops as a result of stronger market links and increased farm gate prices as a result of higher quality product; and enhanced bargaining power of farmers. The commodities included in the analysis were sorghum, maize, cassava, Irish and sweet potatoes, millet, groundnut, beans, bananas, coffee, and cotton, but did not include rice and investments in livestock production. Assumptions were: (i) yield increase between 4 percent (coffee) and 50 percent (groundnut), (ii) income increase by 20 percent by the end of the project for project beneficiaries. This resulted in an economic internal rate of return (EIRR) estimated to be 33.9

percent and a positive net present value (NPV) amounted to US\$1.3 billion.

Ex-post economic analysis readjusted certain key parameters: number of beneficiaries, yield increases, adoption rate, and project cost streams. The ex-post analysis additionally included a project carbon balance as a benefit stream (it was estimated that GHG emitted or sequestered by the project measured as CO₂ equivalent was 1.2 tons per hectare per year).

However, the ICR did not report on the monetary value of CO₂ emissions used in the analysis. In addition, rice was also included. Some other assumptions were:

- i. The adoption rate of 49.2 percent was used for SLM practices and technologies, which was the lower estimate from 2013;
- ii. A lag of 5 years for crop diversification/switching was used to account for slow implementation; (iii) 20 years duration and 2018 prices in 2010 constant terms were applied.

Farm budgets (by hectare) were prepared for farms using existing traditional technologies and beneficiary farms using improved new technologies released by NARO. The gross

revenue was calculated based on yields per hectare and farm-gate sale prices. The ICR did not present financial rates of returns coming from the farm budget analysis.

Based on these assumptions, the analysis yielded an EIRR of 37.5 percent, a NPV of US\$700 million, and a NPV per beneficiary of US\$309. The analysis showed higher returns than estimated at appraisal, mainly due to larger yield growth than anticipated and accounting for carbon benefits.

However, the ICR did not provide monetary amounts for the annual carbon benefit streams included in the analysis.

Sensitivity analysis was used to test for impacts of elite capture (reaching only a small portion of total number of beneficiaries), adverse weather shock, increase in fuel prices, and unexpected drops in agricultural prices. All things being equal, in the case of extreme elite capture that created the largest negative impact the project would still yield an EIRR of 13 percent.

On the Operational and Administrative Efficiency, the project had significant delays, closing date was extended for 3 years due to elec-



tions, and government policy and institutional changes.

Right after the project's effectiveness, the elections led to complete staff changes in NAADS, which delayed implementation.

After the GoU's introduction of a new extension policy in 2013 and the subsequent transfer of the extension mandate to the MAAIF from NAADS, the lead agency responsible for implementing more than 60 percent of the project (by cost), meant that the project underwent a major realignment midway through imple-

mentation.

At restructuring, significant modifications were made to components and activities. This major change created substantial disruptions in human resources and institutional capacity



Dr Ambrose Agona, the Director General NARO (cutting a ribbon) representing the Minister of Agriculture at the commissioning of ultra-modern Regional Bio-security Diagnostic Laboratory (RDL) at the National Livestock Resources Research Institute (NaLIRRI), Nakyesesa, May 2019. The facility was funded by the US department of Defense (DoD) initiated under the Cooperative Biological Engagement Program (CBEP) in Uganda being implemented by the Defense Threat Reduction Agency (DETRA).

CHAPTER 04

Agriculture Capacity Strengthening

During the FY 2018/2019, the Agriculture research capacity development efforts focused on four key areas, namely; human resource development, infrastructural development, financial management and Intellectual Property Management.

Human Resource Capacity Development

a. On-boarding of New Staff

During the year 2018/2019, a total of 65 new staff were recruited, out of whom 41 were Male and 24 females. Recruitment by staff category and gender is shown in Table 6.

In the Financial Year 2018/2019 effective NARO started remitting staff social security contributions to NSSF. Since its inception in 1993, staff social contributions were being remitted into NARO Provident Fund Scheme which was succeeded by NARO Retirement Benefits Scheme.

The decision to transfer contribution was made in order to comply with NSSF Act

Table 6: Recruitment of staff during FY 2018/2019

Category	Male	Female	Total
Scientist	12	7	19
Technicians	12	1	13
Support Staff	17	16	33
Total	41	24	65

Section 222, which requires that all eligible persons who are in employment of employers with five or more employees to register with NSSF.

In the same year, NARO put in place a Human Resource Management Information System Data Tool.

The tool enables staff access data thereby improving human resource data reporting at any time.

In the reporting period positions of Finance officers and Stores were re-designated to Accountants and Inventory Management Officers respectively in order to harmonize the two positions with government scheme of service for the two cadres

b. Employee turnover

During the financial year, the organization lost a total of 44 staff through resignations, retirement and termination of service. Gracefully, no death was registered. The breakdown of staff departures is summarized in Table 7.

Table 7: summary of NARO staff turnover FY 2018/2019

Cause of separation	Staff category			Total
	Scientists	Technicians	Support staff	
Resigned	7	1	10	18
Retired	4	6	11	21
Terminated	2	1	2	5
Died	0	0	0	0
	13	8	23	44

The total turnover rate for the period is 4.9% with a voluntary turnover rate of 2.0% and involuntary turnover rate of 3.0%.

Turnover by staff category revealed that the highest rate of 52% in support staff followed by scientists at 30% and technicians at 18%.

c. Training and staff development achievements 2018/2019

During the year 2018/2019, NARO continued to develop the capacities of her staff through sponsorship of long-term and short-term trainings as well as developing staff skills and competencies through mentoring, coaching and attachments.

Staff were also facilitated to attend seminars, workshops and conferences which enhance organizational performance. The specific achievements include:

Long term training: Under long-term training, six scientists successfully completed PhD training. These are:

- i. Walter Anyanga Okello
- ii. Chloe Kemigabo
- iii. Cassius Ariho
- iv. Julius Sserumaga
- v. Ronald Kakeeto
- vi. Rolland Agaba

During the same period, five scientists completed and graduated with Masters of Science degrees. These included;

- i. Nuwahereza Nelson
- ii. Boma Paul
- iii. Chobet Ondhoro Constantine
- iv. Namayanja Diana
- v. Luzinda Haris

In the course of the year, two scientific meetings were arranged by the training commit-

tee where scientists on long-term training presented their academic research work

Short-term training: Short-term courses facilitated includes an induction workshop for 46 new staff. Team building activities and motivational talks were conducted and 14 scientists were supported to present papers in international conferences.

Continuous professional development: Seventy-three staff were supported to grow professionally by supporting them to belong to relevant professional associations through paying membership and annual subscription fees as well as facilitating them to attend accredited professional courses and conferences in Uganda.

d. Performance management

Following the introduction and implementation of a new performance management system in the previous year, work in 2017/2018 focused on supporting directors and supervisors to appraise their subordinates against the agreed performance targets.

A total of 788 staff were appraised with 72

Table 8: Summary of NARO staff performance FY 2018/2019

	Performance rating	Score range	Frequency	Percentage
1.	Outstanding performance	(80%)+	232	29.4
2.	Very good performance	(65%-79%)	477	60.5
3.	Satisfactory performance	(50% - 64%)	77	10
4.	Poor performance	(41% - 49%)	2	0.3
5.	Unacceptable performance	(0 - 40%)	0	0
	Total		788	100%

Table 9: NARO staff performance by category FY 2018/2019

	Staff category	N	Mean score	Average Performance rating
1.	Director	18	84.3	Outstanding
2.	Scientist	239	76.2	Very good performance
3.	Technician	163	75.1	Very good performance
4.	Support staff	368	74.9	Very good performance
	Total	788	75.5	

staff not being appraised due to various reasons. The overall performance rating for the year 2017/2018 is summarized in the table 8.

The overall performance rating for the year 2017/2018 by staff category is summarized in the table 9.

The above tables help to understand the individual and organizational level of performance. Table 8 demonstrates that approximately 80% of the appraised staff had a performance rating of very good performance with a score 65% and above.

Table 8 explains the performance rating by staff category. Indicated that Directors

performed at and outstanding rate and the scientists, Technicians and support staff performed at a very good performance rate. This overall individual performance explains the level of achievements registered by NARO as an organization during the Financial year 2018/2019.

Financial resources

NARO's annual budget for FY 2018/2019 was funded through direct budget support from government of Uganda under GoU development, GoU recurrent and Non Tax Revenue (NTR) as well as external financing especially for off-budget projects

Budget performance for FY 2018/2019 NARO received a total of UGX 63.857 billion under GOU budget out of the annual budgeted UGX 69.5 billion for the FY 2018/2019. This represents a 92% budget release performance. This total GoU funding received of UGX 69.5 billion cv. UGX 89.9 billion for 2017/2018 and UGX 114.1 billion for 2016/17 indicate a continued declining trend in budget allocations to NARO. To effectively implement NARO's strategic interventions for transformation, adequate funding of at least UGX 300 billion per annum is required for agricultural research and development.

The development budget release performance was at 91% while recurrent was at 100%. However, absorption of the development funds was low due to the protracted procurement process. This could also be explained by the implementation of the Integrated Financial Management System (IFMS), which slowed the payment process because of the learning curve for the staff in the IFMS process that begins with e- requisition, LPO and invoicing before payments are effected. Amidst the associated challenges, NARO finally started utilizing IFMS.

NTR performance for the FY 2018/2019 was 61.5%. Overall, NTR greatly improved during FY 2018/2019 with NARO posting a budget performance of 61.5%, which is above the average mark of 50%. During FY 2018/2019, NARO implemented a total of 118 off-budget projects supported by development partners to a tune of UGX 35.52billion. This represents a 32% of the annual budget which indicates an 8% increase from FY 2017/2018. The steady up-ward trend in external funding makes it slightly possible to implement research and to attain meaningful agricultural transformation.

Table 10: Summary of annual financial performance for FY 2018/2019 (Billions)

Source	Approved Annual Budget	Annual Budget Release 2018/2019	Annual Budget Spent 2018/2019	% Annual Budget Released	% Annual Budget Spent	% Annual Released Spent
GoU Recurrent wage	22.472	22.472	22.472	100	100	100
GoU Recurrent Non-Wage	7.099	7.099	7.099	100	100	100
GOU Development	32.783	29.891	29.891	91	91	100
Total GOU	62.354	59.462	59.462	95	95	100
NTR	7.146	4.395	4.395	62	62	100
Domestic Arrears	0.114	0.114	0.114	100	100	100
Total Budget	69.614	63.971	63.971	92	92	100
Total Excluding Arrears	69.500	63.857	63.857	92	92	100

Support to the Competitive Grant Scheme

NARO operates a research Competitive Grant Scheme (CGS) for the NARS which commenced in 2006.

This is intended to strengthen the National Agricultural Research System (NARS) through mobilizing the best available scientific expertise in the public and private sectors to work on specific high priority projects in accordance with the national agricultural development strategies; promote research partnership and collaboration; improve research quality and increase total research funding.

Through this arrangement, research challenges of strategic importance are tackled using well laid out work plans with clear outputs to be delivered after a specified period.

For the financial year 2018/2019, twenty-one (21) projects handling different research areas of strategic importance, were selected for funding. Progress so far registered has revealed the different stages of project progress and achievements (Annex 2).

These projects are funded by the GoU budget and are implemented under the



A screen house constructed at Nabuin ZARDI under the Competitive Grant Scheme

CGS mode. They have three-year period, during which they will generate different problem-solving technologies in the crop, livestock, fisheries and agro-engineering sectors. Unlike the previous cohorts, where some of the research teams were headed by private sector and university based Principal Investigators (PIs), all cohort V projects are led by PIs based in NARO institutes; this arrangement does not lock out the different partners that remain integral to the research process.

The approach was adopted upon the closure of Agricultural Technology and Agribusiness Advisory Services (ATAAS) that saw a reduction in research funds amidst the need to sustain research activities in NAROs PARIs. It is envisaged that using the CGS arrangement, GoU funds will be used more effectively to bring forth important research outputs.

The second half of 2018/2019 saw several projects take off after spending much of the first half of the year settling in.

Intellectual Property Management

NARO has made critical advances in putting in place an effective institutional Intellectual Property (IP) management system and is considered as one of the leading Research and Development organizations in IP management with an active policy and structures in the region. The drive for NARO to institutionalise IP was triggered by the fact that most NARO technologies and innovations were being misappropriated and accessed by various industry players in and outside the country without due recognition and acknowledgement.

Since establishment, NARO IP management office has championed a number of initiatives all aimed at having a vibrant IP system. These initiatives include awareness campaigns aimed at creating an IP conscious society and IP protection.

Achievements on IP Management

a. Contribution to the National Plant Variety

Protection System

NARO together with the Integrated Seed Sector Development (ISSD) and the African Agricultural Technology Foundation (AATF) have been supported the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) to develop National Regulations for the Plant Variety Protection (PVP) Act, 2014. The IP office through Directorate of Agricultural Technolo-

gy Promotion leadership together with MAAIF engaged various partners including AATF, ISSD to secure funding that would facilitate the process. To this end, ISSD committed a grant of up to USD 30,000 to facilitate the process.

b. The Institutional IP Policy Implementation

Following the approval of the Intellectual Property Policy framework, NARO through

No.	Technology	About the technology	Status of protection
1.	BCTB trap Lead inventor: Dr. Godfrey Kagezi, NACORI	The technology relates to a black coffee twig borer <i>Xylosandrus compactus</i> (Eichhoff) trap comprising of a holder container in the shape of a bottle, a lure vapor dispenser and a chamber for killing and storing the beetles.	Patent filed and examination in progress
2.	Herbal Dewormer Lead inventor: Dr. Godfrey Nsereko, NaLIRRI	This technology discloses a herbal formulation for treatment of livestock helminthes and where the herbal formulation is derived from the extracts from the medicinal plants <i>Cassia occidentalis</i> and <i>Euphorbia hirta</i> and the method of preparation of the formulation	Utility model application being drafted
3.	Aflatoxin Binder Lead creator (s): Dr. Swid Mugerwa and Mr. Abasi Kigozi, NaLIRRI	This invention relates to the process of extraction and use of soil minerals to dissolve Aflatoxin trapped in feeds thus enhancing feed intake, feed utilisation efficiency and weight gain ultimately boosting productivity. The minerals in the composition provide immunity against Newcastle and infectious bursal disease especially in layers and broilers.	Patent turned into utility model and granted
4.	NARO musical tune	A composed musical tune that act as a bed for NARO infotainment materials.	Copyright granted

her IP office developed a project proposal in response to the expression of interest and proposal call for Africa by the World Intellectual Property Organisation. NARO was successful and on 4th March, 2019 received a notification letter from WIPO indicating that NARO had been selected as among the 5 institutions in Africa to pilot and implement the project of IP policy elaboration and implementation in Africa.

c. Streamlining Commercialisation in NARO

NARO has made a number of initiatives towards achieving effective technology transfer and commercialization. These initiatives

include establishment of the Incubation and Commercialization Office and strengthening of the business wing NARO Holdings Limited.

These are all aimed at enhancing access to NARO technologies through the commercial route and ultimately respond to research sustainability and create stronger linkages between research and industry or private sector.

d. IP protection

To date, NARO has filed over 10 patents, 4 utility models 1 copyright among others both nationally with the Uganda Registration Services Bureau (URSB) which is the National IP

office and Regionally with African Regional Intellectual Property Organisation (ARIPO). Particularly, in 2018/2019, the following technologies were assessed and protected. The list below excludes those whose process of filing and protection was incomplete.

Finally, NARO, continues to use IP as a tool that will provide an enabling environment that stimulates innovation and transfer of generated technologies to end-users through commercialisation which will ultimately contribute to research continuity and improving researchers' welfare.

Addressing environmental and social safeguards

NARO has registered considerable achievements in the implementation of its environmental and social safeguards including gender and Diversity programs. In an effort to ensure that all gender categories (children, women, youth, the elderly and persons with disabilities) benefit from its technological development and dissemination initiatives at the grassroots, the organization has endeavoured to develop technologies in various disciplines (agricultural engineering, crops, livestock and fishers) to cater for production challenges.

In this regard, prevailing gender concerns in

agricultural research projects at institutional and grassroots level are often analysed and integrated into the different technology generation and dissemination interventions for different sub-project activities.

The major gender concerns addressed were: women's limited voice and decision-making ability, lack of access and control over production factors (land, finance, in-and output markets), limited engagement in research, extension and capacity building processes, poor access to technology, limited interests of youth in agriculture, food,

income insecurity and poor nutrition.

NARO has also been engaged in the management of social risks. This has involved building capacity of the local communities including institute workers, staff and community personnel to address social concerns including child-labour, HIV/ AIDS, gender and sexual harassment.

Under infrastructural developments, gender equity considerations have been embedded to ensure that harm and discomfort are not caused to the people utilizing them.



CHAPTER 06

Report and Audited Accounts

Statement on Internal Audit

Internal Control

In compliance with the Public Finance Management Act 2015, section 48, the Department ensured that a sound control function was in place to ensure that NARO achieves its objectives. This was done by: -

- Reviewing the internal control procedures and proposed practical and value-added recommendations to address control weaknesses and/or process inefficiencies
- Reviewing the economy, efficiency and effectiveness of operations including non-financial controls of an entity
- Reviewing the organisation's compliance with laws and regulations
- Reviewing the reliability and integrity of financial and operating information.
- Review of the existing system for safeguarding the assets and, verify the existence of the assets.

Risk Management

In compliance with the Public Finance Man-

agement (PFM) Act 2015, section 45(2)

NARO has in place a Risk Management Framework. The framework outlines NARO's risk management process and sets out how risks shall be identified, assessed, mitigated, monitored and reported. Emerging risks were identified, communicated to management and the risk register was updated. The identified risks formed a basis of preparing the risk-based audit plan for the financial year 2019/2020.

The top five high rated risks as included in the risk register 2019 were:

- Financial risk:** The risk that financial resources may not be disbursed in accordance with the approved work plan on a timely basis.
- Human resources risk:** The risk that

staff may leave the organisation due to low salary and low funding

- Climate risk:** The risk that unpredictable weather patterns may affect research output through dry spells/heavy rainfall and pests and disease outbreaks.
- Operational Risk:** The risk that people, processes, systems, or external events may impede the implementation of the approved work plan.

Overall rating by the Internal Auditor General

In compliance with section 48(8) of the Public Finance Management (PFM) Act 2015, the overall rating by the Secretary to the Treasury of NARO was, Needs improvement.

Opinion of the Auditor General

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OFFICE OF
 THE AUDITOR GENERAL
 APOLLO KAGWA ROAD,
 PLOT 2C,
 P.O. Box 7983,
 KAMPALA.

VISION: "To be an effective and efficient Supreme Audit Institution (SAI) in promoting effective public accountability"

MISSION: "To Audit and report to Parliament and thereby make an effective contribution to improving public accountability and value for Money Spent"

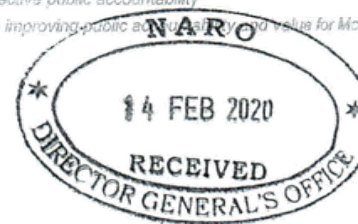
IN ANY CORRESPONDENCE ON

THIS SUBJECT PLEASE QUOTE NO:.....

DCG.159/349/01/19

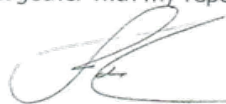
6th December, 2019

The Rt. Hon. Speaker of Parliament
 Parliament of Uganda
Kampala



REPORT OF THE AUDITOR GENERAL ON THE FINANCIAL STATEMENTS OF NATIONAL AGRICULTURAL RESEARCH ORGANISATION FOR THE YEAR ENDED 30TH JUNE 2019

In accordance with Article 163 (4) of the Constitution, I forward herewith audited financial statements of National Agricultural Research Organisation for the year ended 30th June 2019 together with my report and opinion thereon.



John F.S. Muwanga
AUDITOR GENERAL

Copy to: The Chairperson
 Public Accounts Committee
 Parliament of Uganda
Kampala

" The Accounting Officer
 National Agricultural Research Organisation
Entebbe

For the FY 2018/2019 the Auditor General presented a clean opinion indicating that NARO's financial statements present fairly in all material respects, the financial position and results of the organization. This section presents excerpts from the Auditor General's report.

REPORT OF THE AUDITOR GENERAL ON THE AUDIT OF FINANCIAL STATEMENTS OF NATIONAL AGRICULTURAL RESEARCH ORGANISATION FOR THE YEAR ENDED 30TH JUNE, 2019

THE RT. HON. SPEAKER OF PARLIAMENT

Opinion

I have audited the accompanying financial statements of National Agricultural Research Organisation which comprise the statement of Financial Position as at 30th June 2019, the Statement of Financial Performance, Statement of Changes in Equity and Statement of Cash Flows together with other accompanying statements for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In my opinion, the financial statements of National Agricultural Research Organisation for the year ended 30th June 2019 are prepared, in all material respects, in accordance with section 51 of the Public Finance Management, 2015 and the Financial Reporting Guide, 2018.

Basis for Opinion

I conducted my audit in accordance with International Standards of Supreme Audit Institutions (ISSAIs). My responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of my report. I am independent of National Agricultural Research Organisation in accordance with the Constitution of the Republic of Uganda, 1995 (as amended), the National Audit Act, 2008, the International Organization of Supreme Audit Institutions (INTOSAI) Code of Ethics, the International Ethics Standards Board for Accountants Code of Ethics for Professional Accountants (Parts A and B) (IESBA Code), and other independence requirements applicable to performing audits of Financial Statements in Uganda. I have fulfilled my other ethical responsibilities in accordance with the IESBA Code, and in accordance with other ethical requirements applicable to performing audits in Uganda. I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my opinion.

Key Audit Matter

Key audit matters are those matters that, in my professional judgment, were of most significance in my audit of the financial statements of the current period. These matters were addressed in the context of my audit of the financial statements as a whole, and in forming my opinion thereon, and I do not provide a separate opinion on these matters. I have determined the matters described below to be key audit matters communicated in my report.

1.0 Implementation of the approved budget

Section 45 of the Public Finance and Management Act, 2015, requires the Accounting Officer to control the regularity and proper use of the money appropriated to the vote.

According to Section 45 (3) of the same Act, the Accounting Officer shall enter into an annual performance contract with the Secretary to Treasury which shall bind the Accounting Officer to deliver on the activities in the work plan for the vote for the financial year. Work plans are based on outputs to be achieved for the financial year, and during implementation, effort is required to be made to achieve the agreed objectives/targets for the entity within the available resources.



CHAPTER 07

The NARO Strategic Plan

The New NARO Strategic Plan 2018/2019 – 2027/2028

The new strategic direction in the next 10 years (2018/2019 -2027/28) was derived using the principle of Theory of Change which was built on the performance of the previous strategic plan (2008/09 -2017/2018), stakeholders' views, SWOT and PESTEL analyses. The focus is towards agricultural transformation hinged on niche markets and industry. Below are excerpts from the strategic plan.

Rationale and focus of the Strategic Plan 2018/2019 -2027/28

The development of the 2018/2019 -2027/28 strategic plan is as a result of shift in focus from simply increasing agricultural production and productivity to causing real sector and socio-economic transformation. In addition, changes in terms of geo-political, socio-economic, technological, and ecological, environments require new strategic thinking and interventions. For example, the increased integration of the East Africa Community Partner States and other regional and global markets has opened up more opportunities as well as challenges.

The human population, for instance, has increased from 24.2 million in 2002 to 34.6 million in 2014 thus increasing unemploy-

ment rate from 1.9% in 2006 to 9.4% in 2014, and rural-urban migration especially of the youth. The continuously increasing effects of climate change and variability has brought about uncertainty and curtailed the predictability of the agricultural production systems.

All these necessitated change in the strategic direction of agricultural research as detailed in this strategic plan that has been developed through extensive country-wide consultations. The strategic direction is inclined towards increasing niche markets, agricultural research products and services suited for industry.

Process of developing the Strategic Plan

This strategic plan was developed through

a consultative process managed by a task-force team appointed by the Director General. The team comprised different stakeholders including private sector, universities, MAAIF, NARO Secretariat and PARIs.

The process involved: production of an Inception Report; literature review; review of performance in implementation of the previous strategic plan; stakeholder mapping, key informant interviews (KIIs), focus group discussions (FGDs), a review of impact and success stories, consolidation of stakeholder views, and drafting of the strategic plan.

The draft strategic plan was presented to stakeholders for inputs and ownership and finally approved by the NARO Council.

Vision, Mission, Goal and Core Values

Thus NARO has accordingly adopted, a new set of VISION, Mission, Goal and Core values as enshrined in the strategic plan.

Vision

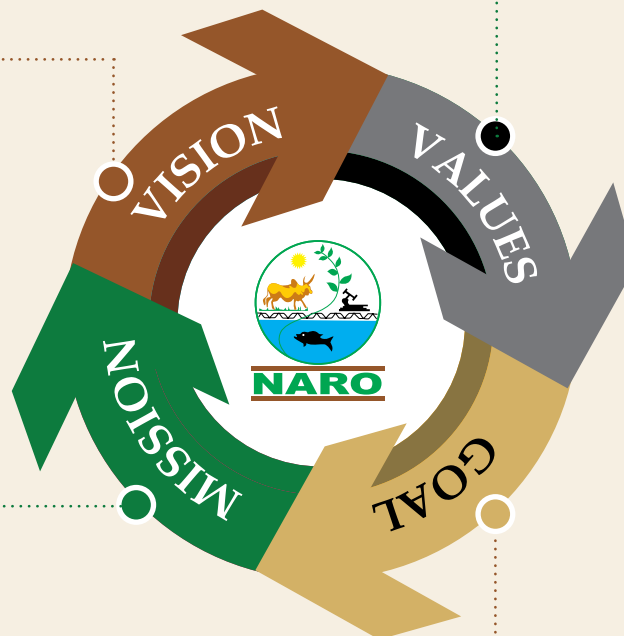
A competitive society supported by a dynamic agricultural research innovation system

The vision statement is anchored on the government's aspirations to transform Uganda from a peasantry to a modern and prosperous society. NARO's contribution is, therefore, targeted to build a climate-resilient, food secure and economically competitive society.

Mission

To innovate for sustainable agricultural transformation

In principle, NARO's mandate is to conduct agricultural research in Uganda. The mission focuses on developing and promoting technologies and innovations for agricultural transformation. Internally, NARO will continue to build a reputable agricultural research and innovation system that is less dependent on donor funding and loans by expanding its income portfolio through internally generated revenue.



Goal

To increase total factor productivity and access to agricultural research products and services for inclusive growth

Given the ever increasing scarcity of factors of production, intensification along the commodity value chain is paramount. To address this, NARO will generate safe and competitive technologies and innovations driven by markets and industry. This will maximize gains from production factors thus making chain actors have comparative advantage in the market place.

Core Values

To achieve the strategic direction, NARO is committed to upholding the following principles and values:

a) Inclusivity: Inclusivity creates opportunities and conducive environment for all interested stakeholders to participate in research service delivery. NARO will continue operating the Competitive Grant Scheme (CGS) and strategic allocation of core funds to facilitate public-private sector partnerships.

b) Subsidiarity: NARO now coordinates a pluralistic NARS, subsidiarity will be key to increasing stakeholder engagement and equity, and to give all constitutes a sense of belonging.

c) Transparency: Transparency is a vital value for enhancing mutual trust and building healthy partnerships. NARO will establish mechanisms for participatory resource allocation, peer review, information sharing and allow open discussion on resource mobilisation ventures. NARO's pursuit for transparency will also ensure integrity in all aspects. This will promote professionalism and ethics in agricultural research service delivery.

d) Accountability: NARO will promote the principle of value-for-money in resource allocation, utilisation and reporting among the various actors in agricultural research.

e) Excellence: NARO will continue to pursue excellence and design modalities to ensure that pluralism accentuate research processes and outputs. The organisation will ensure that all service providers comply to standards of excellence and will provide conducive environment for creativity in the frontiers of science.

The Strategic Results

NARO aspires to achieve a sequence of strategic results for realization of its vision. These are framed into four broad strategic areas of markets, industry, technology uptake and institutional orientation for agricultural transformation.

Overall change on the society

In order to achieve a food secure, healthy and economically vibrant society, NARO's desired overall result is "Communities practicing transformative agriculture to spur markets and industrial development".

The elements of this transformation include increased agricultural markets, proliferation and expansion of industries, new business entities, increased income levels, food and nutrition security, increased productivity, improved production methods, and optimal resource use.

It is envisioned that the different communities in the country will use new technologies and innovations driven by markets and industry. To realise this important change, NARO will pursue four main strategic results presented below;

Strategic Result 1: Increased niche markets for communities in agricultural sector

Strategic Result 2: Increased research products and services suited for industry

Strategic Result 3: Communities increasingly using improved agricultural technologies and innovations

Strategic Result 4: Institutional orientation to agricultural transformation

Strategies for achieving the desired results

Strategic Result 1: Increased niche markets for communities in agricultural sector

This strategic result area seeks to increase niche markets created along product lines that eventually demand for raw materials whose production will be enhanced by the newly generated technologies and innovations. The strategy is also intended to increase access to regional and international markets. This will enhance adoption of improved technologies. Strategies to achieve this result area include:

- a. **Increasing product intensification and diversification:** NARO will re-focus the research agenda towards market-oriented product development. It will involve identification of stakeholders' demands, understanding the markets, increasing access to market information, increasing product development and value addition.
- b. **Increasing market-oriented production:** NARO will contribute to stimulation of commercial production through provision of industry and market-oriented varieties, breeds, prototypes, protocols and practices.

Strategic Result 2: Increased research products and services suited for industry

This aims at generating research products and services that are suitable for industry. This will spur increased production of raw materials and create more niche markets for commodity value chain actors and consequently enhance adoption of technologies.

The suitable products for industry will also contribute to reducing commodity imports and save the country billions of shillings

annually. The strategies for achieving this result area include:

- a. **Creating increased demand for NARO products by industry:** NARO will generate competitive products and services and put in place quality assurance mechanisms in order to sustain demand from industry.
- b. **Increasing Innovations:** NARO will increase support for innovation, technology incubation and techno-entrepreneurship development. The support will involve provision of sustainable funding mechanisms, adequate infrastructure, human resource development and enabling policy framework.
- c. **Increasing public private partnerships:** This will be achieved through creating effective partnerships with industry for joint technology development and promotion. NARO will also increase engagement with other commodity value chain actors.

Strategic Result 3: Communities increasingly using improved agricultural technologies and innovations

The focus of this strategic result is to increase utilization of improved technologies and innovations by different commodity value-chain actors.

For the communities to effectively respond to the niche markets and industry, they will need to use highly productive and efficient technologies and innovations. The strategies for the realization of this strategic result include:

- a. **Increasing availability of improved technologies and information:** The focus is to improve access to improved technologies and innovations by communities. This will require increased generation of gender-responsive, relevant and environmentally aligned novel technologies for various strata of users including urban population; increased production of early generation seed and prototypes; and increased technology incubation. NARO will deliberately put effort to track and withdraw degenerated technologies, build resilience for climate adaptation; and involve youth in research and development. In addition, NARO will strengthen integrated approaches to

technology development for enhanced relevance. To minimise rate of degeneration of technologies especially varieties, NARO will continue to breed for solutions to multiple constraints including increased stability and bio-diversification. NARO will contribute to seed policy formulation processes as part of the effort to increase availability of quality seed for farmers.

- b. **Enhancing conservation and harnessing genetic resources:** NARO recognizes the importance of indigenous genetic resources. Therefore, efforts will be intensified to protect, preserve and conserve genetic resources. Bio-prospecting will be enhanced to increase new products on the market and widen the use of genetic resources.
- c. **Enhancing Natural Resource Management:** Natural resources are the basis on which agricultural technologies and innovations are built. NARO will continue to develop technologies, innovations and management practices that enhance environmental resilience and sustainability of natural resources.

d. Increasing uptake of technologies and innovations: NARO will direct efforts to increase access to technology information and improve capacity of communities to use technologies and innovations. This will involve developing and implementing a strategy for effective dissemination of information and sharing of knowledge, and skills development of end-users. Capacity will be built for influencing policies regarding inputs and community access to credits. Furthermore, NARO will ensure that there is a functional outreach service provided in conjunction with the Directorate of Agricultural Extension of MAAIF, Operation Wealth Creation, local governments and private agricultural research service providers. Lastly, NARO will pursue a fundamental principle of strengthening partnerships for technology generation and dissemination with different players in the commodity value chain.

Strategic Result 4: Institutional Orientation to Agricultural Transformation

NARO's previous efforts were largely focused on productivity enhancing technol-

ogies. This current strategic plan intends to move from primary technologies to products which will drive the agricultural transformation agenda.

This result area is, therefore, intended to orientate NARO as an institution to product-market-industry driven research and development mode. The strategies for institutional orientation to achieve this dream include:

- a. Securing adequate and sustainable resources for research and development:** This calls for increased and sustainable funding; enhanced governance and management; improved human resource capacity, improved research infrastructure and functional and sustainable partnerships and collaborations
- **Increased and sustainable funding:** NARO will solicit government's commitment to provide adequate sustainable budget allocation; strengthen strategies to increase internally generated funds, for instance, through enacting laws to enable NARO create a business unit and increase resource

mobilization from development partners.

- **Enhanced governance and management:** NARO will strive to enhance competence in governance, management and leadership skills, policy matters, societal accountability, monitoring and evaluation, strategic partnerships, resource mobilisation and management. This is will be achieved through a combination of adequate induction, short trainings and exposure visits.
- **Improved human resource capacity:** To attract, develop and retain adequate, competent and motivated human resource, NARO will regularly undertake functional analysis and review the human resource development manual based on prevailing conditions. NARO will advocate for improved remuneration and motivation of staff.
- **Improved research infrastructure:** In order to appropriately address demands of market, industry and respond to emerging challenges, NARO

will develop internationally recognized research infrastructure. This will require preparing and implementing a guided infrastructural development plan; investing in advanced scientific tools and ICT; and securing certification and accreditation status of the research facilities as a centre of excellence. NARO will encourage integration of infrastructural development into donor funded projects. Functional and sustainable partnerships and collaborations. NARO will create and sustain functional strategic partnerships, collaboration and networks to increase resource mobilization, research products and services, technology uptake, and improve visibility. This will be achieved through an integrated approach involving development and implementation of a robust partnership policy and strategy.

b. Developing and implementing transformational policies and processes:

This will entail increased influence on policy formulation, review and implementation; reengineered processes for transformation; improved work culture; and a functional and effective

planning, monitoring, evaluation learning and reporting system.

- **Increased influence on policy formulation and implementation:** Favourable policies are crucial for achievement of the transformation agenda. NARO will build capacity in policy analysis and impact evaluation of research to the economy; create linkages with relevant institutions and ministries to advocate for quick enactment of policies and related laws for enhancing innovation. In the advent of advancement in gene sequencing and bio-informatics, NARO will strengthen regulation of access and transfer of genetic materials to protect ownership of indigenous genetic resources. For emerging issues, NARO will build resilience with other relevant ministries to ensure effective response.
- **Re-engineering processes and improving work culture:** This aims at rethinking and redesigning the way work is done, re-orientating mindsets of the work force, and changing the institutional culture of NARO from output focus to outcomes and hence transformation.

tion. NARO will institutionalize critical reflection and soul searching; strengthen subscription to defined work culture; create platforms for common and integrated conceptualization of ideas and strengthening team work at all levels.

- **Building functional and effective Planning, Monitoring and Evaluation system:** The focus is to have a PM&E system that resolutely fast tracks the transformation agenda including performance and impact of NARO's technologies and innovations. This will involve institutionalising PM&E and thus allocating adequate funds, building human capacity at all levels, and developing PM&E policy framework
- **Improving communication and information management;** For purposes of improved planning and implementation of the research agenda and making information and knowledge accessible by stakeholders, NARO will develop and implement communication and knowledge management policy and strategy. NARO will allocate adequate human, financial and physical resources to the function.

Performance measurement of the Strategic Plan

To effectively measure the performance of this strategic plan in contributing to the agricultural transformation agenda, Key Performance Indicators have been identified as set out in Table 10.

Table 10: Key Performance Indicators

Strategic Result	Key Performance Indicators
Overall Desired Change: Communities practicing transformative agriculture to spur markets and industrial development	Percentage change in per capita income of agricultural households
	Percentage change in household food and nutrition security
	Percentage change in marketed share of agricultural produce
	Level of growth of industries attributed to agricultural research and development
Strategic Result 1: Increased niche markets for Communities in agricultural sector	Number of market-oriented products generated
	Number of markets created along product lines
Strategic Result 2: Increased research products and services suited for industry	Number of research products and services suitable for industry
	Number of technologies and innovations incubated
	Number of functional public-private partnerships
Strategic Result 3: Communities increasingly using improved agricultural technologies and innovations	Number of improved technologies and innovations adopted
	Number of community segments using improved research products and services
	Extent of conservation of genetic resources
	Extent of contribution to natural resources management
Strategic Result 4: Institutional Orientation to Agricultural Transformation	Percentage change in funding for agricultural research and development
	Level of compliance with institutional procedures and policies
	Level of competence of human resources
	Number of research facilities of international standards
	Number of partnerships and collaborations created
	Number of policies that support transformation agenda
	Number of re-engineered processes for transformation
	Change in quality of M&E products
	Level of outreach to public with generated knowledge and information



CHAPTER 08

Awards and Recognitions

Awards and other forms of recognition speak volumes about an organization's products, services, work ethos, among others hence substantiating their credibility. In this chapter we bring you various recognitions associated with NARO in the FY2018/2019.

NARO's Banana research wins best Visionary Government Program award

NARO's National Banana Research Program was honoured as the best Visionary Government Agricultural Research Program of 2018 during the 6th Visionaries of Uganda Awards hosted at Serena hotel Kampala, November 29th 2018.

While endorsing the significance of the awards, the Guest of Honour, the Vice-President, H.E. Edward Kiwanuka Ssekandi, said by recognizing and rewarding excellence, the awards encourage quality products, service and positive competition, which are the bedrock of socio-economic development.

The annual initiative was launched in 2012 by President Yoweri Museveni. Sectors that have been earmarked as drivers for the realization of Vision 2040 include agriculture, due to its multiplier effect in terms of increased production and value-addition, which will lead to the creation of smaller industries into processing thus giving birth to industrial hubs.



“Competition in the private sector and accountability of government institutions will be crucial drivers in Uganda’s ambition to achieve middle-income status” officials observed.

While endorsing the significance of the awards, the guest of honour, the Vice-President, Edward Ssekandi, said by recognising and rewarding excellence, the awards encourage quality products, service and positive competition, which are the bedrock of socio-economic development.

“This ceremony comes at an opportune moment when local producers and service providers need to benchmark what they put on the market vis-a-vis global players. This event, therefore, underscores the need to emphasize quality products and services in a competitive global village,” he said.



Banana plantlets in a screen house at the National Agricultural Research Laboratories, Kawanda.

“Proper accountability of funds in government institutions will facilitate the implementation of initiatives aimed at propelling the country to middle-income status by

2040. Every year, government institutions are given billions of shillings, so we have to see value for money”, Job Mwesigwa, the team leader of the award organizers, said.

“Thus, we go to the ground to see what they have done,” Mwesigwa said, stressing that it is a result-oriented initiative.

Research and surveys are done by the National Planning Authority (NPA), a partner in the implementation of the initiative. Mwesigwa added that prior to the awards, the private sector and government agencies showcased their work.

He highlighted that besides performance in the market, they look at corporate social responsibility from private companies.

Ssekandi said Uganda needs organizations and entrepreneurial-minded people who are market-driven and meet the expectations of the people and economy.

NARO's banana research is using science to increase the productivity of labour of more than 20 million Ugandans eking their livelihood out of the banana industry and also the productivity of 1.3 million hectares of land allocated to banana production country wide.

This, it is hoped, will boost its already big contribution to achievement of Uganda's Vision 2040. ■

NARO awards biotechnology essay-writing winners

Students who participated in the 6th National Biotechnology Essay-writing Contest were on 2nd April 2019 awarded in a colorful ceremony that took place at the National Crops Resources Research Institute, Namulonge in Wakiso. Here is a fairly edited version of an article by New Vision's Reporter Christopher Bendana;

Crisha Phionah Mbabazi, a student of Kololo SSS, won the secondary school category. She was presented with a tablet. She said she was motivated to participate in the contest because of the role biotechnology can play in addressing some of the current problems affecting crops, including pests and diseases and pests.

Steven Marvin Nsubuga, a student of administrative science at Kyambogo University, reigned supreme in the tertiary institution category. He won himself a laptop. The essay contest organized by Uganda Biosciences Information Centre (UBIC) was held under the theme: *Modern Biosciences for more Nutritious Food and Industrial Development*.

Dr. Barbara Zawedde, the co-ordinator of UBIC, implored the students to invest in science of the future that will take Uganda forward. As many as 146 submissions in the secondary school category were received from 24 secondary schools from across the country.



Crisha Phionah Mbabazi receives her present from Edward Sebukyu, an official from the education ministry. (Photo: Christopher Bendana)

A total of 56 submissions were received from 14 universities. Other students were awarded with cash.

Zawedde said there were also internship opportunities at the research institute for the winners. ■



CHAPTER 09

Challenges and Recommendations

Outstanding challenges and remedial steps

The following are the outstanding challenges experienced in the FY 2018/2019 and the remedial steps being taken.

a. Effectively conducting research under budget support

The bulk of NARO's budget is under support to NARO (GoU development) mainly caters for capital items. Over the year's funds for core technology generation and dissemination and maintenance of infrastructure have been categorized as consumptive expenditure and restricted to about 20% of the total budget. NARO is engaging with Ministry of Finance, Planning and Economic Development (MoFPED) to provide a code for core technology generation and dissemination so that it is not categorized as consumptive expenditure and therefore cannot be restricted to about 20% of the total budget.

b. Meeting expectations with inadequate and unsustainable funding

Underfunding of research results in under delivery on public expectations, including adequate engagement of stakeholders. Notably from 2008 – 2018, Uganda's agricultural research intensity ratio – that is, agricultural research spending as a share of

its GDP (Ag GDP) – remained less than the minimum investment target of 1 percent set by the African Union and the United Nations. This calls for deliberate step up in increasing spending on agricultural research. NARO is currently engaging the Government of Uganda to deliberately increase spending on agricultural research and staff.

c. Low salaries

Staff salaries have remained very low leading to staff demotivation. This has increased levels of staff turnover with experienced scientists quitting to join universities and international research organizations. For example, in 2018/2019 FY a total of 80 senior scientists have either absconded from duty or resigned from NARO to take up higher paying jobs. Raising the wage bill and enhancing staff remuneration is required to effectively deliver expected research products and services.

d. Working with limited research infrastructure

Whereas there has been notable improve-

ment in research infrastructure supported by loans to government and development partners, it is still inadequate for executing cutting edge research and responding to emerging issues.

There are inadequate facilities such as scientific equipment including laboratories and transport to effectively conduct research. There is need to improve infrastructure to adequately contribute to agriculture transformation. On her part NARO is strengthening capacities of internal revenue to support research

e. Operating under competing land use interests

NARO operates under uncertain land ownership and distressing pressure from interested parties with immense development plans on land designated for agricultural research. This has slowed down investments in research infrastructure and interrupted effective implementation of land-use plans. This warrants investment in securing land for agricultural research. ■



CHAPTER 10

Publications and information Resources 2018/2019

NARO List of Publications 2018/2019

Crops

Scientific Journal Papers

1. Arinaitwe I.K., C.H.Teo, F.Kayat, R. Tumuhimbise, B. Uwimana, J. Kubiriba, J. A. Harikrishna, R. Othman Yasmin (2019). Evaluation of banana germplasm and genetic analysis of an F1 population for resistance to *Fusarium oxysporum* f. sp. cubense race 1. *Euphytica* (2019) 215: 175. <https://doi.org/10.1007/s10681-019-2493-3>.
2. Arinaitwe I.K., C.H.Teo, F.Kayat, R. Tumuhimbise, B. Uwimana, J. Kubiriba, J. A. Harikrishna, R. Othman Yasmin (2019). Molecular markers and their application in fusarium wilt studies in *Musa* spp. *Sains Malaysiana* 48:1841-1853.
3. B, Mudde and D. W., Miano and F.M., Olubayo and G., Asea and D.C., Kilalo and D.B., Kwemoi and J., Adriko and F., Ssekiwoko and A., Male and A., Kiggundu. 2019. Susceptibility of Common weeds and cultivated crops in major maize growing agroecological zones of Uganda to Viruses Causing Maize Lethal Necrosis Disease. *African Journal of Biological Sciences*, Vol. 1, No. 4, October 2019, pp. 1-14. Available at SSRN: <https://ssrn.com/abstract=3467374>
4. Barnabas Mudde, Florence M'mogi Olubayo, Douglas Watuku Miano, Godfrey Asea, Dora C. Kilalo, Andrew Kiggundu, Daniel K. Bomet, John Adriko. (2019). Role of prevalent weeds and cultivated crops in the epidemiology of maize lethal necrosis disease in major maize growing agroecological zones of Uganda. *Annual Research & Review in Biology*. Vol 32(3): 1-17.
5. Batte, M., Swennen, R., B. Uwimana, V. Akech, A. Brown, R. Tumuhimbise, H.P. Hovmalm, M. Geleta and R. Ortiz (2019). Crossbreeding East African Highland Bananas: Lessons learnt relevant to the botany of the crop after 21 years of genetic enhancement. *Frontiers in Plant Science* 10:81.
6. Blomme, G., Ocimati, W., Nabuuma, D., Sivirihauma, C., Davey, M., Buah, S., Van Den Bergh, I., Vutseme, L., Bahati, L. & Ekesa, B. (2019). Pro-vitamin A carotenoids content of 48 plantain (*Musa AAB genome*) cultivars sourced from eastern Democratic Republic of Congo. *Journal of the Science of Food and Agriculture*.
7. Buregeya, H., Tumuhimbise, R., Kubiriba, J., Talengera, D., Nowankunda, K., Arinaitwe, G., ... Rubaihayo, P. (2018). Development of two high-yielding, consumer-acceptable apple banana hybrids (*Musa species*, AAB genome group) with resistance to *Fusarium oxysporum* f. sp. cubense race 1. *Journal of Plant Breeding and Crop Science*, 10(6), 128-133. <http://doi.org/10.5897/JPBSCS2018.0720>
8. Changa, C. M., Tushemereirwe, W.k, Ssekiwoko, F., Kubiriba, J., Mudonyi, B., Vanhaelewyn, L., And Tusiime, G. 2019. Banana field resistance to insect-vector transmission of bacterial wilt caused by *Xanthomonas campestris* p.v. musacearum. *African Journal of Agricultural Research*. 14(1):24-33. DOI.10.5897/

- AJAR2016.11858.
9. Charles S. Wortmann . Kayuki C. Kaizzi . Nouri Maman . Athanase Cyamweshi . Mohamed Dicko . Maman Garba . Mari-beth Milner . Catherine Senkoro . Bitrus Tarfa . Francis Tettah . Catherine Kibunja . Moses Munthali . Patson Nalivata . Davy Nkonde . Leon Nabahungu . Korodjouma Ouattara . Idriss Serme. 2019. Diagnosis of crop secondary and micro-nutrient deficiencies in sub-Saharan Africa. *Nutr Cycl Agroecosyst*. 113:127-140.
 10. Coulibaly, A., Minhobo, M.Y., Soro, S; Dépo, ORN; Goran, AN; Hala, NF; Barnabas, M and Djidji, H. 2019. Effectiveness of Weather ants (*Oecophylla longinoda*), bait application (GF-120) and neem oil (*Azadirachta indica*) combination in the control of fruit flies in mango orchards in Northern Côte d'Ivoire. *Journal of Entomology and Zoology Studies* 7(6): 01-07
 11. Coulibaly, A; Minhobo, MY; Goran, A.N; N'Dépo, O.R; Soro, S; Hala, N.F; Barnabas, M. 2019. Influence of abiotic factors and mango phenology on fruit fly outbreaks in mango orchards of northern Côte D'Ivoire. *European Journal of Biotechnology and Bioscience* 7(6): 71-78
 12. I.N. Alou, J.M. Steyn, J.G. Annandale, M. Van der Laan. 2018. Growth, phenological, and yield response of upland rice (*Oryza sativa* L. cv. Nerica 4®) to water stress during different growth stages. *Agricultural Water Management* 198, 39-52. <https://doi.org/10.1016/j.agwat.2017.12.005>
 13. John Yawe, Candia Alphonse, and Obeti Grism Lawrence. 2019. "Quantitative rice post-harvest losses in the Albertine and Olweny Rice Hubs, Uganda." *International Journal of Scientific Research and Management* 7 (04).
 14. John Yawe, Isaac Simate Nyambe, John Shindano. 2018. Effect of Zambia's groundnut drying surfaces on aflatoxin contamination. Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Germany: LAP LAM-BERT Academic Publishing.
 15. Kabod, N.P., Sseremba, G., Buteme, R., Masanza, M., Kizito, B.E. and Kasharu, K.A., 2018. Stability for descriptors of *Solanum aethiopicum* Shum group (family Solanaceae). <https://doi.org/10.5897/JPBCS2018.0755>
 16. Kagezi GH., Kucel P., Kobusinge J., Olango N., Nakibuule L. and Wagoire WW. 2018. Predicting the response of insect pests and diseases of Arabica coffee to climate change along an altitudinal gradient in Mt. Elgon region, Uganda. *Journal of Agriculture and Environmental Sciences* 7(1):134-140. <https://pdfs.semanticscholar.org/d7a9/b25108e6e449bf6f583cb389a5de2ce247e1.pdf>
 17. Kagezi, G.H., Kucel, P., Kobusinge, J., Olango, D.N., Nakibuule, L., Nanjogo W., Nambozo, P.B., Olal, S. and Wagoire, W.W., 2018. Farmers' knowledge and perception of the use of pesticides in Arabica coffee, *Coffea Arabica* agro-ecologies of Uganda. *Journal of Agriculture and Environmental Sciences* 7(2):173-188. http://jaesnet.com/journals/jaes/Vol_7_No_2_December_2018/17.pdf
 18. Kakeeto, R., Baguma, S. D., Subire, R., Kacheru, J., Karungi, E., & Biruma, M. (2019). Genetic variation and heritability of kernel physical quality traits and their association with selected agronomic traits in groundnut (*Arachis hypogaea*) genotypes from Uganda. *African Journal of Agricultural Research*, 14(10), 597-603.
 19. Kakeeto, R., Musinguzi, J., Auma, L., Odogwu, B., & Ssekiwoko, F. (2018). Genotypic response to weeding regimes of upland rice on woodland savannah

- sub-ecological area of Lake Albert crescent zone of Uganda. *African Journal of Plant Science*, 12(11), 299-308.
20. Kakeeto, R., Sibiya, J., Melis, R., & Biruma, M. (2019). Farmers' perceptions of drought and other production constraints, drought mitigation options, and their implications for groundnut breeding in Uganda. *Indian Journal of Agricultural Research*, 53: 45-50
 21. Kakeeto, R., Wambi, W., Barwogeza, M., Auma, L., Odongo, W., Ozuma, G., & Ssekiwoko, F. (2018). Harnessing cultivar performance and stability for deploying superior groundnut plant types in the Lake Albert Crescent Zone of Uganda. *African Journal of Agricultural Research*, 13(22), 1120-1127.
 22. Kamusingize, D., Majaliwa, J. M., Komutunga, E., Tumwebaze, S., Nowakunda, K., Namanya, P., & Kubiriba, J. (2018). Allometric relationships and carbon content for biomass-carbon estimation of East African Highland Bananas (*Musa spp.* AAA-EAHB) cv. Kibuzi, Nakitembe, Enyeru and Nakinyika. *African Journal of Agricultural Research*, 13(36), 1865-1873. <http://doi.org/10.5897/AJAR2016.11960>
 23. Kayuki C. Kaizzi, Angella Nansamba, Ruth Kabanyoro, Jimmy Lammo and Harrison Rware. 2018. Upland rice response to fertilizer in three agroecological zones of Uganda. *African Journal of Plant Science*. Vol. 12: 65-72
 24. Kikulwe, E. M., Okurut, S., Ajambo, S., Gotor, E., Ssali, R. T., Kubiriba, J., & Karamura, E. (2018). Does gender matter in effective management of plant disease epidemics? Insights from a survey among rural banana farming households in Uganda. *Journal of Development and Agricultural Economics*, 10(3), 87-98. <http://doi.org/10.5897/jdae2017.0877>
 25. KÖBERL, M., DITA, M.A.D., NIMUSIIMA, J., TUMUHAIRWE, J.B., KUBIRIBA, J., STAYER, C.P. AND BERG. G. 2018. The banana microbiome: stability and potential health indicators. *Horticulture*. 1196: 105-112. DOI: 10.17660/ActaHortic.2018.1196.12.
 26. Kobusinge, J., Kagezi, G.H., Kasoma, A., Kucel, P., Nakibuule, L., Perfecto, I. and Wagoire WW. 2018. Farmers' knowledge of pests and diseases in the coffee-banana agroforestry systems of mid-eastern Uganda. *Journal of Agriculture and Environmental Sciences* 7(2):109-119. http://jaesnet.com/journals/jaes/Vol_7_No_2_December_2018/12.pdf
 27. Mudonyi, B., Vanhaelewyn, L., Tusiime, G., Ssekiwoko, F., Kubiriba, J., Tushemereirwe, W. K. and Changa, C. M. (2019). Banana field resistance to insect-vector transmission of bacterial wilt caused by *Xanthomonas campestris* p.v. *musacearum*. *African Journal of Agricultural Research*, Vol. 14(1), pp. 24-33, DOI: 10.5897/AJAR2016.11858.
 28. Nakanwagi, M.J., Sseremba, G., Kabod, N.P., Masanza, M. and Kizito, E.B., 2018. Accuracy of using leaf blade length and leaf blade width measurements to calculate the leaf area of *Solanum aethiopicum* Shum group. *Heliyon*, 4(12), p.e01093. <https://doi.org/10.1016/j.heliyon.2018.e01093>
 29. Nakanwagi, M.J., Sseremba, G., Masanza, M. and Balyejusa Kizito, E., 2017. Performance of *Solanum aethiopicum* Shum group accessions under repetitive drought stress. *Journal of Plant Breeding and Crop Science*, 10(1):13-20. <https://doi.org/10.5897/JPCS2017.0690>
 30. Namaganda, J. M., Kashaija, I. N., & Maslen, R. (2018). Host status of the common weeds of banana establishments

- to banana nematodes in central Uganda. Academic Journal of Plant Sciences, 11(1), 1-10. <http://doi.org/10.5829/idosi.ajps.2018.11.1.01.10>
31. Obeti Grism Lawrance, Joshua Wanyama, Noble Banadda, Alphonse Candia, Samuel George Onep and Ronald Walozi. 2019. Preferences of Ugandan Consumers for rice varieties and brands on the local market. Published in Journal of Environmental Science and Engineering, B 8 (2019): 28-36.
 32. Olal S., Olango N., Kiggundu A., Ochwo S., Adriko E., Nanteza A., Matovu E., Lubega GW., Kagezi G., Hakiza GJ., Wagoire WW., Rutherford MA., and Opiyo SO. 2018. Using Translation Elongation Factor Gene to Specifically Detect and Diagnose *Fusarium xylaroides*, a Causative Agent of Coffee Wilt Disease in Ethiopia, East and Central Africa. Plant Pathology and Microbiology 9:5. <https://pdfs.semanticscholar.org/9bcc/aa6cf766216b4546b063f6c57ed7364bcd4b.pdf>
 33. Olal, S., Bitalo, D.N., Olango, N.D., Mulindwa, J., Ochwo, S., Opiyo, S.O., Arinaitwe, G., Ogwok, E., 2019. De novo genome sequence of a *Fusarium xylaroides* race pathogenic to robusta coffee (*Coffea canephora*) in Uganda. Microbiol Resour Announc 8:e00520-19. <https://doi.org/10.1128/MRA.00520-19>
 34. Olal, S., Olango, N., Kagezi, G., Kucel, P., Musoli, P. and Wagoire, W.W., 2018. Increase in coffee wilt disease due to Poor farmer adoption and adaption of the recommended control methods. Book of programme and abstracts, NARO-MAK Joint Agricultural Dissemination Conference, 12th – 15th November 2018, Munyonyo, Uganda
 35. Onyilo, F., Tusiime, G., Tripathi, J. N., Chen, L., Falk, B., Stergiopoulos, I., ... Tripathi, L. (2018). Silencing of the Mitogen-Activated Protein Kinases (MAPK) Fus3 and Slt2 in *Pseudocercospora fijiensis* Reduces Growth and Virulence on Host Plants. Frontiers in Plant Science, 9(March), 1-12. <http://doi.org/10.3389/fpls.2018.00291>
 36. Samuel Tuhaise, Jesca L. Nakavuma, John Adriko, Kenneth Ssekatawa and Andrew Kiggundu (2019). In vitro regeneration of Ugandan passion fruit cultivars from leaf discs. BMC Res Notes. 12:425. <https://doi.org/10.1186/s13104-019-4469-8>
 37. Samuel Tuhaise, Jesca L. Nakavuma, John Adriko, Kenneth Ssekatawa and Andrew Kiggundu (2019). Establishment of a transformation protocol for Uganda's yellow passion fruit using the GUS gene. African Journal of Biotechnology. 18(20), 416-425. DOI: 10.5897/AJB2019.16795
 38. Ssebulime G, Nyombi K, Kagezi GH, Mpiira S, Byabagambi S, Tushemereirwe WK, Kubiriba J, Karamura EB and Staver C. 2018. Canopy management, leaf fall and litter quality of dominant tree species in the banana agroforestry system in Uganda. African Journal of Food, Agriculture, Nutrition and Development 18(1):13154-13170. <http://www.bioline.org.br/pdf?nd18020>
 39. Ssebulime, G., Kagezi, H.G., Nyombi, K.v., Mpiira, S., Kucel, P., Byabagambi, S., Tushemereirwe, W.K., Kubiriba, J., Karamura, E. and Staver, C.P. 2017. Farmers' knowledge of the banana (Musa Sp.) agroforestry systems in Kiboga District, Central Uganda. Africa Journal of Food, Agriculture, Nutrition and Development. 17 (4):12557-12573.
 40. Ssebulime, G., Nyombi K., Kagezi, G.H., Mpiira, S., Byabagambi, S., Tushemereirwe, W.K., Karamura, E.B., Kiyingi, I., Balimunsi, K.H. and Staver, C., 2019. As-

- sessing the potential of trees to sustain soil fertility in the banana agroforestry system in Uganda. *Agroecology and Sustainable Food Systems* <https://doi.org/10.1080/21683565.2019.1566190>
41. Ssebulime, G., Nyombi, K., Kagezi G.H, Mpiira S., Byabagambi S, Tushemereirwe, W.k. Kubiriba, J. Karamura, E.B. and Staver C. 2018. Canopy management, leaf fall and litter quality of dominant tree species in the banana agroforestry system in Uganda. *African Journal of Food, Agriculture, Nutrition and Development*. Vol. 18(1). <https://www.ajol.info/index.php/ajfand/issue/view/16810>
 42. Sseremba, G., Tongoona, P., Eleblu, J., Danquah, E.Y. and Kizito, E.B., 2018. Heritability of drought resistance in *Solanum aethiopicum* Shum group and combining ability of genotypes for drought tolerance and recovery. *Scientia horticulturae*, 240, 213-220. <https://doi.org/10.1016/j.scienta.2018.06.028>
 43. Sseremba, G., Tongoona, P., Eleblu, J.S.Y., Danquah, E.Y. and Kizito, E.B., 2018. Linear discriminant analysis of structure within African eggplant 'Shum'. *African Crop Science Journal*, 26(1), 37-48. <http://dx.doi.org/10.4314/acsj.v26i1.3>
 44. Sseremba, G., Tongoona, P., Eleblu, J.S.Y., Danquah, E.Y., Kaweesi, T., Baguma, Y., Masanza, M. and Kizito, E.B., 2018. Stability of *Solanum aethiopicum* Shum accessions under varied water deficit stress levels and identification of pertinent breeding traits for resistance to water shortage. *Euphytica*, 214(1), 11. <https://doi.org/10.1007/s10681-017-2097-8>
 45. Sseruwagi, P., J. Wainaina, J.Ndunguru, R. Tumuhimbise et al. (2018). The first transcriptomes from field-collected individual whiteflies (*Bemisia tabaci*, *Hemiptera: Aleyrodidae*): a case study of the endosymbiont composition. *Gates Open Research* 2018, 1:16.
 46. Tinzaara, W., Ssekiwoko, F., Kikulwe, E. and Karamura, E. (2018). Effectiveness of learning and experimentation approaches for farmers as a community based strategy for banana xanthomonas wilt management. *Journal of Agricultural Extension and Rural Development*. Vol. 10 (7), pp. 134-143.
 47. Tumuhimbise R., H. Buregyeya, J. Kubiriba, W. K. Tushemereirwe, A. Barekye, R.S. Tendo, B. Namagembe, S. Muhangi, F. Kazigye, D. Talengera, J. Tindamanyire, K. Akankwasa, G.Nabulya, J. Namaganda, W. William, A. Kushaba, M. Namuddu, N. Oyesigye, P. Namanya, I.K. Arinaitwe, A. Waniale, D. Karamura and E. Karamura (2019). 'NABIO808' (Syn. 'NAROBAN5'): A tasty cooking banana cultivar with resistance to pests and diseases. *Crop Breeding and Applied Biotechnology* 19 (4): 502-506.
 48. Tumuhimbise, R. and D. Talengera (2018). Improved propagation techniques to enhance the productivity of banana (*Musa* spp.), *Open Agriculture*, 3:138-145.
 49. Tumuhimbise, R., A. Barekye, J. Kubiriba, W.K. Tushemereirwe, K. Akankwasa, I. Arinaitwe and D. Karamura (2018). New high-yielding cooking banana cultivars with multiple resistances to pests and diseases ('NAROBan1', 'NAROBan2', 'NAROBan3' and 'NAROBan4') released in Uganda. *HortScience*, 53(9):1387-1389
 50. Tumuhimbise, R., Barekye, A., Kubiriba, J., Akankwasa, K., Arinaitwe, I. K., Karamura, D., & Tushemereirwe, W. K. (2018). New High-yield Cooking Banana Cultivars with Multiple Resistances to Pests and Diseases ('NAROBan1', 'NAROBan2', 'NAROBan3', and 'NAROBan4') Released in Uganda. *HortScience*, 53(9), 1387-1389. <http://doi.org/10.21273/hortsci13207-18>

Conference Papers, Posters

51. Falconnier G., Corbeels M., Boote K., Adam M., Basso B., Ruane A., Affholder F., Ahuja L.R., Alou I.N., Amouzou K.A., Chen Y., Deryng D., Elsayed M.L., Faye B., Folorunso A., Gaiser T., Galdos M., Gayler S., Gerardeaux E., Giner M., Grant M., Hoogenboom G., Ibrahim E.S., Jones C.D., Justes E., Kamali B., Kersebaum K.C., Kim S.H., Kumar S.N., van der Laan M., et. al. 2019. Model intercomparison of maize response to climate change in low-input smallholder cropping systems. Poster presented at the 3rd Agriculture and Climate Change Conference Budapest, 24 th to 26 th March 2019.

52. Caroline Nankinga, Samuel Balagadde, James Kanjigye, Paul Sigombe, Jerry Anyoli, Leeroy Sigombe, Collins Wanyama, Geoffrey Arinaitwe, Florence Nampeera, Wilberforce Tushemereirwe 2018. *Ceratitis capitata* (Wied) infestation in hot pepper treated with bio-pesticides and implications on the Integrated Pest Management strategies in Uganda. Paper presented at the 10th International Symposium on Fruit flies of economic importance, April 23-27th, 2018, Tapachula, Chiapas Mexico
53. Caroline Nankinga, Florence Nampeera, William Waswa, Victor Lubega, Geoffrey Arinaitwe, Wilberforce Tushemereirwe 2018. Up take of Male Annihilation Tech-

nique in Integrated Fruit Fly Management in Uganda. Paper presented at National Agricultural Research Organization - Makerere University (NARO-MAK) Second Joint Scientific Conference 12-15 November 2018, Speke Resort Munyonyo, Kampala, Uganda

Thesis

54. Sseremba, G. 2019. Genetic diversity and breeding of *Solanum aethiopicum* Shum group for drought tolerance. PhD Thesis. University of Ghana Legon. <http://ugspace.ug.edu.gh/handle/123456789/30947>

55. Fisheries

Scientific Journal Papers

56. Aruho, C., Walakira, J.K. & Rutaisire, J. (2018). An overview of domestication potential of *Barbus altianalis* (Boulenger, 1900) in Uganda. Aquaculture Reports 11, 31-37.
57. Atukunda, G., State, A.E., Molnar, j. & Atekyereza, P. (2018). Aquaculture Development and Uganda's Agricultural Ex-

tension System: The Case of Fish Farmers in Central and Northern Regions. J Fish Aqua Dev, an open access journal ISSN: 2577-1493

58. Basiita, R.K., Zenger, K.R., Mwanja, M.T., Jerry, D.R. (2018). Gene flow and genetic structure in Nile perch, *Lates niloticus*, from African freshwater rivers and lakes.

PLoS ONE 13(7): e0200001. <https://doi.org/10.1371/journal.pone.0200001>

59. Egessa, R., Gandhi W. P. & Ocaya, H. (2018). Benthic macroinvertebrate community structure in Napoleon Gulf, Lake Victoria: effects of cage aquaculture in eutrophic lake. Environ Monit Assess, 190:112, <https://doi.org/10.1007/s10661-018-6498-5>

60. Gidudu, A., Mugo, R., Letaru, L., Wanjohi, J., Nakibule, R., Adams, E., Flores, A., Page, B. & Okello, W. (2018). Evaluation of satellite retrievals of water quality parameters for Lake Victoria in East Africa. *African Journal of Aquatic Science*, <http://www.tandfonline.com/loi/taas20>
 61. Mangeni-Sande, R., Taabu-Munyaho, A., Ogutu-Ohwayo, R., Nkalubo, W., Natugonza, V., Nakiyende, H., Nyamweya, C. S., Muwanika, V. B. (2018). Spatial and temporal differences in life history parameters of *Rastrineobola argentea* (Pellegrin, 1904) in the Lake Victoria basin in relation to fishing intensity. *Fish Manag Ecol*. 2018;1-7.
 62. Nduwayesu, E., Hwang, B.-K., Lee, D.-J., & Shin, H.-O. (2019). Acoustical Survey for estimating fish biomass at Chilam Bay, Korea. *Ocean and Polar Research*, 41(1), 11-18. <https://doi.org/10.4217/OPR.2019.41.1.011>
 63. Nkalubo, W., Balirwa, J., Bassa, S., Muhumuza, E., Nsega, M. & Mangeni, R. (2018) Fish Breeding Areas as a Management Tool for Fisheries Resources in Lake Victoria, East Africa in *African Journal of Tropical Hydrobiology and Fisheries* 16: 1-9
 64. Nunan, F., Cepi, D., Yongo, E., Salehe, M., Mbilingi, B., Odongkara, K. et al. (2018). Compliance, corruption and co-management: how corruption fuels illegalities and undermines the legitimacy of fisheries co-management In *International Journal of the Commons*, 12(2), 58-79.
 65. Odongkara, K., Yongo, E., Mhagama, F., Onyango, P., Chimatiro, S., Tumwebaze, R., Akumu, J., Mbilingi, B., Okura, R., Nansuuna, A., Ochaya, H., Owili, M., Bwana, E. & Onganda, M. (2018). Strategies to Improve Trade in Dagaa (*Rastrineobola argentea*) from Lake Victoria. *African Journal of Tropical Hydrobiology and Fisheries*, 16(1).
- ### Conference Papers, Poster
66. A Nankabirwa, R Egezza, L Musinguzi, V Natugonza, J Naluwairo, G Magezi and R Ogutu-Ohwayo (2018). Cyanobacteria dominance in Lake Wamala along a land degradation gradient. A poster presentation made at the NARO-MAK Conference November 2018, Speke Resort Munyonyo-Uganda.
 67. Caroline Nankinga, Florence Nampeera, William Waswa, Victor Lubega, Geoffrey Arinaitwe, Wilberforce Tushemereirwe 2018. Up take of Male Annihilation Technique in Integrated Fruit Fly Management in Uganda. Paper presented at National Agricultural Research Organization – Makerere University (NARO-MAK) Second Joint Scientific Conference 12-15 November 2018, Speke Resort Munyonyo, Kampala, Uganda
 68. Caroline Nankinga, Samuel Balagadde, James Kanjigye, Paul Sigombe, Jerry Anyoli, Leeroy Sigombe, Collins Wanyama, Geoffrey Arinaitwe, Florence Nampeera, Wilberforce Tushemereirwe 2018. *Ceratitidis capitata* (Wied) infestation in hot pepper treated with bio-pesticides and implications on the Integrated Pest Management strategies in Uganda. Paper presented at the 10th International Symposium on Fruit flies of economic importance, April 23-27th, 2018, Tapachula, Chiapas Mexico
 69. Falconnier G., Corbeels M., Boote K., Adam M., Basso B., Ruane A., Affholder F., Ahuja L.R., Alou I.N., Amouzou K.A., Chen Y., Deryng D., Elsayed M.L., Faye B., Folorunso A., Gaiser T., Galdos M., Gay-

ler S., Gerardeaux E., Giner M., Grant M., Hoogenboom G., Ibrahim E.S., Jones C.D., Justes E., Kamali B., Kersebaum K.C., Kim S.H., Kumar S.N., van der Laan M., et. al. 2019. Model intercomparison of maize response to climate change in low-input smallholder cropping systems. Poster presented at the 3rd Agriculture and Climate Change Conference Budapest, 24 th to 26 th March 2019.

70. Falconnier G., Corbeels M., Boote K., Adam M., Basso B., Ruane A., Affholder F., Ahuja L.R., Alou I.N., Amouzou K.A., Chen Y., Deryng D., Elsayed M.L., Faye B., Folonrunso A., Gaiser T., Galdos M., Gayler S., Gerardeaux E., Giner M., Grant M., Hoogenboom G., Ibrahim E.S., Jones C.D., Justes E., Kamali B., Kersebaum K.C., Kim S.H., Kumar S.N., van der Laan M., et. al. 2019. Model intercomparison of maize response to climate change in low-input smallholder cropping systems. Poster presented at the 3rd Agriculture and Climate Change Conference Budapest, 24 th to 26 th March 2019.
71. Wanda, F.M., Beine,P., Ogwang,J., Matuha,M., Amondito, B., Nabwire, R., Molo, R., Bwambale, M. and Akumu, J. (2018) . Status of Kariba weed (*Salvinia molesta*)

infestation on lakes Kyoga and Kwana: Its impacts and control strategy. A poster presentation made at the NARO-MAK Conference November 2018, Speke Resort Munyonyo-Uganda.

Book Chapters

72. Kische-Machumu, M.A., Natugonza, V., Nyingi, D.W., Snoeks, J., Carr, J.A., Seehausen, O. and Sayer, C.A. (2018). The status and distribution of freshwater fishes in the Lake Victoria Basin in. Freshwater biodiversity in the Lake Victoria Basin: Guidance for species conservation, site protection, climate resilience and sustainable livelihoods. Cambridge,
73. Sayer, C.A., Máiz-Tomé, L., Akwany, L.O., Kische-Machumu, M.A., Natugonza, V., Whitney, C.W., Omondi, R., Nshutiyayesu, S. and Kabuye, C.S. (2018). The importance of freshwater species to livelihoods in the Lake Victoria Basin in Freshwater biodiversity in the Lake Victoria Basin Guidance for species conservation, site protection, climate resilience and sustainable livelihoods

Technical Reports

74. Nakiyende, H., Mangeni-Sande, R., Nkalubo, W., Bassa, S., Muhumuza, E., Tumushabe, H., Mulowoza, A., Kagoya, E., Mpomwenda, V., Mudondo, P., Mangeni, R., Byamukama, P., Bakunda, A., Rukunya, E., Taabu-Munyaho, A., (2018). National report of the frame survey 2018 on the Ugandan side of lakes Edward and Albert. National Fisheries Resources Research Institute, (NaFIRRI)
75. Thesis
76. Nduwayesu, E. (2019). Acoustical survey for estimating fish biomass at Chilam bay, Korea; Graduate School of Global Fisheries, Pukyong National University, Pukyong, Korea
77. Mangeni, R.S., (2018). Spatial and temporal variations in population and biological characteristics of silver cyprinid, *rastrineobola argentea* (pellegrin, 1904), in the Lake Victoria basin.; Makerere University; Department of Environmental Management, College of Agriculture and Environmental Sciences, Kampala, Uganda.

ANNEX 1: MSIPs supported by NARO institutes

Name of MSIP	No. of MSIPs	Institute Responsible	Support provided by NARO
Cassava MSIPs	4	NACRRI	• Training on seed propagation. • Training on collective marketing. The volumes have overwhelmed the current users (Beer Industry). • NARO works with desk at MAAIF on commodities to see how MSIPs can be developed and maintained.
Bean MSIPs	4	NACRRI	• Training on seed propagation. • Training on collective marketing
Oil Palm MSIP	1	NACRRI	• Data collection and situation analysis on seedlings • NARO does the support role and provides standards • Technical guidance on agronomic practices • Training in seed propagation • National surveillance of agro ecological potential of oil palm
Horticulture MSIP	1	NACRRI	• Provision and advice on quality fruit seedlings
Sweet potato MSIP	1	NACRRI	• Data collection and situation analysis on fruit seedlings • Mobilisation of stakeholders done to bring NAADs and MAAIF onboard
Kalongo Agribusiness Maize-Platform (Nakasongola)	1	NARL	• NARO's role was mainly coordination
Bean MSIP	1	NARL	• Coordination and supporting meetings
Nakaseke Maize Ordinance Platform	1	NARL	• Agronomic practices • Access to good seed • Post-harvest handling trainings • Post-harvest handling demos. • Post-harvest handling technologies
National Coffee Research Agenda/platform(NCP)	1	NACORI	• NACORI is part of the steering committee • Provides coffee research information to stakeholders • Provides improved coffee varieties and related agronomic practices to users • Provides quality seed
National Cocoa Platform	1	NACORI	• Provides cocoa research information to stakeholders • Provides improved coffee varieties and related agronomic practices. • Provides quality seed

Name of MSIP	No. of MSIPs	Institute Responsible	Support provided by NARO
Tree germplasm exchange and nursery accreditation MSIP	1	NAFORRI	• Information sharing and management options • Training of stakeholders • Website Information
Shea tree breeding seed orchard	1	NAFORRI	• Information sharing and management options • Training of stakeholders
Forestry invasive species network for Africa	1	NAFORRI	• Information sharing and management options • Training of stakeholders • Website Information
1 Dairy Farmers Network	1	NALRRI	• Provide technical livestock information to actors
Sorghum production and value addition MSIP	1	NASARRI	• Provided technical livestock information to actors. • Climate change adaptation technologies
Millet MSIP	1	NASARRI	• Provided technical livestock information to actors. • Climate change adaptation technologies.
Banana MSIP	1	NASARRI	• Provided technical livestock information to actors. • Climate change adaptation technologies. • Supportive roles such participate in meetings.
The functional rice, seed value chain and dairy MSIPs	5	Buginyanya ZARDI	• Providing quality seed. • Participating in meetings
Potato platforms supported	3	Kacwekano ZARDI	• Providing quality seed. • Participating in meetings
Functional milk platform supported	1	Mbarara ZARDI	• Financial support from NARO Kawanda banana programmes • Technical trainings from different projects under NARO. • Collective marketing is being promoted thus farmers able to access organized markets. • Training on BBW control
Vegetable MSIPs	1	Mukono ZARDI	• Agronomic practices • Seed quality processing • Produced descriptors for seed companies • Established linkages with MAAIF • Provided an irrigation facility. • Trained on seed rates and spacing
Potato MSIP	1	Mukono ZARDI	• Facilitated meetings and field trips • Trained farmers on agronomic practices • Contributed to acquisition of processing machinery
Pineapple MSIP (brisk Juice) in Kayunga and Luwero	1	Mukono ZARDI	• Facilitated meetings and field trips • Trained farmers on agronomic practices. • Contributed to acquisition of processing machinery

Name of MSIP	No. of MSIPs	Institute Responsible	Support provided by NARO
Maize MSIP	1	Mukono ZARDI	
Northern Uganda Local Seed Business Association. (QDS of rice, G.nuts, soya bean-QDS.	1	Ngetta ZARDI	• Training in production and marketing inspection. • Sampling and seed testing in partnership with MAAIF
Potato value chain MSIP	1	Rwebitaba ZARDI	
Bean value chain MSIP	1	Rwebitaba ZARDI	
Karamoja regional agricultural research & development MSIP	1	Nabuin ZARDI	• Coordinating actor meetings. • Disseminating technologies
Nalikonyen seed multiplication MSIP	1	Nabuin ZARDI	• Coordination and bring different stakeholders together • Provision of foundation seed • Capacity building and technical back stopping • Financial support • Tech transfer
Sweet potato seed multiplication MSIP	1	Nabuin ZARDI	• Coordination and bring different stakeholders together • Provision of foundation seed • Capacity building and technical back stopping • Financial support • Tech transfer
Cassava MSIP	1	Abi ZARDI	• Distribution of post-harvest handling equipment • Provision of clean foundation seed for multiplication with LSBs • Funds and venue to facilitate synergy meetings • Training community based facilitators • Business plan development
Apiary MSIPs	3	Abi ZARDI	• Championing on station field demonstrations to learning farmers in the region • Development of Apiary production manual • Training on product development
Integrated Composite Cassava MSIP	1	Abi ZARDI	• Mobilized and profiled the platform stakeholders
Mango MSIP	1	Abi ZARDI	• Beneficiaries trained and equipped with start-up inputs; spray pumps and chemicals, nursery management, and post-harvest handling
Fish MSIP	1	Abi ZARDI	• Trainings conducted for fryer multiplication and feed processing. • Sponsoring farmers during field days. • Showcasing the fish products and other technologies
Total	49 MSIPs		

ANNEX 2: Progress by projects funded under the CGS model 2018/2019

Project code	Project Title	Progress
CCGS/5/01/18	Climate-smart and nutrient-rich income under forage varieties for increased peri-urban dairy and poultry production systems. * Project title changed to "Overcoming nutritional barriers livestock diets in efficient utilization of lablab in."	Nutrient profiling (including level of fermentable carbohydrates and mineral composition) of 25 lines out of the 60 lab-lab seed accessions conducted, anti-nutrient factors (phytate, trypsin & tannin content) of 60 lablab accessions assessed, invitro digestibility of 60 lablab accessions determined, 24 lines have been established at Nakyesasa advanced from the one year data set and a field trial has been, in order to develop lablab fodder with tolerance to animal trampling and grazing pressure.
CCGS/5/02/18	Milk fortification to improve micronutrient status and alleviate common health problems	≥ 50 Plants were collected and assembled, from which 10 were screened for analysis. Proximate composition (MC, Ash, CP, Fiber, Fat) and secondary metabolite composition (Tannins, Phenolics, Flavonols, Antioxidants, Anthocyanins) in all the ten was determined.
CCGS/5/03/18	Enhancing utilization of low tannins drought resilient improved coloured sorghum technologies for increased commercialization in food and feed value chains	A total of 108 germplasm were acquired from ICRISAT Nairobi. These were planted to obtain seed, for further use in the next trial. Twelve (12) lines promising low tannin sorghum lines were selected for advancement, and are currently under NPT evaluation in 10 locations. Five (5) acres of early generation seed has been established and the plants are at booting stage. One processor identified but MoU has not yet been signed. 5 demonstrations were established of which 3 in Kumi, Lira and NaSARRI were managed by NaSARRI and two in Karamoja and Yumbe is managed by our partner IRC. Information materials on improved sorghum have been developed and translated in local languages; these are yet to be printed.
CCGS/5/04/18	Ensuring sustainable food and nutritional security through vegetable breeding in Uganda	A survey to assess the current status of tomato production in Uganda was conducted in the eastern districts of Mbale and Bulambuli. Eight advanced tomato lines imported from Korea were screened against diseases under field conditions; Pruna and Vega were identified to be tolerant to diseases than other lines. Sufficient seed for field screening of 17 advanced tomato lines imported from AVRDC have been realized. Twenty three (23) tomato populations (F3) were advanced (to F4) and evaluated for multiple disease resistance under field conditions at Namulonge. Laboratory analysis of fruit sample is on-going.

Project code	Project Title	Progress
CCGS/5/05/18	Development of Sustainable Innovations for Improved Highland Maize Productivity in Uganda	Twenty three (23) lines were selected from a total of 298 fixed lines at Rwebitaba ZARDI. Lines were obtained from 4 different sources (Kitale, Pool 9, Ecuador, assorted). Thirteen (13) new DT lines; 30 MLN resistant lines requested from CIMMYT, Kenya. The 30 QPM hybrids planted in three locations are currently at flowering stage in Bukwo and Bulambuli, and at grain forming stage in Fort portal. About 100 kg of assorted maize breeder seed produced, and about 150 kg at grain hardening stage at Ikulwe station, Mayuge. These comprise the 76 parental lines, breeder seed of NAROMAIZE 731 & NAROMAIZE 733. 120 F1 single cross hybrids expected following a total of 120 cross pollinations. Seed increase of the 76 inbred lines completed. All the plants in nursery are currently at grain hardening stage. 30 kg of NAROMAIZE 733 produced was supplied to Pearl seed Ltd for foundation seed production.
CCGS/5/06/18	The treasure of microalgae in Industrial effluent management	Preliminary findings of dominant algal bloom species at Napoleon Gulf, Murchison Bay and algal pond at Mabira have been obtained. Physico-chemical environment characterized in the sampled sites has been undertaken. Algal bloom database for Lake Victoria and its basin developed http://nafiri.000webhostapp.com . Algal bloom distribution map for Lake Victoria generated. Three dominant species identified in the sampled areas of Lake Victoria, and one species from sewage algae ponds within its basin. Project awareness has been created through electronic (NTV) and print media (New Vision). A qualitative survey to establish the perceptions of the impact of algal bloom among fishing communities has been done, and has established that Blooms "Mubiru" are attributed to flower farms and lower fish catches and fish spoils is attributed to "Mubiru".
CCGS/5/07/18	Enhancing cocoa productivity through connecting farmers to sustainable strategic research interventions	Forty eight (48) Yeasts samples with ethanol and pectinolyase producing activity were collected and presented for isolation and identification at Makerere University Food Science Lab (CAES). On-station (NaCORI-Kituza) cocoa field rehabilitated of 19.65 acres was undertaken. Training farmers in best coco agronomic practices was done. One vegetative cocoa propagation protocol was developed. One cocoa manual on GAPs and post-harvest handling drafted. Sixty (60) farmers in Bundibugyo trained on GAPs and post-harvest handling practices. Fermentation trials using the single fermentation box done in Mukono district. Single fermentation box determined to be efficient (reduces fermentation time from 7 days to 5 days with fermented bean consistence).

Project code	Project Title	Progress
CCGS/5/08/18	Domestication of Stingless Bees in Uganda	A field survey conducted revealed that stingless bee honey yield is high. Some local names of stingless bees were registered. Seventy two (72) stingless bee samples were collected from Luweero, Wakiso, Kyenjojo, Kabarole, Bundibugyo and Bunyangabu districts. These were sent to the National Museums of Kenya (NMK) for identification. Two species, <i>Meliponula bocandei</i> and <i>M. ferrugenea</i> have so far been confirmed. Seventy two (72) feral stingless bee colonies were observed for: nest structure, ability to survive after transfer to the hive and their possibility for domestication. Five (5) hive prototypes have been designed. One of the prototypes is very convenient for <i>M. bocandei</i> , Other hive designs are being tested. Meliponaries established at Kyembogo (10 surviving colonies) and Nakyesasa (23 surviving colonies). Development of stingless bee products (propolis, honey, pollen) is ongoing.
CCGS/5/10/18	Out-scaling NARO polycyclic aromatic hydrocarbon safe smoking technologies for increased market competitiveness of fish value chain actors	The design work of first prototype of second generation NARO PAH-Safe smoking kiln has been completed. It will be called NAROFIK-3. Just like NAROFIK-2, it will consist of a smoke generation unit, smoke transmission system, smoke filter and dehydration chamber. The inner shell of the dehydration chamber will be made of mainly aluminum and fitted with fat trapping plates. A 30% reduction in production cost of NAROFIK-3 for the same size of NAROFIK-2 has been anticipated. The first prototype of NARO PAH-Safe liquid distiller has been fabricated. The dry run tests have shown that the prototype produces some liquid smoke. However the water distribution mechanism in the distillation column needs improvement before full on-station tests are done. Seven 7 potential entrepreneurs for setting up smoked fish processing enterprises have been identified. Dissemination materials Leaflet, Poster, YouTube https://www.youtube.com/watch?v=e8EEya-KU38&list=PLVJDrn5Y8TuzYFNSiwdYzhqnToguYQrLO&index=3 have been prepared.
CCGS/5/11/18	An instant and nutritional enhanced maize product	A comprehensive survey on maize and maize product markets has been done and a report is in place. A handling and marketing hub has been established with Nakaseke Farmer group. An effective technology transfer model linking the hub, SME processors and NARL Pilot plant for upscaling and out scaling has been developed. Nutrient profiles of maize and potential composite materials have been under taken. Instant Maize-based formulations / protocepts have been developed. Feasible Snack prototypes as a basis for enrichment have been developed and are under test.

Project code	Project Title	Progress
CCGS/5/12/18	Development of potato varieties adaptable to unique environments	Multi-locational evaluations have been done in the different project sites (Kisoro, Kabale and Ruchiga). These have been harvested and presented for inspection to the MAAIF evaluation team. On-station trials for early maturing and late blight traits have been done; plants have been harvested for evaluation. Samples of harvested plants have been presented to a few processors for consumer preference evaluation. Productivity for Kinigi variety starter materials has been assessed, for different in-vitro micro propagation media and mini-tuber productivity. Assessment of the proliferation rates has been done with data analysis on-going.
CCGS/5/13/18	Harnessing the domino effect for transformative technology promotion and outreach	Fifteen (15) researchers from 5 ZARDIs were trained in qualitative data cleaning, transcription and analysis. At least 4 factors that significantly influence systematic adoption of technologies were determined from the qualitative study undertaken.
CCGS/5/14/18	Refurbishment and establishment of the National Forestry Research Laboratories at Kifu, Mukono	Draft architectural designs prepared, however, the two (2) laboratory blocks were not refurbished and the one (1) block for wood science and forest engineering was not constructed. Sixty (60) institute staff were not trained in use and management of laboratory infrastructure. Instead assorted items were delivered to furnish different laboratories for forestry research, these included 53 pieces of equipment, and the second lot is under clearance
CCGS/5/15/18	Establishment of a general screen house capacity (pathology, drought resilience and breeding)	Construction of screen house (96000X28800 sq feet) for Germplasm Characterization, Drought (Moisture Stress) Screening, and soil fertility (Plant Nutrition) Screening was undertaken.
CCGS/5/16/18	Extending Biological Control of Kariba Weed in The Infested Water Bodies (Kyoga, Nile & Albert Complex) of Uganda	Two (2) community sensitization workshops were held in districts surrounding Lake Kyoga (Kaberamaido and Amolatar) so as to integrate communities in the biological control of Kariba weed. Number of lakeside weevil rearing units constructed and maintained. Procurement of construction materials (angle bars, rolls of chain link wire, galvanized wires and fertilizers) for one additional rearing facility in Apac district has been completed. Breeding stock comprising of 5,000 adult weevils were maintained in rearing tanks at Namulonge.
CCGS/5/17/18	Developing Sustainable Options for Control of Red gum Lerp Psyllid and Bronze bug Eucalyptus Pests in Uganda	Bio-agents were provided by FABI in January 2019, after a dossier was submitted to MAAIF for a phyto-sanitary certificate for the importation of <i>C.nockae</i> . A protocol to guide importation, rearing, release and post release monitoring of establishment, parasitism levels and dispersal of <i>C.nockae</i> was developed. The parasitoid has been dispersed to over 250 km in two years and reduced the <i>G. brimble combei</i> populations by 30 – 57% in the sites where releases were made.

Project code	Project Title	Progress
CCGS/5/18/18	Title changed to: "Strategic mechanisms to advance resilient Tilapia (SMART) in Uganda: Developing diagnostic capacity for emerging aquatic diseases	Five (5) fish farms were surveyed in Mukono, Buikwe and Wakiso districts with 80 fish screened for aeromonas hydrophila and TILV using selective media, in order to assess presence of emerging aquatic pathogens. 50%: passive epidemiological surveys conducted mainly 42 land-based fish farms in eleven districts. 331 fish samples screened for bacteriology and 29 fish preserved in RNA later (-20oC) for screening for viruses (TILV & ISKNV). Characterized one pathogen (Edwardsiella tarda). In vivo assays were conducted to determine the efficacy of Plant N extracts as a growth promoter, immune-stimulant and prophylaxis against pathogenic Aeromonas hydrophila in Nile tilapia. Built capacity to diagnose/detect Tilapia Lake Virus. Fish farmers sensitized on fish health management. Designed bills of quantity for the diagnostic laboratory. An algorithm for fish diseases has been incorporated in a mobile app (AgroMarketing Day: http://www.agromarketday.com/ - and MoU signed with company), for effective linkages between key stakeholders in the aquaculture.
CCGS/5/19/18	Towards an effective M&E system in NARO	Inception and Stakeholder meeting held in April 2019, where stakeholders got an in-depth understanding of the project and the components of an effective M&E system, project proposal was refined in relation to expected outcome, NARO strategic agenda and the national development goal. Twelve (12) M&E components identified and the project implementation plan was reviewed and refined.
CCGS/5/20/18	Commercialization of Nile perch oil Products	Protocols for Nile perch fat transportation, Nile perch oil extraction, and physical chemical characterizations developed. Nile perch oil has been extracted, purified and stabilized. Physical characteristics and major chemical profiles of Nile perch oil have been established.
CCGS/5/21/18	Improvement of Landrace Sorghum 'Godo' and Enhancing Adoption of Newly Released Sorghum Varieties in the West Nile Agro-Ecological Zone	Process of phenotyping 996 F3 crosses is ongoing at Abi ZARDI, genotyping for 94 land races has been initiated, extensive germplasm collection was done for the land races, mapping the distribution of land races in the West Nile region is ongoing. Establishment of crossing block with key land races has been initiated. Four groups of seed business farmer to produce, package and market already released sorghum seed were identified and profiled. Two of the groups have started production of QDS.

References

1. ATAAS Project Efficiency. Excerpt of the Independent Evaluation Group (IEG) Implementation Completion Report (ICR) Review UG-ATAAS (P109224). Report Number: ICRR0021593
2. Christopher.C. (2019). 'NARO awards biotechnology essay-writing winners'. The New Vision, 19th April. Available at: <https://www.newvision.co.ug/news/1498873/naro-awards-biotechnology-essay-writing-winners>. Accessed: 5th May.
3. MandiPlus Stakeholders' workshop report. Uganda, Kampala. 2018. September 20-21, Gerald Adiga^{1*}, Titus Alicai¹, Charles Liri¹, Phillip Abidrabo¹, Stephen Angudubo¹, Paula Adoch¹, Julius Baguma¹, John Bosco Okori¹, Saulo Alves Santos de Oliveira², Eder Jorge de Oliveira², Caroline Otto³ and Dominik Klauser³. Effectiveness of "Mandiplus" cassava seed piece treatment in improving the rate of cassava seed production in Uganda Conference poster.
4. The biennial NARO-Mak Joint conference and the first Feed the future Innovation Lab for Nutrition Annual Scientific Symposium 2018 report.
5. The NARO Strategic Plan 2018/2019 – 2027/2028.

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