



NATIONAL AGRICULTURAL RESEARCH ORGANISATION

*Co-ordinating, Overseeing and Guiding
Agricultural Research*

2015/2016 ANNUAL REPORT



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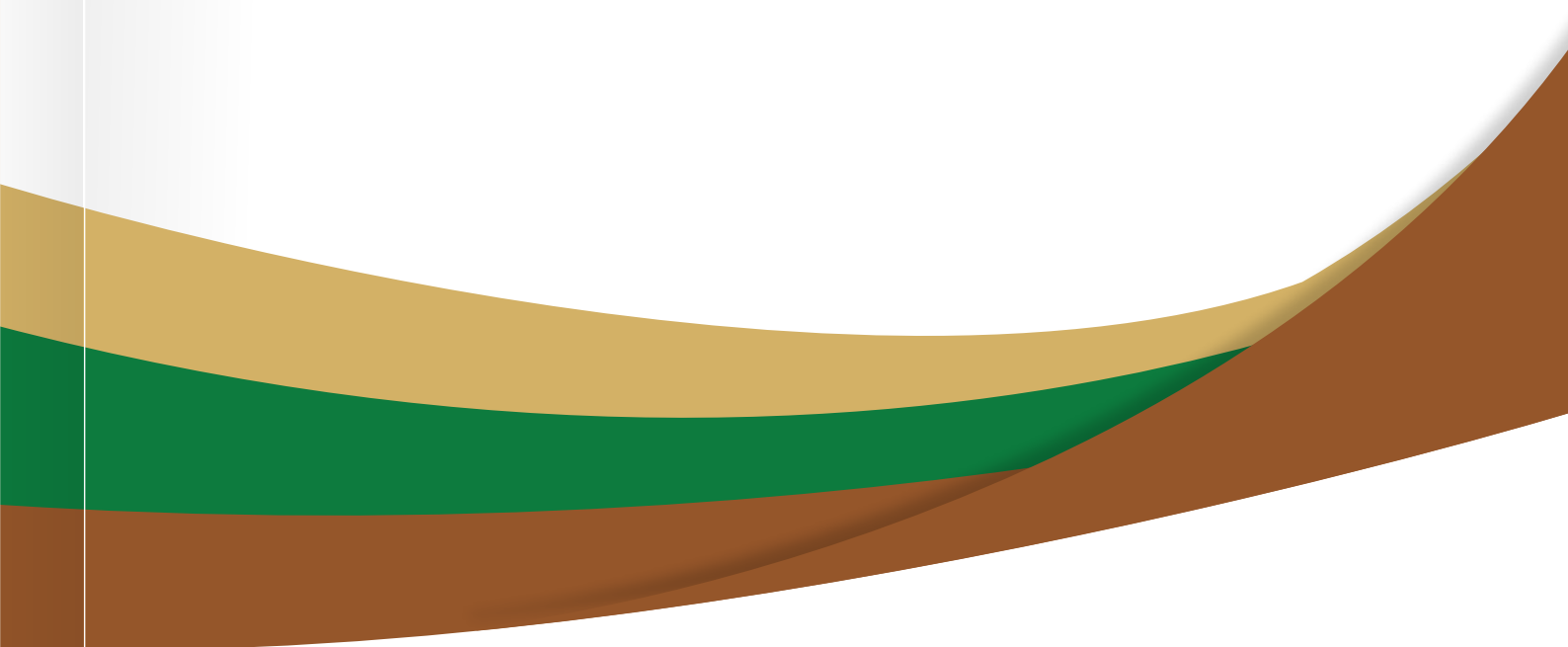
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National Agricultural Research Organisation (NARO) is the apex body for guidance and coordination of all agricultural research activities in Uganda. It is composed of 16 public agricultural research institutes spread all over Uganda, both at national 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 market responsive, client-oriented and demand-driven national agricultural research system.

Mission

To generate and disseminate appropriate, safe and cost effective technologies.

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

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Word from Chairman of NARO Governing Council

NARO's mandate is generation and promotion of Technologies, Innovations and Management Practices (TIMPS) in crops, livestock, forestry and fisheries sub-sectors. Furthermore, agricultural research integrates indigenous knowledge (IK) with modern scientific methods in addressing the challenges of biodiversity conservation, characterization and bio-prospecting.

The Governing Council has approved a number of policies and strategies that have provided direction to agricultural research.

NARO's collaboration and partnership with development partners, NGO's, Government Agencies, farmers and farmer groups continued over the past year and will do so for the foreseeable future.

We gratefully appreciate the support and participation of the district local governments where NARO's institutes are located.

T h e

districts are our key partners and provide favourable environments for uptake of agricultural technologies and innovations.

I thank the Government of Uganda and Development Partners for supporting agricultural research in this country. The support has enabled National Agricultural Research Organization (NARO) to contribute meaningfully to sustainable agricultural productivity, economic growth, food and nutrition security as well as poverty eradication in the country.

Lastly, I thank the scientists, technicians and support staff for a job well done in the last reporting year. We did not experience any challenges that curtailed the activities. We look forward to another successful year in 2016/17.



Prof. Joseph Obua
CHAIRMAN,
NARO GOVERNING COUNCIL



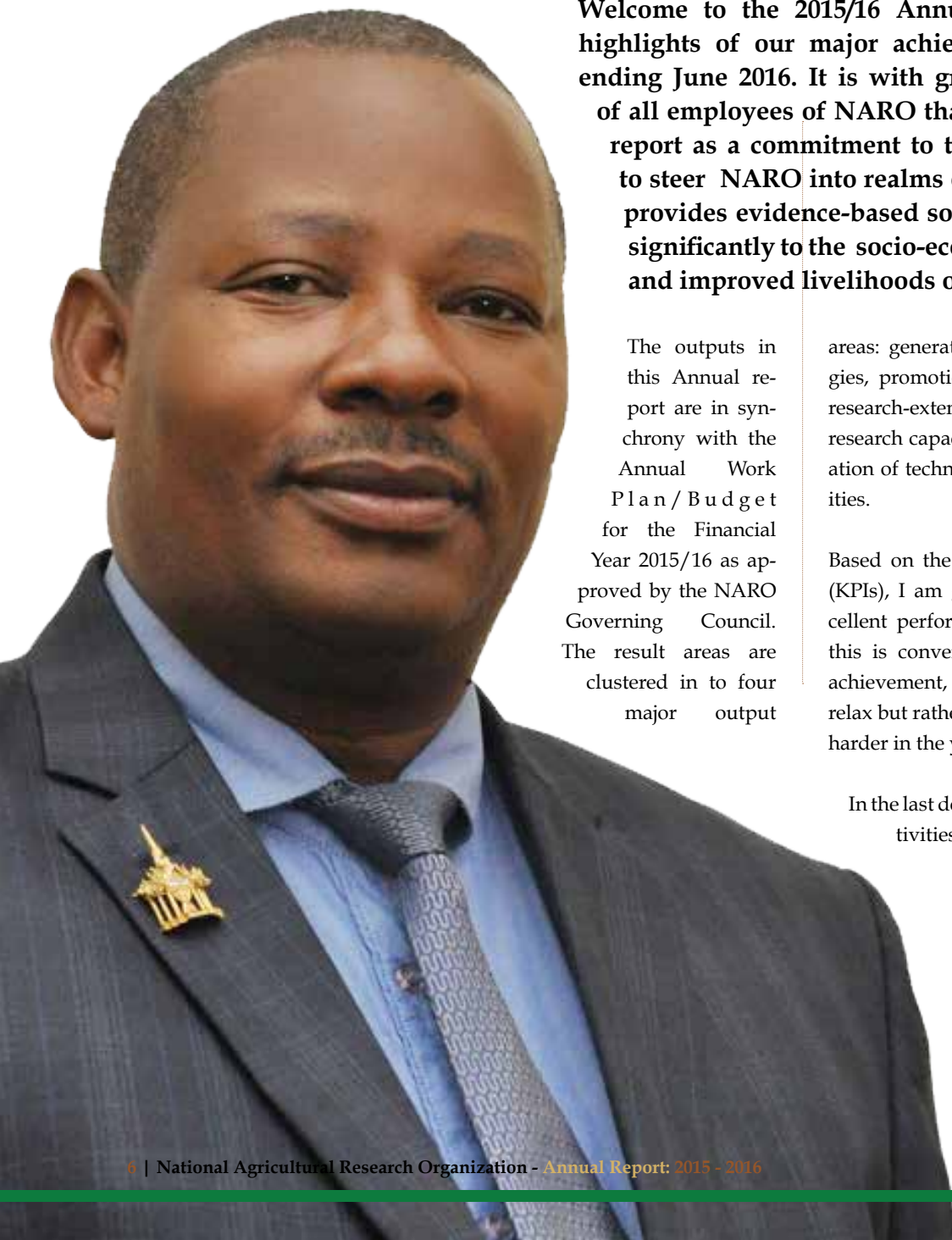
The Governing Council has approved a number of policies and strategies that have provided direction to agricultural research.

Members of the 3rd NARO Council (2012- Oct 2015)

Representation	Names
Eminent Scientist	Prof. Joseph Obua
Farmers (UNFFE)	Ms. Monica Kabatooro
Farmers (UNFFE)	Mrs. Victoria Kakoko Sebagereka
Farmers (UNFFE)	Mr. Jimmy Besigye
Farmers (UNFFE)	Mr. Patrick Cheborion
Private Sector	Dr. John Bahana
Uganda NGO Forum	Mr. Richard Ssewakiryanga
Universities	Prof. David Kabasa
Public Agricultural Research Institutes	Dr. William Wagoire Wamala
Private Agricultural Research Providers	Dr. Theresa Sengooba
Uganda Local Government Authority (ULGA)	Mr. Harun Mawanda
Permanent Secretary- MAAIF	Mr. Komayombi Bulegeya
Permanent Secretary- MoFPED	Mr. Titus Kajura
Director General	Dr. Ambrose Agona
Executive Director - NAADS	Dr. Samuel K. Mugasi
Executive Secretary - UNCST	Dr. Peter Ndemere

Foreword by the

Director General



Welcome to the 2015/16 Annual Report that gives highlights of our major achievements for the year ending June 2016. It is with great honour on behalf of all employees of NARO that I present to you this report as a commitment to the trust in our ability to steer NARO into realms of modern science that provides evidence-based solutions and contribute significantly to the socio-economic transformation and improved livelihoods of our target clientele.

The outputs in this Annual report are in synchrony with the Annual Work Plan / Budget for the Financial Year 2015/16 as approved by the NARO Governing Council. The result areas are clustered in to four major output

areas: generation of agricultural technologies, promotion and strengthening of the research-extension interface, agricultural research capacity strengthening and generation of technologies for priority commodities.

Based on the Key Performance Indicators (KPIs), I am glad to report to you an excellent performance in all areas. Whereas this is conventionally a very satisfactory achievement, we do not see it as reason to relax but rather as an impetus to work even harder in the years to come.

In the last decade, we have aligned our activities towards the Integrated Agri-



The Governing Council has approved a number of policies and strategies that have provided direction to agricultural research.

cultural Research for Development (IAR4D), a research paradigm that seeks to ensure that research does not only lead to knowledge and publications, but translate into tangible impact for the farmer. We endeavour to solve critical agricultural challenges for increased productivity and ultimate socio-economic transformation of Ugandans.

In the year 2015/16 we made breakthroughs with potential to increase efficiency, effectiveness and impact of our efforts to meet the ambition of SDG 2030 agenda and we have created benefits for our people, the economy and the environment.

We developed superior technologies with farmer preferred traits that are high-yielding, nutrient enhanced, disease and pest resilient, and climate smart responsiveness, among

others. With these, we have successfully cultivated and contributed to food and nutrition security, employment, and wealth creation.

We wish to thank the Government of Uganda, development partners and other collaborators for the support and, the NARO Governing Council for the guidance throughout the financial year.

I wish you a good reading!



Dr. Ambrose Agona
**Director General,
National Agricultural Research
Organisation**

Members of NARO Top Management 2015-2016

NAMES	POSITION
Dr. Ambrose Agona	Director General, National Agricultural Research Organisation
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
Mr. William Amigo	Ag. Head, Internal Audit

2015/16 HIGHLIGHTS

Agricultural technologies

86

Improved productivity technologies generated

Staff emoluments

UGX3.5 Bn

Staff salary increment approved

Research studies

66

Research studies conducted under competitive grants scheme

Training & capacity building

55

Staff were sponsored for PhD and 29 for Masters Courses with the support from Government of Uganda and Projects; EAAPP and ATAAS.

Varieties released

46

New varieties submitted to Variety Release Committee

Physical Infrastructure

Infrastructure developed in the Institutes through the support of EAAPP and ATAAS Projects

Innovation platforms

44

Technological Innovation Platforms (TIMPS) established





A happy farmer showing a good harvest of groundnuts. In FY 2015/16, NARO submitted for release two improved groundnut varieties, namely; DOK IR and DOK IT.

Chapter 1: Technology Generation

NARO generated a total of 86 agricultural improved productivity technologies for dissemination, submitted 46 new crop varieties to the Variety Release Committee and undertook 66 research studies under the competitive grants scheme. This chapter highlights notable achievements made in the various subsectors such as crops, livestock, forestry, fishing and other research activities.

➔ Crop sub-sector

In line with subsection (iii) of the second objective of the National Agricultural Policy (NAP 2013); that of generating, demonstrating and disseminating appropriate, safe and cost effective agricultural technologies, this section highlights achievements made in crop improvement technologies in the FY2015/16.

1. Oil Palm

Oil palm (*Elaeis guineensis* Jack) is among the priority crops promoted in Uganda to increase domestic vegetable oil production and its by-products. Oil palm is a priority crop in vegetable oil production because it yields the highest edible oil per unit area compared to other oil crops. Since 1972, research has been at forefront in promoting oil palm production through introduction of oil palm hybrids which were studied comprehensively.

In 1990s, comprehensive yield studies of oil palm fresh fruit bunches at Kituza revealed that at 11 years of growth without any soil amendment yields ranged between 14 to 17 MT per hectare per year. These results demonstrated that commercial oil palm production was viable in Uganda. The success of these oil palm research trials contributed a great deal to the current investment of 6,440 hectares by Oil Palm Uganda Limited (OPUL) and 4,424 hectares by out-growers in Kalangala district.

Research boosts oil palm production

In order to sustain 10,864 ha oil palm investment in Kalangala, NARO has continuously undertaken physiological, agronomical and pathological studies to address oil palm

production constraints that hinder the realization of full potential out of the oil palm investment. Such studies are providing strategic solutions that are expected to increase oil palm yields from the current average yield of 12 MT per hectare per year to 20 MT per hectare per year by 2025.

In the last nine years, oil palm adaptive trials which were established in Masaka, Mayuge, and Buvuma and Kibaale districts.

The adaptive trials have provided the much needed oil palm production suitability information which has led to earmarking of Buvuma and the lake shore districts of Mayuge and Masaka for oil palm production to begin in 2018.



Oil palm nursery in Kalangala District. NARO has undertaken various studies to address oil palm production constraints.

2. Beans

Approximately 85% of the 18 million rural Ugandans grow and depend majorly on beans as food and for income generating purposes. For this reason, NARO continues to support bean research and development through the following initiatives;

First suite of high-iron beans to address nutrition deficiencies released

Beans are a key source of zinc and iron, which are important micro-nutrients for prevention of anaemia in expectant mothers and new-born infants. Deficiencies of zinc and iron are currently controlled by supplementation, which involves provision of iron and zinc rich tablets to the target population, but this strategy is expensive and less sustainable to impact a large number of venerable people in rural areas. A cheap and effective alternative would be consumption of common foods with high levels of these micro-nutrients.

To that effect, NARO released nutritious bean varieties which were bred for high levels of iron and zinc. The varieties (Nutri-beans) NAROBAN 1, NAROBAN 2, NAROBAN 3, NAROBAN 4C and NAROBAN 5C can yield up to 2,200 kg/ha (for bush varieties) and 3,700 kg/ha (for climbers). These varieties are expected to provide a cheap and ready alternative source of micro nutrient nourishment to the most vulnerable communities, which is often dominated by the rural poor.

The new bean varieties have also been recognised as a key component in the Uganda Anaemia Prevention and Control Strategy – with the overarching goal of reducing maternal and new born anaemia in Uganda. Some of the strategy's key objectives include improving practices and services that enhance intake of iron and associated nutrients.

Introducing pre-cooked beans to improve food and income security

Many People who prefer 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 precooked bean product whereby dried beans are pre-cooked under pressure, dried, packed and stored.

That will see consumers cook beans for only 15 minutes, as opposed to hours, before serving. This precooked 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 United Nations 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 market for bean growers while improving nutrition of the consumers.

To realize multiply and supply specially selected bean varieties to pre-cooked bean processing plants, a total of 76 farmer groups with a membership of 3,092 farmers have already been profiled from 10 districts which will generate incomes and enhance the capacity of beans production in the country.



A woman winnowing beans. NARO has generated and disseminated a number of bean varieties to meet the various needs of the consumer.

3. Plantain Banana

Banana in Uganda is mainly cultivated by small holders with mean on-farm productivity of 10tons/ha/yr; way below the crop's attainable yield on Research stations of 60tons/ha/yr while simulation data estimates that it is possible to produce at 130tons/ha/yr. This is due to a combination of on-farm production constraints including soil nutrition and water stresses, pests and diseases. The millions of Ugandans depending on banana will not get out of subsistence agriculture if their levels of productivity remain this low.

Four matooke hybrids with resistance to key pests and diseases and improved fruit quality developed

The four matooke hybrids (M30, M31, M32 and M33) are in advanced stages of release. Earlier reported as NABIOs, they have high resistance to black Sigatoka pest, high yielders and have some better acceptable traits to consumers than local landraces such as Mb-wazirume.

A total of 41 new banana hybrids were selected from about 2500 new banana genotypes that were established in Early Evaluation Trials (EETs) at NARL-Kawanda during this reporting period and are being bulked for Preliminary Yield Trials (PYT) establishment (Annex 1).

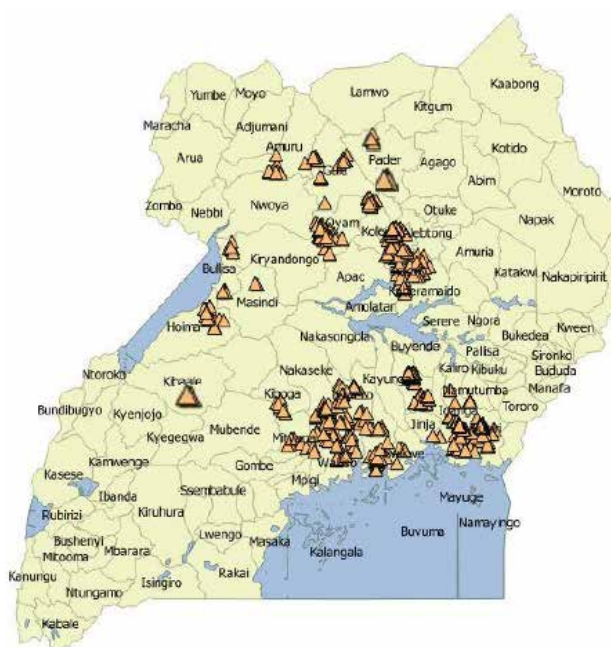
This is the biggest selection so far made from a matooke EET, with a good number of hybrids acceptable to the consumer as the local land race 'Mb-wazirume' at that very early stage of development. It implies that the breeding pipeline is starting to chun out matooke hybrids at a faster rate and that NARO banana hybrids will in future be more acceptable to the consuming community.

Brazilian dessert bananas introduced in the country

From the EMBRAPA dessert bananas introductions, two varieties; Victoria and Princess expressed good level of resistance to Fusarium wilt race1 disease at Kawanda and were acceptable to consumers (See Table below).

This once released will add to the profile of the available dessert bananas resistant to Fusarium wilt.

Distribution of banana hybrids in the four regions of Uganda



Contribution of banana hybrids to household income



Performance of introduced dessert bananas

Genotype	FOC severity score	Bunch weight (kgs)	General consumer acceptability
BRS Caprichosa	0	9.0±1.0	2.5±0.2
BRS Garantida	0	8.3±1.2	2.5±0.2
BRS Pacovan	0	8.4±0.4	2.6±0.1
BRS Platina	0	11.3±1.8	2.7±0.2
Prata_Nyerere	3	6.9±0.3	2.9±0.3
Silk	3	6.3±0.3	3.8±0.3
BRS Princesa	0	7.8±0.3	4.8±0.3
BRS Victoria'	0	8.3±0.5	4.6±0.5
Sukali Ndiizi	4	5.3±0.8	4.6±0.3

FOC severity scale; 1 = no discoloration, 2 = 1-15% discoloration, 3 = 16-33% discoloration, 4 = 34-50% discoloration, 5 = more than 50% discoloration

Consumer acceptability scale; 1=Extreme dislike, 2= Dislike, = 3= like moderately, 4 = like, 5 = Extreme like



Banana plantlets in a Greenhouse at the National Agricultural Research Laboratories (NARL), Kawanda.

The programme is also developing transgenic bananas with enhanced levels of Provitamin-A (PVA) and BXW transgenic resistance. In Uganda, vitamin A deficiency (VAD) is one of the major public health problems with between 15-32% of children under five years of age and expectant mothers.

NARO, in collaboration with Queensland University of Technology, has proved that phytoene synthase genes from *Asupina* relative of banana elevate PVA levels that sufficiently address VAD.

Integrated technologies for Banana Bacterial Wilt (BBW) control developed

In the reporting year, Banana Bacterial Wilt disease (BBW) was effectively controlled and most of previously affected fields were revamped in at least 60 districts. This translated into banana production recovery of 72% on previously affected fields, an equivalent of UGX 350billion by the November 2015. Banana Bacterial wilt (BBW) was first reported in 2005 in South-western Uganda, the region that produces more than 60% of Uganda's bananas annually (Kalyebara, *etal.*, 2006).

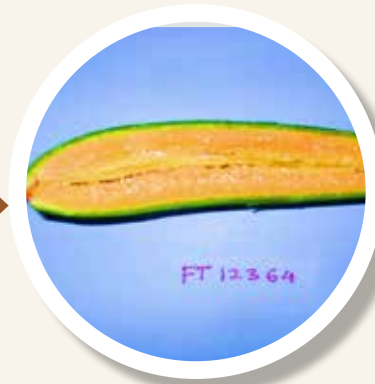
Transgenic M09 BBW resistant lines being prepared for planting CFT in product development phase.

FT12
350



71 $\mu\text{g/g}$ DW;
12.5 Kg;
pGen2-M

FT12
364



84.86 $\mu\text{g/g}$ DW;
11 Kg;
pGen2-P

Nakitembe lines have with PVA levels greater than 20 $\mu\text{g/g}$ dry weight and bunch weight greater than 10kg

4. Rice

The Agricultural Sector Strategic Plan (ASSP 2015/16 - 2019/20) targets to Increase rice productivity from the current 2.5 MT/Ha to 4 MT /Ha by strengthening research to produce pre-basic and basic seed. Here below are highlights of achievements in rice research as of 2015/2016 financial year.

Rice production up-scaled

Three rice varieties; NAMCHE 1, NAMCHE3 and NERICA have been deployed for large-scale with Vinayak Agro-Farm in Nwoya district. Total area planted was 1,200ha (3,000 acres). Two farmer groups in Alebtong and Doho districts were also supported with four sets of labour saving, drudgery reduction and processing equipment. These include; Walking tractor, Reaper, Thresher and milling equipment.

PRiDe project boosts rice seed production

PRiDe project provided technical backstopping for the production of quality rice seed in five zonal agricultural research and development institutes in Uganda. This was a complementary effort towards building the capacity of the agricultural scientists, extension workers and farmers for participatory rice research. As of June 2016, the project had produced a total of 38.2 tons of quality rice seed, surpassing the initial target of multiplying 10 tons of rice per year by October 2016.



Director Ngetta ZARDI, Dr Laban Turyagyenda (C), Christine Adong (2R) of Integrated Seed Sector Development and some members of Latyeng Farmers Group celebrating the bountiful rice harvest in Bungatira Subcounty, Gulu District.

5. Cassava

Cassava, which can grow well on marginal lands, is one of the most important staple foods in Uganda. It is estimated that 60% of the production is destined for household consumption and 40% for marketing (Kimathi, et al, no date). Sometimes known as a “poor man’s crop”, cassava is predominantly grown by subsistence farmers as a staple crop on plots averaging 1 to 3 acres, Mugisa (2010). However, the trend is changing and as shown in this report, cassava is becoming a leading commercial crop of high industrial value.

Two improved cassava varieties released

In the reporting period, NARO released two cassava varieties: NAROCASS1 and NAROCASS2 that are highly tolerant to cassava brown streak disease and resistant to cassava mosaic disease and with yields of 30-35 tons ha⁻¹. A summary of key attributes of the two varieties is tabulated below;

VARIETY: NAROCASS1	VARIETY: NAROCASS2
Maturity: 12 months	Maturity: 12 months
Field longevity: 3 years	Field longevity: 3 years
Av. No. of tubers/stool: 8-28	Av. No. of tubers/stool: 6-22
CMD: Resistant	CMD: Resistant
CBSD: Tolerant	CBSD: Tolerant
Yield: 35-45 Tons/Ha	Yield: 25-35 Tons/Ha
Dry matter content: 38%	Dry matter content: 39%
Starch yield: 28%	Starch yield: 32%
	

The drills have indeed led to a noticeable improvement of cassava seed pathways (chains); producing 13,545 bags of pre-basic seed (breeder), enough to plant 50 ha (125 acres) of basic/foundation seed in the reporting year.

Capacity of cassava seed producers boosted

The capacity of seed producers/entrepreneurs from the districts of Arua, Soroti, Amuria, Kamwenge, Kabarole, Nakasongola, Kiryandongo, Mukono, Lira and Apac was built in the various aspects of quality seed production.

Biodegradable poly-films developed from cassava

The newly-enforced ban on thin plastic bags in Uganda is creating market for biodegradable poly-films that can be shape into bags, mugs, handbags and phone covers, among others. Bags made from these poly-films are also known for being safe for food packaging and preservation.



Members of Njimile Farmer Group in Vura sub county, Arua district pose for a group photo with NARO scientists during Participatory Variety Selection (PVS). NARO has released two improved cassava varieties in the 2015/16 Financial Year to add into the basket of collections to meet various user-needs.

biodegradable poly-films

By Lominda Afedraru

Cassava is mainly used as a food crop for many who grow and those who consume it in the eastern, northern and central parts of the country. But, this is changing as some farmers are processing fine flour from cassava for supply to industries that make confectioneries.

Other uses

In other parts of the world, there are various non-food uses for cassava. It is applied in manufacturing of paper, textiles, medicines and adhesives, among others. Scientists at National Crops Resources Research Institute (NaCRRI) in Namulonge are making biodegradable plastics from cassava via a method known as bioprocessing. Ephraim Nuvamanya, a scientist involved in the experiment, says they use the tubers and peels of the bitter cassava variety.

It is being carried out under Eastern Africa Agricultural Productivity project (EAAP) in conjunction with University College Cork in Ireland.

Reduce cyanide

The reason for the focus on bitter cassava is that it is neither consumed by human beings nor animals. It has a sizeable amount of cyanide thus unsafe for consumption. This particular type is grown in most parts of West Nile and western Uganda in areas bordering Rwanda. "Cassava consumers have tried to boil and ferment bitter cassava but it is still not good for human and animal health, this is the reason why we think it is good to utilise in biodegradable plastic products," Nuvamanya said.

"We are using a technology which is not sophisticated but we need a technique, which will enable us rupture all the cells in the bitter cassava and destroy the cyanide."

Alternative methods

Dr Steven Tumwesigye from National Agricultural Research Laboratories (NARL), who wrote a paper on processing of bitter cassava for packaging material, points out that bitter cassava cultivars have been utilised as an emergency food and less as alcohol, flour and

starch. The traditional methods applied in transforming roots into dried products had been a factor in low-value products and negative environmental impact.

This means an alternative for improved human safety and minimised environment impact is needed.

This is the basis for exploring the use of bitter cassava to produce biodegradable polythene paper in a bid to steer our agriculture from low-productivity enterprises to high-productivity commercial production.

Bitter cassava which has lasted in the field between 12 to 18 months is most appropriate. "Both unpeeled and peeled roots are processed in two stages; mechanical tissue rupture and biopolymer release and recovery in order to obtain biopolymer powder to complete the entire process," Dr Tumwesigye says. "Findings show that using both peeled and unpeeled roots has a positive impact in reducing the cyanide in bitter varieties."

Environmental concerns

Application of sodium chloride also has a significant influence on the ratio in both the lined film product and in the interaction with

peelings. The experiment therefore means bioprocessing has a high chance of protecting the environment because of its indirect way of minimising waste.

Cassava as the main component in making packaging material is a unique one in eastern Africa. It is particularly important for cassava communities, which are exposed to environment-based dangers caused by bitter cassava.

The process

Ephraim Nuwamanya, who is part of the research to make biodegradable plastics from bitter cassava, explains the process: We get cassava root mainly from bitter cassava variety, crush it in order to obtain powder containing starch, protein, fibre and vitamins. We mix this powder in water in the presence of sodium chloride, heat it and we get a paste out of it which is passed through a machine called thinner to make a film-like lining. It is then put in an oven to dry to make polythene, which is put in a silk gel and later dried. The product is what can be used to shape into a bag, mug, handbag and phone cover, among others.

The Daily Monitor, August 27, 2014.

Ultra-modern cassava flash dryer established in Apac

Following the overwhelming uptake of improved and high yielding varieties of cassava in northern Uganda, the farming communities are already reaping the benefits of a flash dryer with capacity of processing tons of fresh tubers into quality flour. Established in Apac district, the flash dryer is a state of the art machine designed to dry wet cassava mash extracted from the cassava graters into

High Quality Cassava Flour (HQCF) within three minutes ready for human and commercial use. The technology was introduced to investors of Wind Wood Millers Limited and Adyaka Wholesalers Limited in Lira and Apac districts, Northern Uganda, under the Cassava Adding Value for Africa- Phase Two (CAVA II) project implemented by the Africa Innovations Institute (AfriII).

Case 2: The contribution of cassava to industry

Outcome of cassava research resulted into large-scale commercial ventures in the beverage industry: Kamtech Logistical Uganda Ltd produces 1.2 million litres of ethanol per annum; and 25,000 litres of Engule beer per week. The director of Kamtech Logistical Uganda Ltd Bobby Arecha says they have invested over US\$1.6M into the plant to process 150 tons of cassava daily which produces 4,000 litres of ethanol.

"We produce only 10 percent of what government requires and

getting more actors in the business will go along away in implementing government's efforts and also reduce on its cost of importing ethanol," he says.

Found in Barlwala village, Adekokwok sub-county in Lira district, the company buys cassava chips from 8,000 farmers from Teso, Lango, Bunyoro, Acholi and West Nile. The company also employs 65 workers including scientists and chemists and it hopes to increase the number in the near future.

6. Potatoes

Potato is an important food and cash crop in Eastern and Central Africa. The increasing population figures in the region and high rate of urbanization have increased the potato demand. Despite its importance, farmers are frequently faced with several challenges that are related to lack or shortage of consumer-preferred good quality potato seed. On realizing these challenges, researchers are continually working to improve the potato seed system and varieties suitable for the various potato products and markets.

Three high yielding *Solanum* potato varieties released

Three high yielding *Solanum* potato varieties have been released in the 2015/16 Financial Year, namely; NARO-

POT1, NAROPOT2 and NAROPOT3 with yields of 28, 24, and 21 tons ha⁻¹ respectively. A total of 1.3 tonnes of pre-basic seed of the improved varieties have been availed to the different uptake pathways.



NAROPOT1

Tolerant to late blight

Yield: 28 t/ha



NAROPOT2

Resistant to late blight

Yield: 24 t/ha

Maturity: 100 days



NAROPOT3

Resistant to late blight

Yield: 21 t/ha

Maturity: 30 days

7. Tea

A few years ago Tea companies based in Uganda used to cross the borders and part with over US\$ 8,340 (approximately UGX 30) to import a single tea clone considered to have superior qualities for multiplication and dissemination. Once here in Uganda, individual farmers would equally part with handsome amounts of money to procure the clones from the tea estate managers so that they could produce quality tea that was marketable both locally and globally. This ostensibly expensive endeavour was dictated by the fact that the estate managers and farmers did not know which tea clones they had in their possession in order to produce quality seedlings. They had to rely exclusively on screened clones from a foreign country.

Indeed that was in the past. When Rwebitaba ZARDI was created in 2011 it took over the then Rwebitaba Tea Research Centre in Kyenjojo District to ensure that best clones are correctly identified, multiplied and disseminated to farmers and other tea nursery operators. Through a programme dubbed; quality tea production through early stage appraisal for seed system in Uganda, the country's Tea industry has been given a significant boost.

Thousands of priority tea clones availed to farmers

The tea programme has between 2013 and 2016, availed a total of 3,990,220 cuttings of priority tea clones, namely; 6/8, 31/8, 108/82, 100/5 and 303/577 to 10 nursery operators and 6 large scale tea farmers in Kabarole and Kyenjojo districts to raise 1,245,850 tea plantlets for supply to tea farmers under NAADS and Operation Wealth Creation. Plantlets raised from these cuttings have been planted on over 440 hectares. There is a direct correlation between the increased national acreage in tea production from an estimated 28,000 hectares five years ago to 35,000 hectares now with the interventions by NARO - Rwebitaba tea program.



Tea nursery bed at Rwebitaba Zonal Agricultural Research and Development Institute.

8. Coffee

In the Marketing Year (MY) 2015/2016, Uganda had a record production of 4.5 million bags after recovering from a drought in 2014/2015 (UCDA, GTA 2016). The government has since embarked on production enhancement programme that is being implemented by Uganda Coffee Development Authority (UCDA). The program's activities include promotion of improved varieties, streamlining of farm inputs supply, and the revamping of agricultural extension services. NARO has contributed significantly towards this programme as explained in the proceeding sections.

Three improved coffee varieties recommended for release

In 2016, NARO through the National Coffee Research Institute (NaCORI) recommended for the release and commercialization of three high-yielding and disease tolerant lines of Robusta coffee varieties, (3/15/1, 245/21/5 and NFCT3). Some of the key attributes of the varieties are; high yields (7.12, 5.45 and 4.65 t/ha⁻¹ respectively), good sensory taste and large bean size, among others. The intervention was aimed at sustaining the increasing demand for Robusta coffee production, and catering for

the farmer concerns in the diverse ecological areas in the country. See **Annex 2** for Cost benefit estimates for Arabica coffee in Uganda.

Integrated Pests and Disease management package developed

The Black Coffee Twig Borer (BCTB) is one of the notorious insect pests affecting coffee production in Uganda. Findings from a 2016 study on BCTB conducted by NaCORI in Robusta growing regions, showed that Uganda loses about 9% and total national output for coffee amounting to US\$50 million in



Ngetta ZARDI Farm Manager, Mr. Apele Bushira, showing robusta coffee mother garden at the institute.



Candidate lines for release: 3/15/1 (Top), 245/21/5 (Middle) and NFCT3 (Bottom)

annual export earnings due to the pest. To manage BCTB, some coffee farmers use chemicals and cultural options, which often involve high costs, enormous labour and time. In 2016, scientists at NaCORI designed a modified integrated pest management (IPM) package incorporating BCTB trapping technology named “**Uganda BCTB Trap**” and is ready for dissemination to coffee farmers. The BCTB uses locally available materials, and traps between 20-30 beetles every two weeks.

This strategy has been promoted in the diverse Robusta coffee growing region. It has been successfully adopted by farmers in

the central region particularly in the greater Masaka sub-region. A 2016 survey done by NaCORI shows that BCTB damage has generally declined in the central (4-fold), particularly in Masaka (34-fold) and Rakai (18-fold) districts.

This decline is attributed to increased effort of using NaCORI’s recommended management options by the farmers – central (56%), Masaka (80%) and Rakai (100%). Farmers are also being encouraged to use other pest management options such as planting recommended shade trees, remove suckers and un-productive primaries, among others.



The BCTB Trapping Technology

Description of “Uganda BCTB Trap”

- Non-coloured water-bottle
- Ethanol lure concentration of 30% in dispenser vials
- Traps placed at lower two-third of tree canopy
- Trap density of 15 traps/ha of coffee
- Trap placement at beginning of the rainy season
- Replenishment schedule for dispensers at every other two weeks

CWD Diagnostic Kit developed

A tool kit and protocols for laboratory and field detection of CWD was developed. The kit diagnoses CWD pathogens in latent stages in both planting materials and soil. The innovation will help coffee farmers test for CWD in soil and plant parts. Early detection of CWD in these materials enhances its prevention and management, especially in coffee nurseries and new coffee establishments. The kit is ready for evaluation.

Effect of shade trees on coffee yield and quality quantified

As part of the campaign to improve coffee production and productivity, NaCORI embarked on a study to understand the underlying factors influencing performance of coffee trees under the different shade tree species. In the first year of the study, an assessment taking into consideration the morphological characteristics, yield indicators and quality of coffee under different shade tree management treatments for eastern zone revealed that: shade tree species: *Ficus ovata*, *Cordia Africana* and *Albizia coriaria* are best-choice shade-trees in Elgon Arabica zone due to increased yields and out-turn and better quality (bigger bean size).

Relatedly, on the use of shade tree species to address diverse soil nutrient deficiencies and malfunctions in coffee plantations, preliminary quantification of the effects of shade trees in the Mt Elgon area during the first year of a projected four-year assessment showed that: Arabica coffee under shade trees are more robust as result of increased length of coffee bearing head (6.8%), stem internodes (23.5%), primary internodes (14.3%) and canopy diameter (17.3%). The direct effect arising from possible nutrient effects is yet to be determined as soil samples from various shade-tree systems are being analysed at Makerere for constituent nutrients while coffee bean samples from various shade systems in are being processed for nutrient and quality analysis

NaCORI has also recommended coffee friendly shade tree

species for the different ecological regions in the country. For example, in Mt Elgon area it is *Ficus ovata*, *Cordia Africana* and *Albizia coriaria*; in Busoga, *Ficus natalensis*, *Ficus mucus*, *F. ovate*; in Central *Ficus natalensis*, *Ficus mucus* and *Albizia cloraria*; In West Nile *Ficus natalensis*, *F Mucus* and *Albizia cloraria* while in the mid-North it is *F.natalensis*, *A. cloraria* and *Cordia Africana*.

Technology promotional activities

A total of 56,83 Robusta CWD-r cuttings and 100,000 Arabica seedlings, 900kg seed were availed to farmers through the Uganda Coffee Development Authority and Operation Wealth Creation. With completion of a modern tissue culture or molecular laboratory at NaCORI, the capacity to produce planting materials will significantly increase from about 100,000 to one million per annum. The facility is expected to enhance production of quality planting materials using tissue culture applications. NARO projects to increase production rates from about 50,000 (propagated through cuttings) to one million plantlets every year. The facility was constructed and will be equipped with financial support from UCDA.

Throughout the year, institute staff exhibited technologies at coffee shows, field days and key stakeholder workshops. Over 3,000 stakeholders were reached during these events, and also availed information materials inform of leaflets and brochures. A total of 70 nursery operators were trained on good agronomic practices. These were in Mukono, Buikwe, Kayunga, Gomba, Nakaseke, Lwengo, Kalungu, Masaka, Kyenjojo, Kabarole and Mubende districts. Others are Mityana, Luwero, Bukomansimbi, Rakai, Mpigi, Wakiso, Ntungamo, Mbarara, Kiboga, Hoima and Ibanda

Seed production

A total of 56,830 CWD-r cuttings; 100,000 Arabica coffee seedlings and 900kg of Arabica seed were produced, and availed to farmers through UCDA (through Operation Wealth Creation/NAADS) and registered nursery operators across the country. Several nursery operators have set up mother gardens for CWD materials, and consequently created employment opportunities for the public, especially the youth. On-station demonstration of coffee varieties have been set up at NaCORI, Buginyanya and Mukono-Kamenyamiggo for stakeholders to learn from. Coffee mother gardens have also been maintained at Kituza, Buginyanya, and Mukono for future research prospects.

9. Fruits

The Government of Uganda has in the recent past prioritized fruits such as mangoes and citrus for export with projected foreign exchange earnings of US\$30million. To ensure sustainable supply of fruits, Government of Uganda in partnership with the Korean Government commissioned a fruit processing factory in Soroti district in 2016. This heavy investment by the government in the fruits sub sector could be disappointed by the low yield (1.2 and 3.0 MT/ha) of citrus in Uganda. To counter the above, NARO has ventured into the following research streams.

Tackling citrus leaf and fruit spot diseases

The low yields in the fruit industry can, in part be attributed to diseases prevalent in major citrus producing areas. Some of the major diseases include; leaf and fruit spot, citrus bacterial canker, anthracnose, citrus scab, greasy spot and black spot.

Through the NARO Competitive Grant Scheme, studies were conducted to address these challenges using disease management and control interventions. Trials were established at Kiige Citrus Scheme in Kamuli District to evaluate several Integrated Pest Management strategies including use of fungicides, insecticides, fertilizers and pruning. These would be introduced to farmers through trainings and information materials.

6,000 apple root stock availed to uptake pathways

A total of 6,000 apple root stock were availed to uptake pathways in the reporting year from the apple mother gardens in Kachwekano and Buginyanya ZARDIs. In addition, 1.5 million apple rootstock seedlings of consumer preferred varieties are ready for grafting.

Meanwhile, on-station demonstration of improved mango and citrus varieties are being maintained at Abi, Bulindi, Buginyanya, Mbarara, Mukono, Nabuin, Ngetta, and Rwebitaba ZARDIs and in NACRRI, NARL and NaFORRI.



A citrus farmer showing his disease free oranges.

10. Cocoa

Cocoa research was re-initiated during the reporting financial year. The main activities included rehabilitation and evaluation of varieties that had been 'abandoned' for over three decades in the fields at Kituza a research center established by the colonial administration in the 1930s.

The work during the year was mainly on rehabilitation of fields at Kituza where 441 individual genotypes were recovered from three cocoa germplasm fields. A total of 14

genotypes with yield potential of 630-4100kgs of dry beans, which is 30-3500kg above national farm yield average, were identified and are being propergated on station.



One of the fields rehabilitated at Kituza to recover individual cocoa genotypes. Inset is a cluster of coco pods on a cocoa tree.

11. Groundnut

In Uganda, groundnut, *Arachis hypogaea* L. is the second most important legume after beans. It is grown by smallholder farmers primarily as a rain crop during the two seasons of the year for household income, nutrition and food security.

High yielding, stress tolerant groundnut varieties submitted for release

The per capita consumption of groundnuts by children and women on a daily basis is 37 and 65 g respectively (Mugisha et al, 2014) showing a substantial contribution to household nutrition.

NARO through its groundnuts improvement programme has an active breeding pipeline that is sustainably releasing improved stress tolerant varieties with superior yields. The rate of growth for both production and productivity are positive, signifying an increment in both land sizes and yields. Results indicate that sizable research benefits (US\$32.3- US\$47 million) are generated by adopting rosette

resistant seed varieties. Adoption of improved groundnut varieties significantly increased the net value of income by US\$130–254 per hectare and also significantly reduced poverty as measured by headcount index (Kassie et al., 2010) thereby contributing to the achievements of the Millennium Development Goal of eradicating poverty and hunger in Uganda.

In the year under review two varieties; DOK IR and DOK IT which are high yielding, drought tolerant and disease resistant to leaf spot and rosette, were submitted to the Variety Release Committee in MAAIF.



DOK IR

Yield	2.5-3.0t/ha
Maturity	80-90 days
Characteristics	i) Drought tolerant ii) Resistant to leaf-spot and rosette
Seed colour	Red



DOK IT

Yield	2.5-3.0t/ha
Maturity	80-90 days
Characteristics	i) Drought tolerant ii) Resistant to leaf-spot and rosette
Seed colour	Tan

12. Finger millet

Among the cereal crops grown in Uganda, finger millet ranks second to maize in terms of total national production. Projections in the year 2004 stand at 412,000 hectares with total grain production of 700,000 metric tons (FAO, 2005).

Finger millet is grown throughout the country but mainly produced in Eastern, Northern and Western regions by small-scale farmers and purely at subsistence level. Up to 65% of the country's finger millet is in the districts of Kabale, Hoima, Busenyi, Masindi and Mbarara in the western region; Iganga, Kamuli, Kumi, Soroti, Mbale, Tororo in the eastern region; and Gulu, Kitgum, Lira, Apach and Arua in the northern region. It is a staple diet of many subsistence farmers and rural workers in Uganda as an important source of calories and protein. It is considered the domain of women, who also use it as a cash crop, generally managing the resulting income for the benefit of their households. Cultural, religious and traditional factors

strongly influence the demand for finger millet in Uganda where it plays important role in gift-giving, symbol of fertility, symbol of manhood and so on. Those cultural influences create strong demands for finger millet where it is produced (Wanyera, 2005).

Six Finger millet varieties submitted for release

In a bid to fill up the different genetic gaps in varietal choices currently available in the country, NARO has in the reporting year, submitted six finger millet varieties to the Variety Release Committee (VRC). The FMS 383, FMS376 and FMS 72 have the following attributes:

Name		Unique features/ attributes/ description
FMS 383		Yield: 3-4.1 t/ha Maturity: 100 days Resistant to leaf blast 8 - 9 fingers per panicle 5 - 9 productive tillers
FMS 106		Yield 2.9-3.9 t/ha Maturity: 105 days Non-shattering Resistant to leaf blast

Name		Unique features/ attributes/ description
FMS 376		Yield: 2.9 - 4.07 t/ha Maturity: 102 days Resistant to leaf blast Diastatic Unit 56.63
FMS 72		Yield: 2.7 – 4.4 t/ha Maturity: 110 days Medium tall, and erect Resistant to leaf blast Diastatic Unit 56.63
IE2440		Yield : 2.6 - 3.5 t/ha Maturity: 100 days Drought Stay green Good brewing Resistant to leaf blast Diastatic Unit 57.3
SEC915		Maturity: 100 days Yield : 2.8 – 3.7 t/ha Resistant to leaf blast Nutritionally rich grain (12.5% protein) Excellent malting quality

13. Apiary

The key constraints faced by bee keepers in most parts of the country are; bee pests and diseases, delayed hive colonization and bee forages. NARO conducted a survey which determined the incidence and severity of bee pests and diseases in Kihungya, Biiso and Buliisa sub counties of Buliisa district of the Lake Albert Crescent Zone (LACZ) in order to design management practices to address the constraints faced by bee farmers.

Increasing productivity of apiary in Uganda

The most common bee pests according to rank were; black ants, bee pirate wasps, wax moths and red ants. Most bee keepers (89.1%) had experienced pest attacks in apiaries and delayed hive colonization. The result further showed that 52.2% of the bee keepers did not use improved management practices for controlling bee pests, citing limited knowledge. As an intervention, NARO has since established an apiculture research project at Bulindi ZARDI in the LACZ to disseminate improved apiculture technologies to the bee farmers. The project has established on-station trials and demonstrations, and conducted trainings on apiculture technologies

Bee forage plants evaluated

An on-station trial to evaluate the performance of common bee forage plants (Sunflower, *Calliandra calothyrsus*, *Ocimum sp.*) for increased production of bee products (honey) was es-

tablished. Mean number of bees/flower/20 min were; Sunflower (9), *Calliandra calothyrsus* (4) and *Ocimum sp* (3). These bee forages produce numerous flowers, very attractive to bees with high nectar content to bees. Sunflower had the highest mean number of foragers because of its type of inflorescence (the flowers are clustered together)

Cup kit for queen bee rearing

More research was conducted on the different queen bee rearing methods (grafting method, cup kit method and miller method) for increased honey bee colony in the LACZ of Uganda. Cup kit was established to be the most effective queen rearing method because of the low mortality rates (High survival rate of emerging queens). Cup kit is being promoted among bee farmers in the zone. NARO has similarly established apiary research programmes at NaLIRRI, Abi, Ngetta and Rwebitaba ZARDIs.



Apiculture technician, Ms. Lydia Kabasomi displays bottles of NARO-value -added honey at Bulindi ZARDI

14. Appropriate Engineering

Appropriate engineering mainly deals with research and development of tractors, harvesters, threshers and various other farm machineries. Achievements for the year are presented below.

Agro-machinery for small-scale production systems developed

NARO through the Agricultural Engineering and Appropriate Technology Research Centre (AEATREC) has fabricated and promoted the light weight rice thresher and the Hydraulic Ram Pump to support farmers in reduce drudgery and pump water for irrigation in Alebtong and Doho rice producing areas in Northern Uganda. In the event that the threshers will be used by all rice farmers, the country will be able to save US\$5.92 million.



The light weight thresher

- Threshing output 550-700Kg/litre of fuel (Petrol)
- With threshing efficiency of 98%
- Mobility: Hand pushed on two wheels



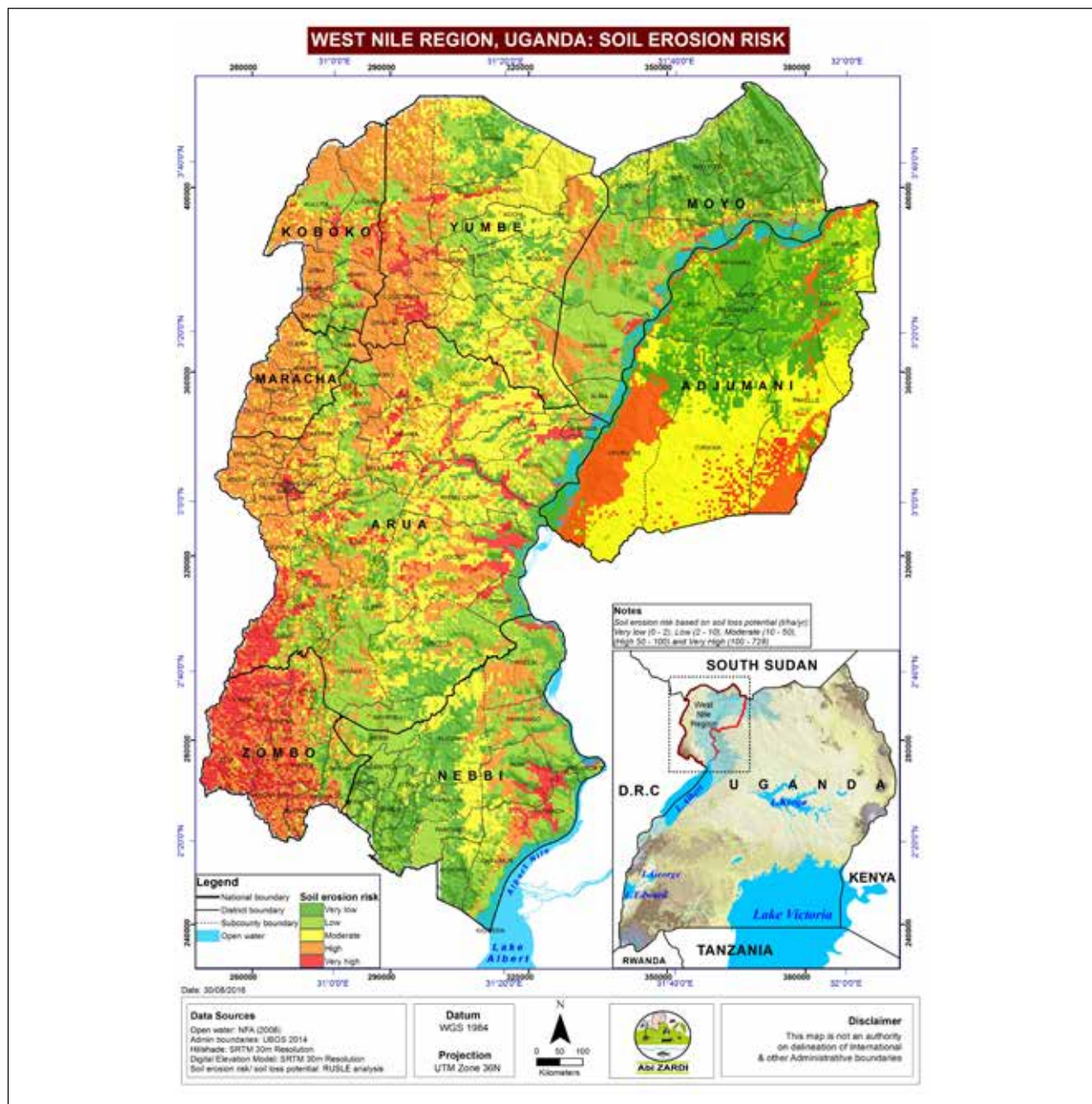
Hydraulic Ram Pump

- Water can be raised to a delivery head of 45-50 m at a fall of 5-7m
- Powered by water to pump water and runs continuously
- Can irrigate 0.5-1 acre per day

15. Sustainable Land Management (SLM)

Under sustainable land management, Soil erosion hazard cartographic maps were generated for West Nile districts. The maps show the degree of erosion that has happened in the region to guide the districts in soil erosion control measures. A soil erosion model is being used to estimate soil loss in the next 20 years if mitigation measures are not taken.

The project also rehabilitated unproductive and degraded grazing lands in Sembabule, Wakiso, Nakaseke and Nakasongola Districts.



Sustainable Management of grazing lands

Planned Annual output	Output achieved	Remarks
At least 100 acres of unproductive degraded grazing land rehabilitated	Nutritive and palatable pasture restored on 80 acres of unproductive grazing land in Sembabule, wakiso, Nakaseke and Nakasongola	• Milk production increased from 2.6 to 6.7 Litres /day • Daily weight gain improved from to 160 to 283 g/day • Reduced time taken to achieve market weight (400kg) from 7 to 4 years



0 t/Ha



4.5 t/Ha



0.75 t/Ha



5.5 t/Ha

16. Addressing climate change effects

The United Nations Development Programme (UNDP) warns that progress in agricultural development achieved over the last decade may be slowed down or even reversed by climate change as new threats emerge to water and food security, agricultural production and access, nutrition and public health.

Indeed as the world's climate changes at an unprecedented rate in recent human history, societies consequently need to learn to cope with the changes predicted; warmer temperatures, drier soils, changes in weather extremes and rising sea levels, among others. As noted in the previous sections of this report, agriculture in Uganda is a major economic sector, employing approximately 69% of the labor force and contributing 26% to the countries' national gross domestic products in 2015/16; yet the sector is largely rain-fed and therefore its success is sensitive to climate variability.

Climate SMART technologies released

In a bid to boost the adaptive capacities of the farming communities in the country, NARO has continually released Climate SMART technologies especially crop varieties that are early yielding and drought tolerant. Some

of these varieties submitted for release in the reporting year include two groundnut varieties; DOK IR and DOK IT and six finger millet varieties; FMS 383, FMS 106, FMS 376, FMS 72, IE2440 and SEC915.

Three valley tanks, seven shallow wells constructed

Another notable contribution in transforming and reorienting agricultural systems to the new realities of climate change has been through the construction of valley tanks and shallow wells. Three valley tanks of average capacities of 14,000m³ (14 million litres) were constructed in Nakasongola, Nakaseke and Kalungu to serve an average of 1,000 households. Seven shallow wells were also constructed in Pallisa, Mukono, Luwero, Nakaseke and Soroti districts to serve the vulnerable locals.



Part of Mubuku prisons maize garden which dried due to drought in 2014 (Source: Internet). NARO has developed climate smart technologies to mitigate the effects of climate change.

17. Bolstering the Community Seed Banking in Uganda

Farmers hold a considerable amount of Plant Genetic Resources for Food and Agriculture (PGRFA) though most cultivars are grown in relatively small proportions. Diversity of Plant Genetic Resources provide options for resilience against pests & diseases, poor weather and also source of good attributes for incorporation into new improved varieties.

Without this diversity, the future of both the crop and the farmers is threatened and so is the economy of the country. Furthermore, reduced production as a result of lack of availability of affordable planting materials plus other socio-economic factors lead to dependency on external sources in the farming communities. A pursuit to establish community seed banks (CSB) as a remedy for seed insecurity started in 2008. Three community seed banks have been established. The first such facility, Kiziba Community Seed Bank (KCSB) was opened in Kabwohe, Sheema district in 2010. Three years after KCSB, Nakaseke Community seed Bank was constructed and opened. The third facility in Rubaya, Kabala district was also established in 2015.



Kiziba Community Seed Bank, opened in June, 2010.



Nakaseke Community Seed bank, opened in January, 2013.

Rationale for CSBs establishment

A study carried out in three sites revealed that some varieties of beans had become rare and others were no longer available in the area. Getting good quality seed to plant was also a big problem as most farmers relied on exchange between fellow farmers, shops and markets where there was no quality control resulting in rampant seed borne diseases in the area.

They also wanted a place where they could deposit some of those varieties that were losing popularity in terms of market, yield, taste in case these varieties regained popularity in the future, or hosted other attributes that were not presently relevant. As such, through a project, whose main objective was to control, minimize and manage the incidence of pests and diseases in Banana and bean and to increase seed diversity and food security among smallholders in these regions, community seed banks were constructed to support farmers' concerns. Through this initiative, farmers in these communities are able to access a wide variety of beans, they have diversified farms and benefit from capacity building initiatives of the project that help them manage their farms as well as controlling pests and diseases on their farms, consequently there is improved food security, incomes and livelihoods. Furthermore, farmers outside the community are also benefiting from this initiative as they buy seed at a minimal price from the gene bank and access a wide variety of germplasm.

Formulation of CSBs

Formulation of Community Seed Banks is through a stepwise approach involving community diagnostic and needs analysis, construction of the bank, selection of the management committee, implementation which involves management plans and capacity building from a network of stakeholders.



Linkage network



Management, sustainability and prospects

The gene bank is managed by the farmers themselves with technical support from Bioversity International and NARO staff. The management consists of a seed bank manager in charge of the overall day to day functioning of the seed bank; a records manager in charge of keeping records; a quality control manager in charge of sorting, grading and post-harvest handling of seed including preservation and storage; and a distribution manager in charge of distributing seed to farmers. There are also committee members who are community mobilizers and act as chairpersons of the villages – they are responsible for mobilization, field monitoring, training on good management practices and seed collections and data collection in their respective villages.

The gene banks are currently functioning as community

level initiatives managed by members of the community with the sole purpose of distributing seed to farmers. It is an attractive venture especially for the surrounding communities. However, most of the requirements both financial and technical are supported by Bioversity and NARO; this may not be sustainable in the long run especially if and when these projects wind up. This notwithstanding the seed banks have the capability to become sustainable if they become profit making enterprises, for instance if the farmers can raise some income from sale of seeds.

Links with other organizations may provide more opportunities for the seed banks to evolve further. Exposure to the Multilateral systems (MLS) is also an opportunity for the seed banks to collaborate with other countries to increase diversity and receive technical and financial support.



Livestock sub-sector

One of the objectives of the National Agricultural Policy (NAP 2013) is to increase incomes of farming households by among others providing vaccination services for animal vector and disease control. The policy also explicitly underscores the importance of cost-effective technologies and research services to enhance production and increase quality of products. In this subsector we bring to you some of the achievements made in the FY2015/16.

Anti-tick vaccines in the offing

NARO developed and evaluated four recombinant Subolesin tick vaccines for control of the three most economically important ticks (brown ear tick, blue tick and the bont legged tick) in Uganda. Results showed an 80% reduction in brown ear and blue ticks burdens among Zebu and Sahiwal cattle.

Millions of forage seeds availed to uptake pathways

NARO produced 2 million seedlings of alfalfa (>40% crude protein) and 10 tons of *Chloris gayana* enough to plant 400 ha of pasture for forage. 500 MT of hay, 700 MT of silage and haylage, 10 MT of *Chloris gayana* seed, 2,000,000 seedlings of Alfalfa and 10 MT of Lablab seed were also produce. On-station demonstrations of improved forages have been maintained in the ZARDIs (Bulindi, Abi, Mbarara, Ngetta, Nabuin, Buginyanya).

Feed and forage seed production



Haylage



Chloris gayana seed



Silage



Alfalfa seedlings



Lablab seed

Aflasafe broiler ration developed

The Aflasafe broiler ration comprises of 1% aflatoxins binder that sequesters aflatoxins in poultry feeds and this results in reduction of aflatoxins induced mortality from 40 to 2%, and increases mature weight of broiler birds by over 12% from 2,213 grams to 2,481 grams in seven weeks. It also boosts birds' immunity through enhancement of Newcastle disease anti-body concentration in the blood from 4.75 to 7.91 ppm.

Muguga cocktail vaccines for dairy cattle and meat

Identified strains of indigenous Theileriaparva antigens missing in the Muguga cocktail that should be incorpo-

rated to make the vaccine more potent in Uganda for both dairy and beef cattle.

NARO kuroilers and improved Mubende goats in the offing

Developed elite indigenous lines (Our own kroiler). The F1 generation showed a 20% increment in both meat and egg production after intensive selection of indigenous poultry ecotypes.

Mubende goat breed F1 generation produced for further evaluation for increased meat production and twinning rate after intensive selection of indigenous selection of indigenous ecotypes.

→ Forestry sub-sector

According to the ministry of water and environment report on the state of Uganda's forestry (2016), the country's forest cover reduced from 4.9 million hectares in 1990 to 1.8 million hectares in 2015 translating into a loss of 3.1 million hectares in 25 years or an average annual forest loss of about 122,000 hectares. Some of the causes this unprecedented loss of forest include need for more land for agriculture by the growing population, urbanization and rampant felling of trees for timber, firewood and charcoal burning rampant fires and livestock damage on forest plantations. This is not just a threat to particular groups of people but rather a danger to humanity given the devastating impacts such as climate change, soil degradation, reduced biodiversity, degradation of water sheds, food insecurity due to exacerbated drought, and loss of biological diversity among others. As part of its contribution to the forestry sub sector in 2015/16 FY, NARO achieved the following;

Enhanced establishment rates of trees in dry ecologies using hydrogel technology

As shown in the pictures below, hydrogels enhance the establishment rate of trees in dry ecologies. This technology is to be promoted in the dry ecologies of the country as a way of restoring forest cover in the country.



Managing the spread of eucalyptus pests using a biological control agent

Again in the 2015/16 Financial Year, three exotic pests attacked Eucalypts including the hybrid clones that were introduced by NARO in 2008. These insect pests include; Blue gum Chalcid (*Leptocybe invasa*), Bronze bug (*Thaumisticoris perigrinus*) and Red gum Pysillid (*Glycaspis brimblecombei*).

NARO in partnership with the Forestry and Biotechnology Institute (FABI) of South Africa has identified biological control agents (*Selichtrodesi neseri*, *Cleruchoides noackae*, and *Psyllaephagus bliteus*) and is to introduce these against the three pests respectively.



Eucalyptus Trees devastated by the exotic pests

➔ Fisheries sub sector

The overall goal for the fisheries subsector is to ensure increased and sustainable fish production and utilization by properly managing capture fisheries, promoting aquaculture and reducing post-harvest losses (NFP 2005). In line with the policy, NARO achievements are highlighted below.

Cage Culture and Water Based Aquaculture Parks mapped out

Guidelines for selection and zoning of sites for cage fish farming and aquaculture parks as well as a manual for operation of cage fish farms and aquaculture sites have been developed.

The frameworks are applicable in facilitating establishment and operation of cage fish farms in Uganda and other East Africa states sharing Lake Victoria.

A comprehensive map for cage culture and aquaculture parks in seven districts (Busia, Mayuge, Jinja, Buikwe, Kalungu, Masaka, Kalangala) has also been developed.

The guidelines and manuals have been printed, availed to stakeholders and are expected to contribute to sustainable utilisation of water resources for cage fish farming. The utilization of proposed sites is expected to lead to enhanced practices of cage fish farming that will ultimately improve production from aquaculture.



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

Cage fish farming demo established

A cage fish farming site has also been established near NaFIRRI, Jinja to act as a site for research and demonstration of cage fish farming technologies. In addition, information has been obtained on cage culture operation practices and is applicable for estimating capacity for the sites.

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



Genetic improvement in growth of Nile tilapia

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

F2 generation fish fry



Appropriate packaging in fish fry



Developed second Felial generation of Victoria strain of Nile tilapia with growth performance of 6.5% from 2.03g to 2.45g per day

Breakthrough in control of endo-parasites and bacterial infections in fish

With intensive promotion of commercial aquaculture in Uganda to achieve 200,000 tonnes from aquaculture by 2016, high fish stocking densities under commercial fish production will undoubtedly increase disease outbreaks.

Preliminary observations indicate that although parasite induced mortalities occur, the intensity of parasites on diseased fish in most cases is too low or not detected at all, suggesting other infections such as bacteria, viruses or fungi.

Preventing fish disease is one of the major routes through which fish loss can be mitigated. Knowledge on the occurrence, distribution, and potential risks of pathogens to farmed fish can help in designing management strategies for increased aquaculture productivity and sustainability.

NARO has therefore identified infectious *Aeromonas* sp strain from commercial cage fish farms on lakes Victoria and Albert. Accordingly, four plant extracts (garlic, *Occimum* sp., *Bidens pilosa* and *Musa* sp.) were purified and profiled for in situ assays on infectious *Aeromonas* bacteria.



Three plant based extracts from Mujaja, Black jack, and Banana leaves have been developed for control of bacteria (*Aeromonas hydrophilla*) that are common disease causing agent in most Cage disease outbreaks

A Fish Feed Aflatoxin Binder Developed

Aflatoxin poisoning due to consumption of moldy grains and cereals continues to be a public health threat. At only 5ppm in fish feeds, they reduce metabolism, growth and can cause death

MBAZARDI toxin binder sequesters about 60% of aflatoxins in moldy fish diets reducing their absorption into blood





Speaker of Parliament, Rt. Hon. Rebecca Alitwala Kadaga, listens to a NARO scientist during a Research Extension Interface Week at the parliamentary buildings, Kampala, September 2015

Chapter 2: Research Extension interface

The research extension interface refers to any point of contact NARO is utilizing to ensure the various stakeholders and users of improved agricultural technologies are identified, linked, have access and are satisfied with the agricultural research services provided. The mechanisms are characterized by organizational, institutional and personal contacts, home and farm visits, mostly by extension agents to seek first-hand information about new innovations to researchable constraints and challenges in the farming community.

NARO continues to provide leadership and advocacy for the promotion, protection and development of agricultural research services in Uganda at *various times*; in *collaboration with various other stakeholders*, at *various events and platforms* to ensure improved technologies are accessed by the *targeted or intended audiences*.

National Events

World Food Day, 16th October 2015, Rwebitaba ZARDI

Uganda joined the rest of the World to celebrate the 33rd World Food Day with the theme “*Social Protection and Agriculture: Breaking the Cycle of Rural Poverty*”. The World Food Day (WFD) was celebrated at Rwebitaba ZARDI at Kyembo-go station, Fort Portal town, Kabarole district in the western highlands of Uganda.

World Food Day is organized by the Ministry of Agriculture, Animal Industry and Fisheries in collaboration with the Food and Agriculture Organization of the United Nations. The President of Uganda, H.E. General Yoweri Kaguta Museveni officiated the WFD celebrations. The celebrations were graced

by the country representative of Food and Agriculture Organization (FAO), Dr Alhaji Jallow. President Museveni toured exhibition stalls by MAAIF, NARO, local farmers, agricultural input dealers and international exhibitors.

In his address, the President reiterated that “Biotechnology is to impart certain qualities and the farming community should modernize their thinking about biotechnology”. This is because biotechnology improves quality of crops in Uganda. He thanked FAO for the support it has given Uganda over the years and called upon the government to raise pay for scientists because they are the country’s primary vehicle to development.

The President also noted the significantly small financial resource available for agricultural research. The President said that “more than before, our scientists now developing and



H.E Yoweri K. Museveni the president of the Republic of Uganda visiting a NARO stall at the World Food Day (WFD) Celebrations 2015 at Rwebitaba Zonal Agricultural Research and Development Institute (ZARDI) in Fortportal District.

processing more improved agriculture technologies to increase agricultural production and productivity. Therefore work with them”.

NARO has been hosting the World Food Day celebrations in the Public Agricultural Research Institutes for the last five year as follows: NACRRI (2014), NASARRI (2013), Mbarara (2012), Abi ZARDI (2011) and Mukono (2010). NARO will be hosting the next World Food Day celebrations in the Public Agricultural Research Institutes scheduled as follows: Ngetta (2016), Kachwekano ZARDI (2017), Nabuin ZARDI (2018) and Bulindi ZARDI (2019).

Jinja Agricultural show

NARO participated in the 23rd Source of the Nile Agricultural and Trade Show at Jinja Show Grounds. Jinja town is situated 80km to the East of Kampala. The show is an annual event with over 200 local, regional and international exhibitors. The annual theme for the exhibition was: “Climate Smart Agriculture for Sustainable Food Security and Wealth Creation.

This show is organized by the Uganda National Farmers Federation and the Ministry of Agriculture, Animal Industry and

Fisheries. Since 1993, this show is the most popular and the leading exhibition event which combines agriculture and trade sectors in Uganda. The show ground has a training centre on good agricultural practices, pest and disease management and agriculture for profit.

Joint planning and priority setting

MAAIF and NARO forged joint planning and priority setting modalities which include;

a. District Adaptive Research Teams

NARO supported District Adaptive Research Teams in setting up demonstrations to promote agricultural technologies, innovations and management practices.

b. Innovation platforms

NARO spearheaded in establishment and supporting of innovation platforms premised on commodity value chains.

c. Farmer-Led and farmer-managed community seed banks

Established and maintained farmer-Led and farmer-managed community seed banks in Mbarara and Nakaseke.

Operation Wealth Creation (OWC) and NARO

Operation Wealth Creation is a task force initiated by the Chief In Command (CIC) to provide a platform for coordinating National Social Economic Transformation through other stake holders in the production chain as well as mobilizing citizens to participate in commercial Agriculture. OWC is a platform to coordinate Ministries, Departments and Agencies. The Private Sector and non-state actors are critical components of OWC activities.

How did it start?

OWC has its roots on the Hero's day celebrations 9th June 2013 at Butalangwa when the NRA/M veterans met and told the CIC that low incomes in households was critical issue in spite of earlier programmes to eliminate poverty e.g. PAPSCA, PAP, PEAP, PAF, PMA and others which failed to meet their expectations.

Poverty was an enemy which required urgent interventions So an operation code named "Operation Wealth Creation" was initiated under the command of Gen. Salim Saleh and initially operated in Luwero Triangle and Rwenzori regions that were major battle venues for NRA/M revolutionary struggle. It later rolled out to cover all political constituencies throughout the country.

What's the scope?

Provision of strategic interventions such as:

- Planting and stocking materials
- Value addition
- Tractorization and mechanization
- Water for production focusing on small scale irrigation
- Streamlining the output marketing structures
- Farmer cooperatives/institutions
- Handle post-harvest handling structures
- Marketing, addressing both domestic and external markets

Expectations of OWC from NARO

- Commercial production and multiplication of high quality planting materials and stock in large quantities for farmers to eventually eliminate fake and substandard materials currently on market
- More intensified interaction with farmers out there in the field.(as the excellent work NARO is doing in Sustain-

able Land Management projects in different parts of the country).

- Increased farmer training at NARO institutes

Some OWC achievements

- Excitement by small scale farmers to demand technologies after losing confidence in NAADS methods of work
- Positive debate on agricultural development has been generated including the formation of the Uganda Development Forum body uniting MDAs to tackle agricultural development holistically where NARO is a big player.
- Reported increase in production e.g. maize production has risen from 2.4m MT to above 4m MT last season (2015 season A) according to the Grain Council.
- The MAIIF is reinstating a single spine extension service



OWC Liason Officer, Maj. Peter Murara Rwego (In army uniform) together with NARO scientists during a visit to a demonstration site in Kikandwa village in Nakaseke district



The Director of Research, Abi ZARDI, Dr. Julius Mukalazi visibly happy with the cassava seed multiplication garden at the institute under the Eastern Africa Agricultural Productivity Project (EAAP).

Chapter 3: Eastern Africa Agricultural Productivity Project

The EAAPP project for Ethiopia, Kenya and Tanzania was approved by the International Development Association (IDA) Board on June 11 2009 under the Eastern Africa Agricultural Productivity Project (EAAPP-APL1). However, the one for Uganda focusing on cassava (EAAPP-APL1A) was approved in October 29, 2009. Thus, EAAPP-Uganda with the establishment of the Cassava Regional Centre of Excellence (CRCoE) as a center piece has been implemented over a period of five years starting in fiscal year 2010/2011. In this chapter we bring you a summary of the project accomplishments.

Eastern Africa Agricultural Productivity Project (EAAPP) was developed as a two phased programme to be implemented in Ethiopia, Kenya, Tanzania and Uganda. EAAPP started in 2010 and ended in 2015, and aimed to raise farm incomes, reduce poverty and improve food security by: (i) strengthening Regional Centers of Excellence (RCoE) in agricultural research in the four countries and (ii) supporting these centers in the production of selected varieties of improved seeds and improving access of poor farmers to more productive plant varieties and animal stocking materials.

This effort was in response to the following challenges that were affecting agricultural research and productivity in the region, namely; low allocation of resources to agriculture and agricultural research; poor facilities and low salaries for staff in research; low total number of agricultural scientists; lack of a larger shared technology space in the region; limited access by neighboring countries to cultivars available in one country; lack of harmonized policies and regulations relevant to the seed industry; undeveloped informal markets for planted seeds for cassava, wheat and rice; and serious attack on cassava production by cassava mosaic disease (CMD), cassava brown streak disease (CBSD) and cassava bacterial blight (CBB) across the region

Objectives

The project's objectives were to: (i) enhance regional specialization in agricultural research; (ii) increase regional collaboration in agricultural training and dissemination; and, (iii) facilitate increased sharing of agricultural information, knowledge and technology across national boundaries.

Outcomes and selected success stories

The EAAPP identified six indicators for measuring the project outcomes. The project outcomes and indicators were on (i) adoption of new technologies (indicator - *Rate of change in adoption of new technologies*), (ii) land area covered with seeds of improved cultivars (indicator - *Rate of increase in land area with seeds of improved cultivars (%)*), (iii) productivity at farm level of the disseminated new technologies, (iv) level of stakeholder satisfaction with the technologies (indicator - *Level of stakeholder satisfaction with the technologies, innovations and uptake pathways (%)*), (v) regional specialization and collaboration in agricultural research (indicator - *Rate of change in regional specialization and collaboration in agricultural research (regional integration)*) and (vi) information and knowledge transfer across national boundaries. EAAPP project achieved all the targets set for each of the indicators. The project outcomes and indicators are presented and discussed below:

Indicator 1: Rate of change in adoption of new technologies

The trend of adoption of varieties and management practice was generally well above the targets as indicated in Table 1.

Table 1. Rate of change in adoption of new technologies

Commodity	Baseline 2010-11 YR 1 - 2011		Target and (Actual) Cumulative Values				
			YR 2 - 2012	YR3 - 2013	YR 4 - 2014	YR5 - 2015	
Cassava	New Varieties	67	4 (71)	8 (74)	12 (75)	16 (78.5)	20 (80)
	Management practices	67	4 (71)	8 (74)	12 (75)	16 (77)	20 (78)
Rice	New Varieties	54	4 (65)	8 (67)	12 (69)	16 (75)	20 (77)
	Management practices	70	4 (71)	8 (72)	12 (75)	16 (77)	20 (79)
Wheat	New Varieties	12	4 (12)	8 (31.5)	12 (13)	16 (13)	20 (15)
	Management practices	3	4 (3)	8 (19.4)	12 (54)	16 (54)	20 (58)
Dairy	New Pasture & Fodder Varieties	67	4 (5)	8 (10)	12 (20)	16 (20)	20 (23)
	Breed	56	4 (5)	8 (10)	12 (10)	16 (10)	20 (15)
	Management practices	36	4 (9.7)	8 (4)	12 (65)	16 (67)	20 (70)

The higher adoption rates was due to the fact that EAAPP interventions addressed salient issues of productivity in the four commodities. For example new cassava varieties addressed the constraints of Cassava Mosaic Disease. In addition, there was also deliberate involvement of Zonal Agricultural Research and Development Institutes (ZARDIs) and Local Governments (LGs) in technology promotion. While the cassava plays an important food security role, it has increasingly gained commercial importance. Thus, in some areas like northern and eastern Uganda where cassava diseases had wiped out the crop, farmers went for new improved varieties of NASE series that are tolerant to diseases hence achieving high levels of adoption.

For rice, adoption was beyond the target because there were already some varieties in the pipelines; thus, adoption increased because 6 new upland rice varieties (NamChe-1, Namche-2, NamChe-3, BamChe-4, NamChe-5 and NamChe-6) and five new lowland rice varieties (Agoro, Okile, Wita-9, Komboka and NERICA-6) were released in 2013 and farmers adopted them immediately. This was in addition to a number of management practices that have also been adopted.

Under wheat, Kenyan wheat lines were also accessed, evaluated and 6 lines (K. Korongo, K-Tae, K-Sunbird, K-Hawk, K-Kingbird, K-Eagle10 and K-Wren) were availed to farmers. In addition, three new wheat varieties were released namely; NARO-wheat1, NARO-wheat2 and NARO-wheat3 which are resistant to stem rust Ug99 and have yields of 3t/ha.at

Indicator 2: Rate of increase in land area with seeds of improved cultivars

In general, reports have indicated that there was an increase from a total of 727 million ha in 2010 to 1,386 million ha in 2015. The increase in land area was well above the targets. For instance, there was considerable increase in the land planted with improved cultivars under cassava which increased from 493m ha in 2010 to 1,194.1m ha in 2015.

Many cassava farmers who received improved planting materials were encouraged to expand their acreage as a large readily available market for stems existed both within and outside the country (Rwanda and South Sudan) during the project period. The land area increase is also attributed to the many technologies/varieties released at the time of the project – cassava released and or promoted 8 varieties (NASE 14 – 19 and NAROCASS I & II). In this case farmers were much interested

in trying out all of them. Thus, farmers increased their acreage under improved varieties from an average of about 1.4 to 3 acres per farmer (CRCoE, Internal Evaluation Report 2014).

Indicator 3: Level of stakeholder satisfaction with the technologies, innovations and uptake pathways (%)

This indicator measured stakeholder appreciation of the attributes of the new technology or innovation and the extent to which they were accepted by end-users. Farmer satisfaction with technologies increased from an average of 22.8 percent to 68.8 percent of households in targeted project areas. The greatest increases in satisfaction were seen in cassava and wheat. This may be partly the result of disease resistant traits of the new technologies.

The cassava farmers expressed satisfaction above the target because of the release of new varieties that was a big relief. For instance, farmers appreciated NASE 14 because it has good taste, is more palatable and suitable for consumption, is resistant to CMD and tolerant to some extent by then to CBSD and; had high yield of 35mt/ha. Many farmer groups sold their cuttings to Operations Wealth Creation (OWC) for distribution to farmers in other areas. Farmers in Kiryandongo, Masindi, Apac and Lira sold stems and cassava flour to Rwanda and South Sudan.

Benefit Cost Ratio

From use of improved technologies (varieties & agronomic practices) average Benefit Cost Ratio (BCR) for cassava fresh roots is 4.5, implying that every 1 shilling invested earned 4.5 shillings on top

Indicator 4: Rate of change in regional specialization and collaboration in agricultural research (regional integration)

The rate of change in regional specialization and collaboration in agricultural research is a composite indicator which had several components. It related to the joint planning and implementation of agricultural research, training and dissemination activities in at least two EAAPP project countries. Progress was measured by identifying numbers of jointly planned and implemented regional sub-projects (30% weighting) and training and dissemination activities (30%), advances in policy harmonization (10%), monitoring evaluation systems (15%) and capacity development (15%). The average baseline value for this indicator across the four countries was 10% in 2010, rang-

ing from zero in both Kenya and Tanzania to 35% in Uganda.

There was also a good level of exchange and sharing of germplasm from the regional centres. Uganda shared most of the cassava germplasm across the other countries while the other also shared in the commodities they were leading in; some cassava planting materials were accessed by Rwanda and Southern Sudan. For rice, there were already some regional projects like AfricaRice, IRRI, AGRA that EAAPP built on. Since the regional projects were already in existence, it was easy for EAAPP to be incorporated in this regionality aspect by taking advantage of the experience and network already established. NaLIRRI acquired superior forage germplasm from Kenya which in the past was very difficult to get. Scientists were able to quickly evaluate the germplasm and get better performing grass/pastures..

Improved office, laboratory and field infrastructure

Under the EAAPP project, NARO improved agricultural sector research and development physical infrastructure. Four office blocks were rehabilitated to a modern status at Nam-

ulonge-NaCRRI, Arua -AbiZARDI, Lira-NgeZARDI and Hoima-BulZARDI (ii) Four screen houses at NaCRRI and selected ZARDIs for controlled pest and disease research work were rehabilitated, (iii) Four bio-agent rearing screen houses at NaCRRI and three other ZARDIs for rearing of natural enemies of cassava green mites (CGM) cassava mealybug (CM) and whiteflies were rehabilitated (iv) animal feeds and breeding and health laboratories at Nankyesasa – NaLIRRI were rehabilitated and (v) Food Bioscience Lab-Value Addition was rehabilitated at NARL, Kawanda. Under NAGRC&DB, a liquid nitrogen plant of capacity 90 liters/hour was installed to produce nitrogen.

Specifically under cassava in Namulonge there are seven specialized Labs within the Cassava Center: General training lab, Product development lab, Carbohydrate lab, Chromatography lab, Diffractometry lab, Protein and pigments lab, and Preparation lab which are key in research undertakings. Reduced savings due to these laboratory structures are indicated per activity in table below:

Labour saving Costs and Value for money

Activity	Cost/Yr (US\$) (Internal)	Cost/Yr (US\$) (External)	Savings	% Savings
Starch extraction yield and proximate analysis	7,984.0	18,540.0	10,466.0	56.7
Analysis of pigments (beta carotene and anthocyanins)	12,000	22,890.0	10,890.0	47.6
Analysis of nitrogen and proteins	19,840.0	39,950.0	20,110.0	50.3
Bioethanol development	3,450.0	16,850.0	13,400.0	79.5
Development of Biodegradable plastics	96,770.0	29,750.0	20,073.0	67.5
Other products development (Prototypes)	1,900.0	4,700.0	2,800.0	59.6
Laboratory consumables (Distilled water etc)	10,000	25,000.0	15,000.0	60.0
Total	64,851.0	157,590.0	92,739.0	58.8

These facilities are also utilized by private sector and the region and Non Tax Revenue is realized. The table below gives NTR in 2015/16 under NaCRRI Cassava Center.

Contribution to NTR : 2015-2016

N0	Activity/Engagement	Amount utilized (US\$)
1	Composite analyses	6,285.7
2	Product validation	1,285.7
3	Training and short education tours	1,028.6
4	MSc student attachments	3,260.0
5	PhD student attachments	1,624.0
	Total	13,484.0

NB: Revenue from lab is ploughed back through purchases of consumables, payment of hired and labour and maintenance among others.

Success stories

A: Cassava:

Efficiency of technology dissemination was enhanced through use of ZARDIS and local farmers to multiply and distribute cassava planting materials (NASE 14).

“Example Mr Alengo Patrick (local seed multiplier) from Alebtong district this year alone received a tender of 8700 bags of cassava stems for farmers in 6 selected districts in northern Uganda. In addition, he processes cassava and has a tender to supply 120 tons of HQCF to Kotido district” (NaCRRI, 2015).

Sale of cassava stems within Uganda and neighbouring countries

Source of Material	Destination	Quantity	Rate/bag	Gross profit
From 2 EAAPP farmer groups	Rwanda	17,000 bags (Feb, 2015)	20,00 UGX (after taxes)	UGX 340 million (US\$113, 333)
Mostly from EAAPP beneficiaries	Nation wide	77,006 bags (Mar 2015)	20,000 UGX (after taxes)	UGX 1.5 billion (US\$513,373)
		80,000 bags (Nov 2015)	20,000 UGX (after taxes)	UGX 1.6 billion (US\$449, 438)
Total		174,006 bags		UGX 3.44 billion

Source: CRCoE, NaCRRI reports 2015.

2. Under the auspices of Uganda Investment Authority (U.I.A) Cassava Regional Center of Excellence (CRCoE) is back-stopping initiative by cassava stakeholders in the Private sector to form an Association that can influence cassava commercialization in Uganda.

3. Uganda Breweries buying HCQF from farmer groups to produce “Ngule” beer.

4. These success stories and the contribution from the laboratories at Cassava center as in two tables above are contrary to the perception that countries in the EAC region are allegedly capitalising on Uganda’s weaknesses and promoting trading in cassava and cassava by-products.



- Uganda Breweries produces 200,000 cases/Monthly
- Progressively move from drying cassava on ground to now having a flash drier

B: Dairy cattle/improved forages

Napier grass accessions tolerant to Napier stunt disease improved fodder DM yield by .50% (24 tons/ha compared to 12 t/ha/yr for local accessions) leading to increased milk yield & household income by 30%.

Individual farmers multiplying Brachiaria produced about 800 bags of planting materials/ha/HH/year with a net income of about Ushs 16 million/acre/yr

“Improved forages have increased milk yield and income. Last season I sold 400 bags of Brachiaria planting materials at Ushs 20,000 per bag. I have been able to educate my children and pay our bills. My farm is now a training Centre for farmers from within and outside Uganda. The farmers pay for the training” said Mr. Daaki Peter, Masaka district (Monitor Newspaper, 4th November 2015).

Under NAGRC&DB, a liquid nitrogen plant of capacity 90 liters/hour was installed to produce nitrogen, a raw material in artificial insemination (AI). The plant produced 121,676lts of Nitrogen that was distributed to 64 AI centers.

- 215 mobile liquid nitrogen containers were procured for delivery of semen
- An assortment of AI equipment and 10,000 doses (3,000 sexed) were procured.
- To date a total of 125,452 doses have been produced.
- 70,814 doses have been distributed
- Conception rate improved from 3 to 2 serves/conception

How has Government positioned itself in readiness for Phase II of the Eastern African Agricultural Productivity Programme?

EAAPP Phase II has been named Eastern and Central Africa Agriculture Transformation (ECAAT) project focusing on regional agricultural production constraints (e.g., pests, diseases, poor soil management) food markets, regional/country surpluses, import substitution, export promotion and improving smallholder access to regional markets (policies).

Recommendations

On the basis of the findings in this ICR report, the following recommendations have been made for the attention of government, World Bank, EAAPP Regional Programme Phase II and EAAPP Uganda PCU.

Government

- NARO and MAAIF should follow-up with Ministry of Finance in order to expedite the “Expression of Interest to the World Bank to support of Phase II of EAAPP”
- There should be resources deliberately allocated for supporting district and academic institution involvement in EAAPP activities
- Uganda needs to expedite the development and approval key policies such as cassava policy, livestock policy and legislation on animal feed.
- There will be need to include wheat and other commodities that the expansion countries will bring on board among the national research and production agenda
- There is need to harmonize and address disparity in allowances paid to scientists as they travel across the different countries while implementing EAAPP activities.



- There is need to periodically sensitize scientists on the critical and relevant government policies, regulations and guidelines that have direct and/or indirect implications and linkages to the research processes, innovations and initiatives that the scientists undertake.

Bank

- Favorably consider supporting the implementation of Phase II of the EAAPP regional programme
- Encourage other countries in the region to join the EAAPP as envisaged in the PAD

Regional Programme – Phase II

- Need to balance between upstream, mid-stream and down-stream activities in Phase II
- Support be given for formation and/or strengthening of national and regional Professional Associations (e.g. Breeders Association) associated with the commodities under EAAPP
- There is need to develop mechanism for utilizing ICT and to support more lesson learning and sharing of best practices in technology development and dissemination across the regions
- Need to support a seed processing unit that will handle seed dressing, drying, packaging and seed certification; there is also need to engage the private sector in forage seed production and marketing
- Project should include post-harvest handling and value addition such as seed dressing, drying and packaging that can improve the shelf life of seeds, their marketability and conformity to seed certification standards.

- One of the following two options be considered for selection of regional coordination of EAAPP Phase II. *Option 1:* Continue with ASARECA as the coordinating body subject to a successful organizational review and restructuring that will result in the organization having appropriate human resource capacity, capability, competence and intellectual resource to coordinate regional projects run by senior research scientists in the region. *Option 2:* Use the Secretariat of one of the existing regional economic institutions i.e. COMESA, EAC, IGAD to coordinate EAAPP
- Review the funding options for ASARECA inputs e.g. through direct commissioning for specific inputs.
- There is need to bring and strengthen engagement of

universities, farmer institutions and decentralized governments into the research and extension efforts under EAAPP in order to enhance more effective utilization of agricultural knowledge and information system for agricultural development in the region.

- The composition of a project steering committee should include policy and decision makers as well as senior scientists with high level of management / governance experience.
- Policy briefs on each of the four commodities need to be developed from time to time for the purpose of informing and mobilizing political support from the politicians, policy makers and key decision makers.

EAAP accomplishments in pictures



Farmers being trained on feed formulation



The calves from sexed semen



Functional modified grater and chipper models at AFAMCOS in Soroti district





Technicians sampling for herbage biomass yield and tolerance to Napier stunt disease



Disease control under EAAPP Dairy research component



A hybrid between local Napier grass variety and sugar cane under Napier stunt disease screening trial at NaCRRI



Lablab forage seed multiplication



Multiplication of Napier grass varieties that are tolerant to Napier stunt disease by farmers.



- ✓ 5 lowland rice varieties released (2014).
- ✓ WITA 9, NERICA 6, KOMBOKA (IROSN 221), IR 136 (Agora) and TXD 306 (Okile)



The Cassava Regional Center of Excellence building at National Crops Resources Research Institute (NaCRRI).

Chapter 4: Agriculture Capacity strengthening

This chapter presents highlights of built-capacity for enhanced agricultural research services especially in the three broad areas of human resource, physical infrastructure and financial management.

Human Resource

A total of 65 staff was sponsored for PhD and 29 for masters' courses with the support from EAAPP and ATAAS projects as well as other sources of funding, mainly the Government of Uganda (see table below for summary).

Most of the candidates are at different stages of their training apart from four who have successfully completed their studies. Additionally, over 82 staff benefitted from short-term trainings based on their individual training needs. Short-term training as indicated in the staff development plan refers to any capacity building that is below Masters Level including on-station/institute trainings as well as outside station trainings.

Staff salaries

In efforts to enhance staff salary, a sum of 3.5 billion shil-

lings was lobbied for and the NARO Governing Council approved the application of the resources as follows; 2.1 billion shillings for increase salaries of the existing staff, 968 million shillings for an additional 60 staff to be recruited in the financial year 2016/17 and 384 million shillings for promotion of staff.

Owing to resource limitations, the promotion of some staff arising out of evaluation of the year 2016 were differed to a future appropriate date. The differed promotion shall take precedence over any other future staff promotion in NARO

Summary of staff on long-term trainings

SOURCE OF FUNDING	PhD	MSc
EAAPP FUNDING	34	8
ATAAS FUNDING	6	10
OTHER FUNDING	25	11
TOTAL	65	29

Physical Resources

Funds under this project supported investments in equipment, facilities and their maintenance. Specifically the funds were invested in infrastructure development – laboratories, office and conference facilities. Facilities such as ICT and specialized research and transport equipment will be procured.

During the reporting period, the main civil works were supported under the Agricultural Technology and Agribusiness Advisory Services (ATAAS) project and most of them have been completed. These include; rehabilitation and construction of offices laboratories, stores, and screen houses at various NARO Institutes. The works were su-

pervised by Infrastructure Design forum (IDforum) and contract management teams constituted at each of the NARO institutes headed by the Director of that institute. There is also an overall NARO -wide Contracts Management Team (CMT) to oversee the works progress.

Rehabilitation and construction of offices, laboratories, stores, and screen houses at various NARO institutes

Civil Works facility	Location	Status
New office building with conference facility of approx. 350 sq. m; Rehabilitation of the office building at Buginyanya into a laboratory	Buginyanya (BugiZARDI) Station	Completed
New office building with conference facility of approx. 350 sq. m;	Bulegeni Site	Completed
New Administration Building with conference facilities of approx. 350 sq. m; New Director's house; Laboratory of 200 sq. m; Store of approx. 80 sq. m;	Nabuin (NabuZARDI) Station	Completed
New office building with conference facility of approx. 350 sq. m; Laboratory building of 200 sq. m	Ngetta (NgeZARDI) Station	Completed
Rehabilitation of the 3 No. Laboratory blocks (including the cold room) for Sorghum, Soil Chemistry and Entomology	Serere (NaSARRI) Station	Completed
New office building with conference facility of approx. 350 sq. m; Laboratory building of 200 sq. m	Bulindi (BuZARDI) Station	Completed
New office building with conference facility of approx. 350 sq. m;	Nakyesasa Station	Completed
New Conference and Training Facility of approximately 350 sq. m	NaFIRRI, Kajjansi Station	Completed
Rehabilitation of the Mini-conference Facility and Ablution Blocks	NAROSEC Entebbe	Completed
Rehabilitation (Re-roofing) of the tissue culture laboratory at Kachwekano; New Conference and Training Facility of approximately 350 sq. m	Kachwekano (KaZARDI) Station	Completed
Screen house of 148 sq. m	Karengyere Station	Completed
New Conference and Training Facility of approximately 350 sq. m; Rehabilitation of water works	Mbarara (MbaZARDI) Station	Completed
New office building with conference facility of approx. 350 sq. m; Laboratory building of 200 sq. m	Kamenyamigo Station	Completed

The project also planned to procure additional facilities such as ICT and specialized research and transport equipment that are critical for efficient and effective conduct of research. Progress on implementation of the ATAAS procurement plan is shown in Table below.

Progress on NARO ATAAS procurement plan

Contract lot No.	Contract description	Users	Suppliers	Contract amount (Estimated)	Status
a. Goods					
1	Laboratory Equipment and Hardware	All PARIs	N/A	N/A	Bidding Document with specifications being reviewed.

Contract lot No.	Contract description	Users	Suppliers	Contract amount (Estimated)	Status
1	Soil Analysis Machine (Spectrometer with Accessories, Installation, Commissioning and Training)- lot-1; and Soil Analysis equipment- Alpha Spectrometer (01), Conservation Agriculture equipment for Zonal Technical Service Units (Peddle sprayer, ripper & seeder) (20)- Lot -2 for SLM	SLM	N/A	N/A	Advert for the bidders ran and bidding in progress.
1	Data Collection Tablets (200) for NARO Scientists and Assorted ICT Equipment for SLM (Desktop computers (04), laptops (09), GPS receivers (09), Projector, Cameras (12), accessories	NARO Scientists. SLM	N/A	Specifications for the data collection tablets yet to be developed by the user.	Specifications for the data collection tablets yet to be developed by the user.
1	Double Cabins Vehicles (4No.)	NAROSEC and SLM	N/A	N/A	Advert for the bidders ran and bidding in progress
1	Assorted Office Furniture for NARL (Conference Hall) , NAROSEC (refurbished mini Conference Hall and reception), & SLM	NARO-SEC Rwebitaba NARL SLM	N/A	N/A	Advert for the bidders ran and bidding in progress.
	Small Office Equipment for SLM (Plotter cartridge (6no), Munsell colour charts (4no), and Mobile platform ladders (2no)	SLM	N/A	N/A	Specifications yet to be received from the user.
b Civil works					
Lot 1	Construction of a Cattle Shed at Nakyensasa	NaLIRRI	Buildbase Contractors Ltd	3,940,357,624	Contract Signed on November 19, 2015. Site handed over and work in progress
c Consultancies					
1	Research Scientists to Support NARO Secretariat and NARO Institutes	All PARIs	19Research Scientist's	251,000	2ndyear of contract running up to May 30,
2	Supervision Services for Construction and Rehabilitation of NARO Infrastructure	All PARIs	Infrastructural Development Forum	105,632.94 (Supervision)	Supervision Consultants on board. Phase II of the contract on going.
3	Environmental Impact Assessment Consultant-Civil Works under NaFIRRI	NaFiRRI	WSS Services Ltd	47,200	Final Report presented to NEMA for approval.
4	Support to Business Development Studies and Plans for PARIS	All PARIs	Big Drum Advisory Services	119,400	Final Report presented to management and approved.
5	Staff Training in Environmental and Social Safeguards	All PARIs	Atacama Consulting Services in Association with EOH	87,084	Contract signed dated January 11, 2016. Inception report to be presented to management for approval.

Contract lot No.	Contract description	Users	Suppliers	Contract amount (Estimated)	Status
	Consultancy for Procurement Audit and Training	All PARIs	N/A	N/A	Terms of Reference to be developed and sent to the bank for a No Objection.
6	Consultancy Services for Environmental Audit of the ATAAS Project.	NARO-SEC	N/A	N/A	Terms of reference sent to the bank for approval.

Financial Management

NARO operates with two sources of funding namely; Government of Uganda, local and international development partners. In the FY 2015/16, a total of UGX 98.983 billion was approved, out of which 73.984 billion was released and 86% of the released funds were effectively spent.

Budget Performance FY 2015/16

1. Excluding	Arrears Taxes	Approved Budget	Releases	Spent by end Jun 2016	% Budget Released	% Budget Spent	% Release Spent
Recurrent	Wage	18.972	18.972	4.743	100.0%	100.0%	100.0%
	Non Wage	8.765	7.499	7.499	86.0%	86.0%	100.0%
Development	GoU	9.130	9.130	9.130	100.0%	100.0%	100.0%
	Donor*	54.364	35.054	25.048	64.0%	46.0%	71.0%
GoU Total		36.868	35.601	35.601	97.0%	97.0%	100.0%
Total Gou + Donor (MTEF)		91.231	70.655	60.649	77%	66%	86%
2. Arrears and Taxes	Arrears	0.743	0.743	0.743	100.0%	100.0%	100.0%
	Taxes**	0.000	N/A	N/A	N/A	N/A	N/A
	Total Budget	91.974	71.398	61.392	78%	67%	86%
3. Non Tax Revenue		7.008	2.586	2.492	37%	36%	96%
	Grand Total	98.983	73.984	63.884	75%	65%	86%
	Excluding Taxes, Arrears	98.24	73.241	63.141	75%	64%	86%

Summary of Key Performance Indicators FY 2015/16

Key Performance Indicators	Target	Achieved	Performance (%)
Generation of Technologies			
No. of improved productivity technologies generated	60	86	>100
No. of research studies under competitive grants scheme	65	66	>100
No. of new varieties submitted to Variety Release Committee	20	46	>100
Research Extension Interface Promoted and Strengthened			
No. of technological innovations delivered to uptake pathways			
No. of technological innovation platforms established	5	44	

Operationalizing the Directorate of Agricultural Technology Promotion

1. Introduction

A new directorate to serve as a gateway for the public's access to agricultural technologies developed by the National Agricultural Research Organization (NARO) was established. With approval of the NARO Governing Council during its business sitting in September 2015, the directorate was named "The Directorate of Agricultural Technology Promotion - DATP", and mandated to coordinate the promotion of agricultural research products, services and innovations for their effective and efficient utilization by intended users, thereby increasing NAROs visibility and relevance. Considering that it is through linkages and networks that NARO technologies would be widely disseminated, the directorate was as well be mandated to spearhead and guide strengthening and establishment of strategic collaborations and partnerships that service both inputs and outputs of research in NARO. Consequently, NARO Management embarked on providing it with staff to enable it perform its ascribed functions, roles and responsibilities.

2. Background of the Directorate

The importance of a strong and centrally coordinated system for facilitating uptake of research services and products (technologies, innovations and management practices - TIMPs) had always been recognised and harnessed in NARO. This was however downplayed by the reforms in 2005, which disparaged the significance of a coordinating function in the broader picture of agricultural technology generation, promotion, dissemination and transfer continuum. Such structures existed before and had contributed to increased uptake of research products. Examples include establishment at NARO headquarters of the (i) Research and Extension Liaison Unit (RELU) in 1993 for coordinating technology transfer, (ii) Publications Unit (PU) in 1996 to coordinate the production and distribution of NARO publications, (iii). Library and Information Service Network (LISN) coordinated by the Agricultural Research Information Service (ARIS) in 1995, (iv) Uganda Journal of Agricultural Sciences (UJAS) in 1997. All this was aimed at NARO having its generated results consolidated and publicised

for wide access by intermediary service providers (especially extension workers) and transfer to end users for utilisation.

With weakness in the extension systems, and through a review of MAAIF and NARO in 1999, a concept of client-oriented adaptive research and technology dissemination tailored to agro-ecological zones was embraced. NARO decentralized its services by creation of Agricultural Research and Development Centres (ARDCs), in order to bring services nearer to end-user communities. For effective coordination an internal restructuring was done at the headquarters between 1998 -2001, resulting into the birth of two directorates; one to coordinate research and the other to coordinate outreach and partnership agenda. The Outreach and Partnership Directorate (OPD) assumed the functions formerly played by RELU, PU, LISN, in addition to coordinating and guiding the ARDCs' agenda.

The NARO reform that led to the NAR Act 2005 upgraded the ARDCs to Zonal Agricultural Research and Development Institutes (ZARDIs), joined them to the National Agricultural Research Institutes (NARIs) which together formed Public Agricultural Research Institutes (PARIs) as semi-autonomous bodies from the apex body, NARO. A Quality Assurance Directorate was created and the Outreach and Partnership Directorate and its function were suppressed. Along implementation of the reformed (new) NARO, functional gaps were realised. This led to NARO Management engaging the Ministry of Public Service in 2013, to review the NARO Secretariat structure. As a result, among others, a recommendation to consider establishment of a directorate to oversee operationalisation of the research-extension-stakeholder function was made. It aimed at having the process of disseminating NARO-generated products coordinated in order to enhance their utilisation by intended users. It was also deemed important for such a directorate to coordinate the technology transfer processes that would lead to commercialisation of NARO technologies, via incubation, patenting, licensing, in addition to the well

appreciated broad outreach (including communication) and the growing need for records and knowledge management. It was against this background that the directorate of “Agricultural Technology Promotion” was established (Min. 142: GC/18/7/3/2013), and replaced the Directorate of Quality Assurance in the NARO Secretariat structure.

3. The Directorate’s purpose

The purpose of the directorate is to enhance access and utilization of agricultural research products, services and innovations, and strengthen formation of viable partnerships.

4. Key functions of the Directorate

The Directorate will undertake the following support functions:

1. Outreach and extension liaison
2. Protection, incubation and commercialisation of NARO technologies
3. Partnerships and networks formation and nurturing
4. Knowledge (data, information, publications and records) management
5. Awareness and Development Communication

5. Operationalization of the functions

In executing the functions, the directorate will put emphasis on development of strategies, guidelines, standards and compliance measures, for enabling communication and dissemination of NARO products in harmonized approaches, including branding. Similarly focus will be put in providing frameworks for enhancing commercialization and protection of NARO products. To establish compliance to and performance of the developed and rolled out guidelines, the directorate will supervise, monitor and analyse the implementation of such guidelines. To achieve this, it will develop tools for collecting data while conducting assessments, and also for soliciting feedback from the end-users, on performance of disseminated technologies, then using it to provide recommendations to research coordination for improving research processes and products. The guidelines will be directly implemented by the Public agricultural Research Institutes (PARIs) and other Agricultural Research Service Providers (ARSPs). To reach out to more intended beneficiaries, the directorate will develop mechanisms for harnessing synergies from relevant partnerships and

networks within NARO, and multi-institutional ones nationally and globally.

Considering that the directorates and units at the secretariat are interdependent, the directorate of Agricultural Technology Promotion sees its key linkages to the other directorates as follows, to mention but a few:

i. The Directorate of Corporate Services:

1. Policies and MoUs formulation processes
2. Compliance standards development
3. Procurement procedures
4. Public relations information management

ii. The Directorate of Research Coordination:

1. PM&E frameworks (indicators, targets) development
2. Demand articulation and priority setting process
3. Technology performance feedback

iv. The Directorate of Human Resource

1. Directorate staff recruitments and welfare
2. Identification of training needs

v. The Directorate of Finance:

1. Development and implementation of budgets
2. Accountability procedures

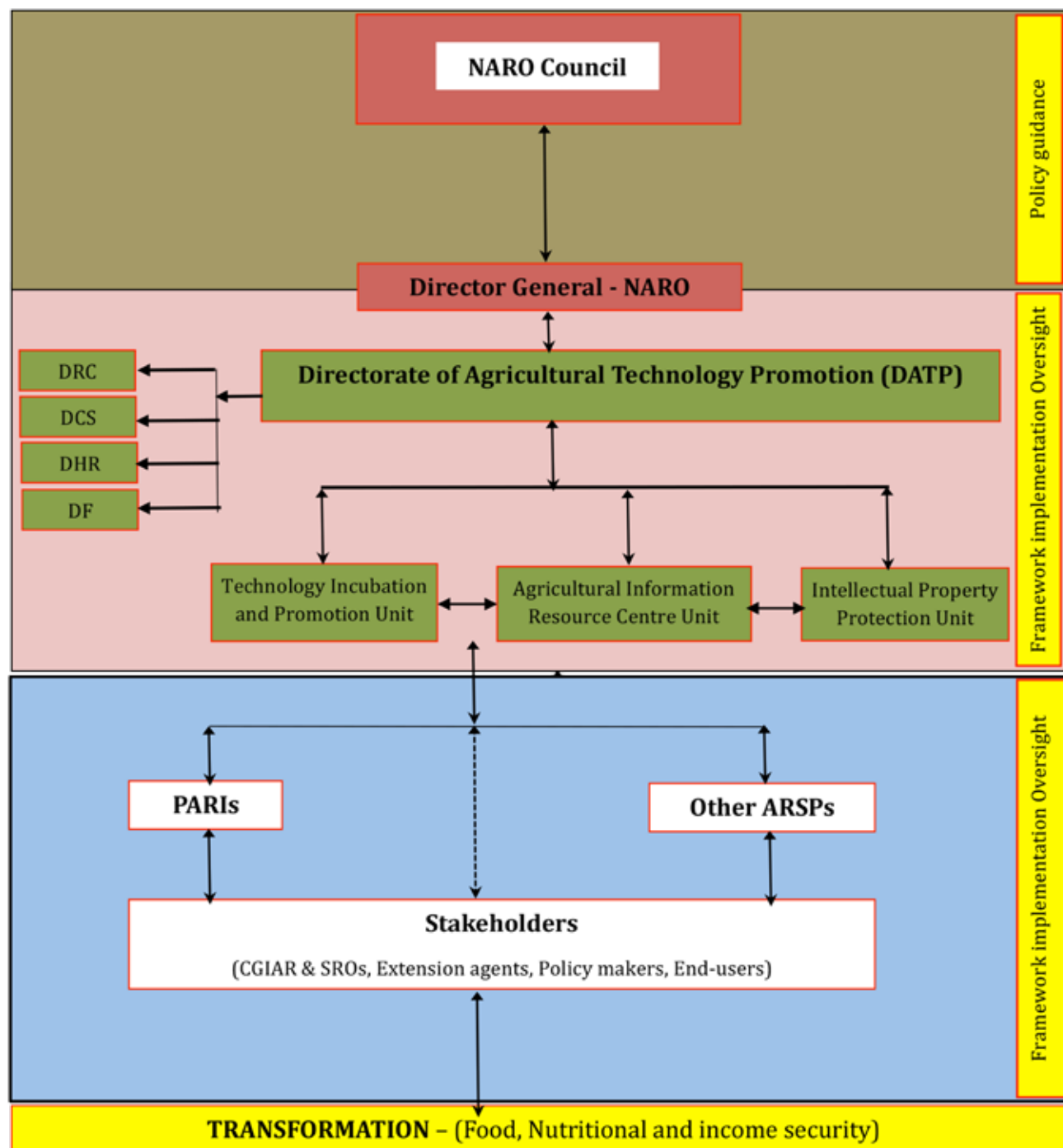
vi The Department of Internal Audit

1. Risk assessment processes

For all the directorates/departments above, DATP will access their information or records for centralised management/storage in the central database.

External of NARO Secretariat, the directorate will liaise with PARIs and other ARSP who receive NARO funds under the competitive grant scheme. The directorate will provide guidelines for implementation of technology promotion activities to these institutes/service providers, supervise implementation of the guidelines and prepare and submit compliance and performance reports to the Director General for management decisions. The DATP will also link with partners and networks, and establish avenues for enabling exchange of knowledge to support both technology generation and utilization.

Structure of the Directorate of Agricultural Technology Promotion (DATP)



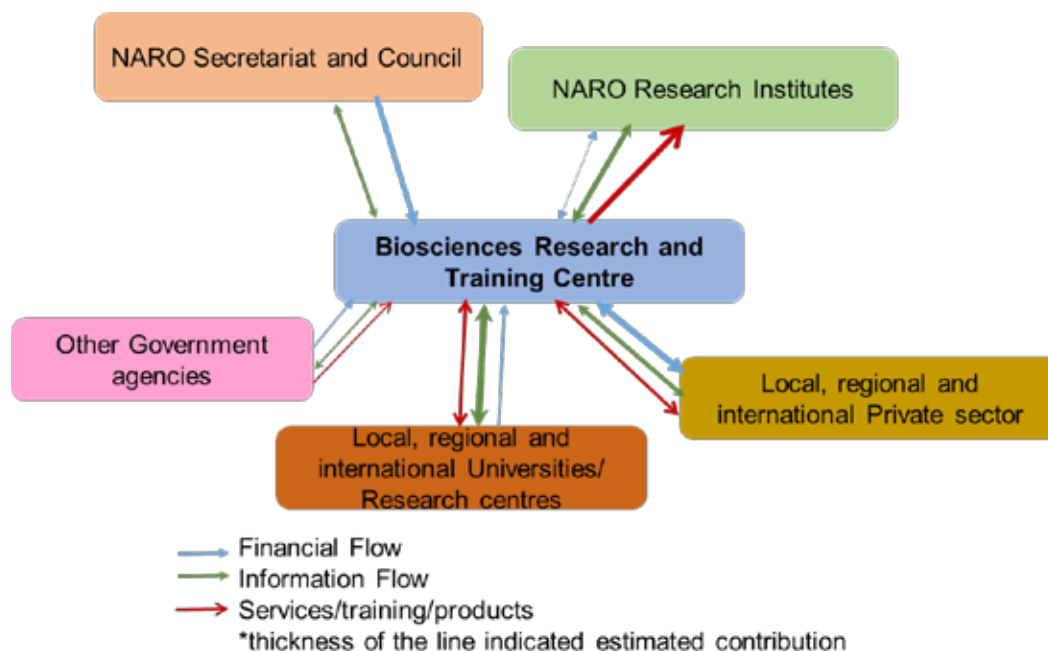
Other establishments

Uganda Biosciences Research and Training Center (UBRTC)

Established in August 2015 under NGC MIN. GC26/26/6/2015, the center is expected to use the latest knowledge and cutting-edge technologies for products development or services. The Objectives are; to provide state-of-the-art facilities and expertise to conduct research for product and technologies development, to provide services to research

capabilities of NARS and other institutions for delivering excellent products, to conduct training to enhance skills in innovative biosciences research, and bio-business; and to operate a KCM hub to promote products and technologies generated by the Center.

UBRTC Partnership Framework



66 Research studies supported under the competitive grants scheme

The National Agricultural Research Act of 2005 provides for the establishment of the Competitive Research Grant in the National Agricultural Research Organisation (NARO). The purpose is to strengthen the national agricultural research system (NARS) through better involvement of different stakeholders and actors.

The scope of Competitive Grant Scheme (CGS) includes addressing innovative non-core research area priority interventions agreed by stakeholders in Agricultural Sector.

A considerable good progress in delivery of results and prod-

ucts has been registered so far through implementation of the 41 three-year projects since 2014

According to the CGS National Coordinator, Dr. Julius Mukalazi, the coordination unit shall continuously follow-up, monitor and evaluate the 66 projects currently under implementation, for timely delivery of quality research results/products.

In a competitive research grant scheme, research providers are selected on a competitive basis, using calls for proposals and scientific peer review to allocate set funding.

It catches up with research paradigm shift in NARO where research does not only lead to knowledge and publications, but also and first of all should contribute to change and innovation for the betterment of people, while also preserving the natural resource base for future generations

One of the biggest advantages of this kind of funding is that it breaks through the previously held view that perhaps public research service providers such as those in NARO are cut-off from farmers because they work in the “ivory towers” as the

proverb has it and are not ‘talking’ to the real practitioners (farmers), and the practitioners maybe are also “scared” to talk to ‘those clever scientists’. The beauty with CGS is that it is open to a variety of potential contributors who may wish to finance specific research or technology transfer activities through the fund.

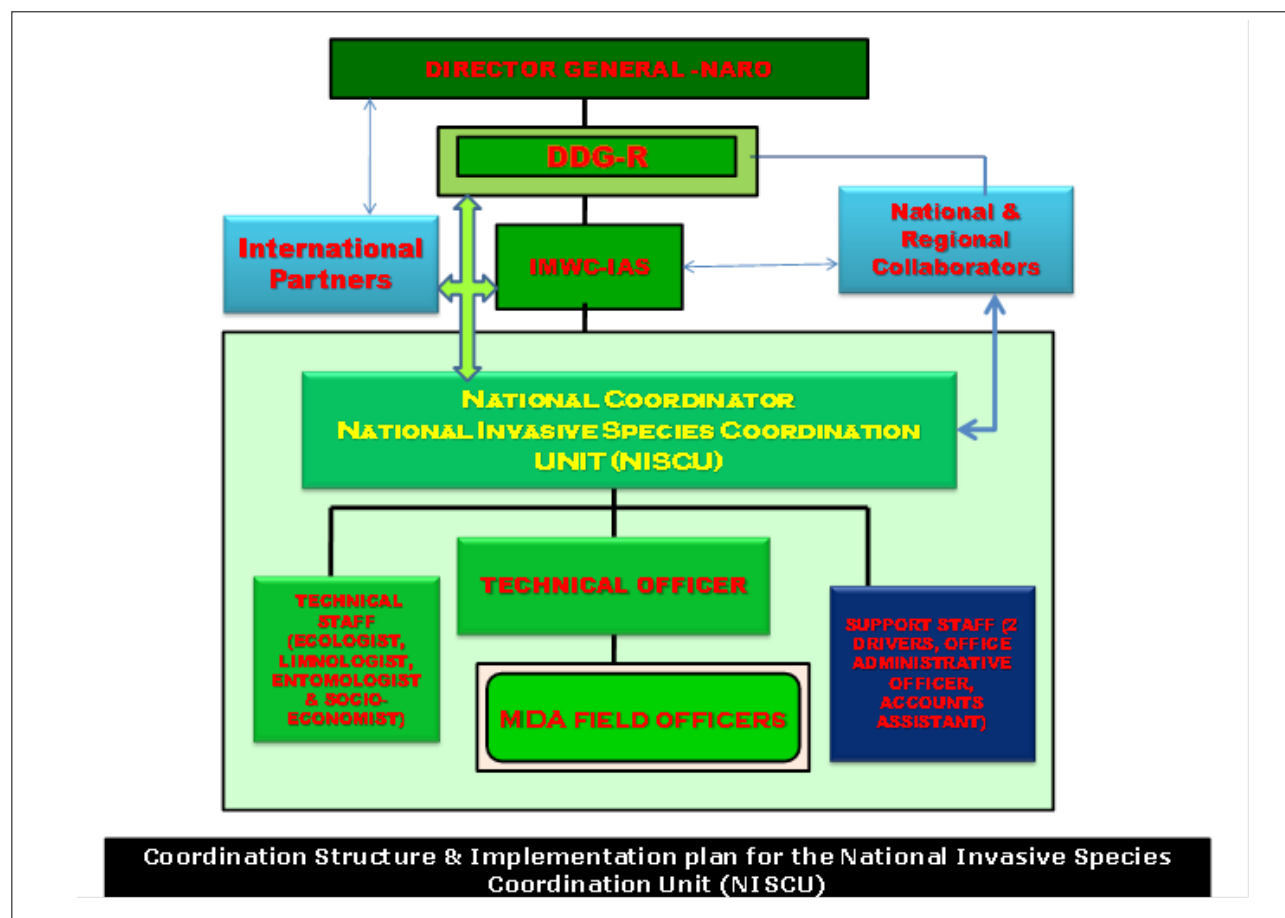
An increased pluralism in agricultural research therefore means that intended beneficiaries and other stakeholders should feel encouraged to participate in the grant scheme.

National Invasive Species Coordination Unit (NISCU)

An inter-ministerial unit ratified by NARO Council in 2015 to Coordinate and Champion a Collective, effective and Sustainable Management and Control of Invasive Alien Species in Uganda. It coordinates all IAS management efforts to minimize impacts on biological diversity, ecosystem functioning, climate change and land-use, promotes

national, regional and international partnerships for the management of IAS, Influences policies for effective and sustainable IAS management ,and spearheads generation and deployment of scientific IAS control innovations through cutting edge R&D.

Operational structure of NISCU





Chapter 5: Report and audited accounts

The primary role of internal audit is to provide independent assurance that NARO's risk management, governance and internal control processes are operating effectively. This report outlines the internal audit work carried out for the year ended 30th June 2016.

Internal Audit Statement

Routine audits were carried across Public Agricultural Research Institutes (PARI's) and at NAROSEC in accordance with the approved workplan. At the end of each quarter the consolidated internal audit reports were consolidated and presented to the Audit and Risk Committee and Management for appropriate decision making. This improved governance, internal control and risk management processes leading less financial accountability queries from the office of the Auditor General.

Value for Money (VFM) audits were conducted to ascertain the efficiency and effectiveness with which resources were utilized. This contributed to a culture of economical use of resources. Processing audits were carried out through reviews of sensitive areas such as procurements, civil works and deliveries of supplies.

This led to reduction in mal-procurements, substandard works and delivery of substandard goods Supervisory visits to the sixteen (16) NARO PARIs were conducted quarterly to assure quality and timely Internal Audit Service.

The Audit and Risk Committee members were inaugurated. The Committee provided objective advice and insights into NARO's strategic and organizational governance processes, control risk management framework. In doing so, they identified potential improvements and

made recommendations to the Governing Council and Management.

There has been significant action taken in implementing internal Audit recommendations. Management responses and the level of evidence provided to confirm implementation continued to improve but was not consistent. There is need for Internal Audit to make a follow-up on a continuous basis to ensure that all audit recommendations are implemented to mitigate against repeat of the same audit findings.

Internal Audit continues to work with Directors of Research at PARI's and Directorates at NAROSEC to ensure that steps are taken by management to mitigate the identified risks and implement recommendations on a timely basis.

Opinion of the Auditor General

Article 163 of the Constitution of the Republic of Uganda, 1995 (as amended) and Section 13 and 19 of the National Audit Act, 2008 gives the Auditor General the responsibility to audit and express opinion on the financial statements of NARO.

Indeed for the 2015/16 Financial Year the Auditor General has expressed that opinion to the effect that the NARO financial statements for the year are free from material misstatement. An extract from the Auditor General's reads:

"In my opinion the financial statements of the National Agricultural Research Organisation (NARO) for the year ended 30th June, 2016 were prepared in accordance with Section 51 of the Public Finance Management Act, 2015 and the Financial Reporting Guide, 2008."

Chapter 6: Challenges and Recommendations

This chapter outlines some of the challenges and gaps experienced during the implementation of plan for the FY2015/16. It correspondingly outlines a prescriptive paradigm shift to address future challenges as well as a synopsis of the current and future strategic research direction. Lastly, the chapter presents an outline of benchmarked best practices in research and lessons from other countries.

Challenges during the implementation of plan for the FY2015/16

- Delayed release of funds and budget inadequacy
- Inadequate human and financial resources and equipment occasioned by budget short falls
- Non-sustainable and unpredictable funding modalities
- Noncompetitive salaries among similar agencies
- Procurement delays in acquisition of services
- Weak dissemination of research findings, up-scaling on farm and on-station research demonstrations.
- Deteriorating infrastructure: Low quality of laboratories in Rwebitaba and NaCORI
- NARO land encroachment.
- Delay in enactment of Biotechnology and Biosafety Bill.

Recommendations

- Raise MTEF ceiling and government commits predictable and sustainable funding mechanisms
- Acquire land titles in NARO's names
- Gazette all research land
- Intensify research-farmer interface
- Expedite enactment of law on Biotechnology and Biosafety

Current and future strategic research directions

- Genetic improvement of crop varieties and animal breeds

- Improving crop and animal management practices
- Management of plant and animal health
- Product development and diversification for a number of value chains
- Mechanization of production and value addition
- Gender mainstreaming in agri-enterprises
- Natural resource management including Climate smart agriculture
- Application of modern biotechnology
- Vaccine development
- Bio-prospecting of indigenous plants: aquatic, terrestrial and subterranean

Best practices in research and lessons from other countries

- Potential research structure for creating impact in households livelihoods in the country, for example ICRISAT in India, one research programme has more than 30 scientists
- Enabling environment like the passing of the Bio-technology bill
- Up to date documentation, ICT and Automation: weather forecast, use of drones in data collection; traceability of products; pest and disease outbreaks etc.
- Create critical skills, infrastructure and resources for NARO to be able to generate the Elite lines for improving breeding programs

7.0 Publications & information Resources 2015/16

Journal Publications

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Annexes

Annex 1: Banana genotypes selected from the first project early evaluation trial established in September 2015

No.	Genotype Code	Cross	NSLL	YLS	BWT (Kgs)	DTM	Consumer acceptance
1	10/569-10	365K-1x402	7	5	9		*
2	10/569-15	365K-1x402	10	9	8	184	****
3	10/574-3	199K-1x402	8	7	6	147	****
4	10/579-1	1411K-1x2905	9	9	14	196	*****
5	10/579-2	1411K-1x2905	12	11	12	196	****
6	10/579-3	1411K-1x2905	13	11	10	196	****
7	10/579-4	1411K-1x2905	10	8	12	63	*****
8	10/585-6	401K-1x402	11	8	20	164	****
9	10/585-7	401K-1x402	8	6	8	150	*
10	10/585-8	401K-1x402	9	6	9	147	***
11	10/595-1	199K-3x402	9	7	8	138	****
12	10/601-2	1154K-1x402	12	9	14	133	****
13	10/601-5	1154K-1x402	11	9	12	-	****
14	10/601-7	1154K-1x402	8	7	10	175	****
15	10/669-24	1411K-1x402	12	10	5	175	*****
16	10/669-38	1411K-1x402	14	8	10	168	****
17	10/669-5	1411K-1x402	15	10	11	175	*
18	10/669-62	1411K-1x402	9	7	7	175	**
19	10/669-83	1411K-1x402	9	5	6	164	**
20	10/669-85	1411K-1x402	9	5	8	171	**
21	10/671-5	376Kx402	8	5	8	182	**
22	10/672-1	401Kx402	6	5	7	147	***
23	10/672-2	401Kx402	-	-	10	-	****
24	10/672-4	401Kx402	10	9	6	174	*****
25	10/672-5	401Kx402	12	10	7	189	***
26	10/672-8	401Kx402	11	9	7	161	****
27	10/686-12	365Kx402	9	9	5	163	****
28	10/687-5	660K-1x716	8	6	5	147	***
29	10/689-5	660K-1x2905	15	13	7	161	***

No.	Genotype Code	Cross	NSLL	YLS	BWT (Kgs)	DTM	Consumer acceptance
30	10/689-7	660K-1x2905	9	9	6	196	***
31	10/700-10	660K-1x716	11	9	15	167	***
32	10/700-12	660K-1x716	11	11	6	140	***
33	10/700-14	660K-1x716	7	6	10	168	****
34	10/700-17	660K-1x716	13	9	6	147	***
35	10/700-18	660K-1x716	9	7	6	160	**
36	10/700-20	660K-1x716	-	-	8	-	****
37	10/700-8	660K-1x716	11	9	8	154	*****
38	10/702-2	199K-3x2905	12	12	12	182	*
39	10/669-32	1411K-1x402	7	5	8	180	***
40	10/601-1	1154K-1x402	10	10	10	171	****
41	10/601-3	1154K-1x402	11	9	11	168	****
42	Mbwazirume	N/A	8.7	6.5	7.8	97.5	**

NSL= number of green standing leaves, YLS= youngest leaf spotted at flowering, BWT= bunch weight (kg), NLH= number of leaves at flowering, and DTM=days to bunch maturity.

Remarks=Defines the level of consumer acceptance of the test genotypes compared to Mbwazirume (a local check)

***** (5 stars) = No sap and deep yellow pulp colour same as that of Mbwazirume

**** (4 stars) = No sap and yellow pulp colour almost same as that of Mbwazirume

*** (3 stars) = No sap and yellow colour slightly lighter than that of Mbwazirume

** (2 stars) = With little sap and colour slightly lighter than that of Mbwazirume;

Annex 2: Cost benefit estimates for Arabica coffee in Uganda

ACTIVITY		UNIT	UNIT COST (UGX)	TOTAL (UGX)
1. Maintenance cost: (weeding, pruning, de-suckering, manure application, harvesting etc.	90	man-days	3,000	270,000
2. Equipment (Depreciation cost)				200,000
3. Input costs:				
Fertiliser	2	Bags	130,000	260,000
Herbicide	4	litres	20,000	80,000
Pesticide	2	Litres	25,000	50,000
Fungicide	10	Kgs	25,000	250,000
Manure	10	MT	60,000	600,000
Mulch	5	MT	40,000	200,000
4. Harvesting	60	man-days	3,000	180,000
5. Pulping and Fermentation	10	man-days	3,000	30,000
6. Drying	10	man-days	3,000	30,000
Sub-total				2,150,000
Contingency (5%)				107,500
Sub-total costs/ha/year				2,257,500
Yield/ha/year	1020	Kg		
Cost of production per kg of parchment	1	Kg	2,213	2,213
Average farm gate price/kg of parchment	1	Kg	7,000	7,000
Farmer's margin/kg of parchment	1	Kg		4,787
- Gross income/ha/year				7,140,000
- Net income/ha/year				4,882,500

- Farm gate price based on the 2011 season average
- An acre has 680 trees spaced at 8ftx8ft (2.44mx2.44m)
- Yield/tree is 0.7kg of parchment at optimal management over a 5 year cycle
- Parchment refers to pulped coffee

Annex 3: Cost benefit estimates for Robusta coffee in Uganda

ACTIVITY		UNIT	UNIT COST (UGX)	TOTAL (UGX)
1. Maintenance cost: (weeding, pruning, de-suckering, manure application, harvesting etc.	90	man-days	3,000	270,000
2. Equipment (Depreciation cost)				200,000
3. Input costs:				
Fertiliser	2	Bags	130,000	260,000
Herbicide	4	litres	20,000	80,000
Pesticide	2	Litres	25,000	50,000
Fungicide	10	Kgs	25,000	250,000
Manure	10	MT	60,000	600,000
Mulch	5	MT	40,000	200,000
4. Harvesting	60	man-days	3,000	180,000
5. Pulping and Fermentation	10	man-days	3,000	30,000
6. Drying	10	man-days	3,000	30,000
Sub-total				2,150,000
Contingency (5%)				107,500
Sub-total costs/ha/year				2,257,500
Yield/acre/year	1020	Kg		
Cost of production per kg of parchment	1	Kg	2,213	2,213
Average farm gate price/kg of parchment/kg	1	Kg	7,000	7,000
Arabica coffee grower's margin/kg of parchment	1	Kg		4,787
- Gross income/ha/year				7,140,000
- Net income/ha/year				4,882,500
-Net income/acre/year				1,953,000

- Farm gate price based on the 2011 season minimum
- An acre has 680 trees spaced at 8ftx8ft (2.44mx2.44m)
- Yield/tree is 1.5kg of parchment at optimal management over a 5 year cycle
- Parchment refers to unprocessed coffee

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