NARO

NARO Successful Interventions Generated and Disseminated Towards Agricultural Development in Uganda

1992 - 2017



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ISSN 1026-0919, e-ISSN 2410-6909 www.NARO.go.ug

Citation: NARO, 2017. NARO's Successful Interventions generated and disseminated in Partnerships working toward Agricultural Development in Uganda. National Agricultural Research Organisation (NARO)

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NARO

NARO successful interventions generated and disseminated towards Agricultural Development in Uganda

November 2017

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ACKNOWLEDGEMENTS

This inventory has been a collaborative effort and we would like to thank all the people and organizations that contributed to it. First, we wish to appreciate the support by the World Bank and the National Agricultural Research Organization (NARO) through the Competitive Grants Scheme (CGS) which made this work possible. We acknowledge the efforts of NARO Top Policy Management (TPM) for approving the financial support to this project. The visionary leadership and inspiration from NARO Deputy Director Generals (DDGs)-Dr. Imelda N. Kashaija and Dr. Yona Baguma throughout the implementation of this project merits special applause.

We are especially grateful to all NARO Institute Directors, Program Leaders, Scientists and Technicians for their dedication and commitment towards providing the content for the inventory. Journalists and NARO Communication Officers are particularly appreciated for their active role in data collection and content development. Appreciation also goes to all the authors who took time to research, interview and document NARO's successes/efforts in their respective institutes and spheres of expertize. We also acknowledge the people who willingly participated in interviews, contributed to and assisted this work in myriad ways, enriching the content with their experiences and critical ideas.

Special thanks go to Dr. John Balirwa and Dr. Stella Kabiri for their insightful advice as internal reviewers. The Project team; Anita Tibasaaga, Joshua Raymond Muhumuza, Owen Singura, Kefa Atibuni, and Victoria A. Mbigidde who shared the stress and excitement in the production of this book is gratefully acknowledged. We are deeply indebted to Dr. Barbara Mugwanya Zawedde– Coordinator, Uganda Biosciences Information Center (UBIC) and Project Principal Investigator for her pioneering and passionate leadership that provided the spark for this work from start to finish.

We believe that this compilation, presenting a diversity of concepts, perspectives, strategies and approaches, offers a highly valuable resource for everyone with an avid interest in agriculture, and NARO's efforts towards improved agriculture and national development.

LIST OF ACRONYMS

AbiZARDI	Abi Zonal Agricultural Research Development Institute
ADB	African Development Bank
AGRITT	Agricultural Technology Tranfer
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ARDCs	Agricultural Research and Development Centres
BugiZARDI	Buginyanya Zonal Agricultural Research Development Institute
BuZARDI	Bulindi Zonal Agricultural Research Development Institute
CABI	Centre for Agriculture and Biosciences International
CBOs	Community Based Organisations
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Dévelopement (The French agricultural research and international cooperation organization)
CSOs	Civil Society Organisations
DANIDA	Danish International Development Agency
DFI	District Farm Institute
DFID	Department for International Development
EAAPP	Eastern Africa Agricultural Productivity Project
GDP	Gross Domestic Product
IAEA	International Atomic Enercy Agency
JICA	Japan International Cooperation Agency
KaZARDI	Kachwekano Zonal Agricultural Research Development Institute
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MbaZARDI	Mbarara Zonal Agricultural Research Development Institute
MoFPED	Ministry of Finance, Planning and Economic Development
MuZARDI	Mukono Zonal Agricultural Research Development Institute
NAADS	National Agricultural Advisory Services
NabuZARDI	Nabuin Zonal Agricultural Research Development Institute
NaCORI	National Coffee Research Institute
NaCRRI	National Crops Resources Research Institute
NaFIRRI	National Fisheries Resources Research Institute
NaFORRI	National Forestry Resources Research Institute
NaLIRRI	National Livestock Resources Research Institute
NARIs	National Agricultural Research Institutes
NARL	National Agricultural Research Laboratories
NARO	National Agricultural Research organization
NARP	National Agricultural Research Policy

NARS	National Agricultural Research System
NaSARRI	National Semi Arid Resources Research Institute
NgeZARDI	Ngetta Zonal Agricultural Research Development Institute
NGOs	Non Governmental Organisations
PATTEC	Pan African Tsetse and Trypanosomiasis Eradication Campaign
PMA	Plan for Modernisaion of Agriculture
RwebiZARDI	Rwebitaba Zonal Agricultural Research Development Institute
WHO	World Health Organisation
UBOS	Uganda Bureau of Statistics

Chapter 1
INTRODUCTION

1.1 About the National Agricultural Research Organization (NARO)

The agricultural research system in Uganda has evolved over the years from sub-sector based research institutes into a unified National Agricultural Research Organisation (NARO) under the 1992 statute. The statute mandated the organisation to;

"undertake, promote and co-ordinate research in all aspects of crops, fisheries, forestry and livestock, while ensuring dissemination and application of research results.

Reforms in agricultural research led to a review of the NARO Statute 1992 and resulted into the National Agricultural Research Act 2005. The "old NARO" comprised of nine National Agricultural Research Institutes (NARIs) and 12 agro-ecologically-based Agricultural Research and Development Centres (ARDCs) in accordance with decentralisation policy. The ARDCs implemented outreach and partnership programmes to strengthen relevance and dissemination of research products and services. The Organisation registered several achievements and gained national, regional and international accolade. The inception, growth, and achievements of NARO (1992 -2002) have been documented (Mukiibi, 2003).

Following the launch of the Plan for Modernisation of Agriculture (PMA), NARO re-aligned her strategy to focus beyond "technology development" to a "people impact-orientation". The re-alignment gave birth to the National Agricultural Research System (NARS), which provided mechanisms for integration of Research and Development (R&D) issues through a resource-to-consumption innovation systems approach with broader multi-stakeholder participation.

1.2 The National Agricultural Research System (NARS)

The National Agricultural Research Act (NAR Act 2005) transformed the "old NARO" from a predominantly public sector research organisation to a "new NARO". This brought on board a cross-section of entities with the competence and interest to participate in the delivery of agricultural research services. Key stakeholders in the NARS include the semi-autonomous Public Agricultural Research Institutes (PARIs) and the non-PARIs such as universities, other tertiary institutions, Community Based Organisations (CBOs), Civil Society Organisations (CSOs), several players in the private sector, and farmers/farmer groups/ associations. The semi-autonomous PARIs consist of National Agricultural Research Institutes (NARIs) and Zonal Agricultural Research and Development Institutes (ZARDIs). The mandate of the NARIs is to conduct basic and applied research of national and strategic importance (priorities) in all aspects of crops, livestock, fisheries, forestry and any emerging issues in the agricultural sector. The mandate of the ZARDIs is to conduct applied and adaptive research and to facilitate dissemination of appropriate technologies to uptake pathways. However ZARDIs may also conduct basic research on commodities of zone specific importance. ZARDIs address priorities that are articulated by geographical innovation through platforms participatory processes. In this inventory, we highlight some of the successful interventions generated and/or disseminated by the PARIs.

1.3 Rationale for the Inventory

Since its inception, NARO has made significant achievements especially in the generation of technologies and formulation of policies and strategies. Adupa and Opio (2006) for example noted that NARO had generated a total of 313 technologies in all sectors of crops, livestock, fisheries and forestry. Undeniably the number of technologies continues to surge over the years as scientists continue to work hard in responding to the challenges in the agricultural sector. This is illustrated by the increase in number from 313 to 533 technologies generated by 2011 (NARO Technology Register, 2011). Despite the apparent success that NARO has registered, no concerted efforts have been made to systematically document these achievements for benchmarking and dissemination. Even where there have been attempts to document, the efforts seem not to be recognized by both the intermediate and end users, a good number of whom and not aware of the role NARO plays in the socio-economic transformation of the country. In addition, the available documentation is fragmented with regard to commodities, disciplines or systems.

1.4 Objective

The project aims to contribute to increased public awareness of NARO's technologies to enhance their adoption and sustainable use. The overall objective of this inventory is to document successful interventions of NARO to agriculture and national development. This was achieved by documenting some of the major successful interventions as reported by the PARIs. In

this project, a *"successful intervention"* was defined as a technology or policy generated and/or introduced by NARO, whose impact can be demonstrated at the end-users' level.

1.5 Methodology

The study was conducted to collect and collate NARO's achievements that are presumed to be success stories since her inception in 1992. Specifically, existing information on perceived NARO's successful interventions was captured from current and past researchers from the 16 NARO institutes.

In August 2016, a call for abstracts inviting submissions from all NARO institutes was sent out. The Call indicated that an intervention may be ranked as a success if it met the following criteria:

a) A research output that has economic, social or environmental benefits to the communities or livelihoods;
b) A well-documented intervention that provides opportunities to NARO's clientele and the surrounding communities; or
c) A research activity that has been implemented to the expectation of stakeholders.

The abstracts were expected to provide answers to the following research questions:

1. What was the intervention introduced or disseminated?

   In this research question, respondents had to provide information about the variety, approach or practice, formulation, policy brief, prototype, and technology.
2. Why the intervention?

   Respondents had to provide reasons for generation and/or introduction of the intervention.
3. What was the product development process?

   Respondents had to indicate NARO's role in development process, the partnerships and their key responsibilities.
4. What was the dissemination process?

   Respondents had to indicate how dissemination was done, number of people targeted, when, how long it took for the product to be adopted, how long it lasted and it's geographical reach?.
5. What were the success factors?
6. What were the challenges, and how they were addressed?
7. What were the impacts and implications to various stakeholders?

Respondents were required to indicate the social and economic benefits as well as any environmental gains at household and community level.

Three months after the Call for abstracts, with two reviews, only 12 out of 37 abstracts received from PARIs met the required criteria. It was however noted that based on historical reports, many successful interventions were not reported. In this regard, the project team conducted a comprehensive face-to-face survey with NARO staff at the institutes. Two survey tools including questionnaires were developed: one was used to conduct focus group discussions with the PARI top management while another was used to obtain information about specific interventions from key informants. The focus group discussions with top management aimed to understand how the PARI had evolved over time, and to identify and rank the top ten interventions at each PARI. Key informants (within and outside NARO) were interviewed to provide more information, based on the abstract criteria indicated above, on the top four interventions per institute.

Results of the survey were presented to stakeholders (representing the various PARIs) during two validation meetings (one targeting socio-economists and communication officers of the institutes, and another targeting the PARI management and scientists). The findings from these activities were compiled into chapters 2-8 of this inventory.

Chapter 2-8 discuss the ***Evolution of the National Agricultural Research Institutes (NARIs) and their top successful interventions.***

Chapter 9-17 discuss the ***Evolution of the Zonal Agricultural Research and Development Institutes (ZARDIs) and their top successful interventions.***



Evolution of the National Agricultural Research Institutes (NARI) and their top Successful Interventions

(in alphabetical order)

Chapter 2
NATIONAL COFFEE RESEARCH INSTITUTE - NACORI

2.1 Background

The National Coffee Research Institute (NaCORI), launched on August 8, 2014, is one of the sixteen Public Agricultural Research Institutes (PARIs) under the umbrella of the National Agricultural Research Organization (NARO). The creation of NaCORI is in line with the National Coffee Policy (NCP) (2013). Coffee is Uganda's top foreign exchange earner that has been positioned by Government as a core contributor to the country's transformation agenda. According to Uganda Coffee Development Authority (UCDA), the sector was employing over two million people by 2013 and the numbers continue to increase. NaCORI also undertakes research on cocoa hence the institute's mandate:

"to conduct and manage basic and applied research of strategic nature and national importance in all fields pertaining to coffee and cocoa".

This mandate is line with the Government's National Development Plan (NDP), Agricultural Sector Strategic Plan, the Coffee Policy, and an annual production target of 20 million bags of coffee by 2020 strategy.

2.2 Institutional changes and their impact on delivery of the mandate

Over five decades, management of coffee research in Uganda has undergone various changes. In the 1990s, coffee research was managed by the then Kawanda Agricultural Research Institute (KARI) (now the National Agricultural Research Laboratories-NARL). In 1996 a sub-station at Kituza was upgraded into the Coffee Research Institute (CORI) with the mandate of conducting research on coffee, cocoa, oil palm and tea. Following the enactment of the National Agricultural Research Systems (NARS) Act 2005, CORI was amalgamated with the Namulonge-based National Crops Resources Research Institute (NaCRRI) as a Programme handling research on the four crops (coffee, cocoa, oil palm and tea). However, coffee stakeholders were concerned with this development pointing out that it would not effectively deliver the desired research outputs required to meet the demands of Uganda's coffee industry. The stakeholders therefore requested the government to undertake reforms not only in coffee research but the entire coffee industry for better productivity of the commodity. The fruits of these campaigns and the responsiveness of the government of Uganda among others resulted into the National Coffee Policy (NCP) in 2013, and subsequently the establishment of National Coffee Research Institute (NaCORI) in 2014. Currently, the Institute has three programs: Plant Improvement and production; Plant Health; and, Value Addition and Agribusiness.

2.3 Top successful interventions identified by NaCORI

1. Development of Coffee Wilt Resistant varieties to boost the coffee sector.
2. Management package for the Black Coffee Twig Borer (BCTB).
3. Drought-mitigation measures: Recommended shade tree species.
4. The Coffee-Banana/legumes intercropping system.
5. The Seasonal Coffee Management Calendar; a complete guide to yield maximization.

2.3.1 Development of Coffee Wilt Resistant varieties boosts the coffee sector

Background

Coffee wilt disease (CWD) was an epidemic that wiped out many coffee plantations in various parts of Uganda since 1993. In 2002, a joint survey by NARO, the Uganda Coffee Development Authority (UCDA) and Centre for Agriculture and Biosciences International (CABI) established that the coffee wilt disease had wiped out 45% of the country's coffee plantation or an equivalent of 200 million plants causing an estimated loss of USD 27 million annually. However, it was noted that there was an increasing demand for Uganda's Robusta coffee worldwide. Therefore Uganda invested in CWD research in order to tap into the existing market.

The Intervention

The outcry from coffee stakeholders led to release of seven new wilt resistant varieties (K1- K7). These varieties are unique in that they are resistant to not only the coffee wilt but to other coffee diseases and produce good cup quality. A number of partners came in arms to get solutions and these include NaCORI acting as Project Lead and developers of the varieties, CIRAD FRANCE that was responsible for conducting technical research, UCDA, USAID, and CABI–Africa that provided financial support, BUCADEF that offered extension services, coffee exporters (Kyagalanyi) who generated plants and multiplied the varieties, and Uganda Coffee Alliance that supported chains of nursery operators. NAADS helped in identifying farmers and disseminating coffee seedlings.

Given the mass effect of the wilt disease on coffee, there was need to enhance learning so the team carried out training, engaged the media and also developed information and education materials including posters and manuals to enhance the learning process focusing on coffee farmers, nursery operators and extension staff. Dissemination activities were conducted with the help of extension workers who had to be trained first before taking on the task. From 2009, Scientists and the trained extension officials engaged in a number of outreach activities like establishing On-Farm Trials, exhibiting at coffee and Agricultural shows, regular monitoring and technical backstopping.

Beneficiaries

Although there was high disease pressure in the then Mpigi and Luwero districts, all Robusta growing areas benefited. 250 nursery operators across the country, robusta coffee growers and political leaders benefited from the intervention. The Minister of Agriculture, Animal Industry and Fisheries (MAAIF) Hon. Vincent Bamulangaki Ssempijja, and amember of Parliament, Hon. Mathias Kasamba, adopted these coffee wilt resistant.

Success Factors

The intervention's success at both technology development and dissemination levels was a result of a number of factors: high demand from farmers, political will, availability of funds, institutional, human and infrastructural capacity for research and dissemination, commitment by all partners and, as well as, together with etc.) support from the media and local government in mobilising farmers.

Challenges

Clonal coffee multiplication is a slow and tedious process requiring skill, a kit and sufficient capital. Therefore, many nursery operators tended to either produce limited amounts of coffee wilt disease resistant (CWD-r) clones or avoided the whole process altogether.

Outcome

Despite the challenges, this intervention has contributed to improved livelihoods especially in the Robusta coffee growing areas. Increased incomes for the coffee farmers, nursery operators and associated employment opportunities illustrate the effectiveness of the intervention. In addition, clonal coffee technology is environmentally friendly.

2.3.2 Management package for the Black Coffee Twig Borer (BCTB)

Background

The Black Coffee Twig Borer (BCTB) is one of the most important insect pests of coffee in Uganda. The beetle attacks the berry-bearing primary branches causing them to wilt and die. An estimated loss of about 10% of the coffee export volume valued at US$50 million annually is attributed to this beetle. It was with this background and outcry from stakeholders (farmers, UCDA, NAADS, MAAIF) that led to establishment of a multi-institutional task force in 2012 with NARO taking lead.

The Intervention

In-vitro tests were conducted and highly systemic insecticides selected. Field evaluations of the pesticide complemented the selection process. As a result, a management package for the Black Coffee Twig Borer (BCTB) was released. The management package reduces attack of BCTB, leads to zero infestation where it has been applied hence minimising costs. For effective adoption, the dissemination process for this intervention involved training extension workers, conducting farmer field schools, exhibiting at deliberate coffee and Agricultural shows, technical backstopping and media engagement, especially Radio talk shows around the central part of the country. Within three years of its release/introduction, all coffee farmers in Masaka and Rakai districts have embraced the intervention leading to reduced infestation of up to 34 and 18 units, respectively.

Success Factors

The success of the BCTB management intervention was due to the priority given to BCTB by the government and availability of funding in addition to the extension in between systems and areas of focus, media partnerships and supportive political leadership. From conception to dissemination, the intervention was funded and supported by a range of partners including Uganda Coffee Development Authority (UCDA), United States agency for International Development (USAID), European union, Makerere university, Café Africa, Government of Uganda and farmer groups.

Outcome

As a result, the community is realizing improved income and livelihoods, BCTB incidences have greatly reduced. The intervention is cost effective, created employment opportunities and motivated economic growth. Socio economic surveys indicated that approximately 1.2 million households have benefited from this intervention.

Recommendations

Despite the success registered in some areas of the country, there is need for increased sensitization and establishment of linkages in order to upscale the technology adoption. For this BCTB management package to be highly effective, the following is

recommended: (i) avoid using BCTB-infested planting materials, (ii) regular field inspection, trimming and burning of infected material, (iii) avoid bushiness by planting coffee and shade trees at the recommended spacing. This should be coupled with proper and adequate de-suckering and pruning, (iv) eliminate alternate host plants for BCTB within and around coffee fields, (v) enhance plant nutrition by applying fertilizers and manure, conserve moisture and minimize soil loss/erosion, and (vi) in case of heavy infestation, spray with a mixture of imidacloprid (e.g. IMAXI) and tebuconazole (e.g. ORIUS).



Fig. 1: Uganda's Black Coffee Twig Borer (BCTB) trap mounted in a coffee tree canopy

2.3.3 Drought-mitigation measures: Recommended shade tree species

Background

Shade is important for coffee productivity as it buffers coffee plants from extreme environmental conditions, improves soil fertility, reduces incidences of some pests, diseases and weeds, improves quality and quantity, conserves biodiversity and provides product diversification. However, if not properly managed, trees can compete with coffee for moisture, nutrients and light.

The Intervention

Basing on farmers' preference but with scientific knowledge, NaCORI identified and recommended three shade tree species for each of the six coffee growing sub-regions in Uganda (Table 1) that have the capacity to overcome these constraints. One of the key considerations at the determination of the best shade tree species per region was that the tree is not an alternate host to key pests in the region especially the black coffee twig borer. For example, some shade trees e.g. Albizia chinensis promote infestation of BCTB on coffee. Some species cannot also withstand strong winds, therefore, unsuitable for regions like northern Uganda.

NaCORI has multiplied seedlings of the recommended tree species at Kituza along Mukono-Katosi Road. Efforts by NaCORI are underway to disseminate these species in collaboration with other NARO Zonal Institutes and other institutions such as National Forestry Authority (NFA) with help of all coffee extension workers country wide.

Table 1.Site-specific shade trees for the diverse coffee agro-ecologies of Uganda

Region	***Tree species***	Local dialect
Central (Robusta)	***Ficus natalensis***	Mutuba
	Albizia coriaria	mugavu, muyisa
	Ficus mucuso	mukunyu, kabalira
Mid-northern (Robusta)	***Ficus natalensis***	annar, ananga
	Albizia coriaria	itek, ober, bata, latoligo, omogi, ayekayek
	Cordia africana	Akoiyi
Southwestern (Robusta and Arabica)	***Ficus natalensis***	mutooma, ekitooma
	Albizia coriaria	musisa, murongo, muyenzayenze
	Ficus mucuso	Mukunyu
Busoga (Robusta)	***Ficus natalensis***	mugaire, kiryanyonyi
	Ficus mucuso	Mukunyu
	Ficus ovata	Kookowe
Mt. Elgon (Arabica)	***Cordia africana***	chichikiri, guchikiri, chikichikiri
	Albizia coriaria	chesovio, kumoluko
	Ficus natalensis	gugaire, kumuruba, kuruba
West Nile (Arabica and Robusta)	***Ficus natalensis***	mutuba, ubi, laru
	Albizia coriaria	Oyo
	Ficus mucuso	Uwi

2.3.4 Coffee-Banana/legumes intercropping system

The Intervention

Challenges related to limited land resources to accommodate enough food and cash crop production were the basis for this intervention. It is suspected that with inter-cropping, commodities (banana and coffee) the farmer benefits from livelihood related issues including income and food security. This was proved through a baseline survey conducted in 1997 which revealed that there was scarcity of both banana and coffee as farmers chose one of them so the solution was to intercrop the two hence introducing the Coffee-Banana/legumes intercropping system.

Success Factors

The system, which was the first of its kind as coffee-banana/legumes inter-cropping, was properly designed. Makerere University, Café Africa, USAID, UCDA, EU and farmers were major partners in implementing this intervention with NARO as the lead institution in undertaking the research. A team of experts including Dr. Ronald Ozima. Dr Wetala Patrick, Mr. Patrick Kucel, Prof Zaake, and the Late Dr Kibirige Sebunya were very committed to ensure success of the project. The mass media especially radio played a key role in dissemination of information hence increasing the adoption rates. The dissemination process was characterised by distribution of supporting information materials like manuals and brochures combined with training of extension workers.

Outcome

Although the intervention focus was on farmer groups, students and extension workers, workers close to 1.2 million coffee farming households benefited from this intervention a year after it was introduced. Since introduction of this intervention, a change in farmer's livelihoods has been observed, mainly due to increased income levels. It was noted that the intervention is cost effective and more profitable. As a result, the system doubled profitability per unit area than when the two crops are planted separately.



Fig. 2 Coffee-banana intercropping with recommended spacing

2.3.5 The Seasonal Coffee Management Calendar, A Guide to yield maximization

The Intervention

Coffee Management Seasonal Calendar is a key tool in the management of coffee that endears coffee farmers to a strict implementation program of the recommended improved coffee production technologies. The coffee season calendar ensures timely application of the recommended improved coffee management practices, hence improved productivity, profitability and competitiveness of the coffee enterprise.

The Calendar consists of monthly schedules of recommended coffee management activities aligned to the coffee cropping season and crop phenology. This is because the management recommendation at a given time is dictated by the phenology of the coffee plant at that time. So far, coffee management season calendars have been developed for the Central, Eastern, South-western, West-Nile and the Mid-northern coffee agro-ecologies. The tool is highly useful to farmers nationwide and has become one of the most important coffee extension guides today. Already the technology is used by the Uganda Coffee Development Authority (UCDA), farmers, farmer field schools, Makerere and Kyambogo universities and the Consultative Group for International Agricultural Research (CGIAR) through the International Institute of Tropical Agriculture (IITA) and Centre for Agriculture and Bioscience International (CABI).

Beneficiaries

In 2017, NaCORI printed and distributed over 50,000 Seasonal Coffee Management Calendars. Compared to the estimated coffee farming households nationwide there still remained a huge gap; however since the technology is already being used as guide by UCDA extension workers, the benefits are felt by more farmers far beyond the boundaries of the Calendar's physical reach.



Fig. 3 Coffee management season Calendar

COFFEE MANAGEMENT SEASON CALENDAR

"MID-NORTHERN UGANDA ROBUSTA COFFEE AGRO-ECOSYSTEMS"

ALEPTONG, AMURU, APACH, DOKOLO, GULU, KOLE, LIRA, NWOYA AND OYAM DISTRICTS

GROW COFFEE FOR POVERTY ERADICATION AND PROSPERITY





FOLLOW COFFEE SEASON CALENDAR TO IMPROVE YOUR YIELDS, QUALITY AND INCOME





HIGH YIELDS, QUALITY

STEPS TO IMPROVED YIELDS, QUALITY AND INCOME

LOW YIELDS, QUALITY AND INCOME

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
»Plan your farm business with your family » Buy essential inputs » Stump coffee due for change of cycle » Clear bush and prepare land for new plantings » Dig new trenches for erosion control » Keep daily records of farm activities	» Prepare planting holes » Clear weeds by slashing » Complete stumping of coffee » Remove old and non-bearing primaries and suckers » Apply pest control measures » Complete digging new erosion control trenches » Keep daily record of activities	» Plant coffee at on-set of rains » Plant inter-crops or cover crops if young coffee is not mulched » Slash or Mulch and ring-weed old coffee »Remove suckers on old coffee »Apply manure or fertilizer » Clean erosion trenches and prepare bands » Apply pest control measures » Keep records	» Apply herbicide or slash weeds if coffee is not mulched » Complete planting new coffee » Remove suckers on old coffee » Complete planting of grass on bands » Apply manure or fertilizers if not done » Plant inter-crops or cover crops » Plant banana and shade -trees » Apply pests control measures » Keep records	» Slash weeds if coffee is not mulched or intercropped » Remove suckers and unwanted plant parts » Clean clogged erosion control trenches » Complete planting banana and shade trees » Apply pests/disease control measures » Train young coffee » Keep records of daily farm activities	» Apply new mulch to your coffee »Hoe weed coffee if not mulched » Remove suckers and sick branches » Plant new coffee in place of dead ones » Prune and maintain young shade trees » Train young coffee * Harvest fly crop » Keep records of daily farm activities	» Slash weeds if coffee is not mulched » Remove suckers and unwanted plant parts » Apply pest and disease control measures » Harvest legumes and other short-term inter-crops » Clean erosion trenches and prepare bands » Erect or rehabilitate drying stage and storage facilities » Keep daily records of activities	» Slash weeds if coffee is mulched »Replace dead or missing trees » Plant inter-crops or cover crops for 2nd rains » Remove suckers and unwanted plant parts » Apply manure or fertilizers 2nd time » Apply pest and disease control measures » Complete repair or replacing damaged drying and storage facilities » Keep daily records of activities	»Apply herbicide or slash weeds if coffee is not mulched » Remove suckers and unwanted branches » Trim shade trees of excess canopy » Train gap-filling coffee plants » Rid stores of pests » Properly store processed coffee » Keep daily records of farm activities	»Slash weeds if coffee is not mulched » Remove suckers » Harvest red ripe cherries » Dry-process harvested cherries » Properly store processed coffee »Bulk your coffee and market in groups » Bank all proceeds from coffee sales » Keep daily records of farm activities	»Slash weeds in coffee if not mulched » Replace worn-out mulch » Remove suckers » Harvest red ripe cherries » Dry process harvested cherries » Properly sort and store processed coffee » Bulk and market your coffee in groups » Bank all proceeds from coffee sales » Discuss with family use of proceeds of coffee sales » Keep daily records	» Clean weed your coffee if not mulched » Harvest red ripe cherries » Dry process harvested cherries » Properly sort and store processed coffee »Bulk and market your coffee in groups » Bank all proceeds from coffee sales »Discuss with family use of proceeds of coffee sales » Ensure complete harvest and pick all fallen cherries » Keep daily records of farm activities

Acknowledgement:

Special thanks: *Ms. Winnie Oyella (UCDA Sub-regional Coffee Coordinator, Lango/Teso sub-regions); Mr. D. Opio –Agen, Mr. G. Ocen and Mr. B. Ongom (Agali S/county LG)*

THE POSTER WAS PRODUCED THROUGH FUNDINGS FROM WORLDBANK/ATAAS PROJECT AND UCDA SUPPORT TO COFFEE RESEARCH

Chapter 3
NATIONAL CROPS RESOURCES RESEARCH INSTITUTE-NACRRI

3.1 Background

The National Crops Resources Research Institute (NaCRRI) is a constituent public agricultural research institute under the policy guidance and co-ordination of the National Agricultural Research Organization (NARO).

The mandate of NaCRRI is to generate, develop and disseminate appropriate crop technologies, methods and knowledge on crops of strategic national importance for food and nutrition security, house hold income and export.

Therefore, NaCRRI has the following research programs: Legumes (for beans and soybean research), Root Crops (for cassava, sweet potato and yams research), Cereals (for maize and rice research), and Horticulture (for tropical fruits, vegetables species and essential oils research). The thrust of the current crop improvement and development interventions address stresses (disease and pest resistance, drought tolerance, tolerance to low fertility soils), genetic gains in yield, pre- and post-harvest management, adapted highland varieties, enhanced nutrition (bio-fortification), industrial feasibility, genetic resource conservation, increased shelf-life, value addition and innovative biosciences research and training.

3.2 Institutional changes and their impact on delivery of the mandate

The Institute started out its operations in early 1945 as the Namulonge Cotton Research Station with one office block, currently housing Administration. At that time, its research focus was on cash crops that would boost the national economy, especially cotton. NaCRRI is steadily emerging as a Center of Excellence for agricultural research in the East African region and beyond, on account of compelling technologies developed that are used in the region and NaCRRI's growing human and infrastructural capacity, multiple office blocks and the newly constructed storied office block with conference facilities. The technologies developed from the institute are suitable for various agro-ecological regions and have been widely adopted by farmers across the country.

Infrastructural capacity

With support from development partners and the Government of Uganda, NaCRRI is home to regional initiatives including the Cassava Regional Center of Excellence and the Regional Rice Research and Training Center. The Institute also has a Biosciences Center which consists of four state-of-the-art equipped laboratories for: Cell and Tissue Culture, Molecular Biology, Plant Germplasm Conservation, Nutrition and Bioanalytical research and services. The laboratories have dramatically reduced the cost of research by limiting outsourcing to private and/or international laboratories for some of the services. Other infrastructure capacity developed over time includes: screen houses, warehouses for farm implements and machinery, managed drought screening facilities and a confined field trial village.

Human resource capacity

NaCRRI has also built a cadre of research expertise in various disciplines. There are over 30 PhD and 50 MSc graduates in a range of competencies in agronomy, biotechnology, breeding, communication, entomology, pathology, and socio-economics. With this solid background in personnel and research infrastructural capacity, NaCRRI has been able to attract key regional research projects including the East African Agricultural Productivity Project (EAAPP), Next Generation Cassava Breeding Project, Water Efficient Maize for Africa (WEMA), Promotion of Rice Development (PRiDe) and the Pre-cooked Beans project. The Institute has institutionalized training and hosted trainees from Uganda and foreign universities including India, USA, UK, Nigeria, Tanzania and Rwanda.

Cross-cutting units

The Government of Uganda through NARO selected NaCRRI to host two new units, the National Invasive Species Coordination Unit (NISCU) and the Uganda Biosciences Research and Training Center (UBRTC). NISCU coordinates national efforts in management of invasive species and their impacts on biological diversity in addition to generating and deploying scientific control innovations through cutting edge research. UBRTC conducts specialized crop research, analysis and training in modern biosciences.

3.3 Top successful interventions as identified by NaCRRI

1. Adding proteins on every Ugandan's plate findings: A case of beans
2. NaCRRI successfully stimulated a paradigm shift in Uganda's soybean sub sector
3. Promoting uptake of stress-tolerant and nutritious sweet potato varieties that have increased adoption and consumption of sweet potato in Uganda

4. Reversing the prevalence of cassava mosaic disease by reducing its incidence from 64% in 1994 to 17% in 2013, attributed to 77% adoption of improved varieties
5. Cassava value addition
6. Development and dissemination of upland rice that has curbed rice importation saving more 30 million USD in foreign currency
7. Development and promotion of stress-tolerant maize varieties that have improved on productivity and production, and backstopping the seed industry
8. Grafting technology for mango and citrus earning millions as household income
9. Developing seed systems for indigenous vegetables
10. Establishment of a Biosciences information hub providing services to public and private sector in Uganda

3.3.1 Adding proteins on every Ugandan's plate: A case of beans

Background

Uganda is Africa's second largest producer and consumer of the common bean and is a major supplier of beans to the Kenya, Rwanda and South Sudan markets. Beans are grown country-wide given the favorable tropical climatic conditions. On the other hand, climbing beans mainly grow well in the highlands. Between 1997 and 1998, there were observed incidences of a strange and destructive bean disease which was later identified as the bean root rot. The effect of this disease was so severe that farmers lost 100% of their crop in some regions of Uganda. The most affected region was South Western Uganda where the disease pressure was highest.

The interventions

According to Dr. Stanley Nkalubo, since 1995 NaCRRI has released 32 bean varieties: 23 -fit for lowland and nine climbing for highlands areas. A series of bean varieties including NABE 13, NABE 14, NABE 26C, NABE 27C and two different varieties (NABE 29C & 9C) (C = climbing) were developed, screened and released as resistant varieties to curb the root rot epidemic with the aim to restore resistance in preferred/ indigenous bean varieties with acceptable consumption and market qualities. All other varieties also have significant resistance to root rot and anthracnose diseases but are also fast cooking with high productivity. NaCRRI has also released five bean varieties high in Iron and Zinc.

Success Factors

NaCRRI has played a leading role in designing and conducting breeding and evaluation trials and releases of bean varieties. Development and dissemination of these varieties and supporting technologies have been carried out in partnership with CIAT (International Centre for Tropical Agriculture) that provided some of the elite germplasm; USAID provided financial support while Farm Africa, local extension agencies and farmers' groups conducted trainings and distribution of the information materials. Dissemination of the varieties and supporting technologies have been conducted since 1999 using various techniques such as demonstration plots, availing of seeds at exhibitions, training sessions in appropriate agronomic practices, radio shows, and sharing information materials. Field days, farmer's field schools and Telecentres were used to disseminate the interventions. The released and commercialized varieties have unique traits such as resistance to bean root rot, faster cooking, better and high productivity that have led to very high demand on local, regional and international markets. Other factors attributed to the success of the intervention include availability of research infrastructure, strategic and strong networks and accessibility to demonstration sites.

Beneficiaries

Beneficiaries are mainly individual farmers, farmer groups, as well as seed producers in south western Uganda with specific interest in the districts of Kisoro, Kabale, Lwengo, Sheema, Bushenyi, Lyantonde, and Masaka to mention a few Challenges

The major challenges faced during the development and dissemination processes were the long distances from station to affected regions and the difficulty in recovering of the seed loans given to farmers.

Outcome

Generation of these bean varieties has resulted in restoration of beans production in South Western Uganda, increased food security and income in the adopting households. Households in previously affected areas have continued to expand bean production acreage. The recently released bean varieties high in Iron and Zinc will contribute to reducing the anemia cases, which according to the Ministry of Health stands at 23% in women aged 15-45 years and 50% in children under age five.

Fig. 4 How to grow bush bean varieties



3.3.2 NARO successfully stimulates a paradigm shift in the soybean sub sector in Uganda

Background

Soybean is thought to have been introduced into Uganda between 1918 and 1945 to combat protein malnutrition among soldiers of the Kings African Rifles (KAR) during the first and second world wars, to reduce kwashiorkor among children and to accelerate crop diversification in the country. Early soybean research in Uganda started in the 1930s and resulted in the release of varieties Kabanyolo 1, Kabanyolo 2 and Congo 72. These varieties served Ugandan communities up to the 1990s when Nam 1, Nam 2, and Namsoy 3 were released and commercialized. However, the severe soybean rust epidemic experienced from 1996 rendered these varieties irrelevant because they all succumbed to the disease.

The Intervention

To combat the soybean rust epidemic, soybean breeding research was carried out by the NaCRRI and Makerere University researchers for soybean improvement and development in all major soybean growing areas of Uganda. Investigations were conducted in research institutes, technology development centres, and farmers' fields countrywide using a participatory approach. The principal objectives were to develop soybean varieties that were: high yielding with medium maturity of less than 120 days, resistant to diseases and pests especially soybean rust disease and leaf miners, resistant to lodging and pod shattering, promiscuous in formation of active nodules with local rhizobia, rich in vitamin and oil contents, having high pod clearance and having general end-user acceptance in terms of seed appearance and other traits.

Two strategies were adopted to counter the effects of the soybean rust epidemic in the country. The short term strategy involved introduction and testing of germplasm while the long term involved crossing resistant with elite and susceptible soybean lines. This crossing resulted in the release of six new varieties; Namsoy 4M, Maksoy 1N, Maksoy 2N, Maksoy 3N, Maksoy 4N and Maksoy 5N.

Success Factors

A holistic seed system was adopted to ease farmers' access to new soybean varieties and the supporting information. The research team worked with community based organizations (CBOs), non-governmental organizations (NGOs) and other stakeholders in the soybean value chain using a participatory approach. CBOs and NGOs accounted for

50% of nationwide dissemination of foundation seed to different stakeholders for further seed multiplication. Maksoy 1N is the most widely adopted variety by farmers while Maksoy 3N has the largest quantities of foundation seed disseminated by the program. Availability of a range of varieties, government investment in soybean research and increased private sector investment along the soybean value chain were identified as major success factors for the growth of the soybean subsector in Uganda and success of this initiative.

Outcome

The National soybean area increased from 144,000 to 155,000 hectares between 2004 and 2009, with annual production increasing from 158,000 to 181,000 tonnes respectively. Impact studies showed that these varieties accounted for 93% of the soybean varieties grown by Ugandan farmers. By 2017, the contribution of soybean to small holder household incomes was estimated at UGX 1,185,000 (1USD = UGX 3600/=) per hectare per season (Tukamuhabwa and Obua, 2015). The processing capacity for soybean also increased from 300 MT to 600 MT per day between 2004 and 2011 while the export value of soybean increased by 288% (Ssengendo et al., 2010).

Challenges

Widespread dissemination of these improved varieties has proved a challenge as private seed companies are not keen on certified soybean seed production. This is because the self-fertilization nature of soybean makes it possible for farmers to successfully reproduce seed every season which makes profit making in the seed business rather difficult. There is limited demand of soybean at household level. Further promotion of utilization of soybean products at household and industrial levels remains very important. There is also need to strengthen policies that favour industrial or medium scale processing enterprises in soybean processing to stimulate increased national soybean production.

Fig. 5 What to consider before planning soybean

Source: Tukamuhabwa P and Oloka H.K 2016. Soybean Research and Development in Uganda: A case of paradigm shift in an African University. Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), Makerere University, Kampala.



3.3.3 Nutrition enhancement in rural communities through promotion of Orange Fleshed Sweet potato

Background

In 2002, 20% of Uganda's preschool children and 19% of lactating and pregnant mothers were reported to be Vitamin A deficient. Vitamin A deficiency, one of the most pernicious forms of micronutrient deficiency, can lead to blindness, stunted growth, and early death.

The Intervention

NARO-NaCRRI in partnership with the International Potato Center (CIP) has released over 20 varieties of both white and orange fleshed sweet potato (OFSP). Dr. Robert Mwanga, the 2016 World Food Prize Winner, who received the award because of the orange fleshed sweet potato (OFSP) initiative, indicated that nine OFSP varieties including two landraces have been released to curb Vitamin A deficiency. These varieties have most of the desirable traits. These include high vitamin A content, high b-carotene concentrations, early maturing, high dry matter content, high resistance to common and devastating sweet potato diseases like Alternaria blight and sweet potato virus. . The varieties have been released in series of 2005, 2007 and most recently 2013. Consumption of as little as 125 grams of the released OFSP varieties a day provides adequate beta-carotene to children under five with the daily-recommended dose of vitamin A. According to Dr. Goretti Ssemakula, NARO in collaboration with several partners including HarvestPlus, farmers' groups and schools have been at center stage of dissemination of both planting materials and information packages on management practices, coordination, promotion as well as mobilizing for resources which has enabled achievement of these milestones.

Beneficiaries

By 2009, 65% of Uganda's sweet potato growing households had adopted one or more of the OFSP varieties. Given its potential to significantly contribute to a viable, long–term, effective and sustainable food-based approach to prevent Vitamin A deficiency, other countries including Kenya, Rwanda, Tanzania, Malawi, Ethiopia and Sudan have embraced the technology.

Success Factors

Critical factors for the success include political support given the fact that the challenge was a national concern, strong and well-established partnerships at development and dissemination stages, availability of resources including financial, human and infrastructural facilities.

3.3.4 Cassava Mosaic Disease effectively addressed in Uganda

Background

First reported in 1989, cassava mosaic disease (CMD) wiped out over 500 local cassava varieties leading to loss of biodiversity and economic activity in the cassava industry. In addition, the disease threatened food security as cassava is one of the most important staple food crops in the country. By 1999, the entire country was affected by CMD and the epidemic was also reported in Western Kenya, North West Tanzania, Rwanda, Eastern DRC and South Sudan. This lead to drastic decline in cassava production, food shortage and famine related deaths especially in Northern Uganda. A decline in Uganda GDP reported in 1997 was attributed to the epidemic.

The Intervention

To control the disease, a task force (National Network of Cassava Workers) was formed with specific responsibilities attached to each stakeholder in the network. Initial efforts to offer solutions included evaluating and selection of local varieties which were moderately tolerant to the epidemic. This process saw release of three local varieties in 1993. Research continued with introduction of elite germplasm from IITA- Nigeria. As a result, five more resistant varieties were released. Three more varieties were added in 2003. As efforts mostly concentrated on cassava mosaic disease, cassava brown streak disease also emerged. Intensive research work and investment were directed towards addressing both epidemics. By 2011 seven additional cassava varieties (NASE 13 – 19) were released. According to Dr. Robert Kawuki, more varieties (NASE 14 – 19, and NAROCASS1-2) have been released to manage the major cassava virus diseases. Dissemination, promotion and uptake of improved varieties has been ongoing since 1990 to date.

Outcome

According to Dr. Titus Alicai, by 1994, 64% of the cassava crop was infected with Cassava mosaic disease and after the intervention the rates had dropped down to 18% by 2014. By 2011, 67% of Uganda's cassava growing households had adopted improved varieties and the figure reached 77% by 2015. A cost benefit analysis conducted indicated that every 1 USD invested in 1993 had appreciated to 7.2 USD by 1996. This showed a net present value of 2,000,000 to 90,000,000 with internal rate of return of 121% interest. The same

study was conducted in 1999 and the cost benefit ratio of 1USD had risen to 18 USD with interest of 167%. The Net present value shot from 90,000,000 in 1996 to 131, 000,000 in 1999. The balance of trade implication by 2003 showed 1 USD appreciating to 22USD with interest of 175%. According to Dr. Anton Bua the net present value for 2017 is estimated at 400,000,000 USD.

The technologies have been embraced by neighboring countries. In western Kenya, coverage by NASE 3 AND 4 is at 50%, in Mwanza and Dodoma regions of Tanzania, it is at 30%, in Rwanda, eastern Congo and in South Sudan it is at 100%. As a result of the impact from cassava research, the root crops program of NARO/ NaCRRI has been certified as a Cassava Regional center of Excellence for East and Central Africa.

Success Factors

This success has been achieved partly due to the fact that the problem was central to peoples livelihoods, a strong and committed national capacity to deal with the challenge, dedicated and steady long term funding from both government and partners. In addition a strong, integrated and innovation systems approach to the epidemic, a supportive policy, political and operating environment, strong partnerships and linkages at various levels, an effective and efficient institutional arrangement (NANEC) to deal with the problem contributed to the success.

Fig. 6 Appearance of invested cassava leaves

Disease	Symptoms	Control
Cassava Mosaic Disease	• Leaf wrinkling • Stunted young plants • Reduction in leaflet size • Leaf Chlorosis 	• Plant tolerant varieties e.g. TME 14, NASE 14, NASE 15, NASE 19, NAM 130 • Use clean planting material • Quarantine • Rogue out infected plants • Do not plant in previously infected fields • Create awareness
Cassava Bacterial Blight	• Drops of creamish exudates on stems • Lesions between leaf veins on the lower surfaces of the leaves • Dying of the shoot from the tip ('die-back') • Rapid defoliation   	• Always get planting material from CBB-free plants and/or tolerant varieties (e.g. Nase 3 and Nase 14)
Cassava Brown Streak Disease	• Vein clearing on leaves • Brown streaks on stems • Necrotic tissues on roots   	• Use CBSD-free planting materials • Plant tolerant varieties (Nase 1, Nase 3, Nase 14 and TZ 130) • Rogue infected plants

3.3.5 Adding value to cassava products to increase profitability

The Intervention

Cassava value addition efforts are on-going at the Nutrition and Bio-analytical laboratory at NaCRRI. According to Dr. Ephraim Nuwamanya, a number of prototypes have been developed and ready for commercialization. Table 2 provides details about the different products and the estimated likely impact of these interventions.

Table 2. Description of cassava value addition products and their likely impacts

Product	Product description and stage of development	Likely impact
Biodegradable plastics	Starch from cyanogenic varieties which are not readily used for food is extracted and modified to increase its amenability. This is followed by conversion of this starch into several biodegradable plastics ranging from thin plastics, plastic bags and handling containers. Since its inception, this product has attracted a lot of attention from the different stakeholders and government agencies. It has been seen as a direct replacement for fossil fuel based plastics with a lot of sustainable outcomes including the ability provide farmers with income, spur industrial growth based on local raw materials and increase the competiveness of cassava as an economic crop.	Most of the products produced are domestic and have very high local relevance and ability to impact both the economy and farmers livelihoods. This product can increase cassava production by over 50%, replace up to 25% of plastic products, and save up to close to 5b UGX per year in imports of oil based raw materials.
Biodiesel	Used vegetable oil is a detrimental substance on human health. It has lower anti-oxidant power, and hence is a major cause of cancers and cancer-related infections among consumers. Catalysts have been developed to turn used vegetable oil into biodiesel up to generator grade fuel with good burning rates and low smoke values. Restaurants can use the vegetable oil up to a certain time and later convert it into biodiesel. The biodiesel can then be used for energy production in terms of lighting and heating purposes.	Most restaurants and hotels find it hard to dispose of used vegetable oil and hence find it convenient to re-use it. These products will impact the health of communities, improve disposal mechanisms for used vegetable oil and provide sustainable energy systems.
Bioethanol/ Alcohol	In Uganda, cassava farmers produce alcohol for sale; this is an important economic activity in North, East and west Nile regions of the country. Procedures have been devised for efficient production of ethanol from whole parts of the cassava plant. Better strains of fermenting organisms have been selected with reproducible ways to prototype level and ethanol has been produced at laboratory scale.	Very relevant for farmers, industrialists, health practitioners and the general public. It can replace 90% of imported ethanol in Uganda, and save up to 70% of the cleaning and cosmetics industry based ethanol demands
Adhesives	The paper and plywood industries are working on means to produce high quality glues for the different adhesive and binding works. Through starch modification and chemical treatments different glue products for different purposes have been produced	Relevant to the paper, plywood and packaging industries. Cassava glue can replace 35% of imported glues
Flours (composite)	Cassava flour and flour composite based products have been developed and their consistency has been evaluated and comparisons have been made with local products among the farmers and have been found superior, and provide for wholesome nutrition	Very relevant as the larger proportion of Uganda's population depends on flour based products for calories and protein

Fig. 7 What you need to know about biodiesel

About Biodiesel

Biodiesel is a renewable biofuel made from edible and non-edible plant oils such as: sunflower, jatropha, Ponganmia, candlenut tree (Kabaka'anjagala), recycled cooking oils, animal fat, and microalgae oils.

Biodiesel is called a "green" fuel because it produces less air pollutants than petroleum-based diesel, leaving the environment cleaner and greener. Biodiesel is safe, biodegradable, and can be used in its pure form (B100) or blended with petroleum diesel.

It can be used in any compression ignition engine that will accept regular diesel fuel. An engine does NOT need to be modified to use biodiesel blended with regular diesel.



Biodiesel is ecofriendly



Biodiesel as a Preferred Choice of Energy

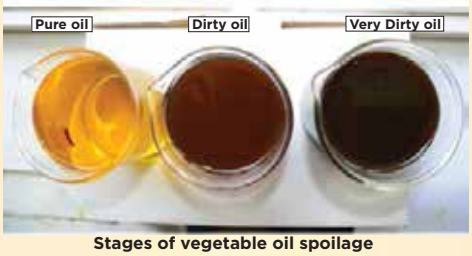
- Reduces greenhouse gases' emissions by 86%.
- Biodiesel is nontoxic and biodegradable
- Biodiesel production reduces wastewater by 79% and hazardous waste by 96% compared to petroleum diesel.
- Helps to keep fuel systems clean
- Improves engine lubricity
- Lowers particulate matter by 47%
- Reduces smog and makes our air healthier
- Reduces hydrocarbon emissions by 67%
- For every unit of fossil energy it takes to produce biodiesel, 5.5 units of renewable energy are returned.

How biodiesel affects engine emissions

- Lower carbon monoxide (CO)
- Lower particulate (PM)
- Lower unburned hydrocarbons (HC)

Making biodiesel from recycled cooking oil

Although vegetable oils have higher smoke points than animal fat, which makes them safer to use for frying food; repetitive use of vegetable oil lowers its smoke point, making it produce harmful gases (oxidative radicals). This is because every cycle of oil use increases the level of free fatty acids and other impurities, which tend to lower the smoke point of the oil.



Stages of vegetable oil spoilage over several cycles of reuse

3.3.6 Introduction of upland rice to reduce rice importation in Uganda.

Background

According to the Uganda Revenue Authority, Uganda spends over UGX 360Billion (USD 100,000,000) annually to import rice from Pakistan. Every month, URA receives 300,000 metric tonnes of rice imported from Pakistan and 25,000 metric tonnes from Tanzania yet the cost of transporting a metric tonne of rice together with other logistical arrangements are $350 (Shs1.2m) without the actual cost of the rice.

The intervention

With support from Rockefeller Foundation, National Crops Resources Research Institute (NaCRRI) with multiple stakeholders notably, AfricaRice, seed Companies, Makerere University and farmers conducted research leading to the release of three upland rice varieties. The three varieties; NARIC 1, NARIC 2, and NARIC 3 were released in 2002 but later succumbed to drought stress. Consequently, an upland breeding program was the initiated in 2006 to develop drought tolerant upland rice varieties and as a result, two upland varieties-NERICA-1 and NERICA-10 were released in 2007. These varieties including NARIC 3 also known as NERICA-4 and SUPARICA-4 gained popularity on the Ugandan and regional markets due to a number of factors like the aromatic properties (NERICA1), and short growth duration for NERICA-10. All these developments made 2013 one of the most outstanding years on NARO's rice research timeline. In addition, six highly drought tolerant rice varieties; NamChe-1, NamChe-2, NamChe-3, NamChe-4, NamChe-5 and NamChe-6 were also released in the same year.

Beneficiaries

Three large scale commercial rice farms and their out-growers adopted varieties released and promoted by NARO to curb rice importation. The proprietors of Amatheon Agri, Omer, and Vinayak farms in Amuru district are confident that if Government supports them and their out-growers to mass cultivate improved NARO rice varieties, they can significantly reduce rice importation in Uganda. The farms mainly grow two NARO's varieties, NamChe 1 and NamChe 3 on a total of over 15 square miles of land (when combined) in Amuru and Nwoya districts, profiling rice as a key commercial and food crop. NamChe-3 does not require a lot of fertilizer compared to NERICA-4; it is drought

tolerant, early maturing and can give an average yield of three tonnes per acre every season and annual yield range of 3000 – 3500 metric tonnes, making it a preferable rice variety by the rice entrepreneurs.

Success Factors

To boost rice production, the farms work with out growers whom they offer free training on the importance of planting improved seed, fertilizer and herbicide application, while paying attention to issues of gender in rice farming. These farmers then become champions who go on to teach other farmers access about rice growing and the importance of working with commercial farms. Vinayak Agro Farm supports the farmers by lending them farm machinery including tractors during planting and harvesting. This has helped to increase appreciation for mechanized farming. It plans to establish a rice mill which will process 50 tonnes daily in addition to cleaning and automated seed packing.

Recommendations to NARO and Government

To boost rice production, the farm managers appeal to NARO to consider establishing partnerships with large-scale commercial farms as is the case in rice-producing countries of China and Pakistan. They believe that this will facilitate transfer of cutting edge research and better yielding varieties. Chinese rice varieties for instance can produce up to four tonnes per acre compared to NARO's one tonne per acre. The farmers urge Government to establish controls on the quality and quantity of rice being imported so as to boost Ugandan growers. Government should also consider incentives for local rice producers to enable them out compete importers and save the country from foreign exchange losses.

Fig. 8 Production of NERICA varieties



3.3.7 NARO Boosts maize production in Uganda

Background

Maize is a major crop in Uganda in terms of production, consumption and income generation. It is a non-traditional cash and export crop. Maize exports increased from 640,000 MT valued at 38.2 million USD in 2011/12 to 787,000 MT, valued at 79.8 million USD (BoU, 2015/2016). Maize is planted on more than 1 million hectares covering approximately 38% of the cultivated land (FAO, 2015). The maize sub-sector employs an estimated four million households. A number of production constraints including diseases and drought prompted maize research and development efforts in Uganda. Earlier

breeding efforts led to the development of Kawanda Composite A (KWCA). In mid 1980s, KWCA succumbed to maize streak virus disease and during 1985 civil war the variety was lost due to looting of all the maize germplasm and progenitors of KWCA at Kawanda Research Station.

The Intervention

NARO has generated and/or disseminated more than 30 maize varieties in the different agro-ecologies in the country. These include hybrid varieties Longe 2H, Longe 3H, Longe 6H, Longe 7H and Longe 8H, and three open pollinated varieties (Longe 1, Longe 4 and Longe 5). In addition, a number of stress-tolerant varieties have also been released and are being commercialized. Hybrid maize is one of the most adopted and widely utilized NARO technologies.

Beneficiaries

From the slopes of Mount Ruwenzori in western Uganda to the flat plains in Amuria district, these improved seeds have changed the maize landscape. The colourful landraces have disappeared and adoption of improved varieties has increased. According to Dr. Godfrey Asea, a maize breeder, the hybrid technology has contributed to the drastic increase in maize production from a few thousand tons in 1990s to 4 million MTs annually in 2015. Large scale farmers with mechanized operations especially in Masindi, Amuru and Nyowa Districts with land under maize of greater than 1000 acres have adopted NARO hybrid varieties. Most of the improved maize varieties marketed by the private seed industry are developed by NARO.

Success Factors

From 1988, the Government of Uganda in partnership with USAID-Man Power for Agricultural Development (MPFAD) has built capacity of new breeders to lead maize research activities at NaCRRI. This has laid a foundation for a strong breeding program that has led to development and release of the first set of hybrids. Positive partnerships between the research scientists and the private sector have greatly contributed to the success of this intervention. Breeders develop breeder and foundation seed, and the private sector especially seed companies are responsible for maize seed multiplication and producing certified seed. The hybrid technology promoted increased investment in seed multiplication by the private sector because it involves trade secret. Taking farming as a business has also increased demand for quality seed. A strong maize value chain is providing opportunities for investment at the different stages.

Challenges

Seed quality assurance and poor seed distribution systems have been a major challenge. There is need to strengthen the seed regulatory system. Price fluctuations have affected the adoption rates of hybrid maize. There is need to promote post-harvest handling including use of silos so that grain price ranges are stabilized.

3.3.8 Establishment of a Biosciences information hub in Uganda

Background

Uganda Biosciences Information Center (UBIC) was established in 2013 as an information hub that develops and disseminates information on modern agricultural biosciences research in Uganda. UBIC is an initiative of the National Agricultural Research Organisation (NARO) hosted at the National Crops Resources Research Institute (NaCRRI) in Namulonge, Wakiso district.

Objectives

UBIC aims to help Ugandans to understand, appreciate, and use novel and innovative technologies to improve agriculture and boost food security, while ensuring better land use and a cleaner environment. In partnership with several stakeholders UBIC aims to help increase their awareness and understanding of modern biosciences which can be used for agricultural enhancement. Importantly, UBIC endeavours to: influence target audiences to make informed decisions about biosciences application and regulation, strengthen biosciences training in the formal education system of Uganda, conduct Biosciences outreach and communication capacity building as well as facilitate knowledge sharing and partnerships among biotechnology communication partners locally and internationally.

Achievements

UBIC supported establishment of a positive policy environment for application of products of biotechnology research particularly the passage of the National Biosafety Act, 2017. This was through its robust biotechnology and biosafety outreach and communication strategies as well as partnership mechanisms. Strategies included close collaboration with NARO biotechnology projects and other partners to organize “seeing is believing” tours and sensitization workshops for over 300 Members of Parliament and Ministers in the ninth and tenth Parliaments.

Over 10,000 stakeholders including farmers’ leaders, extension officers, religious and community leaders, biosciences regulators, students, scientists, opinion leaders, the media, and policy makers have directly benefited from the outreach activities of UBIC. These activities aimed to enhance understanding and appreciation of modern biotechnology. Wider

audiences were reached through their broadcast and print media presence.

Capacity building has been at the center stage of UBIC's objectives and as a result, over 210 scientists and communication practitioners from NARO and other partner agencies have been equipped with skills in science and/or risk communication. Other champions trained as spokespersons included over 60 youth opinion leaders, students and Miss Uganda beauty pageants. Three one-week boot camps were organized at NaCRRI in collaboration with Miss Uganda Foundation to train the contestants in modern agricultural technologies/practices.

UBIC has also organized five National Annual Biotech Essay Writing contests to engage the youth in Uganda's formal education system to participate in the dialogue on relevant technologies for agricultural improvement in the country. The essay contests targeted universities/ colleges and secondary schools students and educators. Primary school students and educators were engaged through two National Annual Agriculture Poster drawing contests. Over 5700 students and educators were engaged during activities organized to support these contests. These initiatives prompted strategic partnerships between NARO and participating academic institutes, the National Curriculum Development Center (NCDC) and the Ministry of Education and Sports.

Outcomes

Through various activities, UBIC has been instrumental in supporting establishment and operationalization of positive policy environment and regulatory framework, and enhancing appreciation of modern biotechnology, which will allow Ugandan farmers to access improved research products developed by NARO.

Fig. 9 About UBIC







Who we are:

Established in 2013, UBIC is an information hub that develops and disseminates information on modern biosciences research in Uganda, for informed decision making about application and regulation.

UBIC is an initiative of the National Agricultural Research Organisation (NARO), which coordinates all agricultural research in Uganda. UBIC is hosted at the National Crops Resources Research Institute (NaCRRI) in Namulonge, Wakiso district.

Why we exist:

Our job is to help Ugandans to understand, appreciate, and use novel and innovative technologies to improve agriculture and boost food security, while ensuring better land use and a cleaner environment. Our outreach and communication activities are geared towards advancing Uganda's march to middle income status by 2040 through modernised agriculture.

What we do:

UBIC works with many stakeholders to help increase their awareness and understanding of modern biosciences which can be used for agricultural enhancement. We endeavour to:

Influence target audiences to make informed decisions about biosciences application and regulation

UBIC works with: farmers, students, scientists, policy makers, religious and cultural leaders, and the media; proving a platform for dialogue and information dissemination on modern biosciences for better and informed decision–making. We produce information materials, use media platforms and conduct awareness meetings.

Strengthen biosciences training in the formal education system of Uganda

UBIC develops and donates teaching aids to science educators and contributes biosciences literature and materials to support curriculum development at National Curriculum Development Center. We conduct essay writing and drawing competitions, outreach sessions and seminars in primary, secondary schools and tertiary institutions, as part of efforts to groom future leaders in science.

Carry-out Biosciences outreach and communication capacity building

Outreach activities are central to our work; enabling us to localize and disseminate factual information on modern biosciences and adequately engage Ugandans. Key recipients of these activities include: policy makers, journalists, farmer associates, and journalists. Science communication training is done for scientists and journalists.

Facilitate knowledge sharing and partnerships among biotech communication partners locally and internationally

UBIC is part of national and international networks such as Uganda Biotechnology and Biosafety Consortium, Alliance for Science, and International Services for Acquisition of Agri-biotech Applications (ISAAA). Through these, we help to advance Uganda's science agenda and support international cooperation for advancements in modern biosciences for agriculture.

Who we work with

- Africa Biosafety Network of Experts (ABNE)
- African Agriculture Technology Foundation (AATF)
- All academic institutions (including universities and schools)

Chapter 4
NATIONAL FISHERIES RESOURCES RESEARCH INSTITUTE -NAFIRRI

4.1 Background

The National Fisheries Resources Research Institute (NaFIRRI) is one of the sixteen public National Agricultural Research Institutes (PARIs) under the policy guidance and co-ordination of the National Agricultural Research Organisation (NARO) which was established under the National Agriculture Research Act of 2005. NaFIRRI headquarters are located along plots 39-45, Nile Crescent & Plots 28-32, Oboja Road in Jinja opposite the wagon ferry terminal while the Aquaculture Research and Development Centre is located at Kajjansi, 12km along Kampala-Entebbe Highway. The institute was established in 1947 by the colonial government as a centre for fisheries research for the East African Community under the East African Fisheries Research Organisation (EAFRO), followed by East African Freshwater Fisheries Research Organisation (EAFFRO). In 1977 when the EAC collapsed, EAFFRO was managed by Uganda Government as the Uganda Freshwater Fisheries Research Organisation (UFFRO). Under NARO, the name first changed to Fisheries Research Institute (FIRI) and later to Fisheries Resources Research Institute (FIRRI) and, following the NAR Act 2005, it became the National Fisheries Resources Research Institute (NaFIRRI).

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

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

Research in NaFIRRI is conducted through four programs:

(i) Capture fisheries and Biodiversity conservation,

(ii) Fish habitant management,

(iii) Fish bio-sciences and Aquaculture and

(iv) Innovations and post –harvest fisheries.

The Aquaculture Research & development Centre (ARDC) at Kajjansi, is responsible for culture of organisms (fish) under controlled conditions. Its units include: genetic improvement and breeding, nutrition and feeds, fish diseases, diagnosis and management.

4.2 Institutional changes and their impact on delivery of the mandate

Over the years, structures have been improved triggered especially by the high number of staff who joined the institute. In terms of infrastructure, new laboratories including a fully equipped analytical laboratory for testing water quality have been put up making a total of eight labs. Office space has also been expanded as well as renovations made on old structures. Staff quarters were also expanded and these currently house over 50 staff members. Three conference rooms, a library and data center, fully linked to international fisheries conduits were expanded. Accounts section, registry and workshops (metal and wood), boat yard and net yard are all in place in addition to three vessels and upgrading the internet and ICT systems. An aquarium is also in place.

The institute has groomed human capacity and currently employs 155 staff, 75 of whom are NARO staff and 80 volunteers both in Jinja and Kajjansi. This is made possible by exchange programs with sister institutes like TAFIRI, Mwanza in Tanzania, KEMFRI, Kisumu in Kenya, national, regional and international universities such as McGill. The Aquaculture Research and Development Centre was initially a department under the current Ministry of Agriculture Animal Industries and Fisheries (MAAIF) teaching farmers how to grow fish and improve fish farming. In 1992, it was turned into a full research station under NARO with an objective of making fish a commercial commodity. With new development, technologies in aquaculture new personnel were recruited and trained leading to number of staff doubling as well as facilities such laboratories to support the transformation into commercial production. The team then began to do research to respond to the demands of investors e.g. fast maturing fish, healthy, good feeding, diversification of fish species. Others include; good production

systems from ponds and other systems which can support intensive production.

4.3 Top successful interventions identified by NaFIRRI

1. Transformation of fisher communities into the first cage aquaculture park in Uganda.
2. Increasing pond production and profitability for small-scale fish farmers: Innovative fish feeds.
3. Successful control of water hyacinth on Uganda's major water bodies.
4. Increasing aquaculture productivity and production in Uganda through quality fish seed development, multiplication and distribution

4.3.1 Transformation of fisher communities into the first cage aquaculture park in Uganda

Background

Fishery development is one of the key global development goals embodied in Agenda 2030 under the 14th Sustainable Development Goal (SDG), in which countries seek to support the restoration of fish stocks to improve safe and diversified healthy diets and provide employment opportunities to the rapidly growing population thus minimizing the rates of malnutrition and poverty. At the national level, cage culture and aquaculture parks have been identified as strategic cutting-edge technologies with the potential to increase fish production (Rutaisire et. al., 2009; MAAIF 2012; Mugamire et al., 2013).

Sea and maritime farming has been on the increase for many years in the developed and developing countries in Europe and Asia. In Uganda, specifically Lake Victoria, it started in 2006 with a pioneer farm called Source of the Nile (SON) Fish farm in Jinja (Kashindye et al., 2015). Since then, many Ugandans have tried it with no success and failures being attributed to majorly to inadequate and poor quality feed, seed and knowledge on Key Cage Fish Farming Concepts.

The Intervention

Since 2010, NARO/NaFIRRI has been funded to train prospective fish farmers and fisher communities in key cage aquaculture concepts so as to address the issues of inadequate knowledge on key cage aquaculture concepts which was one of the factors preventing prospective fish farmers from embracing the technology. The key areas addressed during the training included; State of Uganda's aquaculture industry, overview of cage aquaculture in Uganda; potential for cage aquaculture in Uganda; selection and identification of potential sites for cage aquaculture; Cage Design, Construction, Installation and Routine Management; Nutrition, Feeding and Feed Management in Cage Aquaculture; Water Quality management and Ecological control of Water Environment; Treatment and Prevention of common fish diseases, Value Addition and Marketing of Aquaculture Products.

Nevertheless, NaFIRRI has conducted a feed trial testing the growth performance of Nile tilapia fed on feeds sourced from the different local producers with an aim of generating facts to advise fish farmers and feed manufacturers vis a vis the nutritional requirements of the fish in culture. Another experiment of stocking densities is ongoing so as to inform the growing population of cage fish farmers about the appropriate stocking densities under specific conditions.

Beneficiaries

Technology adoption was facilitated by mobilization of neighboring fisher communities in the areas of Masese with an aim of training them in key cage aquaculture concepts so as to transform the site into an aquaculture park where they could be able to operate cage fish farming with fish in several cages under one group in Masese bay. After a two months' training which entailed fabrication of two (2) low Volume High Density (LVHD) cages by the farmers themselves. The fabricated cages together with feeds from Kajjansi Aquaculture Research and Development Center were used by the community to start the first and biggest Cage Aquaculture Park in Uganda. This Aqua Park currently hosts over 96 fish farmers all of whom were originally fishers, owning over 400 cages in Masese bay with an annual production of over 500 tonnes.

The success realized by the Masese cage fish farmers has resulted into the emergence of other aquaparks like Pearl Aquatics LTD and one fish farm on Lake Victoria in Garuga and Bugala-Kalangala respectively. This has also led to the emergence of other cage fish farms like Uga-chick fish farm, IG Invest LTD, Nile Pile, Kayodeya cage fish farms where NaFIRRI still plays a key role in technical backstopping.

Outcome

With the government's program of introducing Aquaparks, cage culture under the aquapark system has led to the growth of cage culture. There are 28 registered cage fish farmers in Uganda with an average annual production of over 1200 metric tons of fish from 2135 cages and each farmer produces an average of about 180 metric tons per year (Swaibu et

al., 2017). The growth of cage culture is associated with employment generation in form of the on farm workers, fish traders, fish feed manufacturers and fish seed producers.

Challenge

There are many unregistered farmers operating cage fish farming illegally and most do not follow the acceptable standards of cage fish farming. Data on these unregistered farmers has not yet been captured thus there is a possibility of having a great negative impact on fish production.

4.3.2 Increasing pond production and profitability for small-scale fish farmers: Innovative fish feeds

Background

For a long time since its introduction in Uganda in the early 1950s, aquaculture remained a rural subsistence agricultural activity mainly to improve household nutrition through improved intake of animal /fish protein. The largely low input practice also resulted in low productivity (up to 0.01 kg/m2/yr) whose lack of profit could not attract investment in aquaculture as an enterprise. Therefore total National aquaculture production remained very low (not more than 900 metric tons (MT) of fish per year constituting less than 1% of the national fish production. Aquaculture in Uganda remained unattractive even when vast business opportunities were created by the widening fish supply-demand gap due to the declining wild fish stocks. The lack of quality commercial fish feeds that has characterized subsistence aquaculture has been the biggest challenge to investing in commercial aquaculture.

The Intervention

From 1992, NaFIRRI in collaboration with other partners began improving aquaculture yields through improved feeding, using agricultural processing by-products. During 1992-2002 NaFIRRI investigated the use of sunflower oil cake that was found to be rich in protein and plant oil, both as feed and pond fertilizer. The adoption of this technology significantly improved pond yields among adopting farmers from the previous less than 0.05 kg/m2 to 0.75 kg/m2. Further improvements in pond yields were achieved by NaFIRRI through the use of chicken offal from Ugachick Poultry Breeders Ltd that was found to be 80% protein and resulted in yields as high as 2.4 kg/m2 in catfish culture on-station. Average pond yields by adopting farmers increased to 0.95 kg/m2 but wider adoption of this technology was restricted by the limited distribution of the chicken offal.

From 2002, NaFIRRI initiated development of formulated fish feeds by sourcing for ingredients, analyzing them for nutritional qualities, formulating and testing of the feeds. The promising results of these efforts attracted collaboration with private sector (Ugachick Poultry Breeders Ltd) that resulted in the production and availability of commercial fish feeds in Uganda in 2003. This foundation was built on through support from USAID and GoU that resulted in the production of floating fish feeds in 2005.

Beneficiaries

NaFIRRI/NARO has provided the database of the local ingredients that had been identified, the initial formulations and results of the performance of the formulated feeds to feed producers and farmers. NaFIRRI also provided technical guidance on the management of the feeds by farmers.

Outcome

The consequence of availability of commercial fish feeds has led to a significant increase in total aquaculture production from less than 3,000 MT in 2000 to over 10,000 MT in 2005 and to 95,000 MT in 2010. At the same time pond yields have increased from 0.95 Kg/M2 to 1.7 Kg/m2 with proper use of feed and management of water quality. Other interventions, such as improved availability of seed, may have also contributed to the development of aquaculture.

Aquaculture has become much more attractive, judging by the number of investors; availability of quality floating feeds has influenced the adoption of the more intensive cage aquaculture. The increasing demand for quality fish feeds has attracted more investment in feed production. The number of commercial fish feed mills has increased, three of which are in East Africa. Uganda is the main source of quality fish feeds in East Africa, and is contributing to development of aquaculture in the entire region. The main roles of NaFIRRI remain to continue improving quality and cost-effectiveness of feeds and offering technical guidance to feeding management.

4.3.3 Successful control of water hyacinth on Uganda's major water bodies

Background

Water hyacinth (Eichhornia crassipes), an aquatic weed native to South America, was first reported in Uganda on Lake Kyoga in 1988, but developed into heavy infestations on major water bodies (lakes Victoria, Kyoga, Albert, and on River Nile). By 1998, water hyacinth coverage had attained peak biomass coverage of 4,000 ha on Lake Victoria and these infestations disrupted socio-economic activities especially fishing, water transport, hydro power generation and water abstraction. Due to the overwhelming negative impacts of infestations, systematic efforts to control this weed were initiated in 1992 by MAAIF creating a National Technical Committee on Water Hyacinth. This committee was

composed of high level representatives of government institutions and was chaired by the Director General of NARO. This committee elaborated various levels of responsibility which resulted into creation of other organs i.e. administration, coordination and policy; technical evaluation; coordination of control efforts; community participation; monitoring and research; and regional mechanisms to control the weed.

The Intervention

While the committee proposed an integrated management of water hyacinth, use of chemicals was not recommended due to unforeseen environmental concerns. Biological control was therefore deemed environmentally friendly and sustainable, and was applied lake-wide. Mechanical and manual removal were also implemented at strategic sites notably landing beaches, wagon ferry terminals and water abstraction points. Two species of weevils that specifically feed on to water hyacinth: Neochetina bruchi and Neochetina eichhorniae, were imported in 1993 from IITA in Benin, subjected to bio-control process and introduced on lakes Kyoga in 1993 and Victoria in 1995. With participation of local communities, lakeshore weevil rearing centers were established to boost weevil populations for periodic releases.

Outcome

While the process took approximately 7 years to knock down the weed coverage on the three lakes, by 1999, water hyacinth coverage had reduced by more than 80% (> 3,200 ha) to non-nuisance levels of less than 20% (< 800 ha); this was a great relief to various users of the water bodies in question.

Success Factors

Participation of local communities at landing beaches around lakes Victoria, Kyoga and Albert in the control process made a big contribution where government provided hand tools like wheel burrows, forked hoes and spades, slashers, rakes and protective wear to facilitate manual weed removal. Mechanical weed removal using weed harvesters implemented at Nalubale and Kiira dams in addition to the wagon ferry terminal at Port Bell in Kampala complimented the weevil effects. Periodic resurgence of the weed in some bays of major lakes has not resulted in high weed coverage because the bio-control agents are well established in the lake systems. The successful control of the water hyacinth won NARO an award of excellence for effective management of the water hyacinth.

4.3.4 Increasing aquaculture productivity and production in Uganda through quality fish seed development, multiplication and distribution

Background

Fisheries and aquaculture sectors continue to contribute immensely to socio-economic development in Uganda as well as improving food security among rural populations. World over capture fisheries has stagnated, with the only plausible option to bridge the fish supply-demand gap and relieve the pressure on wild fish populations being aquaculture. Similarly in Uganda the sector has been identified and targeted by government to cover the shortfall estimated at around 300,000 tonnes annually. In the late 1980s aquaculture production was a meager 400 tonnes per year and this poor performance was attributed to lack of quality fish seed and feed. This was further compounded by limited number of farmed species, at that time in the country limited to only Nile tilapia and the mirror carp.

The intervention

In the early 1990s NaFIRRI set out to improve the quality of fish seed and to diversify farmed fish species. Research improved fish genetic resource and broodstock management to greatly reduce inbreeding that was greatly contributing to the poor fish seed performance. During the same time the NaFIRRI scientists successfully adopted the technologies of seed production, larval nursing and grow-out of one native species – the African catfish. In early 2000s NaFIRRI scientists domesticated and developed the technologies for seed production and grow-out of yet another fish – the Ningu (Labeo victorianus). In 2015 NaFIRRI domesticated and developed seed production and larval nursing technologies for another native fish species – the kisinja (Barbus altianalis).

In 2010 the demand for quality seed by fish farmers and the growing interest in the sector by investors led NaFIRRI to establish a farmed fish genetic improvement programme for Nile tilapia and the African catfish. At the third generation (F3), the scientists have improved the growth rate of Nile tilapia from what it was before at an average of 0.52g/day to 2.47g/day. Improved fish seed has been distributed at every subsequent generation to both farmers and hatchery operators for seed multiplication throughout the country.

Outcomes

For these and other related efforts, aquaculture production in Uganda has greatly improved fish production to an estimated 100,000 tonnes per year. This has resulted into increased income for the farmers, employment opportunities all along the value chain through the ever increasing investment into the aquaculture sector and food security for the population.

What and Why Cage Fish Farming

Cage aquaculture is the raising of fish in cages suspended in water (see cover picture). There are two types of systems, Low Volume High Density (LVHD) and High Volume Low Density (HVLD). LVHD involves raising fish at densities of 150 - 500 fish per cubic meter and have optimum yields of 150 - 250 kg. m^{-3}. This is preferred because it yields higher production per unit volume and is the one practiced in Uganda. The HVLD involves raising fish at lower densities of 80 - 100 fish m^{-3}.

Cage aquaculture started in Uganda in 2006 using LVHD cages and has demonstrated capacity to produce 150 - 250 kg m^{-3} under good management practices, compared to pond aquaculture which started sixty years ago but has achieved production of only 2 - 10 kg m^{-3}. It however, takes place in water bodies that are used for other social and economic activities, has environmental challenges associated with inputs and wastes that can degrade water and high stocking densities require water of good quality and guidance to optimize production. NaFIRRI has been addressing these challenges by undertaking site capability, suitability, zoning, examining production practices, and monitoring the environment to guide cage fish farmers.

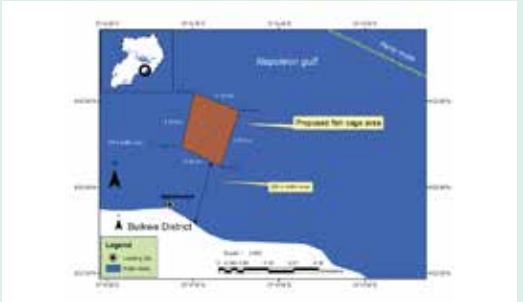
Site selection

The site should be located away from the shore line and major lake uses including: security areas; harbors; navigation channels; protected areas; recreational facilities; landing sites; fishing and fish breeding and nursery grounds; hydropower plants; water intake and extraction points; effluent discharging and waste disposal points; and weed hotspots among others.

Suitability of the site for cage fish farms must be assessed prior to setting up the farm, Ideal characteristics are summarized in the table below.

Ideal water quality characteristic for cage aquaculture culture	
Variable	**Ideal levels**
Depth	5 - 20 m
Dissolved Oxygen (DO)	≥5 mgL^{-1}
Water transparency	>70 cm
Wind velocity	≤10 knots
Wave height	<1 m
Temperature	27 - 30°C
Biochemical oxygen demand (BOD)	≥6 mgL^{-1}
Current speed	10 to 100 cm/sec^{-1}
Carbon-dioxide (CO_2)	<5 mgL^{-1}.
Total phosphorous	<100 µg/L
Chlorophyll-*a*	<75 µg/L
Total Ammonia Nitrogen	<0.01mgL^{-1}
Nitrate	0.1 - 4.0 mg L^{-1}
Nitrite	< 0.2 mgl^{-1}
Total dissolved solids (TDS)	<40 mg L^{-1}
Total suspended solids	<10mgL^{-1}
Alkalinity	120 - 400 ppm
pH	6.5 - 9
Conductivity	30 - 5,000 mSiemens/cm
Salinity	2 - 3 ppt
Hardness	30 - 180 mgL^{-1}
Chloride	60 - 100 mg L^{1-}
Faecal coliform	≤100 count per 100 ml

A description of the location of the site and adjacent areas should be made, the area zoned and its carrying capacity determined. An Environmental and Social Impact Assessment (ESIA) for the area may be required certain sizes of farms. Reports of the site suitability and capability and an ESIA are required for issuance of a production license by the Directorate of Fisheries Resources (DiFR).



An illustration of a cage culture site

Production practices

Nile tilapia is the most widely cultured and recommended species for cage culture as it grows fast, and can tolerate high stocking densities. The seed for culture should be obtained from a certified supplier in Uganda. All male juveniles sexually reversed using hormones are best for cage culture. Efforts should be made to minimize stress during fish handling at all stages of production.



Nile Tilapia

Juveniles of not less than 1g should be stocked in a juvenile cage at a density of 1000 - 2500 fish m^{-3}, reared for 8 weeks, graded and stocked in production cages at a density of 150 - 300 fish m^{-3}. and reared for 6 - 7 months to 350 - 600g and harvested depending on market demands.

Fig. 10 Pollution in Northern Lake Victoria

Fig. 11 Best practices for cage fish farming

Development of Best Practices for Cage Fish Farming to Increase Fish Production in Uganda

1. What and Why Cage Fish Farming

Cage aquaculture is growing of fish in cages suspended in water at Low Volume High Density (LVHD) of 150 - 500 fish m^{-3} or High Volume Low Density (HVLD) of 80 - 100 fish m^{-3}. LVHD started in Uganda in 2006 and has demonstrated better production of 150 - 300 kg m^{-3}.



Structure of a cage

2. Challenges of cage fish farming

Cage fish farming can interfere with other social and economic activities in water. High stocking densities require water of good quality. Inputs and wastes can degrade water quality. Therefore, guidance is required to ensure proper location, optimization of production, and securing the environment. NaFIRRI has been undertaking site capability, suitability, zoning, examining production practices, and monitoring the environment to guide farmers increase fish production and create wealth.

3. Location

Cages should be located away from major lake uses including: security areas; harbors; navigation channels; protected areas; recreational facilities; landing sites; fish breeding and nursery grounds; hydropower plants; Water intake and extraction points; effluent discharging and waste disposal points; and weed hotspots among other.

4. Site selection

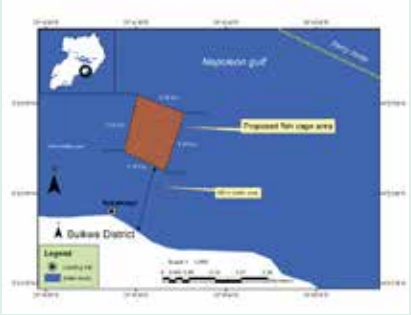
Suitability of the sites for cage fish farms must be assessed prior to setting up a cage fish farm, Ideal water quality characteristics are summarized in the table below.

Ideal water quality characteristic for cage aquaculture culture	
Variable	**Ideal levels**
Depth	5 - 20 m
Dissolved Oxygen (DO)	≥5 mgL^{-1}
Water transparency	>70 cm
Wind velocity	≤10 knots
Wave height	<1 m
Temperature	27 - 30°C
Biochemical oxygen demand (BOD)	≥6 mgL^{-1}
Current speed	10 to 100 cm/sec^{-1}

Ideal water quality characteristic for cage aquaculture culture	
Carbon-dioxide (CO_2)	<5 mgL^{-1}.
Total phosphorous	<100 mg/L
Chlorophyll-**a**	<75mg/L
Total Ammonia Nitrogen	<0.01mgL^{-1}
Nitrate	0.1 - 4.0 mg L^{-1}
Nitrite	< 0.2 mgl^{-1}
Total dissolved solids (TDS)	<40 mg L^{-1}
Total suspended solids	<10mgL^{-1}
Alkalinity	120 - 400 ppm
pH	6.5 - 9
Conductivity	30 - 5,000 m Siemens/cm
Salinity	2 - 3 ppt
Hardness	30 - 180 mgL^{-1}
Chloride	60 - 100 mg L^{-1}
Faecal coliform	≤100 count per 100 ml

5. Zoning and carrying capacity

The site and adjacent areas should be described, the area zoned and its carrying capacity determined. An Environmental and Social Impact Assessment (ESIA) of the site may be required for certain sizes of farms.



An illustration of cage culture site

6. Culture species and seed

Nile tilapia is the recommended species for cage culture. It grows fast and tolerates high stocking densities. All male juveniles sexually reversed are best for cage culture. Juveniles of not < 1 g are stocked in a juvenile cage at a density of 1000 - 2500 fish m^{-3}, reared for 8 weeks, graded and stocked in production cages at a density of 150 - 300 fish m^{-3} and reared for 6 - 7 months to 350 - 600 g before harvesting.



Nile tilapia

7. Feeds and feeding

Juveniles should be fed on powdered feeds or crumbles of at least 45% Crude Protein (CP) for 2 months to attain at least 15g and transferred to production cages where they are fed on 2mm pellets of 35% CP for 2 months, 3 mm pellets of 30% CP for 3 months, and finally 4 - 5 mm pellets of 20 - 25% CP for the rest of the growth period. Fish should be sampled once every four weeks to determine weight gain, Feed Conversion Ratio (FCR) and growth rate to guide adjustment of feed ration size.

8. Production economics

The average weight of fish at harvest is normally 350 to 600 g. The survival rate is 80 - 95% and FCR is 1.2 - 2.0. Estimated yield varies between 80 and 300 kg.m^{-3} depending on site quality and management. (~1200 - 4600 kg for a cage of 2.5x2.5x2.5: 15.6 m^3). The estimated cost of inputs per cage comprises of: The cage (Shs 1,200,000 - US$ 340; Seed (Shs 950,000/= - $270); Feed (assuming FCR of 1.5 would require 1875 kg of feed) which at an estimated cost of Shs 3,000 per kg of feed is Shs 5,625,000/= ($1,610). If we provide for a conservative estimate of US$ 300 for other costs, the total cost of production per cage is ~US$ 2,500. At a selling price of US$ 2.5 per kg of fish, the expected gross income per cage is ~US$ 3,000, providing a net profit of ~ US$ 500 per cage.

9. Monitoring and securing the environment

Fish health should be checked regularly and any infected fish isolated and reported. There should be security measures to avoid escape of fish into the wild, minimize predation and theft. Wastes on the farm should be a managed to reduced contamination and there should be plan to dispose-off materials at close of the farm. Environmental variables in the farm area should be monitored using the data generated during site selection as baseline and compared with NEMA standards.

10. Policies and institutions

Policies and regulation to specifically guide cage culture are still inadequate. However, existing policies and regulations of water, fisheries, environment and local governments can be applied to address the issues and concerns of cage culture but need strengthening.

11. Challenges

The major challenges include: Improving availability of affordable high quality feed and seed; Building human resource capacity; Controlling predators, theft and vandalism; Fish losses due to damage of cage bags; Competition between cultured and wild fish for markets; and inadequate policies specifically addressing cage culture.

12. Conclusions and recommendations

Cage culture has the potential to improve fish production in Uganda with guidance. There is, therefore need to utilize the opportunities and address the challenges of cage culture by continually refining and improving these guidelines with new knowledge and building capacity.

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10 year old Clonal Eucalyptus at NaFoRRI >>

Chapter 5
NATIONAL FORESTRY RESOURCES RESEARCH INSTITUTE (NAFORRI)

5.1 Background

The National Forestry Resources Research Institute (NaFORRI) is one of the 16 Public Agricultural Research Institutes under NARO. It is mandated to undertake research in all aspects of forestry. It started as Forest Resources Research Institute (FORRI) and was located at Nakawa Division in Kampala. NARO took it over in 1994 and later the name was changed to National Forestry Resources Research Institute (NaFORRI). With support from the World Bank, the institute built research facilities in Kifu, Mukono district, where it is currently located.

Research in NaFORRI aims at increasing the benefits derived from trees and forests through conservation and sustainable management of the forest and tree resources.

This mandate is guided by the vision to be the Centre of excellence spearheading forestry research for improving livelihoods, economic growth and natural resource conservation. The mission is to generate and disseminate appropriate technologies on forests and tree resources for increased productivity, conservation of biodiversity and enhanced environment.

A committed team of experts has ably executed the institute's mandate, vision and mission to meet the ultimate objective of enhancing scientific innovations, skills, information and policy advice for increased productivity, conservation and sustainable use of forest and tree resources.

5.2 Institutional changes and their impact on delivery of the mandate

Over time, NaFORRI focus has evolved resulting into four programs to handle its mandate. These are:

Forest Conservation and Management Research Program aims at developing and disseminating technologies and practices for sustainable management of plantation and natural forests. Issues of silviculture (agronomy of trees) are handled in this program.

Agroforestry Research Program aims at developing and disseminating appropriate technologies that integrate trees on-farm to optimize crop yields, livestock production and conserve the natural resource base.

Forest Products and Services Research Program aims at developing and disseminating technologies that enhance efficient harvesting, processing and utilization of wood and non-wood forest and tree products.

Tree Improvement and Germplasm Research Program aims at building on the long-term species introductions and proven evaluations undertaken since 1900. Tree improvement relies on understanding and using variations that naturally occur in the populations**.**

NaFORRI has over time improved the infrastructural and human capacity for research. In 2008 NaFORRI had 13 scientists compared to 21 in 2017; there were five technicians compared to 17 in 2017 in addition to 25 support staff. Causal labor brings total staff numbers to about 105 at any one time. Four staff are on PhD studies at various local and international universities. The infrastructure consists of two administration buildings, two laboratory blocks, one guest house, four green houses and two tree nurseries comprising clonal eucalyptus and a variety of other high quality assorted tree species. The institute has a carpentry workshop unit that produces assorted high quality furniture and other timber products.

5.4 Top successful interventions as identified by NaFORRI

1. Introduction and screening of eucalyptus clones for different agro-ecologies in Uganda.
2. Cypress aphid (Cinara cupressivora) control in Uganda: a successful case of classical biological control.
3. Integration of Calliandra into smallholder dairy production systems.
4. Pine growing boosted through biological control of the pine woolly aphid (Pineus boereneri).
5. Introduction of improved Cashew nut varieties in Mid-Northern and Eastern Uganda.

5.4.1 Introduction and screening of eucalyptus clones for different agro-ecologies in Uganda

Background

Hybrid eucalyptus was first introduced in Uganda in 2002 under a collaborative project of several partners including NaFORRI, with funding from Gatsby Charitable Trust. The 12 hybrids are a product of hybridization between the original landraces of *Eucalyptus i.e. E. urophylla, E. grandis and E. camaldulensis.* Since their introduction, the eucalyptus hybrids have increased the competitiveness of plantation forestry industry in Uganda, improving

livelihoods of eucalyptus farmers. The hybrids are endowed with better wood quality, higher pest and disease resistance and higher volumetric growth than the original landraces. Besides wood quality and volumetric growth, hybrid Eucalyptus species can grow well in all agro-ecological zones of Uganda.

The Intervention

Adaptation trials/site matching was conducted between 2002 and 2012 to evaluate performance of hybrid Eucalyptus in all the agro-ecological zones and recommendations were made of the suitability of the different hybrids. These superior qualities have since then been maintained through clonal propagation. Cloning systems in Uganda are mainly based on the rooting of cuttings obtained from superior hybrid genotypes. It is the best way to commercially capture, exploit and maintain the superior traits (wood properties and fast growth) found in these Eucalyptus hybrid crosses, for a long time. The12 hybrids under mass cloning are: GC 550, GC540, GC796, GC 796/2 GC578, GC 784, GU 7, GU 8, GU 21, GU 607 and GU 609. Cloning allows for production of more uniform raw material, which is highly beneficial to industrial processes. Moreover, clonal eucalyptus propagation is a low cost venture, giving products that meet customer requirements in a shorter time period, in a sustainable manner and with minimum impact on the environment. As pioneers of clonal Eucalyptus technology in Uganda, NaFORRI has maintained a leading role in building stakeholder capacities in this area.

Beneficiaries

There are over 50 commercial private clonal eucalyptus nurseries operating in Uganda. The 12 hybrids have been planted in all the agro-ecological zones of the country. In 2011, of the 43,000ha of total forest plantations that existed in Uganda, 11,000ha were for Eucalyptus species. This coverage has increased over time due to the overwhelming demand of the clonal eucalyptus seedlings. Clonal eucalyptus timber is more popular than pine timber on the open market. Moreover, the timber is easily worked and can be used for light construction, furniture, veneer, boxes, plywood and pulp for paper.

Outcome

There is reduced importation of electricity transmission poles since local eucalyptus trees can produce straight and uniform poles.

5.4.2 Cypress aphid (Cinara cupressivora) control in Uganda: a successful case of classical biological control

Background

Cypress tree species (Cupressus lustanica), a tree native to Mexico is widely grown in East Africa including Uganda. The tree is planted for provision of timber, ornamental purposes and as an agroforestry tree species. Since its introduction in Uganda C. lustanica has generally been free of pests. In 1989 however, the cypress aphid (Cinara cupressivora Fig. 12) were observed in Echuya Forest reserve in south western Uganda infesting cypress trees, causing severe damage to the trees (Fig. 13). By the end of 1995 the pest had spread to all major Cypress plantations, woodlots and hedgerows of Uganda, causing severe die back and mortality. Infestation by the Cypress aphid led the then Forest Department, to suspend planting of C. lustanica.

Fig. 12: Infestation by Cinara cupressivora



Fig. 13: Four months old eucalyptus plantlets



The Intervention

NaFORRI identified indigenous natural enemies within the ecosystem that were preying on C. cupressivora. These included Chelomenspropingua, C. aurora and Exhocomus spp. The most important of these was Exochocomus spp. which could cause 12% pest mortality. However, because of the low impact on the Cypress aphid populations by indigenous natural enemies including Exochomus spp. damage to Cypress remained high. Several aphicides were screened against the pest but could only be used on a limited scale such as the nursery and on hedgerows because of the costs involved and possible pollution of the environment in addition to causing pest resurgences. In 1996, in partnership with International Institute for Biological control (IIBC), NaFORRI introduced Pauesia juniperorum, an exotic biological control parasitoid wasp (Fig.3) in strategically infested Cypress plantations and woodlots of Uganda. These included Mafuga, Kiriima, Suam, Usi and Lendu.

NaFORRI monitored the population dynamics and damage levels of C. cupressivora before and after release of P. juniperorum. Analyses of the results demonstrated that P. juniperorum had established and dispersed effectively, to become an important regulating factor of C. cupressivora populations and damage to sub economic levels. P. juniperorumis is now found wherever Cypress is growing in the country co-existing with C. cupressivora without the latter causing damage to cypress trees.

Success Factors

Attributes of Cypress (the crop), the pest and the natural enemies all contributed to the success of biological control of C. cupressivora. Cypress is a perennial tree crop and thus provides relatively stable habitat and food supply to the pest. The pest population in turn was high, providing a constant food supply for the survival and establishment of the released biological control agent. Synchrony between life cycle of P. juniperorumand that of C. cupressivora has ensured survival and multiplication of the biological control agent (P. juniperorum).

Outcome

The level of damage to Cypress on average reduced from 60-100% in 1996 to less than 10% throughout the country by 2009. National Forestry Authority lifted the ban on planting of Cypress trees and farmers resumed replanting Cypress for timber, ornamentals and other uses.

5.4.3 Integration of Calliandra into smallholder dairy production systems

Background

Smallholder dairy production can be a means to agriculture-led economic development given its potential to improve household nutrition and provide opportunities for additional income generation. In Uganda, however, productivity of this enterprise is hampered by the poor quality and low quantities of feeds, especially during dry seasons. These mainly comprise natural grasses, wild browse and crop residues. Although rich in roughage, such feeds are deficient in proteins resulting in low milk yields. In addition, dairy farmers face difficulties using commercial dairy feed supplements as these are often unavailable, costly and in some instances difficult to transport.

The intervention

*Calli*andra calothyrsus (commonly referred to as Calliandra) provides a solution to this problem by guaranteeing farmers steady supplies of protein-rich feed supplement at negligible cost. This multipurpose exotic shrub has been grown by farmers in Uganda for more than 15 years. It is commonly planted as hedges along farm boundaries or contours to provide fodder for livestock. Its leaves and twigs are used as a protein supplement. A 3kg fresh Calliandra fodder can replace 1kg of dairy meal without affecting milk production. In addition, dairy animals fed on Calliandra produce milk with a higher butter fat content and nutritional value. A

Fig. 14: Exotic parasitoid (Pauesia juniperorum) introduced in Uganda searching for the pests



farmer needs about 500 shrubs to feed a cow annually and these can easily be grown along boundaries of a typical 1 acre farm.

Beneficiaries

Calliandra has gained popularity in Uganda's smallholder dairy systems given that most dairy development projects require beneficiaries to have a Calliandra fodder stand as a condition for receiving a heifer. NARO and its partners have enhanced farmers' access to quality planting materials through seed multiplication and dissemination.

Success Factors

Dairy farmers appreciate Calliandra's fast growth, excellent quality as supplement fodder and ability to re-grow after cutting. The increasing land shortage and the shrub's ability to fit easily into intensive production systems have also led to its successful adoption. Many farmers are also compelled to opt for Calliandra due to the high cost and difficulty involved in accessing commercial dairy feeds. The shrub is also popular given its multiplicity of other uses e.g. stabilization of steep slopes, soil erosion control, soil fertility enhancement, as well as serving as a source of poles, firewood and stakes for supporting crops.

Challenges

Despite Calliandra's popularity among dairy farmers, its promotion still faces several challenges, e.g. inadequate information on pests and diseases, and complexities associated with its use in open livestock systems.

Outcome

Integrating Calliandra into smallholder dairy systems provides farmers with a means out of poverty, by boosting household incomes, improving nutrition. Specifically, it increases farmers' incomes from sales of milk and derived products as well as their savings in terms of money spent on purchasing and transporting dairy meal. It also reduces drudgery involved in searching for fodder from off-farm sources.

5.4.4 Pine growing boosted through biological control of the pine woolly aphid (Pineus boereneri)

Background

Pine tree species have been planted in Uganda since the 1940s. The most planted species are Pinus patula for the highland areas and P.caribaea for lowlands. The tree is planted for provision of timber, ornamental purposes and as an agroforestry tree species. Since its introduction in Uganda Pinus species had generally been free of insect pests. In 1995 however, the Pine woolly aphid (Pineus boereneri) Fig. 15, (called so because of the white wool it produces for protection, was observed infesting Pine trees in Mafuga and Kiriima Central Forest Reserves in South Western Uganda causing severe damage to the trees.

The infestation by aphids has resulted in tree mortality of over 20 %, and 50 % loss of growth increment among infested trees. Wind facilitated movement of the pest.

The Intervention

NaFORRI scientists identified indigenous natural enemies within the ecosystem that were predating on P.boereneri. These included Exhocomus spp., Chelemones propingua and Crysopa carnea. However, because of the low impact on the P. boereneri populations by indigenous natural enemies, damage to Pines continued to be high. Several aphicides were screened against the pest but could only be used on a limited scale such as the nursery because of the costs involved and possible pollution of the environment. Pesticides also cause resistance among pest populations and could lead to pest resurgences. In 1997, in partnership with International Institute for Biological Control (IIBC), NaFORRI introduced an exotic biological control predatory bug, *Tetraphleps raoi*



Fig. 15A: Pineus boereneri hidden under wool; B. Pineus boereneri exposed by removing wool filaments

in Kiriima Forest Reserve in south western Uganda. However, *T.raoidispersal* was slow, so the biological control agent had to be collected from Kiriima Forest Reserve and redistributed to other infested sites in the country. These included Katugo, Kapkwata, Lendu, Awang, Usi, Mafuga and Mwenge Central Government Forest reserves.

NaFORRI monitored the population dynamics and damage levels of P. boereneri before and after release of *T.raoidispersal* Analyses demonstrated that *T.raoi* had established and reduced the level of damage in *P. patula* and *P.caribaea* from an average of 25-59 % in 1997 to less than 5 % in 2009.

Success Factors

Attributes of the crop, the pest and the natural enemies all contributed to the success of this biological control program. Pines are perennial tree crops and thus provide relatively stable habitat and food supply to the pest. The pest population in turn was high providing a constant food supply for the survival and establishment of the released biological control agent. Synchrony between life cycle of *P.boereneri* and that of *T.raoidispersal* also ensured survival and multiplication of the biological control agent (*T.raoi*).The Biological control agent was slow in dispersal and thus had to be redistributed physically in strategic pine sites of the country.

Outcome

The biological control agent T. raoi has also dispersed widely and can virtually be found wherever there is pine woolly aphid infestation is found. Consequently, farmers are now widely planting pine species. for commercial and domestic use. Estimates of Pinus spp plantations by NFA suggest an increase in planting of Pines from 9000 ha in the 1990s to approximately 50,000 ha in 2015 in Uganda. This increase in planting is partly attributed to control of P.boereneri.

5.4.5 Introduction of improved Cashew nut varieties in Mid-Northern and Eastern Uganda

Background

Eradication of poverty is a key development challenge for Uganda. The incidence of poverty is even higher in the rural areas where the majority of Ugandans are still dependent on subsistence farming. This type of farming provides little opportunity for increasing households' standards of living due to its emphasis on producing traditional food crops. In response to the challenge of high rural poverty, NaFORRI in collaboration with the Cashew Development Network for Eastern and Southern Africa (RECINESA) revived cashew nut tree growing in the northern and eastern districts of Uganda. It was perceived that cashew tree crop had significant potential for increasing rural household incomes and food security due to its high demand on the world market.

The Intervention

NaFORRI and RECINESA addressed major cashew production constraints in the region through a number of interventions. These included the evaluation and multiplication of selected genotypes for distribution to farmers, packaging knowledge and technology transfer to resource-poor farmers. The project organized cashew tree farmers into cohesive farmers groups through which they were assisted to establish village nurseries and farmers were trained on cashew production. Cashew demonstration plots were also planted in eastern Uganda. The new varieties that have been introduced are high yielding, short rotation varieties and many of them started flowering at three years.

Beneficiaries

In Uganda, agro-climatic conditions suitable to cashew nut growing are found in northern and eastern districts. Although the crop had been introduced in Uganda as far back as the 1970s, its cultivation had for long been constrained by the poor varieties grown that yielded nuts not suited to market preferences. Discouraged by failure to get market for their produce, farmers neglected the cashew trees or converted them to other uses. The introduction of improved varieties has revitalized the cashew subsector and thousands of cashew seedlings have been planted by small-scale farmers in the districts of Iganga, Mayuge, Tororo, Kamuli, Pallisa, Budaka, Namutumba, Bugiri, Busia, Mbale, Kumi, Bukedea, Soroti, Lira, Amuria, Abim, Oyam, Nakapiripirit, Dokolo, Amolatar, Kaberamaido, Apac, Gulu, Kitgum, Nebbi, Moyo, Amuru, Arua, Moroto and Kotido. It is estimated that about 80,000 trees have so far been planted by farmers in northern and eastern districts of Uganda. There are also efforts to develop low-cost cashew processing technologies and link Ugandan cashew producers to lucrative markets.

Outcome

Cashew nut is one of the few high value crops in Uganda that can fetch up to UGX 25,000 per kg thus enhancing household incomes. The high market price and improved varieties of cashew nuts has encouraged more production of the crop thus enhancing income for many households in the growing regions.



National Livestock Resources Research Institute (NaLIRRI)

Chapter 6
NATIONAL LIVESTOCK RESOURCES RESEARCH INSTITUTE (NALIRRI)

6.1 Background

The National Livestock Resources Research Institute (NaLIRRI) is a Public Agricultural Research Institute (PARI) mandated to;

"Generate and transfer technologies and knowledge in areas of: Animal health, including aquatic animal health, Animal breeding, including theriogenology, Animal nutrition, Apiculture, Socio-economics, and Emerging issues such as Avian Influenza, Napier Stunt Disease, Swine Flu and climate change".

The institute aims to become a center of excellence spearheading the generation and transfer of improved and appropriate livestock technologies and knowledge for sustainable development. To achieve this vision, the institute aspires to contribute to the improvement of the welfare of Ugandans and the conservation of the natural resource base by increasing productivity and utilization of livestock resources. Major partners and collaborators include World Bank, Farmers, DANIDA, Local Universities, DFID, Private Sector, WHO, NAADS, FIND, NGOs, CBOs, ADB/PATTEC, ASARECA, Liverpool & Yale Universities, EANETT, JICA/Other Japanese Programs, UBS Optimus Foundation, and IAEA.

6.2 Institutional changes and their impact on delivery of the mandate

National Livestock Resources Research Institute (NaLIRRI) is one of 16 semi-autonomous Agricultural Public Research Institutes established for the purposes of providing agricultural research services under the policy guidance of the National Agricultural Research Organization (NARO). The institute owes its origins to the colonial period when the East African Trypanosomiasis Research Organisation (EATRO) was founded in 1956. EATRO's mandate was to conduct research on tsetse flies and trypanosomiasis in both humans and animals across Uganda, Kenya and Tanzania under the jurisdiction of the East African Common Services Organisation which later became the East African Community. After the collapse of the East African Community, EATRO was handed over to Uganda government in 1977 and renamed Uganda Trypanosomiasis Research Organisation (UTRO). UTRO was mandated to conduct research on tsetse flies, human and animal trypanosomiasis. In 1992, UTRO was merged with the then Animal Health Research Centre at Entebbe to form the Livestock Health Research Institute (LHRI) to handle livestock health and theriogenology, including sleeping sickness in man. Prior to 2005, the reorganization of agricultural research in 1992 saw the unit transformed into the Livestock Research Institute (LIRI) and soon after LIRRI under NARO. In 2005, the National Agricultural Research Act 2005 established a National Agricultural Research system for Uganda. This comprised, among other bodies, semi-autonomous National Agricultural Research Institutes like NaLIRRI, to manage and conduct strategic agricultural research.

6.3 Top successful interventions as identified by NaLIRRI

1. Improving feed availability in smallholder dairy production systems.
2. Nakyesasa Dairy Research and Business Hub combats National Pasture Seed Scarcity.
3. Selective Breeding improves SEAZ traction capacity, spurs agricultural productivity.
4. Crossbreeding of the SEAZ cattle with Boran for increased meat productivity.
5. Indigenous chicken breeds improved through cross breeding: The SAARI Crossbred chickens.
6. Breeding enhances indigenous goats for meat productivity.
7. Fodder conservation technologies support year round livestock forage availability.

6.3.1 Improving feed availability in smallholder dairy production systems

Background

Small-scale dairy production plays a crucial role in food security, and overall household health and livelihoods. Zero-grazing (stall-fed) intensive dairy systems are being promoted, owing to increasing shortage of open grazing land alongside precise dairy production requirements. Women both in male and female headed households are major contributors to, and beneficiaries from, smallholder dairy production systems. These systems are constrained by rapid climate change, its attendant extreme weather conditions and feed scarcity. Productivity of Napier grass (Pennisetum purpureum) - the major forage in zero-grazing systems is constrained by long droughts, poor agronomic practices (fertilizer application and cutting frequency and height, and pests and diseases – notably Napier Stunt Disease (NSD) that dampen its regeneration and biomass yields.

The intervention

NARO through the National Livestock Resources Research Institute (NaLIRRI) embarked on a promotion program for key forage and feed technologies to amplify feed availability in small holder dairy production



Fig. 16A: Brachiaria mulato intercropped with Bananas; B. Calliandra forage multiplication filed

systems in the country. Major forage species under this program were forage grasses Pennisetum purpureum and Brachiaria hybridcv. Mulato, forage legumes; Lablab purpureus, Clitoria ternatae, Macroptilium atroprupureum and Centrosema pubescen as well as forage trees and shrubs such as Calliandra calothyrus, Gliricidia sepium and Lithonia diversifolia. Forage and feed technologies promoted included dry season feeding and protein and energy feed formulation. The former included technologies such as silage production and hay making while Homemade dairy meal, Lablab and Calliandra leaf hay dry season protein supplements, sorghum stover-tithonia rations and multi-nutrient feed blocks comprised the latter

Integration of forage legumes into Napier grass and cereal cropping systems, recommended acreage for Napier grass-forage legume mixture to provide year round dairy cow requirements, staggering planting dates of Lablab into maize crop to avoid competition and NSD management package were among the management practices promoted to enhance feed variety, rations and quality.

Recommended feed processing equipment were the manual metallic forage chopper, motorized manual forage chopper, improved heavy pressing surface hay baler and a modified pellet making machine (from Musa Body Fabricators). Technology dissemination strategies employed included on-farm demonstration trials, farmers' demo sites and cross visits, newspaper articles, radio and television programmes, farmer workshops and demonstration site field days.

Success Factors

The success of this intervention was hinged on participatory involvement of key actors in the feed value chains (farmers, local leaders, extension staff), beneficiary farming community, hosting, monitoring and evaluation of demonstration processes, community's ability to compare and contrast own and improved Technology Innovations and Management Practices (TIMPS), integrated manure, leguminous crop residue soil fertility enhancement and the availability of Napier grass varieties tolerant to NSD.

Challenges

High cost of planting materials especially seed, low grade dairy breeds kept by farmers which inhibited appropriate response to quality feeds as well as an attitude of rationing feeds and water - underfeeding which compromised the effectiveness of feed supplementation were top among the challenges faced during the implementation of this intervention. Effects of climate change made basal feed supplement a serious constraint to farmers.



Fig. 17A: Community-based multiplication field; B. Well managed Chloris field for farmers' group

Outcome

This initiative contributed to improved knowledge and skills on fodder management; milk yield increased due to improved feeding, milk yield and fodder availability increased by between 10-20% and over 20%, respectively. Adopters established 2,700 acres of fodder in key districts where zero grazing is a major enterprise and beneficiaries by 2017 are upscaling technology dissemination through visitors received from Uganda and abroad.

6.3.2 Nakyesasa Dairy Research and Business Hub combats National Pasture Seed Scarcity

Background

The livestock sub-sector contributes 18% of agriculture gross domestic product (AGDP) and between 7%-9% of the national gross domestic product (GDP). Although livestock plays a crucial role in the lives of Ugandans, its productivity is limited by feed shortage, especially during the dry seasons. Inadequate feed was identified as one of the major constraints limiting livestock production (Mubiru et al. 2003 and Nakiganda, 2004). This is mainly caused by limited pasture seed supply sources and insufficient quantities to meet farmers' demand. Uganda lacks a commercial seed company with reliable production and/or steady supply of pasture seeds, yet there is high demand of pasture seeds by livestock farmers to improve dairy productivity through producing quality and adequate forage resources.

The Intervention

With support from EAAPP, NaLIRRI started producing pasture grass and legume seeds (Table 3) from 2010 to 2015.

Table 3: Forage Seed Production by Nakyesasa 2010 – 2015

Type	Species	Selling Unit	Quantity produced	Value of seed (UGX '000')	Estimated area planted (acres)
Legume	Lablab	Kg	6,800	136,000	1,133
Legume	Clitoria ternatea	Kg	450	6,750	225
Legume	Brachiaria splits	Sacks	10,000	200,000	1,000
Grass	Chloris gayana	Kg	4,400	88,000	440
Grass	Stunt disease tolerant Napier	Sacks	6,500	130,000	650
Total				**700,750**	**3,448**
One sack of Napier grass cuttings contains 350 cuttings					



Fig. 19A: Lablab seed; B. Chloris gayana seed; C. Centrosema seed

To facilitate the adoption of developed technologies, several dissemination approaches were employed. These included on farm demonstration trials, demonstrations and field visits to Nakyesasa and ZARDIs, Agricultural Shows and field days, farmer trainings, newspapers articles, TV documentaries, brochures, leaflets, posters and fact sheets, as well as testing and sale of seeds by and to farmers.

Outcome

This project supported the establishment of 3448 acres of forage fields in different parts of the country. This increased fodder availability in Uganda by approximately 32 million tons of fresh weight providing sufficient feeds to 593 Tropical Livestock Units (TLUs) from 2015 to 2016.

Success Factors

A combination of high technical aptitude to handle seed multiplication, availability of land for the seed multiplication at Nakyesasa and contract farmer groups, access to foundation and breeder seed from within NARO, capacity to do adaptive research and selection of relevant pasture species, as well as supportive management at the Institute and NARO secretariat contributed to the success of this initiative.

Challenges

The key challenges faced during dissemination of the intervention were transporting bulky vegetative planting materials of forages, and long and cumbersome vegetative multiplication of planting materials particularly Brachiaria. Multiplication of vegetative planting materials was accelerated and the transport challenge was addressed, by potting Brachiaria splits.

6.3.3 Selective Breeding improves SEAZ traction capacity, spurs agricultural productivity

Background

Cattle play a key role in livelihoods of Ugandans by providing incomes and protein nutrition at household levels. The use of oxen for traction highly compliments crop production through timely and increased cultivated area. It is known that households that include livestock in their enterprise mix tend to be generally less poor (UBOS, 2007). Indigenous cattle breeds comprise of the Ankole, SEAZ and Nganda. The SEAZ, however, is of small size and low in traction ability.

The Intervention

A crossbreeding programme was conducted at Serere station by mating Sahiwal bulls to Zebu cows to develop improved breeds of cattle with improved traction capacity. The improved Sahiwal crossbred cattle produced had heavier birth weights of 19.5 kg or 4 kg (26%) heavier than indigenous Zebu, weaning weights of 92.5 kg or 31 kg (50%) heavier at 9 months, 115.3 kg or 25.1 kg (27.8%) heavier at 12 months and with a pre-weaning growth rate of 405 g/day or an increase of 150.6 g/day (59.2%). The crossbred animals were hardy, had higher growth rates, traction capacity and higher body weights than indigenous SEA Zebu. Between 50% -75% Sahiwal x SEAZ improved cattle were produced through this project.

Beneficiaries

Over 1500 farmers were trained on traction technologies from 2005 to 2008. Crossbred Sahiwal animals were distributed in over 15 districts including Pallisa, Soroti, Kumi, Bukedea, Lira, Gulu, Apach, Dokolo. Dokolo, Katakwi, Amuria, Mbale, Sironko, Tororo, Iganga and Kaberamaido. Performance testing was done with farmers alongside sensitization, training and dissemination of information materials through national and local shows.

Success Factors

An increase in crop-livestock synergies was realized through traction and manure supporting crop production as well as increased crop residues contributing to livestock feed. Concurrent performance testing and selection by the farmers themselves, high levels of farmer sensitization and intensive training plus extensive dissemination of information packages contributed to project success.

Challenge

Lack of breeding bulls to maintain the 50-75% Sahiwal population genotype profile was a major challenge. Artificial Insemination (AI) was used but had limitations due to lack of service providers and high expenses involved. The intervention was implemented in collaboration with regional partners and the NARS such as National Animal Genetic Resource Centre & Databank (NAGRC&DB) and NAADS.

Outcome

The technology enhanced crop production through trained Sahiwal crossbred animals used for ox-cultivation with over 50% more land opened compared to the indigenous small SEAZ oxen. Besides more cultivated area, this intervention resulted in a higher yield of meat and milk and producer household incomes.

6.3.4 Crossbreeding of the SEAZ cattle with Boran for increased meat productivity

Background

Annual meat consumption in Uganda is low estimated at 5.6kg compared to 50kg recommended by FAO and WHO. The food and nutrition security situation is a challenge with average caloric intake per person per day slightly improved from 1,494 in 1992 to 1,971 in 2005 (MAAIF, 2010). According to 1994 figures, there was a meat consumption gap of 800,000 tons with the annual rate of increase projected at 7.4% for beef and goat meat, 3.32% for pork and 4.87% for chicken.

The intervention

A crossbreeding programme was conducted at Serere to develop improved breeds of cattle with increased meat productivity. These improved animals would be availed to farmers for increased meat production and promote better management of livestock under farmers' conditions. Both F1 (50% Boran: 50% Zebu) and F2 (75% Boran: 5% Zebu) crossbred animals were produced with average percentage increase of 75% in body weight compared with pure local Small East African Zebu (SEAZ) of similar age. There was an increase in birth weight from 15.5 to 22.0 kg, an increase of over 6.5 kg or 42% and over 16% (10 kg)

increase in 9 months. Weaning weight increased from 61.5 to 71.5 kg with a pre-weaning gain of 8.5% (21.7 g/day) from 254.5 g/day to 405 g/day and 18.6% (17 kg) increase in 12 month live weight from 90.2 to 117 kg for F1 Boran crossbred animals.

Beneficiaries

Close to 100 Boran F1 crossbred bulls were produced, evaluated and supplied to farmers for breeding for meat production. Further, aided by NGOS, NAADS and individual farmers, improved animals for meat production were availed to the farming communities especially in semi-arid north-eastern region districts. Beneficiaries realized greater income through sales of more meat and live animals on top of improved protein intake by the rural communities from increased meat and milk yield. Farmer trainings were conducted to further optimize the reach and impact of this intervention.

Success Factors

Farmers training and on-farm participatory evaluation including both knowledge and skills development on better management practices led to increased meat productivity and income.

Challenges

The major challenge faced was the shortage of breeding bulls to maintain the 50-75% Boran blood level. AI was recommended as a useful intervention in collaboration with regional partners and the NARS such as NAGRC&DB and NAADS to provide semen and AI support facilities.

6.3.5 Indigenous chicken breeds improved through cross breeding: The SAARI Crossbred chickens

Background

The SAARI Crossbred chicken derives its name from SAARI (Serere Agricultural and Animal Production Research Institute) which is now NaSARRI (National Semi Arid Resources Research Institute) located at Serere (Igola), where the breeding took place. Prior to the SAARI Crossbred chicken, earlier crossbreeding programmes using Arbor Acres and Hybro exotic meat breeds were conducted and evaluated. It was found that the F1 of these meat breeds were poor in egg production yet farmers needed an improved chicken with both high egg and meat production.

The intervention

The SAARI Crossbred Chicken breed was developed from a special crossbreeding programme using imported exotic Bovans Brown cocks and selected indigenous chickens. Bovans Brown was identified, tested and found suitable for crossbreeding to increase both meat and egg production. At 3.0-4.0 kg live weight, the SAARI Crossbred improved chicken weight doubled indigenous chicken live weight of 1.5-2.0 kg at 20 weeks. Additionally, it doubled egg weight and number of eggs produced from 25-30 gm to 45-60 gm and 10-12 to 20-35 respectively.

Beneficiaries

The SAARI crossbred cocks were supplied to over 10,000 farmers in Moyo, Lira, Apac, Soroti, Mukono, Busia, Tororo, Mbale, Sironko, Arua and Adjumani through NAADS, AT Uganda, Action Aid, NaBZARDI and agricultural shows. Performance testing involved selection for higher growth rates, higher adult weights, higher egg yield and good adaptation. It was established that while selection targeted meat and egg yield, farmers favoured and adopted the breed especially for its camouflaging colour pattern of feathers, retention of broodiness, scavenging and good mothering ability of the hens.

Success Factors

Training of farmers, on-farm farmer participatory performance testing and evaluation was conducted alongside shows and dissemination materials as additional technology dissemination approaches.

Outcome

Adoption of the technology resulted into increases of 150% in egg consumption, I69.7% in meat consumption and 79.3% in incomes for local free ranging chicken farmers in districts where cocks were supplied. Technology adoption was facilitated by the quality traits of the SAARI chicken such as high egg and meat productivity, ability to brood and scavenge for its own food, highly adaptive capabilities that allowed easy blending with the environment, palatable meat and yellow yolked eggs, high marketability as well as cooperation of farmers associations created by small groups of farmers.

Challenge

Sustaining production of the 75% Bovans breed level and controlling diseases especially New Castle disease was a key constraint. Attempts to form farmer groups in various districts were not followed up to form effective long lasting associations for sustainability and continuity of the breeding and production of the SAAARI Crossbred chickens.

6.3.6 Breeding enhances indigenous goats for meat productivity

Background

Goats are valuable for income, meat and poverty alleviation and relate well with Government's programme of transforming subsistence agriculture into commercial agriculture (NDP, 2010). Goat population in Uganda increased rapidly to about 12,449,656 of which 98.7% were indigenous breeds comprising Mubende (14.5%), Small East African

(83.3%) and Kigezi (2.2%) goat breeds with only 1.3% being exotic and crossbred (UBOS, 2008). The indigenous goats are generally kept for meat and are well adapted to the local conditions but genetically poor for meat production compared to the Boer goats. The major objective of the goat improvement programme was to develop improved goat breeds for meat and avail them to farmers for increased meat production.

The intervention

Improved Boer crossbred goats for meat had superior meat production capacity where F1 Boer crossbred had an increase in birth weight from 1.5 to 2.0 kg, an increase in 4 month weaning weight from 7.0 to 9.5 kg, an increase in pre-weaning gain from 47.0 g/day to 66.0 g/day and increase in 12 month weight from 12.0 to 18.0 kg.To test the applicability of this technology, on-station performance evaluation was conducted alongside on-farm farmer sensitization, training and farmer participatory performance evaluation under on-farm production environment.

Beneficiaries

These crossbred goats were availed to farmers in over 10 districts including Arua, Gulu, Apach, Lira, Dokolo, Soroti, Kumi, Bukedea, Amuria, Katakwi, Mbale, Sironko, Pallisa, Tororo, Iganga. Distribution was done to individual farmers in partnership with NAADS, NGOs, CBOs and Local Government. These partners also assisted in sensitizing the farming communities on multipurpose value of F1 Boer crossbreeds. The crossbreeding programme made significant achievements. 50-75% Boer crossbred goats with higher growth rates and body weights at birth, weaning (4 months) and adult (12 moths) ages were produced and availed to farmers. Bucks of the 75% were on high demand and supplied mainly for breeding and improvement of village flocks.

Outcome

The introduction of the Boer crossbred goats improved income, meat yield and protein intake as well as overall livelihood and nutritional status of especially rural farm communities. Partnership with NAADS enabled creation of goat breeders and producers associations and accelerated the adoption of better breeding, feeding and health management practices.

Challenge

The principal setback in the implementation of the project was the lack of pure breeding bucks to maintain the 50-75% Boer blood level. To counter this challenge, collaborations with regional partners and the NARS such as NAGRC&DB and NAADS is highly recommended.

6.3.6 Fodder conservation technologies support year round livestock forage availability

Background

Poor nutrition status of cattle is considered the most challenging constraint to smallholder dairy farms in Uganda (Kabirizi, 2006). Most of the smallholder dairy farmers are challenged by acute shortage and extreme fluctuations of feed resources. These shortages and fluctuations are often translated into inefficiencies in nutrient supply to livestock. During rainy seasons, pastures and water are in plenty. However when the dry season sets in, pastures and water become scarce, milk yield reduces by approximately 50% and farmers especially in the cattle corridor lose their animals. In 2014, because of the drought, farmers in Mityana lost 40% of their herds.

The intervention

NaLIRRI has been producing hay and silage to fill the gap of feed shortage during dry periods as well as for urban and peri urban farmers who keep dairy cattle on small pieces of land. NaLIRRI has trained several youths and farmers on techniques of making hay, haylage and silage.

Fig. 20 A. Staking Hay bales in store; B.Silage tubes packaged for transportation



Table 4. Relative annual revenue from conserved fodder usage on 50 farms in Uganda

Feed type	Annual Production (tons/year)	Number of animals fed	Milk yield (litres)	Revenue from sale of milk
Hay (tons)	600	350	630,000	945,000,000
Silage (tons)	5000	500	900,000	1,350,000,000
Total	5600	850	1,530,000	2,295,000,000

Success Factors

These technologies were popularized through on farm demonstration trials, demonstrations and field visits at Nakyesasa and ZARDIs, agricultural shows and field days. Other dissemination platforms included farmers' trainings, newspaper articles and TV documentaries, as well as brochures, leaflets, posters and fact sheets. The project also distributed high quality forage seed/ planting material to farmers for who also trained in forage conservation and further promoted the technologies by sale of the conserved feeds to fellow farmers.Farmers' cooperation, availability of land for the for forage production at Nakyesasa, availability of farm machinery which processes forages efficiently and most importantly technical competences by NARO staff in fodder conservation were key success factors in the implementation of this project.

Challenge

Overwhelming demand of hay and silage is a challenge and opportunity. This has been addressed by opening up more gardens of *Chloris gayana* and maize.

Beneficiaries

Through this initiative, 850 cows of small and medium scale farmers in central and southwestern Uganda were sustained during six months of dry period. This resulted into improvement in dry season milk production by 1,530,000 litres and an equivalent of UGX 2,295,000,000 in revenue was saved for the six months period.



Chapter 7
NATIONAL AGRICULTURAL RESEARCH LABORATORIES (NARL)

7.1 Background

In 1934, Mr K. Bruno, a Danish farmer sold his 630 hectare rubber estate located in Kawanda to the Government of Uganda. In 1937, the Department of agriculture developed the 630 hectare land into the headquarters of its research division with a mandate to conduct research on coffee, tea, cotton and native crops. The then Kawanda Research Station located 13 km north of Kampala city became the hub of scientific research in order to make agriculture more productive and economically viable.

7.2 Institutional changes and their impact on delivery of the mandate

Over the years, the research station has undergone several transformations both in name and mandate. Currently, NARL is one of the 16 Public Agricultural Research Institutes (PARIs) established under the National Agricultural Research Organisation (NARO) by the NAR act 2005.

NARL is mandated to provide research and development services under five delivery program namely; food biosciences and agribusiness, bio-systems and agricultural engineering, soils, environment and agro-meteorology, banana and lastly biodiversity and biotechnology.

NARL's core values are excellence, client and results oriented, integrity, teamwork and environmental and social consciousness. NARL has an information and documentation hub which is supported by an administration unit. The institute has four national laboratories specialized for plant science, food science, soil science and agricultural engineering. It is manned by 101 core staff.

7.3 Top successful interventions as identified by NARL

1. Banana bacterial wilt effectively prevented from decimating Uganda's banana industry
2. Development and promotion of Highland banana (Matooke) hybrids in Uganda
3. Promotion of the sustainable land management (SLM) systems to prolong land productivity in Uganda (Fanya juu/ fanya chini)
4. Introduction of the Fertilizer Optimizer Tool for soil fertility management
5. Development of a lightweight rice sheller to empower women farmers and processors
6. Development of a Water Treadle pump

7.3.1 Banana Bacterial Wilt effectively prevented from decimating Uganda's banana industry

Background

When Banana Xanthomonas Wilt (BXW) was first reported in Uganda in 2001, it was predicted that the disease would destroy 90%, of Uganda's bananas, worth over US$4 billion, in 10 years if not controlled. It would destroy an industry on which half the population of the country depends.

The intervention

BXW control was centered on blocking the bacteria from getting transmitted to uninfected plants. The first option was the suspension of use of tools in the plantation for at least 3 months except when removing diseased plants or harvesting. Tools used for removing diseased plants were sterilised by a flame or JIK. This effectively limited disease spread from plant to plant through cutting tools. Secondly, early removal of male buds, using a forked stick, blocked insect-mediated spread of BXW. The control package was a culmination of epidemiological studies spearheaded by the NARO's banana research team. It was demonstrated that the incubation period within the banana plant is at least three months (the period within which symptoms appear after infection). Studies showed that the bacteria was persistent on cutting tools for more than 20days, justifying the need for their sterilisation. Other studies identified stingless bees as the agents of disease spread from male buds and that early removal of the male buds restricted vectored BXW spread.

The technologies were promoted using the top-down and community based participatory approaches. The top-down approaches involved use of posters, mass media and training of trainers. These approaches were instrumental in swiftly creating awareness of stakeholders about the disease countrywide but ineffective in triggering actions for control. Community based participatory approaches involved dialogue with communities about the problem (BXW); formulating and implementing an action plan to control the disease at community level; support of the community control efforts with sub-county bye-laws and extension staff backstopping, plus sharing lessons across communities.

Outcome

By 2008, BXW had been effectively controlled on 63.5% of the previously affected fields, with a corresponding banana production recovery of 41% across the major banana growing areas of western, Central and Eastern Uganda. By November, 2015, BXW infection, after resurgence, had been controlled in most banana growing areas of Uganda. Monthly banana sales in

previously affected areas had recovered to 64%, worth annual income of UGX 333.6 billion. The Minister of Finance and HE the President of Uganda highlighted this success in the 2016 budget speech and Farmers' day in Bushenyi (November, 2016), where they declared that BXW incidence had been reduced to below 5% across Uganda. The approach used in the control of BXW in Uganda has been published and adopted by FAO for use in other major banana growing areas in six countries of East and Central Africa (BXW Regional Meeting ,Kigali, October, 2014).

Success Factors

Key factors for success included the multi-disciplinary BXW control task forces that formulated and jointly implemented national BXW control strategies both before and after BXW resurgence. Political support by Local and Central Governments, including H.E. the President of Uganda was critical.

Fig. 26 About Banana Bacterial Wilt (BXW)

Banana Bacterial Wilt (BBW) is a disease that attacks all types of bananas (Matooke and non-matooke bananas). The disease is caused by a bacterium (Xanthomonas campestris pv. Musacearum) and is a threat to banana production in the Eastern African region.

In Uganda, it was first reported in Mukono district in August 2001 and since then, it has spread to all banana-growing areas in the country.

Symptoms

The plant wilts starting with flowers or leaves.

Fruits of diseased plants ripen pre-maturely and appear discoloured when cut open. Male buds shrivel, blacken and dry.



Discolouration of fingers when cut open distinguishes the disease from all other diseases and other disorders of bananas known to exist in Uganda.



Transmission and Control

Once an area is attacked, the disease spreads quickly, from one plant to another, mat to mat within a plantation, farm to farm within a village and village to village, if not controlled in time.

Two main modes of BBW transmission:

① Mechanical spread by wounding agents / tools such as pangas, hoes, pruning knives and any other agent (living or non-living) that injures the plant when contaminated.

Control: remove the source of infection (uproot all infected plants early and disinfect tools with JIK as you use them from plant to plant). Cows and goats should not be allowed to pass through banana plantations, as these mechanically spread the disease from infected plants to healthy plants (through feeding on the plants).

Note: Infected plants take some time before expressing the disease symptoms (latent infection). With such plants present in the plantations, farmers unknowingly spread the disease through pruning, corm removal, desuckering, ploughing and harvesting of leaves either used in food preparation or sold to the market.

Control: Suspend pruning, corm removal, ploughing and leaf harvesting and resume these activities only after the disease has been cleared (3-6 months after the last diseased plant). Use tools only when removing infected plants or harvesting. Even during harvesting, take care not to infect other plants (clean the tool every after a plant harvested).

② Transmission by insects that visit banana male buds to feed on sap oozing out when the banana flowers fall off.

As the insects feed from plant to plant, they mechanically bring in bacteria that enter the banana plant through the wounds left when flowers fall off.



Control: Stamp out the diseased plants as quickly as possible before it can spread to other banana plants. Break off male buds from flowered banana plants as soon as the bunch emerges fully to stop insect transmission.

Use a forked stick (NOT a cutting tool) to avoid transmission by tools (pruning knife).



7.3.2 Development and promotion of Highland banana (matooke) hybrids in Uganda

Background

Bananas, locally known as matooke is a major food crop for 58% of Uganda's population. This calls for alternative measures to increase production rates by either increasing area under production or application of fertilizers among other interventions. The crop however faces major challenges including high susceptibility to banana bacterial wilt and nematodes of land races, high incidence of black sigatoka and banana streak virus, local breeds of banana not tolerant to prolonged drought, as well as poor yields and short plantation life span.

The intervention

From 1991 diagnostic surveys were undertaken to identify and estimate the extent of the challenges, yield losses, as well as studies in taxonomy characterization including female fertility. Evaluation trials with focus on response to black sigatoka, yield, food acceptability, and preliminary yield evaluation addressing capacity of a given variety were also undertaken. 2005 marked the year of release of the first ever banana hybrids (M9 and M2) in Uganda. Some of the characteristics of these hybrid bananas include resistance to black sigatoka, tolerance to nematodes and weevils, tolerance to prolonged dry spells with highly acceptable food given its good taste as confirmed by the testing panel. Although released in 2005, the official year when the varieties were recommended for uptake was 2010.

Success Factors

These milestones have been realised in partnership with various partners including IITA, Rockefeller, Makerere University, Bioversity International, AGRA, USAID, World Vision, NAADS, and the local government. Their responsibilities and roles both in development and dissemination ranged from capacity building, availing

germplasm, funding, dissemination and distribution, to coordination, mobilizing farmers and technical back-stopping. The distinct characteristics and ability to tolerance prolonged dry spells resulted in farmers preferring to call M9 hybrid commonly known as *Kiwanganzi* literally meaning - *long lasting.*

Alternative packaging formats and channels were employed to reach the various target groups during the seven year promotion and dissemination campaign. These were in form of posters, leaflets, training guides and production manuals, tradeshows, print media, revolving sucker technique, demonstrations and exhibitions. The campaign covered the whole country with emphasis on Nakaseke, Kyenjojo, Masindi, Amuru, Lira and Gulu districts. High commitment from all stakeholders, and positive attitude of farmers towards the technology played a key role in the success of the intervention.

Challenges

Although the intervention was successful, some challenges were encountered including limited laboratory facilities especially for multiple screening, the long generation cycle which requires a lot of land and time to evaluate, very low germination rate of banana seed.(Bananas are infertile hence low breeding efficiency). Matching multiple attributes for example, taste and smell proved a challenge. Bananas still do not have a well streamlined commercial seed system and farmers have negative attitudes towards hybrids making them difficult to be adopted.

Outcome

Due to this intervention, bananas have been introduced and embraced in northern Uganda, community food security has been restored, increased income rates given the employment opportunities accruing from the technology, M9 hybrid banana has a lot of leaves which act as windbreakers and mulching material hence reducing pressure on swamps and preventing soil erosion in the long run.

7.3.3 Promotion of Sustainable Land Management (SLM) systems to prolong land productivity in Uganda

Background

Land degradation caused by soil erosion, nutrient mining and poor farming practices, is a major problem affecting agricultural production and livelihoods of millions of people in Uganda.

The Intervention

Sustainable land management (SLM) refers to a set of land husbandry practices that are carried out to enhance and maintain long term productivity of land. Such practices include use of soil erosion control measures like use of terraces or contour bunds, popularly known as “Fanya juu/ fanya chini”, use of grass strips, conservation farming, mulching, tree planting, water harvesting and conservation. These practices help to curb soil erosion, improve soil fertility, and increase crop production. They are affordable and improve degraded soils in a relatively short period. NARO in partnership with the Government of Uganda, World Bank, DFID, ASARECA, Makerere University, District Local governments, the National Farmers Federation, Africa Highland Initiative and the ATAAS Sustainable Land Management project among others has been promoting SLM since early 2000s. This initiative has been implemented in conjunction with farmers, extension officers, CBOs and NGOs in almost all districts of Uganda. NARO provides the research capacity and information.

Another key contribution under this intervention is the development of the Uganda Soils Information System (USIS) designed to provide historical and current information about the soils of Uganda as well as other related parameters such as rainfall and temperature that are relevant to agricultural productivity. The development has been supported by GEF funding through NARO’s ATAAS project.

Success Factors

For efficient uptake and dissemination, demonstrations were set up in target areas on farmers’ fields, trainings conducted, and farmer field schools where farmers visited the demos to obtain practical skills and knowledge. Information materials targeting different users such as Publications in journals, Leaflets, brochures, booklets, training manuals and posters were used to enhance learning. Information was also disseminated through multi-stakeholder platforms where trainings were conducted for district officials, agricultural extension staff and farmer groups.

The initiative registered great success because it was highly demanded by farmers, gave quick economic benefits, and generally took a relatively short period for the technology to give results. Availability of expertise, high publicity and sensitization of farmers, high level of commitment by all partners and translation of messages into local languages also facilitated technology dissemination. Furthermore, there was smooth flow of funds to support the activities.

Beneficiaries

Interventions have been made in all agricultural production zones in the country, targeting at least three districts in each zone. The zones include, Abi ZARDI, Buginyanya ZARDI, Bulindi ZARDI, Kachwekano ZARDI, Mbarara ZARDI, Mukono ZARDI, Nabuin ZARDI, Ngetta ZARDI and Rwebitaba ZARDI. At least 10,000 participating farmers have been directly supported and it is estimated that 20% more have adopted the practices, through farmer-farmer, field days, exchange visits, demonstrations, innovation platforms, etc. A further total of 61,618 people in the districts of Mpigi,

Rakai, Masaka, Kalungu, Gomba, Mityana, Mubende, Kalangala, Namayingo, Mbale, Tororo, Tororo, Kabale, Bududa, Bukedea, Bukomansimbi, Bukwo, Kween and Kapchorwa also directly benefited.

Fig. 27 Soil and water conservation activities

SOIL AND WATER CONSERVATION FACTSHEET

Soil and Water Conserving Technologies		
Description of measures		
Agro-forestry trees (Grevillea Gliricidia, Caliandra, Leucaena) • Leaves can be fed to livestock • Branches can be pruned and spread on the ground as mulch • Decomposition of leaves yields manure which improves on soil fertility • Recommended spacing along bunds is 45cm from tree to tree		
Fanya juu / fanya chini terraces • Made by digging a drainage channel and throwing the soil uphill or downhill to make a ridge • Channel is usually 50–60 cm deep and may have cross-ties at 10 m intervals • Grass planted on the ridges helps stabilize the ridges, prevents erosion, and can be used to feed livestock or as mulch		
Grass strips (Napier grass, Makarikari grass) • Planted at a 1 m spacing interval • Slow down run-off down the slope • trap sediment that has been eroded downhill • Cheap and easy to establish and maintain • Provide valuable fodder for livestock		
Stone lines (for reducing soil erosion) • Can be made using loose stones in the field • Are lined up along the contour (with grass/trees planted on either side) • They are small: at most 3 stones wide, and one/two high • Often 25-50 m apart on 2-5 % slopes		

7.3.4 Introduction of the Fertilizer Optimizer Tool for soil fertility management

Background

Optimization of fertilizer use refers primarily to maximizing farmer profit from fertilizer use given that most Uganda farmers are severely limited in their management options by poverty. The dire need to change perception of the populace about the notion that Ugandan soils are fertile, reverse declining soil fertility, solve conflicts between users of inorganic and organic fertilizers, revise the agro-chemical policy to get a fertilizer policy and increase crop yield and farmers' income, are some of the reasons behind development of the fertilizer optimizer tool.

The Intervention

In 2012, NARO, Makerere University and the University of Nebraska, USA introduced the Fertilizer Optimizer Tool. This tool has the ability to give Economically Optimum Fertilizer Rates and the best crop–nutrient rate combination, estimate average effects on yield and net returns. The Alliance for a Green Revolution in Africa [AGRA]) greatly contributed to this initiative by funding the core research.

The technology dissemination process comprised of training extension staff, NAADS Agricultural Advisory Services Providers (AASP)-crops, Agro Input dealers, farmers and other stakeholders, exchange visits, and awareness creation workshops. To further enhance learning, information sharing materials including training manuals, demonstrations, Posters, Brochures and Leaflets were used alongside the physical technology. The technology has been embraced in East, southern and western Africa including countries like Kenya, Tanzania, Ethiopia, Rwanda, Mozambique, Malawi, Zambia, Ghana, Mali, Niger, Burkina Faso and Nigeria.

Success Factors

In Uganda the dissemination was made possible by partnerships, strategic collaboration and networks including CABI which designed information materials and NAADs which mobilized farmers, Agricultural Advisory Services Providers (AASP) – crops, Agro-Input dealers and extension staff. Other factors which contributed to the successful development of the Fertilizer Optimizer Tool included availability of funding, expert human resource Successful dissemination due mainly to the uniqueness of the intervention and demand from farmers.

Beneficiaries

Over 100 extension agents including Agro-Input dealers were trained on how to use the FOT to give Economically Optimum Fertilizer Recommendations (EOR) to farmers.

Outcome

Farmers normally derive maximum profit from using the EOR. Furthermore the EOR are less than the existing recommendations. For instance, for a farmer growing banana, the current recommendation is 217 kg urea per ha compared to the EOR which is 87 kg urea per ha, implying that a farmer saves 130 kg urea per ha which is equivalent to UgX 325,000 per ha. This applies to other crops and other nutrients and minerals.

7.3.5 NARL develops a NARO lightweight Rice Sheller to empower women farmers and processors

Background

Huge post-harvest grain losses, aflatoxin contamination of rice, lack of appropriate rice threshers in communities, long duration of heaping rice without threshing and the urgent need to relieve women from drudgery led to development of this technology.

The Intervention

NARO lightweight Rice Sheller was developed through the engineering arm based at Namalere. The designs were made in 2013, the prototypes were produced and tested in Lira (Itek-okile rice irrigation scheme) and Butaleja (Doho rice irrigation scheme). Successful testing led to more ergonomic and economic evaluation for the machine and later its release for use by farmers in 2014.

The NARO lightweight Rice Sheller draws its name from its attributes. According to Eng. Candia Alphonse, the thresher is very light (138kg) compared to similar previous threshers (300 -1,000kgs), mobility is easy and gender sensitive because it is user-friendly for women and youth. Global Affairs Canada (GAC) funded the development of the thresher through Africarice.

Beneficiaries

Primary target beneficiaries were smallholder farmers, entrepreneurs among the farming communities and private fabricators. The target areas are but not limited to major rice growing areas like Lira, Butaleja, and Amuru districts. Currently, the machine has directly benefited over five hundred (500) farmers.

Success Factors

The success factors for development of the machine included having competent scientists and technicians, availability of the basic raw materials for machinery fabrication, expressed need from farmers, and financial support from development partners.

The Local governments of Lira and Butaleja districts, Lira Rice Promoters Association, and International Fertilizer Development Cente (IFDC) also contributed by mobilizing farmers during the evaluation process and promoting the thresher. NARO on the other hand designed, fabricated, carried out the evaluation process and spearheaded the dissemination activities. Dissemination of the machine was aided by packaging materials such as operation manuals, leaflets, and working drawings for private sector fabricators. In addition to the above, on station study tours by farmers, show casing during agricultural trade shows and training private fabricators close to target areas have been and are being conducted.

Outcome

Having this machine in place has not only led to creation of employment and increased income to communities but has also reduced grain loss from 4.78% to 0.1% translating to more income and food. In the event that the thresher will be used by all rice farmers, the country will be able to save USD 5.92 million (17,760 tons of paddy) annually. Those farmers who hire their threshers out to others at a fee earn additional USD 540 – 1,505 (1.890 - 5.267 million shillings) per year. Similarly the youth that they employ earn additional USD 170 – 200 (595,000 – 700,000) per month. It was observed that rightful dissemination approach contributed to sustained adoption.

Fig. 28 The NARO lightweight rice thresher



Moving back home after a days work

Maintenance

The thresher needs the following maintenance:

1) Check and tighten all loose bolts and nuts before every operation.
2) Clean inside the threshing unit after every work.
3) Lubricate the bearing using grease after every fourteen days.
4) Check belt tension and condition before every operation.
5) Replace the belt whenever it is worn.
6) Service the engine according to the manufacturer's operating guide.
7) The service and repair should be done by trained and experienced person.

Safety precautions

The working parts of the machine (threshing pegs and belts) operate at very high speeds and if wrongly operated could be dangerous to the operator. While operating the thresher one must therefore ensure that:

1) All bolts are properly tightened prior to operation.
2) The belt guards are on and properly secured.
3) No metal and other hard materials enter the rotating parts.
4) Nobody pushes his/her hand into the rotating parts.

Environmental and gender aspects

This machine has no negative environmental effects. The sound produced by the machine is within the recommended level. Always ensure that the thresher is operated on firm ground. This will avoid slippage, minimise vibration and reduce possibilities of loosening the soil. Thethresher can comfortably be operated by men, women and youth.

For more information and inquires contact

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NARO Lightweight Rice Thresher



NARO

Agricultural Engineering and Appropriate Technology Research Centre (AEATREC)

Introduction

Most of Ugandan farmers still thresh rice by beating using sticks. Although cheap, this practice is labour intensive, time consuming, leaves a lot of rice grains on the straws and scatters grains leading to high physical losses of up to 4.8%. In cases where labour is scarce, un-threshed rice grain is left heaped for two to three days which results into rotting thus leading to serious deterioration in quality. AEATREC has developed a gender responsive rice thresher to solve these problems for Ugandan rice farmers.

Attributes and benefits of the thresher

The thresher:

- Weighs only 138 – 145kg depending on the size of the engine.
- Easily hand pushed by women and youth to rice gardens.
- Easily towed to rice gardens through village roads using bicycles
- Women and youth comfortably operate the thresher.
- Requires only three persons for effective operation
- Has threshing efficiency of 99.9%
- Threshing output for all gender category is 650 – 800 kg for a liter of fuel.
- Saves labour and time especially for women and youth.
- Does not damage and break grains during threshing.
- Significantly reduces rice grain losses during threshing from 4.8% to 0.1%
- Economic gain during threshing is UGX 450,000/ha.



Women demonstrating the use of a motorised rice thresher



Three weman handling the operation of threshing

Description

NARO lightweight rice thresher is driven by a 5.5hp petrol engine. It consists of a threshing drum, fixed sieve, feeding tray, clean grain outlet, spent straw outlet, engine, all mounted on a main frame fitted with two wheels to improve transportation. The pulley and belt system is used to transfer drive motion from the engine to various parts of the thresher. The thresher is very compact and much of the weight rests on tyres making it easy to transport just by hand pushing or pulling to rice gardens.

Operation of the thresher

- Place the machine on firm and levelled ground.
- Set the engine choke on and rotate the cranking handle rapidly to start the engine.
- Adjust the accelerator lever to run position to increase the speed of the threshing drum until a small whistling sound indicating optimum threshing speed.
- Pile rice in straw on the feed tray
- Continuously pick a handful of the piled rice in straw from the tray and insert it into the threshing unit.

The thresher will automatically pull and thresh the rice and discharges clean grain and spent straws through different outlets.

7.3.6 Drought mitigation using the Treadle water pump

The Intervention

The AEATREC Treadle water pump was first introduced to communities in 2006. This initiative was spearheaded by NARO while responding to difficulty in accessing water by small scale vegetable growers and farmers in the dry cattle corridor. With a sample sourced from Food and Agriculture Organisation (FAO), evaluations were conducted; modifications were carried out and customized to fit the local environment and farmers. Several testing rounds were undertaken both on station and on farm leading to re-evaluation and producing the technology.

The pump has several unique features tailored to serve the intended purpose. Although it is manual, it requires minimum maintenance and it is made from locally available materials (scrap materials of vehicles). Beneficiaries

The technology registered success in Kiruhura and Mbarara districts where over 200 farmers benefited. Soroti, Busoga, Burundi and South Sudan equally benefited from this initiative.

Success Factors

In an effort to make sure that the treadle water pump was fully optimized, user manuals, posters, repair and maintenance manuals were developed. In addition, physical demonstrations on how the pump works have been and continue to be exhibited at various avenues such as agricultural shows. Private fabricators, farmers and local government saw this come in motion by taking on different roles and responsibilities including sustaining the production of pumps, providing fields for testing and promotion as well as mobilizing practicing farmers. NARO basically took on the training of farmers, funding, provided facilities where fabrications were produced and lastly coordinated stakeholders as noted by Eng. Mutumba Charles.

Dissemination of the intervention was made possible by Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), VECO East Africa, Norwegian people's aid, World vision, who have manned the dissemination beyond Uganda (Burundi and South Sudan). While partners immensely contributed to its distribution, factors responsible for successful development and dissemination include skilled personnel, availability of funding, demand from farmers, support from local government, affordability of the technology, outstanding performance of pumps and the fact that the technology was unique and user friendly.

Outcome

Introduction of the treadle water pump enabled farmers to started realizing increased income, acquired assets, reduced cattle losses during the dry spell, improved health as incidences of water bone diseases reduced, conflicts with other communities reduced as nomadic ways of farmers reduced, soil degradation around water holes reduced, cases of swamp degradation also lowered.

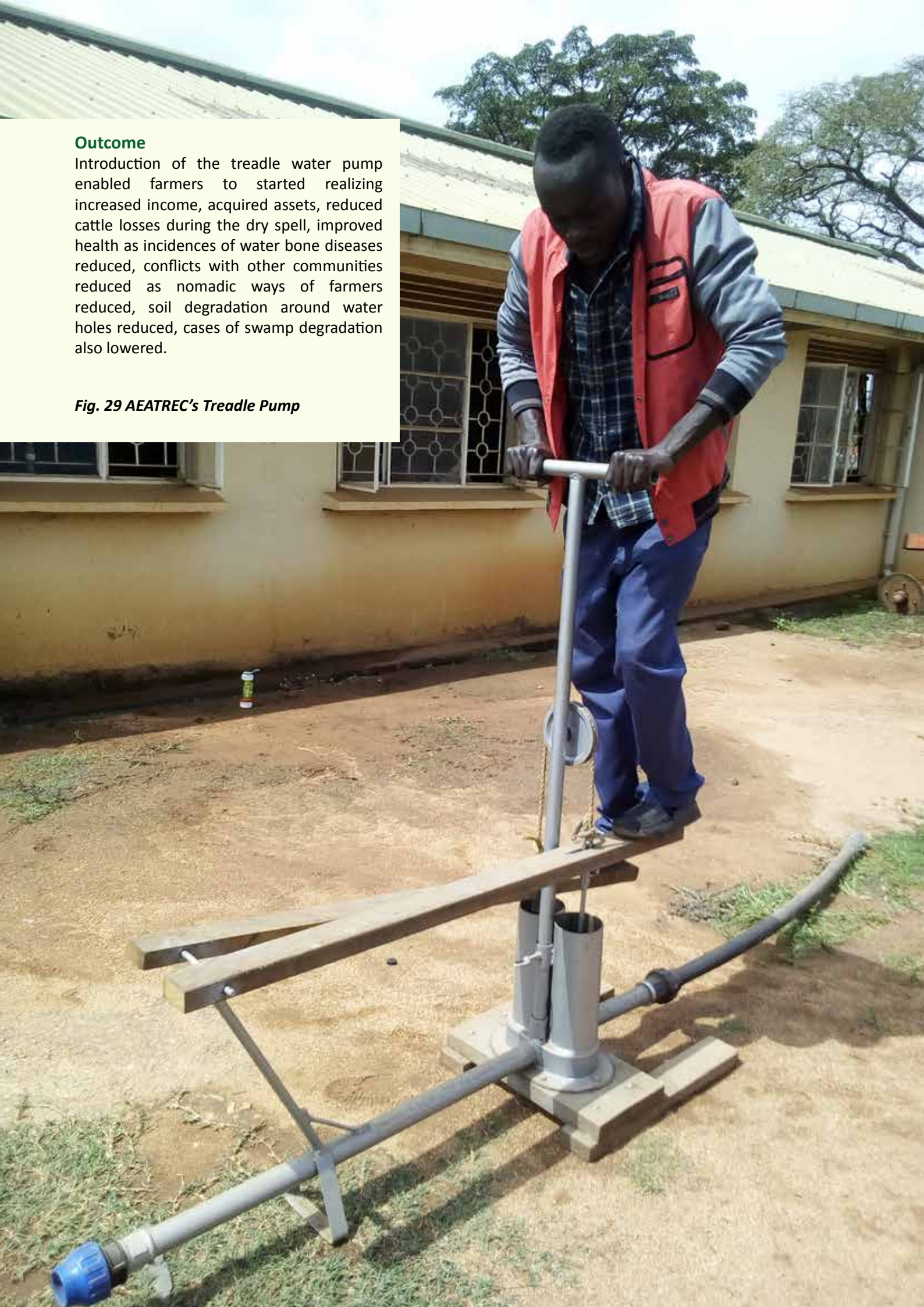


Fig. 29 AEATREC's Treadle Pump

Chapter 8
NATIONAL SEMI-ARID RESOURCES RESEARCH INSTITUTE (NASARRI)

8.1 Background

Located in the Eastern Agro-ecological zone in Serere District 21 km south of Soroti town, the National Semi-Arid Resources Research Institute (NaSARRI) is one of the 16 Public Agricultural Research Institutes (PARIs) of the National Agricultural Research Organisation (NARO) established by the National Agricultural Research Act 2005. NaSARRI was established in 1920 as an experimental station for ox-cultivation technologies that were to support cotton production in the Teso region; the station was also to serve as a training base for the then Department of Agriculture staff. NaSARRI pioneered research on cotton, livestock and other animal traction technologies with emphasis on quality output under the supervision of the then Ministry of Agriculture. In 1992, NaSARRI was renamed Serere Agricultural and Animal Production Research Institute (SAARI). In 2005, SAARI was renamed NaSARRI with the mandate to undertake research in crops production for semi-arid production systems in the areas of seed research and production management, together with range management.

NaSARRI's operational area covers five (5) agro ecological zones comprising of the Eastern Savannah, Karamoja Dry lands, Mid-Northern, Northern and West Nile.

The goal is to generate and disseminate appropriate technologies and information for sustainable agricultural production, economic growth, and poverty eradication for semi-arid ecological zones.

NaSARRI conducts research work on cotton, sorghum, finger millet, groundnuts, sunflower, simsim, pigeon peas, cowpeas, green grams, pearl millet and socio-economics related issues.

8.2 Institutional changes and their impact on delivery of the mandate

The change from SAARI to NaSARRI caused a change in mandate and research commodities. Originally, research activities were conducted on almost all commodities (cotton, sorghum, livestock, simsim, cassava, sunflower) and laboratory activities. However, NaSARRI has now specialized in research on cotton, millet (pearl and finger), sorghum and animal traction suitable for semi-arid lands. This change also expanded the target geographical area from Teso region to all semi-arid and arid areas of Uganda.

8.3 Top successful interventions as identified by NaSARRI

1. Development and adoption of resilient groundnut varieties with improved nutritional and income – generating attributes.
2. NaSARRI commercialized the originally 'poor' man's crop", sorghum.
3. The SAARI-Saimmco Weeder saves the local farmer time and money in Eastern Uganda.

8.3.1 Development and adoption of resilient groundnut varieties with improved nutritional and income –generating attributes.

Background

Grown on approximately 25 % of all the arable land in Uganda as cash crop and food crop, groundnut is a staple legume consumed by over 10 million people in Uganda. The crop is rich in protein, oil and essential minerals like Vitamin and calcium. It is also a substitute for costly animal protein. For example, groundnut has the same energy value as cheese, and thrives well in semi–arid conditions. It is a documented legume in nitrogen fixation for soil fertility improvement. Despite these attributes, the crop was threatened by diseases and pests.

The intervention

In partnership with other stakeholders (each partner with a unique role) NaSARRI, realized increased production of groundnut varieties which are resistant to pests, diseases and bad weather. The technology was developed through a participatory problem identification process which included: assembly of materials to be used; crossing them up (hybridization); selection; multi-locational trials in major growing areas and exposing them to farmers; presenting the superior adapted ones to MAAIF for Distinctness, Uniformity, Stability (DUS) test; release and adoption. The development and adoption of resilient groundnut varieties was associated with improved nutritional and income –generating attributes.

Success Factors

The new ground nuts varieties have multiple unique features including quick maturation (within 75 to 110 days), resistance to groundnut rosette virus, leaf spots diseases and leaf miner pest. The varieties produce high yields and oil, are drought tolerant and are characterized by ease of harvesting and shelling. To ensure wide publicity of the technology, packaging was in form of bags supplied by ISSD, video clips were

aired on both local and international television stations such as NTV, UBC, and Voice of America. In addition, print media, social media, information materials, animations, trainings, field days, demonstrations, agricultural shows were used.

The Success is also attributed to a number of factors including expertise of the technical teams, availability of funding, strategic networks and linkages with key stakeholders, collaborative research and superiority of the technologies.

Beneficiaries

As a result of the above efforts, 14 recommended commercial groundnut varieties were released between 1998 and 2011. These varieties are estimated to be grown by at least 60.% of the groundnut growing farmers in Uganda. Over 100 breeding lines have also been released and NARO has built capacity of breeders in neighboring countries including South Sudan as well as improving groundnut varieties from other countries like Zambia, South Sudan, and USA.

Outcome

The technology has so far reaped dividends, with the technology going global and more than 14 commercially viable groundnuts varieties have been released since 1998. Other added advantages are value addition, enhanced income generation and the emergence of cottage industries (peanut butter, oil, confectionaries).

8.3.2 NaSARRI commercialises sorghum, originally "the poor man's crop"

Background

Sorghum is Uganda's third most important staple cereal crop after maize and millet. Despite its key contribution to the livelihoods of farming communities in northern, eastern and western Uganda, several constraints had made it difficult for such communities to gain the maximum potential benefits from the crop. For example, the average sorghum yield at farm level was only 800kg per hectare compared to 4,000kg. ha^{-1} at the research institute. The low production and productivity were attributed to use of low yielding indigenous cultivars (Kabir and Ededei) which have long maturity periods and are susceptible to pests, diseases and weeds (striga). Consequently, its cultivation was increasingly being neglected as it was considered a poor man's crop with limited uses (for local brews and food only).

The intervention

Against the above background, the NaSARRI Plant Breeding Department in collaboration with multiple partners developed a sorghum breeding research programme that developed Epuripur varieties in 2001 and Seso 1, 2, 3 to address the challenges of low yield and susceptibility to pests and diseases.

Success Factors

A number of approaches such as conventional breeding, marker-assisted selection, farmer participatory varietal selection, enhanced seed systems, value addition, public private sector partnerships and innovation platforms with stakeholders (producers, seed companies & processors) were engaged to ensure generation of best varieties, dissemination and value addition. The success of this intervention is also attributed to the use of sorghum value chain approach targeting gender and various end users (producers, seed companies and processors).

Beneficiaries

According to statistics from Nile Breweries Limited, a leading beer company in Uganda specialized in the manufacture of Senator and Eagle lager beer, using the new sorghum varieties, direct income to farmers from this initiative has increased due to improved quality & productivity of sorghum commanding higher prices over the years (from only 300/= per kg in 2002 to 1,100=/ per kg in 2012), causing an increase in total incomes to farmers from only UGX 180 million in 2002 to UGX 8.7 billion in 2012/2013. In terms of employment creation, over 2m farmers are estimated to be involved directly in sorghum growing and 15,000 indirectly employed as agents, transporters, cleaners, brokers, agro-input dealers, machine operators and agricultural extension staff in seed companies, brewing companies and NGOs dealing in sorghum production and promotion.

Outcome

The new sorghum varieties have diversified uses which include: sorghum cake, sorghum bread, popped sorghum and sorghum composite flour for nutritious porridge and brewers' mash mixed with sorghum stover for feeding livestock (e.g. poultry, goats and piggery).

The intervention is used by the Government of Uganda as the best practice example on how it should collaborate with the private sector to achieve objectives set out in its Poverty Eradication Action Plan, Plan for Modernisation of Agriculture, Operation Wealth Creation and Uganda Vision 2040.

8.3.3 The SAARI-Saimmco Weeder saves the local farmer time and money in Eastern Uganda

Background

Land preparation, planting and weeding are labor intensive activities. When the Universal Primary Education (UPE) policy was introduced in 1998, children who used to assist parents with farming

enrolled in schools, creating labor shortage and leaving animal traction as a sole alternative especially in the Teso region. During planting seasons, most crops are planted at the same time (labor peak) leading to inadequate labor, hence resorting to animal traction. Boda boda business also grabbed potential laborers, leaving fewer people to offer farm labor. This created an opportunity for NaSARRI to promote animal traction.

As far as "Labor Drudgery" is concerned, animal traction solved women's burden of weeding using the hand-hoe. With the spread of animal traction, men joined women in more farm activities including land preparation, weeding and heaping potatoes. Animal traction enabled farmers to increase crop production acreage compared to using the hand hoe. Between 1997 to date, animal traction weeding technologies have been adopted by the farming communities and have greatly improved the lives of small holder farmers in eastern Uganda.

The intervention

Researchers at NaSARRI developed a labor-saving technology with focus on groundnuts and sorghum using animal traction (weeders and SARRI plough) powered by animals especially oxen and donkeys. Initial stages of the development process included designing a prototype which was tested for effectiveness both on station and on farm with farmers. Feedback was used to modify and test the prototype further with farmers. This was followed by recommendations on its use, dissemination and adoption. Farmers were trained and equipped with skills on how to train their oxen to plant in rows and weeding. The same skills could be employed on other crops as long as they are planted in rows. Apart from planting and weeding, this technology can also be used during harvesting of groundnuts, making ridges for potatoes and contours to conserve water using tie ridges; these also control flooding and soil erosion. Dissemination materials were developed and used on farm- demos and physical trainings.

Success Factors

While other weeders come with their own frame, this technology was designed in a way that it can only have a weeder attachment to the plough frame making it cheaper and more affordable for farmers with the cost dropping from UGX 500,000 to UGX 120,000. In addition, the SARRI plough is light but strong and effective even where there are obstacles such as stumps and stones.

Beneficiaries

Following its introduction over 400 farmers adopted the technology in Teso region. Soon after, the technology was adopted by other districts in the various parts of the country including Kitgum, Ntungamo, Ruhama, Kasese, Kotido and Pallisa as well as South Sudan and DRC.

The technology ultimately prompted investments and created job opportunities as farmer groups became seed suppliers of improved groundnuts and sorghum to NAADS, OWC and other NGOs/CBOs and expanding from animal traction to companies for processing sunflower, selling inputs and spare parts. The technology has presented bench marking platform for agriculture ministries of South Sudan and DRC.

Seventy percent (70%) of trained farmers adopted the weeder animal traction technology to weed their crops, while 58% adopted it for ridging sweet potato contours. Among the adopters, draught animal power (DAP) led to an increase in cash balance of up to 600% (groundnuts in Alwa), 340% (Groundnuts in Asamuk), 250% (sweet potatoes and sunflower in Kachede). A total of 42 weeders were given to the trained farmers (seven weeders per site). Farmers in Alwa and Kachede took up weeding and ridging sweet potatoes using oxen as a business and reported that their household income had increased.

Outcome

The technology impacted farming communities through, which improved households' incomes. Farmers were able to buy animals, bicycles, motor cycles and build permanent houses. The social impact of the technology includes improved nutrition and food security, and better family members' health. The trained farmers became leaders of NAADS-formed farmer groups and farmers' foras at sub-county and district levels. The environmental impact included improved soil fertility and moisture retention due to deep ploughing of the crop residue that rots and becomes humus. Farmers were also able to reduce soil erosion by digging ridges.



Evolution of the Zonal Agricultural Research and Development Institutes (ZARDis) and their top successful interventions

Chapter 9

ABI ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (ABI ZARDI)

9.1 Background

Sitting on 83 acres of land, 8kms off Arua town on the Rhino camp road, Abi ZARDI is an outreach station for improved technologies for the West Nile Agro-ecological Zone (WNAEZ) that comprises the districts of Adjumani, Moyo, Yumbe, Koboko, Maracha, Arua, Nebbi, Zombo and Packwach. The region has a total population of 2,661,000 people 99% of of which are dependent on agriculture for their livelihoods (Uganda National Population Census, 2014). Formerly known as Abi District Farm Institute, and later Abi Agricultural Research and Development Center (ARDC) in 2000, Abi ZARDI is mandated to;

"Conduct and manage applied and adaptive agriculture research as a way of contributing to improved livelihoods of the people of West Nile while conserving the natural resource base".

The institute thrives on integrity, professionalism, social responsibility, time management, partnerships, transparency, and environmental sustainability as her core values.

The WNAEZ is one of the most peripheral zones in Uganda, with wide borders with Democratic Republic of Congo and South Sudan. The common challenges affecting agriculture in the region include: complex land tenure system, climate change and influx of refugees from South Sudan who add to stress on land for production.

Thus research areas of focus at Abi ZARDI are: Farming systems and Livelihood Analysis; Natural Resources Management; Crops Research and Development and Livestock and Fisheries Research and Development.

9.2 Institutional changes and their impact on delivery of the mandate

Abi ZARDI has developed human capacity and capacity building strategies to help it deliver its mandate. Abi ZARDI currently has a total of 66 employees 36 of which are NARO recruited while 30 are on contract basis (e.g. security guards), paid using institute funds/income. The institute supports staff capacity development by funding its staff to attend short courses in Uganda and abroad. Abi ZARDI staff also attended short courses and seminars organized by NARO Secretariat. Staff capacity is also enriched through mentoring and staff attachment to other institutes e.g. NaCRRI, JICA.

The institute has an administration block and other office blocks that provide adequate office space for its employees as well as eight staff houses. There is an employee van for staff who reside in Arua Municipality. The institute has a dormitory that provides accommodation for farmers and other persons who access Abi ZARDI for short term training or on-station demonstrations. The dormitory can accommodate up to 40 people. There are two laboratories and a library that needs equipping.

9.3 Top successful interventions by Abi ZARDI in the West Nle Region

1. Soil fertility management for improved agricultural production.
2. Commercialization of Mangoes in the West Nile region.
3. Enhanced fish production through pond and cage aquaculture.
4. Introduction and promotion of goat rearing: The Mubende goat story.



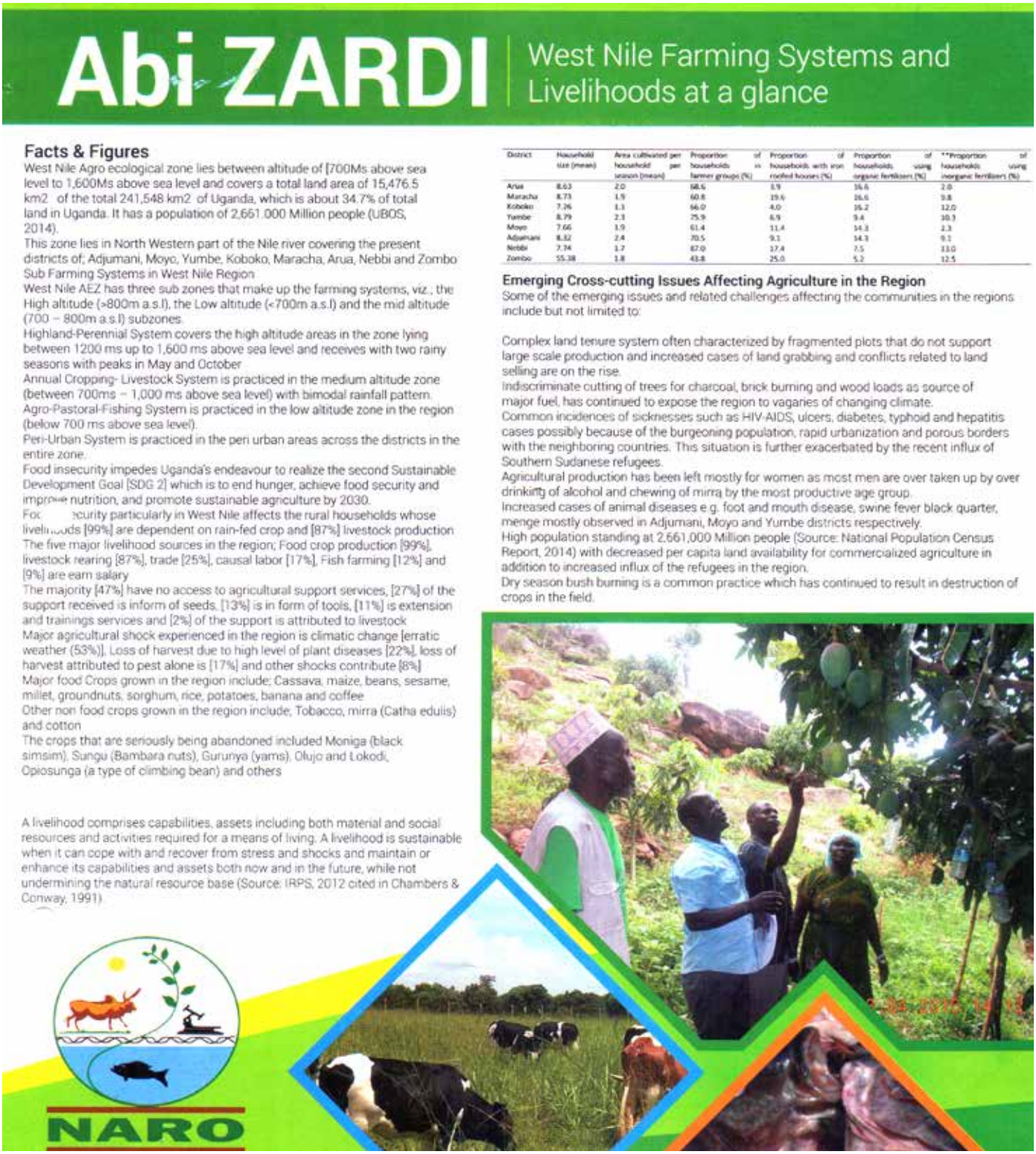


Fig. 30 West Nile Framing Systems and Livelihoods at a glance

9.3.1 Soil fertility management for improved agricultural production in the West Nile region of Uganda

Background

Farmers in the West Nile region have always invested significant effort in sourcing for seed of crop varieties that have superior traits, particularly in terms of yield and tolerance to diseases. However, most of them had not appreciated the need to improve soil fertility until recently when the undeniable effects on crop yields caused by decline in soil fertility began biting hard. This is evidenced by submissions from 98% of the farmers testifying to the fact that soil fertility in the region has declined over the last five to ten years (Abi ZARDI Soil Micronutrient Analysis Survey Report; 2014). If this situation, is not checked, it is bound to negatively affect food security and income generation in the region, thus threatening the lives of over 2.6 million people who largely depend on agriculture for their livelihood.

The intervention

With this background, NARO through the Soils Unit at Abi ZARDI under the leadership of Mr. Emmanuel Odama conducted soil nutrient analysis for the West Nile region through the West Nile Soil Improvement project. Geo-referenced soil samples were taken from the districts of Adjumani (19), Moyo (20), Yumbe (14), Koboko (15), Maracha (19), Arua (33), Nebbi (26), and Zombo (14) after zoning the agricultural and bio-physical areas of the districts. Upon analysis of the soil samples and merging it with GPS coordinates collected during sampling, soil fertility maps were generated in ArcGis 10 using Ordinary Krigging Geostatistical Analyst tool. The maps were generated for the major soil nutrients and organic matter for optimum crop growth. Results indicated that with the exception of Potassium, most of the soil macro nutrients in West Nile region were below the critical levels required for optimum plant growth.

Beneficiaries

The project trained 400 participating farmers and technical field officers on soil fertility improvement as well as water conservation technologies, and developed soil nutrient maps for the region. The maps were distributed to all District Production Offices in West Nile region. Furthermore, Abi ZARDI set up four field demonstrations in Arua, Yumbe, Nebbi and Zombo districts to give farmers an opportunity to practice and learn the importance of using soil amendments for improved crop yield.

Outcome

The generated information initiated productive discussion by policy makers and other critical actors in agriculture to prioritize soil fertility related aspects in the region. As a result of this initiative, districts in West Nile region are directing more resources into soil fertility improvement. Other impacts include wider uptake of mitigation and corrective measures by farmers which is expected to improve the general soil health status in the District, integrating the use of maps in agriculture plans of districts, continued consultations with NARO/ Abi ZARDI Soil Fertility unit.

Success Factors

The intervention was successful because of engagement of a number of partners including Local Governments, and funding agencies, among others. The multi-disciplinary NARO team also helped to ensure success of the project.

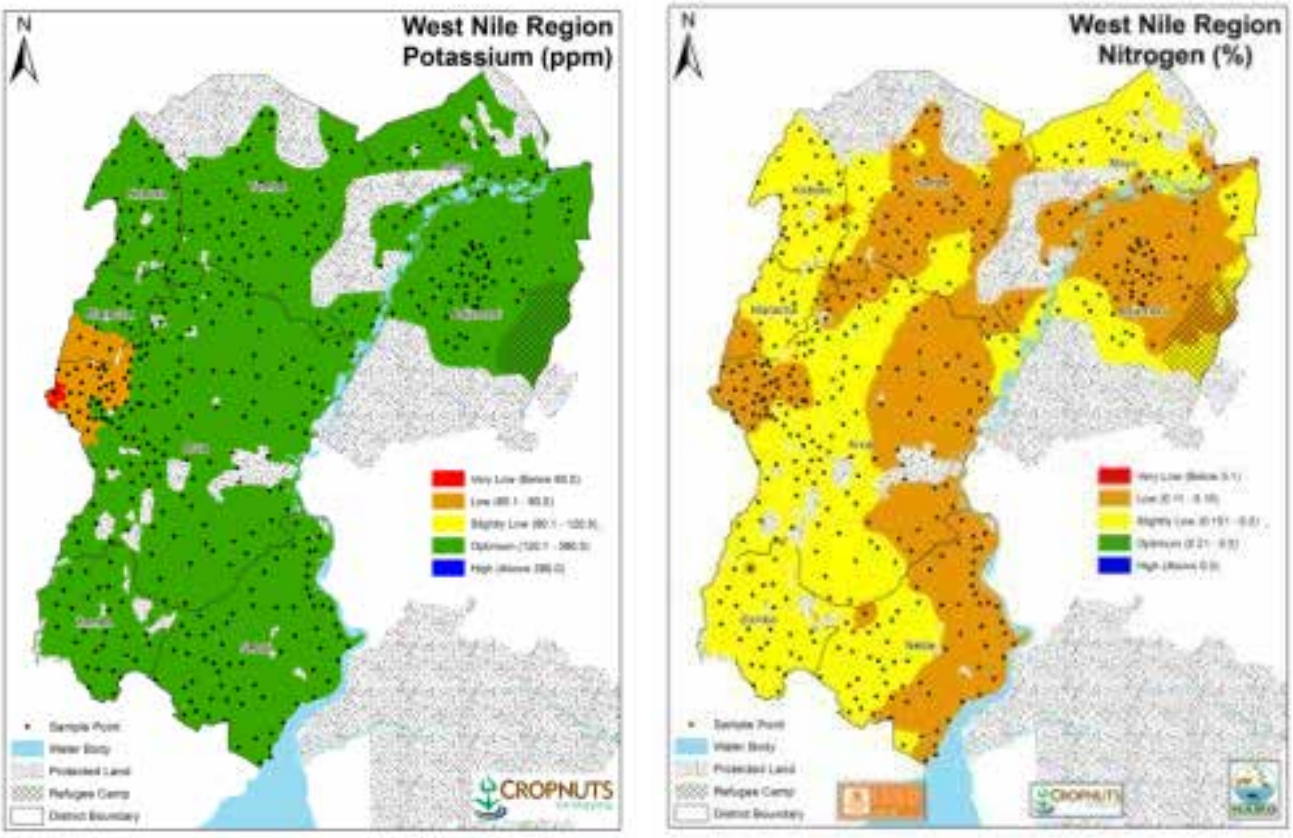


Fig. 31 West Nile soil maps indicating potassium and Nitrogen levels.

9.3.2 Mangoes commercialized in West Nile region

Background

Traditionally in most parts of Uganda, mangoes were known to grow wildly with little or no husbandry practices. The West Nile region was not any different, as little commercial value was attached to mango fruit production and most varieties grown were local, with small and fibrous fruits often infested by pests. This affected their marketability and suitability for sale.

The intervention

In 2012, Abi ZARDI established multiplication sites for improved mango technologies popularly called "mango villages" to promote grafting technology for cultivation of improved mangoes. Improved mango varieties have a competitive advantage over the local varieties given their unique characteristics including less fiber, abundance of vitamins, antioxidants and trace elements leading to high commercial value. They provide income through both sales of fruits and seedlings, as well as provision of shade and windbreaks for environmental conservation and amelioration of the climate at large. Spearheaded by Mr. Dan Acema who heads the agroforestry unit at Abi ZARDI, the Abi team sought to promote mango fruit trees for food security and income generation. Six varieties with desirable attributes namely; Kate, R2E2, Bire, Glenn, Tommy Artkins, and Apple were identified as most suitable for the region.

Beneficiaries

Model farmers were identified and given comprehensive training on nursery practices and inputs (seedlings, chemicals, pots, and spray pumps) for one hectare per mango village. The mango villages were established in Arua, Koboko, Maracha and Moyo. Among the many farmers testifying to the goodness of the enterprise include 67-year old Haji Abdulai Yusufu Banya of Koboko District, chairman of Morita bongo Farmers Group with a one-acre nucleus farm, and an eighteen acre- mixed farm located at Ombaci parish in Koboko District. Another proud beneficiary is Mr. Samuel Dulu who heads Amamua Farmers Group located in Metu Sub County, Moyo District. In 2013 he raised 3,000 mango seedlings and 1,500 for citrus but due to better prices, ended up selling everything to Nimule in South Sudan at 10,000/- per mango seedling and 8,000/- per orange seedling. He bagged UGX 42 million from foreign markets and UGX 1 million from local sales. This marked the turning point in his life.

''Thanks to the introduction of the mango village and training offered, over 15 people have started mango grafting business to provide quality mango seedlings even to foreign markets such as South Sudan and Democratic Republic of Congo'' reported Mr. Acema.

9.3.3 Enhanced fish production in West Nile region through pond and cage aquaculture

Background

Pond and cage fish farming are feasible economic activities for the West Nile region which is endowed with vast water resources (wetland coverage of approximately 2.8 per cent (87 km2) and many fish species. In 2011, approximately 80% of the farmers were using poorly constructed ponds often less than 150 m², which were characterized by loss of ponds to dying out. Furthermore, farmers constantly had limited stock of fish due to lack of quality fish seed. The shortage of fish seed was compounded by the fact that most hatchery facilities were located in Kampala which made access very difficult. Consequently, farmers resorted to using low quality fish seed that would not meet the demand of fish from neighboring countries such as DRC and South Sudan.

The intervention

In 2014, Abi ZARDI partnered with NAADS, District Fisheries Officers of the nine districts in West Nile (Arua, Packwach, Nebbi, Zobo, Maracha, Koboko, Yube, Moyo, Adjumani), and the local government, to train farmers on the production of high quality fish seed. Similarly, farmers were also trained in Catfish breeding and hatchery management. The initiation of cage fish culture in the region followed site suitability assessments of 20 fishing bays along the Albert Nile in the districts of Nebbi, Adjumani and Arua, which Abi ZARDI conducted from November 2015 to April 2017 to identify and map potential areas for cage culture. Working with District Fisheries Officers, farmers, the Food and Agriculture Organization (FAO) and other NGO's in Arua, Nebbi and Adjumani; Abi ZARDI helped to install and stock 30 cages with tilapia fish in the mapped areas.

Beneficiaries

About 200 farmers received training including fish farmers in Maracha district who formed Kijomoro Fish Farmers Association. With the hatchery breeding skills gained, the Association can produce 15,000 fingerlings of catfish every after two months and 20,000 Nile Tilapia fingerlings with each selling at UGX 500 and 200, respectively. Currently, the Association has more than 300 farmers engaged in aquaculture in Maracha, Arua and Koboko districts.

Factors of success

One of the factors for the success of this intervention was the cooperation with various partners and enthusiasm of commercial fish farmers. In addition, Abi ZARDI also distributed a total of 8,000 quality Nile tilapia and 5,000 African catfish fingerings to three research farmer groups from Arua, Maracha and Koboko districts with the aim of raising them to table size fish for sale in 2015.

Outcome

Today, approximately 50 to 60 % of the smallholder subsistence ponds have been transformed into profitable small-scale production units across the nine districts of West Nile through such capacity building programs.

9.3.4 Introduction and promotion of goat rearing in West Nile: the Mubende goat story

Background

Goat farming plays an important role in West Nile with most households owning at least two goats. Approximately 95% of the goats kept in this region are the Small East African breed with tethering as the commonest system of rearing and by communal grazing. Due to their higher reproductive fecundity (i.e. twinning ability and short gestation period), small size and ease of disposal compared to the larger ruminants, goats provide a major source of income and animal proteins to many households in the region. Despite their socio-cultural and economic roles in the livelihoods of people in West Nile, limited knowledge on improved production practices; particularly appropriate goat genotypes constrain successful goat production in the region.

The intervention

The Mubende goat was introduced for crossbreeding with the indigenous goat genotypes in a collaborative project between Abi ZARDI and Makerere University in 2008. The traits of the Mubende goat that offer an edge over the small East African, the Mudende goat has an average birth weight of 2.8±0.7 kg, kid growth rate of 72±29 grams at 60 days and mature weights of 37±5.3 and 33±6.5 kg for males and females respectively.

Beneficiaries

To date over 400 breeding bucks have been disseminated to communities within the West Nile Agro-ecological Zone through sales and distribution under adaptive research arrangement. One of such bucks was named Abi at Moyo babies home where it is crossbreeding with both indigenous small East African goats and exotic dairy goats. The attributes of the Mubende goat make it an important indigenous breed capable of increasing the meat productivity of the Small East African goats.



Chapter 10
BUGINYANYA ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT (BUGIZARDI)

10.1 Background

Located in Bulambuli district, Buginyanya ZARDI started as a field station for coffee in 1967. Operations were field based until 1969 when construction started hence becoming a fully-fledged institution in 1971 under Kawanda research institute, and later coffee research center. Arabica coffee was the key commodity of research.

"Buginyanya Zonal Agricultural Research and Development Institute is mandated to conduct applied and adaptive research to generate and disseminate, respectively, appropriate technologies that address specific needs for the Eastern highlands."

Scientists used to come from Kawanda and Namulonge with 4 senior research officers, support staff and technicians. Kituuza was the main office for coffee research before the administration changed and Bulegeni became the head office. Buginyanya was also handling Bugusege station before it became semi-autonomous. Chronologically from 1974-1977 it was under Kituuza coffee research institute. After management changed, it was became part of Bulegeni District Farm Institute up to 1979.

10.2 Institutional changes and their impact on delivery of the mandate

In 2002, Buginyanya and Bulegeni (formerly a District Farm Institute) formed the Bulegeni Agricultural Research and Development Centre (ARDC) under NARO with a Centre manager as the team leader. In 2006, Bulegeni became a satellite station under Namulonge carrying out demonstrations on annual crops like maize, beans, sweet potatoes and coffee. It was also a training hub for farmers. In 2008, it became a ZARDI with a change of name from Bulegeni to Buginyanya ZARDI with Dr. William Wagoire as the first director from 2008- 2014 he was succeeded by Dr. Lawrence Owere in 2015. The mandate of the institutes was to conduct and manage applied and adaptive research as well as facilitate the development and dissemination of appropriate technologies that address specific needs for the Eastern highlands.

The current institute is operationalised in three stations i.e. Buginyanya main station, Bulegeni and Ikulwe satellite stations. The institute serves 26 districts of Bugisu, Sebei, Bukedi and Busoga sub-regions, stretching from Bukwo to Jinja. In 2008 the institute had five employees which has progressively grown to the current staffing of 36 employees. Eight of these hold PhDs, 6 MSc, 8 bachelor's degrees, 8 diplomas and 5 certificate holders.

10.3 Top successful interventions of by BugiZARDI

1. Alternative low-cost control options of livestock ailments to transform farmers' lives in the South East Agro-Ecological Zone (SEAEZ) of Uganda.
2. Bringing back the glory of the East through Arabica coffee production.
3. Domestic wheat production: a solution to Uganda's import dependence.
4. Potato value chain as a driver of improved livelihoods in Mt. Elgon.

10.3.1 Alternative low-cost control options of livestock ailments in South East Agro-Ecological Zone (SEAEZ) of Uganda

Background

Livestock production is among the key agricultural activities in Uganda contributing about 7.5% of Agricultural Gross Domestic Product (MAAIF, 2013). It has been noted that households that include livestock in their enterprise combinations tend to be generally less poor (Twinamatsiko et. al., 2013). The livestock census (2008) estimated the national herd at 11.4 million cattle, 12.5 million goats, 3.4 million sheep, 3.4 million pigs and 37.5 million chickens. Every category reflected a significant increase on earlier estimates. However, the livestock industry in the south east agro-ecological zone (SEAEZ) faces a number of challenges including but not limited to; prevalence of diseases, worms and, low quality feeds among others (Gidoi et al, 2015). Costs of treating livestock related diseases account for 70% of household's expenditure on livestock. Already available control measures include treatment using synthetic veterinary medicines which are expensive and not easily accessed by livestock keepers especially those dwelling in rural areas (Lagu and Kayanja, 2010).

The interventions

Interventions to control worm infestation include the use of synthetic wormicides and indigenous

practices/knowledge which farmers use to control proliferation of worms in livestock gastro intestinal tracts (GIT). However, most synthetic wormicides are costly and unavailable and as such smallholders quite often use alternatives like plants and other indigenous knowledge to control or reduce worm burdens and other livestock ailments. Grade et. al., (2009), (Nabukenya et al., 2014; Nalule et al., 2011). However, plants with such veterinary medicinal properties in Mount Elgon sub zone have not been established. In addition, procedures on how such plants and plant parts are prepared to form mixtures to be administered to the animals with disorders for treatment remain unknown. This study was therefore conducted to establish affordable alternative options (indigenous knowledge and practices) for controlling livestock diseases and worm infestation in SEAEZ, (Five districts of Bukwo, Kween, Kapchorwa, Bulambuli and Sironko). With the findings showing that the majority of the ethno veterinary practitioners (98%) as men from the age group of 53.5 ± 4.9 years. As a result of this study, a compendium of "next generation veterinary herbal medicine" was established with information on indigenous knowledge and practices on the different veterinary herbs/plants/plant parts used to combat livestock ailments in this region been.

Outcome

The successful documentation and use of the research information has led to increased survival of livestock species which translated into increased livestock products (beef and milk) and savings from the purchase of expensive synthetic veterinary medicine and sale of animal products hence transforming household livelihoods in the long run.

10.3.2 Bringing back the glory of the best through Arabica coffee production

Background

Arabica coffee contributed 20% of the 3.5 million coffee bags exported in 2016. Mt. Elgon area has 90% of the Arabica coffee in the country mainly produced at household level. Forex and income earned from Arabica coffee is limited by use of old varieties, emerging pests and diseases, poor agronomic practices and poor post-harvest handling and storage. This is mainly expressed as low yields of 600-750Kg parchment per hectare.

The intervention

Buginyanya ZARDI in collaboration with NaCORI introduced interventions to improve the quality and yields of Arabica coffee. NACORI handles the issues related to variety improvement through breeding while BugiZARDI oversees the agronomic, pest and disease management and cropping systems related to Arabica coffee. A system of replanting and stumping of the non-productive fields, improved disease management and application of fertilizer/manure was introduced to increase yield increase from 1 tonne to 6 tonnes annually. The institute has a contract with Uganda Coffee Development Authority (UCDA) to supply high quality Arabica coffee seed which is in turn supplied to their nursery operators across the country.

Beneficiaries

The coffee producers in the localities of Masira, Buginyanya, Sisiyi, Kamu and Bulegeni Sub County were trained and participated in the adaptive trials. A significant number have adopted the method of rehabilitation through stumping, uprooting and application of manure and fertilizer annually to increase their yields. The institute has so far supplied about 113 million seedlings to UCDA nursery operators. It is estimated that 85 million of these seedlings are already in productive stage, thus generating income for coffee farmers.

Outcome

There is increased number of trucks carrying animal waste manure during the dry season. There is economic growth in the localities where the interventions were adopted including permanent buildings and more transport trucks being purchased which is attributed to bumper coffee harvests and increased sales. We have observed an ever increasing demand for Arabica coffee field support services, planting materials especially seedlings and number of Arabica coffee buyers within the region. The increasing demand for Arabica coffee seed and seedlings by Kyagalanyi and Kawacom which both operate within Mt. Elgon is added encouragement that BugiZARDI is contributing significantly to the Arabica coffee value chain.

10.3.3 Domestic wheat production: a solution to Uganda's import dependence

Background

Wheat is increasingly in demand in Uganda as a result of income growth, rapid urbanization and changes in people's diets, but Uganda produces less than 5% of its domestic requirements, causing a heavy dependence on imports. Uganda's importation of wheat has been steadily increasing from 111,000 MT in 2011 to 460,000MT in 2015 with the country spending over US $123 million in foreign currency in 2015. The figure is expected to more than double in the next 10 years. Faced with a growing demand for wheat and wheat

products, the continuation of this import-based approach could generate immense consequences for the Ugandan economy and the country's food security.

The intervention

In a bid to reduce the wheat import dependency, the government of Uganda through a five year funding from the World Bank under the East African agricultural productivity project (EAAPP), supported the development and improvement of wheat activities in NARO- Buginyanya ZARDI. This resulted in the release of three improved varieties (NAROWHEAT1-3) yielding two times more than the currently grown local wheat cultivars. Massive popularization and sustainable availability of seed of these improved varieties of high-yielding, stem rust resistant wheat varieties will lead to significant reduction in the country's growing dependence on wheat imports and strengthen the national economy as well as food security. Along with other partners, Buginyanya ZARDI is contributing to the expansion of land under wheat production through application of modern technologies to develop, release and popularise higher yielding wheat varieties. They all adapt to different suitable agro-ecological zones. This will be realised through continued government commitment and investment in wheat research.

Potential Outcome

Wide adoption of the improved varieties will increase Uganda wheat production to 120,000 MT annually, guaranteeing a 25-30% reduction in the country's unsustainable import burden thus saving the country US $30-40 million each year in import costs.

10.3.4 Potato value chain as a driver of improved livelihoods in Mt. Elgon

Background

The high and mid-altitudes are characteristic of the slopes of Mt Elgon whose temperatures are ideal for temperate crops such as the potato. This crop is largely grown twice a year with productivity standing at 7-15 t/ha. In the past most of the seed potato used was from farm saved seed potato which predisposes the crop to adverse disease prevalence and thus lower yields.

The intervention

Since 2008, BugiZARDI has with other partners built capacity of various local groups in improved seed potato production systems. These included small seed plot techniques, positive and negative selection with varying successes. Partners such as International Potato Centre, Austrian Embassy, International Fund for Agricultural Development, German Technical Cooperation and the World Bank have supported the Government of Uganda through the institute over the years. Records indicate that 85% of potato farmers used farm saved seed potato in 2000-2010. More recent information shows an increased demand for certified seed potato with a utilization level of up to 60%. The institute annually provides 10-20 tons of seed potato which only meets 25% of the demand from farmers while 35% is provided by farmer groups.

Beneficiaries

The Mengya Integrated Farmers Association (MIFA) based in Benet, Kween has significantly transformed from producing 5 tonnes to 30 tonnes of seed potato since 2010. This group started from basic training of the management in positive and negative selection in 2010, then post-harvest management and storage of seed potato. MIFA was able to supply 15tonnes to neighboring sub counties through National Agricultural Advisory Services (NAADS) in 2012 and now have a capacity of 50tonnes annually with a wider demand through Operation Wealth Creation (OWC). MIFA under BugiZARDI were able to setup own diffused light stores with a combined capacity of 100 MT of seed potato. The seed potato groups including Wanale Seed and Ware Potato Producers Association (WASWAPA) and Kapchorwa Irish potato Farmers Association have now directed most of their resources to seed potato value chain after identifying its high income potential. Mr. Kiptala Moses of Benet, Kween District converted a video hall in his community into a Diffused Light Store because he says it made more money to store seed than have noisy youth around his premises. Mr. George Shiondo of WASWAPA had only an ordinary house in Wanale Sub County in Mbale, he owns a 3 bedrooms house with servants' quarters in Busamaga area, Mbale town and 2 residential plots, all from trade of seed and potato produced using improved management. These developments are well spread within sub counties that generally produce potato in the sub zone which is a true reflection of improved livelihoods.

Outcome

This commodity is referred to as the "Semester Crop" by participating communities because it has capacity to assist households in meeting their basic needs and improving livelihoods. The seed producer groups now source pre basic seed directly from Kachwekano ZARDI due to the high demand for quality seed usually above

the amount BugiZARDI can supply. Regional markets like South Sudan, DRC and Rwanda have significantly contributed to the current lucrative nature of Potato production.

10.3.5 Two Highland maize hybrids with tolerance to MLN submitted for release

Background

In the highland areas of Uganda (1500 to 3000 metres above sea level), a decline of maize grain yield has been registered among peasant communities, with yields hardly exceeding 2 t ha-1. This is because no hybrid cultivars have been bred specifically for the highland areas of Uganda. In 2013, Uganda experienced an outbreak of the maize lethal necrosis (MLN) disease as a result of farmers importing seed from Kenya. The maize yields further reduced both in the lowland and highland areas, with some farmers registering no yield at all.

The intervention

BugiZARDI set up a project to develop high yielding, MLN tolerant maize hybrids for the highland areas of Uganda. So far, hybrids BH33 and BH31 have been released because of their high grain yields (7.2 t ha-1 and 8.2 t ha-1. respectively) compared to the local and commercial varieties Mahinda (2.7 t ha-1) and H614D (4.6 t ha-1). These hybrids are also resistant /tolerant to a number of diseases such as the maize lethal necrosis, rust, gray leaf spot and Turcicum leaf blight. These hybrids are also early maturing (144 – 154 days) compared to 208 and 164 days for Mahinda (a lock check) and H614D (a commercial check), respectively. It is anticipated that upon release these varieties will reduce dependence on use of Kenyan varieties and lead to sustainable maize production without loss of foreign currency. About 88% of the farmers interviewed (out of 864 farmers) in areas of Bukwo, Rubanda and Bulambuli confessed that they prefer these varieties, mainly because of being slightly early maturing compared to the existing varieties.





Bulindi Zonal Agricultural Research and Development Institute

Chapter 11
BULINDI ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (BUZARDI)

11.1 Background

Bulindi Zonal Agricultural Research and Development Institute (Bulindi ZARDI) is one of the sixteen Public Zonal Agricultural Research and Development Institutes (PARIs) which were established through the NARS Act of 2005. The Institute is responsible for carrying out applied and adaptive research in the Lake Albert Crescent Zone(LACZ) and covers five (5) Districts of Hoima, Masindi, Buliisa, Kibaale and Kiryandongo.

BUZARDI is mandated to improve agricultural productivity of Lake Albert Crescent Zone by conducting applied and adaptive research.

Bulindi ZARDI, formerly a District Farm Institute was elevated to Bulindi Agricultural Research and Development Centre in February 2001 and it changed into a fully-functional Zonal Agricultural Research and Development Institute in 2006. Bulindi Zardi is located 20kms along Hoima - Masindi Road, in Bulindi Village - Kyabigambire Sub-county Hoima district and occupies a total of 1950 acres of land in Kigumba and–Kiryandongo Districts.

11.2 Institutional changes that have helped to achieve the mandate

Bulindi ZARDI currently has a total of 32 staff members; 10 Scientists, 9 Technicians, 13 Support staff and 40 Project Staff distributed among four programs namely; Crops Research and Development Program, Livestock and Fisheries Research and Development Program, Natural Resource Management Program, and lastly Farming Systems and Livelihood Analysis Program.

11.3 Top successful interventions of Bulindi ZARDI

1. Adapting to climate change; the case of Kyabigambire farmers in LACZ.
2. Cassava
3. Cage fish farming: A new way to reap big from a unit volume of water.
4. Imparting skills of improved apiary management.

11.3.1 Adapting to climate change; the case of Kyabigambire farmers in LACZ

Background

In the recent times, drought and un-reliable rainfall regimes associated with climate change have increasingly become major constraints to agriculture in LACZ. Bulindi ZARDI in collaboration with climate change Agriculture and Food Security (CCAFS), a member of the CGIAR based at the international Livestock Research Institute (ILRI), Nairobi implemented a project aimed at enhancing farmer capacity to adapt to climate change through evaluation and promotion of climate change resilient technologies in the Hoima learning site.

The intervention

The project involved participatory evaluation to promote resilient and improved cassava (NASE14 and TME14), improved sweet potato (NASPOT8 and NASPOT11), improved mangoes and soil and water conservation measures.

Beneficiaries

Since its inception, over 280 farmers from the seven villages of Katiraka, Kyamonge, Nyakakonge, Mpaaragasi, Kibaire, Kasinina and Kitanga have benefited from the project and are now out scaling through multiplication of improved cassava varieties of NASE14 and TME14 as well as sweet potato varieties of NASPOT8 and NASPOT11. In addition, sensitization and awareness campaigns have been organised in these communities about climate change and food security. Farmers have responded positively and have embarked on planting trees. About 2400 mango trees have been planted. Four community nurseries multiplying various tree seedlings have been established.

Two farmer organizations: Kyabigambire Farmers Organisation (KYAFO) and Bagonza Tukora Joint Farmers Group are collaborating with Bulindi ZARDI to disseminate the intervention. These groups have been provided with financial support for participating farmers in the seven villages. A memorandum of understanding (MoU) was signed between Bulindi ZARDI and farmers' groups committing that 50% of what has been produced will be passed on to other beneficiaries. This initiative is likely to increase farmers resilience to mitigate climate change.

11.0.2 Eastern Africa Agricultural Productivity Project (EAAPP) activities at BuZARDI – Cassava

Background

Bulindi ZARDI is one of the ZARDIs ear marked for seed multiplication and has multiplied foundation seed/ stock of cassava, rice and pastures for distribution to farmers in Hoima, Kiryandongo, Masindi, Buliisa and Kibaale districts of Lake Albert Crescent Zone (LACZ).

The interventions

Under cassava multiplication, the current focus is on promoting NASE 14 well known for the following attributes: resistance to cassava mosaic disease (CMD), tolerance to cassava brown streak disease (CBSD) yield between 30-35 tones under good management. It has a maturity period of 12 months, post maturity period of up to 2 years in the soil and a desirable flour quality. Bulindi ZARDI boasts of over 172 acres of cassava mother gardens consisting of both old and newly established fields.

Beneficiaries

Since 2012, NARO in collaboration with NAADs at the institute have availed stems to farmers in the zone a number of cassava planting materials to multiply and pass on to others as shown below. From 2012 to 2015, a total of 8,994 bags of clean cassava cuttings have been supplied in the districts of Buliisa, Kiryandongo, Masindi, Hoima and Kibaale. Mr. Kirya Charles a resident of Kinyomozi village, Kiryandogo District is a retired teacher and now a full time farmer. In November 2012, he was given 56 bags of NASE 14 by NARO to establish clean cassava seed multiplication. He harvested 1260 bags from an 8 acre field. As part of the agreement with NARO and NAADs he passed on 40 bags (70% of the original amount received) to another farmer. From the sale of these stems, he earned a total 31,500,000/= (thirty one million five hundred thousand shillings).

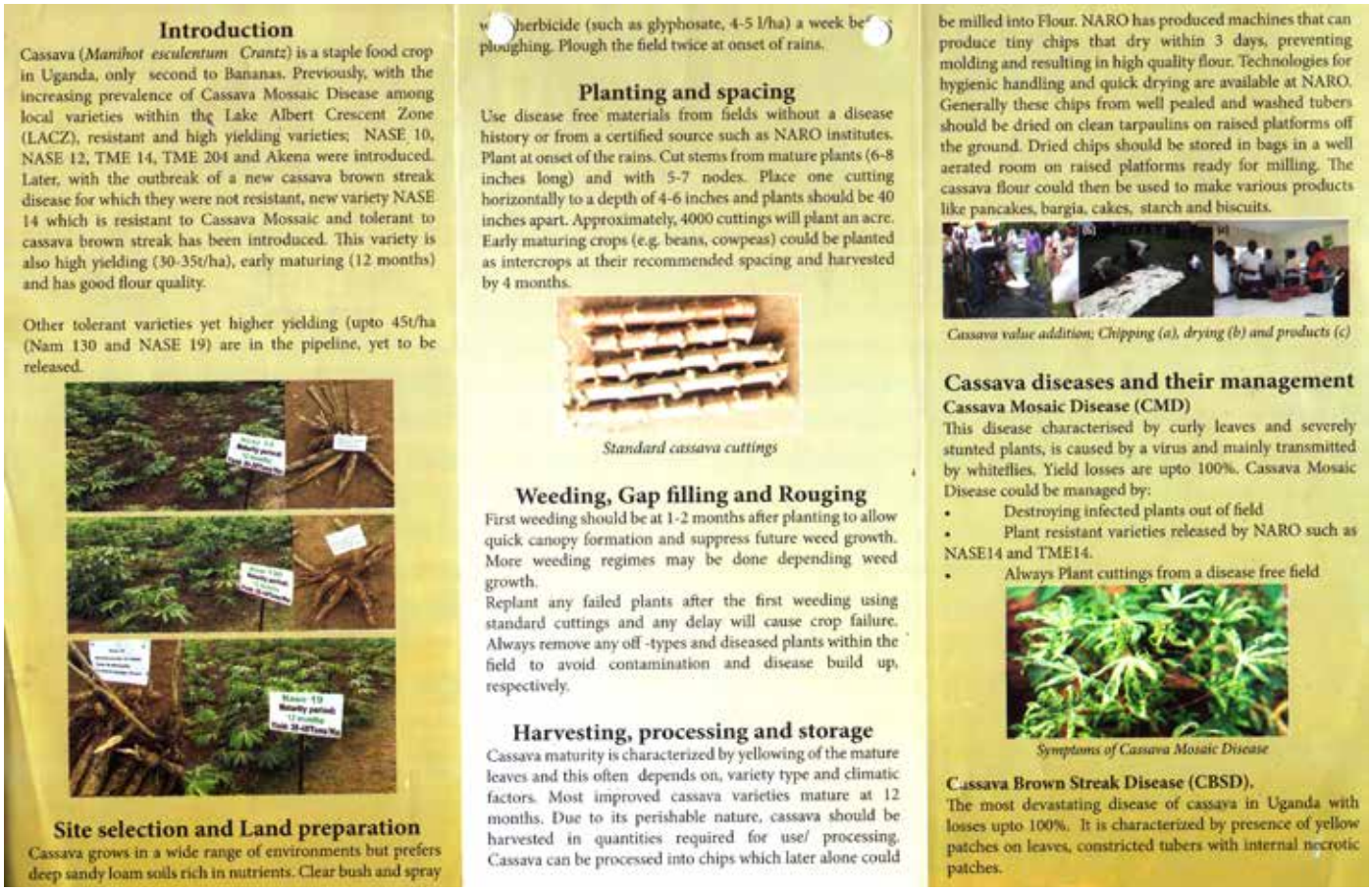
"My experience with this variety is that it is high yielding in both roots and stems, tolerant to cassava mosaic brown streak disease and harsh drought weather conditions" says Charles.

Success Factors

The dissemination was boosted through partnership with NAADs District Adaptive Support Teams (DARSTs) and district local governments.

Outcome

The returns from the sale of fresh cassava tubers remain very low, necessitating value addition. In a bid to boost cassava value addition, 4 cassava processing plants were established in Masindi, Hoima, Kiryandongo and Buliisa. This was realized with support from AGRITT.



Introduction

Cassava (*Manihot esculentum Crantz*) is a staple food crop in Uganda, only second to Bananas. Previously, with the increasing prevalence of Cassava Mossaic Disease among local varieties within the Lake Albert Crescent Zone (LACZ), resistant and high yielding varieties; NASE 10, NASE 12, TME 14, TME 204 and Akena were introduced. Later, with the outbreak of a new cassava brown streak disease for which they were not resistant, new variety NASE 14 which is resistant to Cassava Mossaic and tolerant to cassava brown streak has been introduced. This variety is also high yielding (30-35t/ha), early maturing (12 months) and has good flour quality.

Other tolerant varieties yet higher yielding (upto 45t/ha (Nam 130 and NASE 19) are in the pipeline, yet to be released.

Site selection and Land preparation

Cassava grows in a wide range of environments but prefers deep sandy loam soils rich in nutrients. Clear bush and spray w herbicide (such as glyphosate, 4-5 l/ha) a week be s ploughing. Plough the field twice at onset of rains.

Planting and spacing

Use disease free materials from fields without a disease history or from a certified source such as NARO institutes. Plant at onset of the rains. Cut stems from mature plants (6-8 inches long) and with 5-7 nodes. Place one cutting horizontally to a depth of 4-6 inches and plants should be 40 inches apart. Approximately, 4000 cuttings will plant an acre. Early maturing crops (e.g. beans, cowpeas) could be planted as intercrops at their recommended spacing and harvested by 4 months.

Standard cassava cuttings

Weeding, Gap filling and Rouging

First weeding should be at 1-2 months after planting to allow quick canopy formation and suppress future weed growth. More weeding regimes may be done depending weed growth.

Replant any failed plants after the first weeding using standard cuttings and any delay will cause crop failure. Always remove any off -types and diseased plants within the field to avoid contamination and disease build up, respectively.

Harvesting, processing and storage

Cassava maturity is characterized by yellowing of the mature leaves and this often depends on, variety type and climatic factors. Most improved cassava varieties mature at 12 months. Due to its perishable nature, cassava should be harvested in quantities required for use/ processing. Cassava can be processed into chips which later alone could be milled into Flour. NARO has produced machines that can produce tiny chips that dry within 3 days, preventing molding and resulting in high quality flour. Technologies for hygienic handling and quick drying are available at NARO. Generally these chips from well pealed and washed tubers should be dried on clean tarpaulins on raised platforms off the ground. Dried chips should be stored in bags in a well aerated room on raised platforms ready for milling. The cassava flour could then be used to make various products like pancakes, bargia, cakes, starch and biscuits.

Cassava value addition; Chipping (a), drying (b) and products (c)

Cassava diseases and their management

Cassava Mosaic Disease (CMD)

This disease characterised by curly leaves and severely stunted plants, is caused by a virus and mainly transmitted by whiteflies. Yield losses are upto 100%. Cassava Mosaic Disease could be managed by:

- Destroying infected plants out of field
- Plant resistant varieties released by NARO such as NASE14 and TME14.
- Always Plant cuttings from a disease free field

Symptoms of Cassava Mosaic Disease

Cassava Brown Streak Disease (CBSD).

The most devastating disease of cassava in Uganda with losses upto 100%. It is characterized by presence of yellow patches on leaves, constricted tubers with internal necrotic patches.

Fig. 32 Recommended Cassava agronomic practices

The intervention

Cage Fish Farming is one of the technologies promoted by the Aquaculture team at Bulindi ZARDI. This technology has been disseminated to the fish communities along Lake Albert. The dwindling fish catches on the lake has led to uptake of this technology among the fishing folk on Lake Albert. The Aquaculture team of Bulindi ZARDI promoted the technology under a project titled "Evaluating the growth and yield performance of fish in cages under different stocking densities" and established fish cages on Lake Albert at Piida bay.

11.3.3 Impact of cage fish farming in the Lake Albert Crescent Zone (LACZ)

Beneficiaries

The fishing communities of BAYIPUDA and BUFUDA constituting 15 and 30 members respectively have adopted the technology. These communities have further established fish cages at the same site adjacent to the Bulindi ZARDI fish cages as shown in Figure below. These fish farmers were supplied with about 20,000 Nile tilapia fish fingerlings for stocking in their cages, utilizing the knowledge acquired from the Aquaculture team at Bulindi ZARDI throughout their production cycles. The technology has spread out to other sites on Lake Albert that were identified as suitable for cage fish farming. These sites include Ndaiga in Kibaale and Kaiso-Tonya in Hoima District.

Seven pond culture fish farmers were supplied with 80,000 Nile tilapia fish fingerlings. Two of these are in Kibaale, 2 in Masindi and 3 in Hoima districts. These farmers contribute to disseminating the quality fish types.

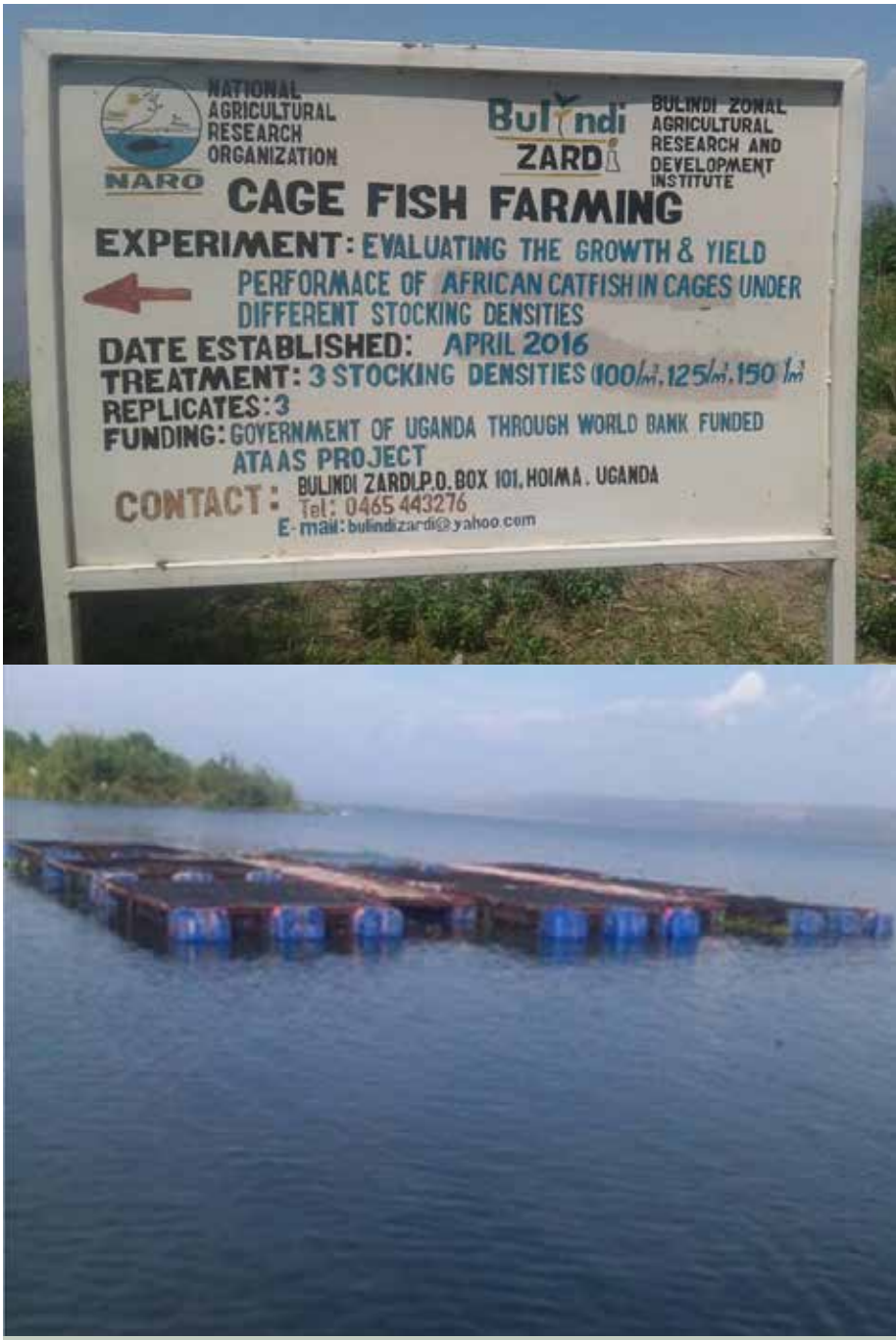


Fig. 33 Piida bay cage fish farming site on Lake Albert



Fig. 34 Bulindi staff Sampling fish in the cages

11.3.4 Imparting skills of improved apiary management

Background

The sweet gelatinous product is mostly made from flower nectar combined with an enzyme secreted by bees, then concentrated by reducing moisture in the honeycomb cells. At least that's the basic science behind the honey we all crave for when we talk about bees. In Uganda certain regions including the Lake Albert Crescent Zone are well known for the outstanding quality of their honey and other bee products.

The intervention

Bulindi Zonal Agricultural Research and Development Institute (Bulindi ZARDI) has been conducting research to increase production and quality of the bee products since 2002.

Beneficiaries

According Dr. Byenkya the Program leader of Livestock and Aquaculture Program at Bulindi ZARDI, a total of over 600 individual farmers and several farmer groups were directly trained in improved apiary management, forage tree production and management, improved hives and improved honey processing. Some of the farmer groups include; Kitengule beekeepers from Masindi district with a membership of 20 farmers, Mungu Bikonye with membership of 15 farmers from Bulisa district and Kampala Bee Keepers Association from Buliisa district. There is a notable increase of bee products in the market within the region.

Success Factors

This accomplishment is attributed to high interest in bee keeping by the communities, excellent partnership with the extension staff in the respective district local governments, NGOs, farmer groups as well as development partners. The partnership was typified by a donation of honey processing equipment they received from International Fund for Agricultural Development (IFAD). The equipment was installed at the institute and many beekeepers in the region are using it to process their honey for better quality and the institute itself is using it to package and brand its own bee products in the market.

Chapter 12
KACHWEKANO ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT (KAZARDI)

12.1 Background

The institute is located in South Western Uganda and has the mandate of conducting adaptive and applied agricultural research as well as dissemination of appropriate technologies in 6 districts of Kabale, Kisoro, Rukungiri, Rukiga Kigezi and Kanungu. KAZARDI has a key strategy which focuses on adaptive research on priority commodities that include apple and potato which are priority crops for the zone.

KAZARDI's mandate is to generate, develop, promote and disseminate technologies, and supporting information, for improvement of the South-western highland agro-ecological zones farming systems.

The institute was commissioned as a District Farm Institute for the greater Kigezi focusing on crops of temperate origin. In 1999 it became an ARDC (Agricultural Research and Development Centre) with focus on strategic research that addresses needs of the SWHAEZ (South West Highlands Agro Ecological Zone). Following NARS act, it was elevated to Kachwekano Zonal Agricultural Research and Development Institute in 2005.

12.2 Institutional changes and their impact on delivery of the mandate

KAZARDI has a total of 50 staff members, 37 of which are core staff. Thirteen scientists (2 women), 7 technicians (4 women), and 17 support staff. There are 13 volunteers who compliment the core team.

Communication has been boosted through increased frequency of staff meetings and training in communication skills. With the current functional team, staff have been able to build teamwork that has enhanced Agricultural Research for Development.

Collaboration with other research institutes and stakeholders is a key factor and in the recent past KAZARDI has partnered with several research institutes i.e. Rwebitaba ZARDI on tea research. Other partnerships include; NARIs and collaborators who have been established to increase on crop research for example NaCRRI, and NARL-Kawanda have evaluated beans, rice and guided GMO confined trial of Potato respectively. This has increased and improved the Institute outputs. Other collaborators/stakeholders are also involved in the dissemination of key research information and technologies i.e. Africa 2000 Network, District Local Government, CARITAS and UNSPPA (Uganda National Seed Potato Producers Association). Other international donor agencies that support technology generation and dissemination are CIP (International Potato Centre), ISSD (Integrated Seed Sector Development), IFDC (International Fertilizer Development Cente) and FAO (Food and Agricultural Organization)

12.3 Top successful interventions as identified by KaZARDI

1. Enhancing production of quality seed potato through private partnerships
2. Enhancing apple growing in SWHAEZ region
3. Enhancing goat productivity at KaZARDI
4. Promotion of farmer run screen-house technology
5. KaZARDI released eight elite potato varieties

12.3.1 Enhancing production of quality seed potato through private partnerships

Background

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. Potato importance continues to rise due to increased demand for seed potato that is always unmet. Despite its importance, farmers are frequently faced with several challenges that are related to lack or shortage of good quality potato seed of consumer-preferred, high yielding varieties. Researchers also did realize that majority of farmers were getting seed from informal sources which subsequently affected the final potato products and markets.

The interventions

The above observations led to the release of KACHPOT1 which was principally breed for potato crisps. Several initiatives have been taken up by NARO through KAZARDI to address the challenge of limited certified quality potato seed in Kabale and Uganda at large. Following the 1st and 2nd season training, approximately 67% of the farmers that were involved and trained during the project are able to apply most of the agronomic practices for potato production very well. These practices include; pest and disease control, soil sterilization and other disinfection techniques, earthing up, mini tuber post-harvest management. This has been done through empowering farmer groups who formed UNSPPA as well as other partners.

Beneficiaries

UNSPPA comprised of organized farmers with whom contracts were signed and linkage made to markets. Apart from UNSPPA the ZARDI partnered with Uganda industrial Research Institute, Tomcris enterprises a potato crisp processor, NANDOs, and Deepa industries LTD. In 2009, Deepa industries signed a contract with 350 farmer households whom it is still engaging in business to supply quality potatoes to date.

A total of 156 farmers (84 male, 76 females) were trained in mini-tuber production focusing on handling of tissue culture potato plantlets, soil sterilization, screen house maintenance, establishment and management of potato crops in the screen house and post-harvest handling (storage and management) of mini-tubers across the site areas where the screen houses were being hosted (Maziba, Kamuganguzi, Bukimbiri 1, 2, 3) and Kisoro Town Council).

As a result of a better seed potato delivery system and market linkages created, a total of 67 seed suppliers were created. Over 350 potato farmers, 36 potato traders and 3 processing companies came together for better synergies. Consequently, between 2008 and 2012, the established potato associations in Kabale and Kanungu earned an income of 149.3 million Uganda Shillings.

Outcome

The partners involved provided good prices for the potato farmers and eased group transport, IFDC assisted in seed production/provision of 6 screen houses for farmers and UNSPPA mobilized farmers together for group trainings and marketing. NARO/KaZARDI built the capacity of farmers to produce quality seed preferred for the market, availed quality seed/plantlets to private seed producers, established seven screen houses, trained community seed facilitators, and sourced funding for the potato technology development and dissemination. Development of high yielding potato varieties tolerant to late blight has resulted into increased yields from 4 tonnes/ha to an average of 25 tonnes/ha. Increased access to high yielding varieties and production of large quantities of high quality seed potato has greatly boosted the potato sub sector. Recently, KAZARDI secured funding from ISSD (International Seed Sector Development) to facilitate establishment and development of 40 Local Seed Businesses (LSB) on potato in the zone to bridge the seed availability gap.

The partnerships created resulted into increase in farmer incomes from potato, improved access to markets, better access to credit facilities, provision of regular extension services and eased group transport arrangements i.e. development of small cottage industries in the region operated by 150 women through processing and marketing of crisps.

Fig. 35 Potato production in South Western Highland Agro ecological zone

Common potato diseases in Uganda

1. Bacterial wilt disease

This is one of the common diseases that attach potatoes in Uganda.

Symptoms of potato bacterial wilt

- Slow wilting of plant starting from one leaf to branch, main stem and progressively to other stems in a growing plant, sometimes accompanied by stunting and yellowing.
- A brown ring in place of vascular bundles in tubers from infected plants when cut in cross section
- In ideal conditions, wilting and eventual death of a whole plant maybe rapid.
- Soil adhered on the eyes of infected tubers especially in dry conditions.
- A milky ooze from the eyes of infected tubers obtained from sick potato plants.
- Puss-like exudates from infected tubers cut in cross-section and pressed.
- Whole tuber rotting and often with a characteristic smell.

Sources of bacterial wilt infection

- Seed-borne infection: tubers used for a new crop may be latently infected
- Soil-borne infection: the seed may be healthy but planted in infected fields.
- Water run- off and irrigation: infection may come in floods and irrigation water.
- Contaminated farm tools and equipment
- Contaminated shoes and boots
- Contaminated compost manures

Bacterial wilt control

- Plant bacterial wilt free seed
- Plant in bacterial wilt free field
- Restricted movement in seed potato fields
- Crop rotation
- Allow land resting and fallowing
- Ridging at planting besides water conservation
- Destroy volunteer potato and other alternate hosts
- Planting disease tolerant varieties

2. Late blight

This is another serious disease that attacks potatoes in Uganda.

- It is caused by a fungus called Phytophthora infestans
- Disease infection and spread is favored by cool, humid and wet weather associated with rainfall mist and fog or conditions that promote prolonged leaf wetness.
- The disease primarily attacks potato leaves but it also infects stems, stolons and tubers.
- The disease also infects tomato, egg plants, pepper, tree tomato and other wild solanum.

Disease symptoms

- Early symptoms appear on lower leaves consisting of small, pale to dark green spots that eventually change into brown or black lesion depending on the humidity of the air.
- Whitish sporulation on lower surface of the leaves appear as white mildew surround water soaked lesions.
- A narrow, pale green or yellow border wide often separate dead from health tissue.
- In ideal condition, the disease may spread from the first infected leaflets on a few plants and to whole field in less than a week, where plants may completely lose all the leaves.

Disease control and management

- Plant disease free seed
- Use protectant fungicides (e.g Mancozeb, Agrozeb etc) and systemic fungicides (e.g Agrolaxyl, Ridomil, Victory etc).
- Proper hilling and earthing up to prevent tuber infection
- Plant resistant varieties
- Destroy sources of primary inoculums (volunteer potatoes)
- Do not store disease-infected tubers

Potato harvest considerations

Pre-harvest preparations

- Dehaulming is done in order to avoid any further transmission of diseases through the stem to tuber, to enable the tuber skin harden and in case of seed to control size.
- Dehaulming is supposed to be done when the crop is mature enough or when tubers attain the desired size and it should be two or more weeks before harvesting.
- Haulms should be cut leaving a stem of about 15cm above the ground
- Maturity of potatoes is indicated by change of colour of leaves from green to yellow and the drying of the plant leaves.
- Harvesting can be done using hands, forked or ordinary hoes.

Before harvesting potatoes, the following should be done;

- Clean the store and spray with insecticides in order to avoid any storage pests
- Clean harvesting materials e.g gunny bags, baskets etc.
- Clean harvesting tools e.g forked hoes, ordinary hoes etc.

Appropriate harvesting conditions

- In case it rains when lifted potatoes are still in the field, the farmer should make sure that they are not wet before taken for storage.
- Harvest when the soil is fairly dry, loose enough to allow ease of lifting potatoes from soil.
- Avoid tuber damage and bruising during harvesting

Potato storage

- Store seed potato on racks in diffused light store that permits light penetration and air circulation for proper sprouting
- In case of ware potatoes, store in dark store or containers that do not allow in light.
- Always manage storage pests like potato tuber moth by dusting tuber with malathion dust.

Partnerships

Kachwekano ZARDI implements most of her activities through both local and international partnerships and collaborations. It has strong linkages with pertinent CGIAR Centers, CSO, and farmer groups in the zone.

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NARO

Potato



Background

Potato yields have remained low in Uganda averaging of 7t ha-1 (FAOSTAT, 2013). compared to what can be achieved (20 tons ha-1) under optimal conditions This yield gap is attributed to poor quality seed, limited access to improved seed, variety degeneration, pests and diseases among other constraints (Wagoire et. al., 2005)

Use of tissue culturing and introduction of new potato varieties which are high yielding with resistance to late blight and bacterial wilt can reduce yield losses.

Newly released potato varieties

Variety Name	Special attributes
NAROPOT 1 	- High yielding 28t/ha - Red skin color - Short dormancy of 90 days - Short maturity period of 90 days - Resistant to late blight - Tolerant to bacterial wilt
NAROPOT 2 	- High yield of 24t/ha - Resistant to late blight - Tolerant to bacterial wilt - Short dormancy period of 90 days - Maturity period of 100 days - Good for crisping and table qualities - Cream flesh color - Red skin

12.3.2 Enhancing apple growing in South Western Highland Agro Ecological Zone (SWHAEZ) region

Background

Research for apples was not initiated until the late 1990s after farmers demanded for integration of fruits in the farming system. NARO through KaZARDI then introduced the temperate fruit species especially apples (Malus domestica). These have been well adapted in the agro ecological environments of Uganda. The adoption by KaZARDI was as a result of an agro-forest's project under ICRAF, formerly based at the National Forestry Resources Research Institute (NaFORRI) at Kifu-Mukono, district.

The Intervention

KaZARDI started to conduct research and to promote apple growing in the SWHAEZ region because of the need for an alternative enterprise in the region of Kigezi. In addition, the climatic conditions of the area offered favorable conditions for the growing of apples. ICRAF provided planting materials and built capacity on apple growing. The development process included: introduction of rootstock from NARL- Kawanda by Dr. Sophie Musana, germplasm from NaFORRI and germplasm introduced by Tom Losan. With the support from the Government, KaZARDI established adaptive trials. Four apple cultivars Anna, Golden Dorset, Winter banana and Rome beauty were the first introductions in 1999. They have been tested for adaptability for over fifteen years.

KaZARDI was also involved in building the capacity of NGOs, extension and community based facilitators and provision of quality apple seedlings. KaZARDI also provided training to private nursery operators and individual farmers so as to solve the problem of raising apple rootstock to which preferred scions are grafted. Information dissemination materials were developed and availed to apple farmers and the wider public. Various outreach approaches were used to disseminate information on apple growing.

Beneficiaries

Since the release of the two apple varieties, several farmers have benefitted from the technology in the SWHAEZ region but figures vary from district to district. The crop has been disseminated beyond the zone of KAZARDI to districts of Kapchorwa, Buginyanya, Bungangabo, Kasese, Bundibugyo and Ntoroko.

Success Factors

Availability of political support was noted to be one of the key factors that contributed to the successful development of the technology as well as the public demand for a perennial crop in the region. Strong and committed partnership of the various players was very helpful.

Outcome

Several Community changes were experienced like construction of semi-permanent houses, creation of employment for apple farmers who can now afford education for their children and some have been able to obtain green houses to generate more root stocks to ease up scaling. Immediate social impact during intervention has been realized in form of increased incomes while provision of soil fertility enhancing technologies has contributed significant impact on the environment. Though labor intensive, research shows that with good management, apples are an income generating commodity and a high income earner.

12.3.3 Enhancing local goat productivity in SWHAEZ region

Background

A Livelihood analysis study indicated the need to improve indigenous goats as a major animal of importance given the nature of land tenure system in the zone. Goat improvement research started at KAZARDI in 2004 and was done on-station before being rolled to farmers in 2007/8. This research was as a result of a government initiative to improve the local goats which had low production, slow growth rate and slow maturity. Local goats were preferred by the community due to their low cost in management, modest feeding habits, high multiplication rates and good nutritional values.

The Intervention

KaZARDI collected a select sample of local goat breeds and improved them by crossing with the South African Boar and later the Savannah. Off springs (F1 crossing) were evaluated with a focus on factors like average daily growth and weight gain as well as survival rate. Several partners were involved in development of this technology i.e. NaGRIC provided the initial South African Boer goats, Sembeguya Estates Limited supplied the genetic resources (animals) for replenishing, National Livestock Resources Research Institute (NaLIRRI) in Tororo for technical backstopping, District Local government carried out day to day management of adaptive research sites and farmer groups for hosting the on-farm trial sites. KAZARDI was responsible for conducting on station and on farm research, training extension workers in goat management, provision of information to NGOs and farmers and data collection.

Beneficiaries

The technology was adopted 3 years later and was disseminated to as far as Kapchorwa and Bulambuli districts. Dissemination to different areas is still on-going to date. A total of 256 households in the zone have benefitted as a result of the technology development.

Success factors

The major factors responsible for the successful development of the technology was high public need, political support, good policy environment for NARO, good leadership, funding by ATAAS and World Bank, farmer trust, hospitality and good team work. Dissemination of the technology was however driven by uniqueness of the Kigezi goats i.e. are hairy, better adapted to adverse weather, short, tastier higher with productivity, and group marketing.

Challenges

Development and dissemination hurdles included limited funding and poor infrastructure e.g. inadequate lab capacity. To overcome the above, more resources were mobilized, capacity built with support from, NGOs, involved volunteers, proper and early planning and utilizing the available infrastructure maximally for studies.

Outcome

The community began rearing improved breeds which led to increased demand and cost price for goats. This change was observed over a period of 3 years. According to KAZARDI survey report 2012, "the average profit realized per farmer from improved goats was higher than the one from local goats by about 14,450 Ugx. Farmers from Kabale and Kisoro districts were obtaining higher profits from improved goats than the local goats. Socially, the farmer feeding habits changed as they could afford to eat nutritious meals earned from sale of live goats and their products i.e. sell a goat at 140,000/-. Social networking among groups increased since many could afford school fees and even better houses. Income generation for goat farmers increased too. There was economic transition from subsistence to commercial goat rearing and many realized that goats could be reared as a business. On the other hand, goat dung could be used to improve soil fertility. Farmers would tether goats in the banana gardens 2-3 weeks before planting season.

As a result of the goat project, a community SACCO was formed by farmers so as to encourage and boost savings. This has the potential to become a spill-over project as noted by the District Commercial Officer and this is soon to become a bank with good office space in Kabale. 62.2% of farmers reported better marketability of improved goats compared to local ones, superior growth rate of 98.1%, 78.1% kidding rate, cultural acceptability of 51% and price per goat rated at 72.1%."

Lessons learnt

Some of the lessons learnt during implementation of the technology include: the need to explore management options for goat worm control and need for intellectual properties law on technologies developed. Improved breeds of goat can be reared for income generation

12.3.4 Up-scaling potato research at KaZARDI

Background

Potato is a crop of major importance in South Western Highlands of Kigezi, but it is challenged by lack of clean planting materials and low productivity. This background that laid foundation for the research initiative.

The Intervention

In responding to the above challenge, KAZARDI developed 13 potato varieties in the initial stages and later evaluated five on-station and on-farm trials for promising varieties. The zoning exercise identified that varieties in circulation were not doing well. New potato varieties were introduced to communities in 2002 and these varieties included Nakpot 1, 2 and 3. Three local varieties preferred by farmers (Rwangume, Rwashakyi and Kinigi) were also cleaned and redistributed. Other varieties released included NAROPOT1, 2, 3 and 4, and KACHPOT 1. Farmers identified KACHPOT 1 as the most preferred for crisps and chips. Traders and seed growers preferred NAROPOT 1, 2, 3 and 4 as they exhibited high yield and resistance to late potato blight.

Success Factors

ASARECA helped to enhance seed production and up scaling while, the Food and Agricultural Organisation (FAO) carried out institutional capacity building and enhancement of farmer trainings through Farmer Field schools. In addition, the International Fertilizer Development Center (IFDC) and International Potato Center (CIP) provided funds for variety cleaning, CIP funded the breeding and germplasm quality assurance, District Local Government provided political support, mobilization, technology awareness and dissemination, Africare (NGO) also helped in participatory research, capacity building, dissemination and group mobilization while UNSPPA provided effective collaboration with farmers to do on-farm research as well as becoming an uptake pathway for the potato germplasm. NAADS helped to build the capacity of farmers and extension staff, Ministry of Finance provided the funds for dissemination while the district local government leaders like LC5, CAO and area Members of Parliament provided publicity.

Challenges

Key challenges experienced during development and dissemination of the potato technology included limited funding, inadequate infrastructure and equipment and limited human resource. The institute however sourced for funds through proposal writing as a means of overcoming shortage of funds.

Outcomes

Because of the wide up take and adoption of the potato, several changes were experienced in the farming Communities. Increased incomes, permanent houses, food and nutrition security were a result of this intervention leading to improved livelihoods. Basing on the KAZARDI survey report 2016, seed producers per season earn an average income of 2,438,742 Uganda shillings. Potato farmers who are linked to markets in Kampala are now empowered to supply big markets like fast food restaurants and these have since formed a savings and credit SACCO (Nyabyumba Farmers' Cooperative Savings and Credit Society Ltd). The potato project pointed to the fact that creating a proper uptake pathway and collaboration with farmers is key to successful dissemination of research technologies.



- Livestock feeding on apple trees seriously reduce their growth.

Management:

- Fencing the orchard
- Bird damage
- Birds damage apple fruits in Uganda due to the small apple orchards owned.
- Fruit damage by birds become severe in seasons when there is no alternative source of food

Management:

- Bagging fruits i.e covering each and every fruit
- Guarding orchards during fruiting time.
- Scare-crows and bird scaring



Birds can be a big threat to apple production enterprise.

Major diseases that attack apples and their management

Like any other crop, apple trees can also be attacked by diseases.Serious diseases that affect apple growing in Uganda include;

- Apple scab
- White Powderly mildew
- Fire blight among others

Apple Scab

This is one of the most serious apple diseases wherever they have been introduced. Becomes severe during the wet season.It attacks the tender parts of the leaves, stems and even fruits.







Management

- Manco-zeb
- Agro-zeb
- Dithane
- Uthane
- Ridomil
- Benlate
- Equation Pro.
- While defoliating, all leaves should be buried or burnt

One month towards harvesting fruits, spraying with systemic chemicals should be stopped

White powdery mildew (WPM)

White powdery mildew mainly attacks apple trees during the dry season and is probably the most serious apple disease in Uganda.It attacks the tender parts of the plant.

Management of white powdery mildew

- White powdery mildew can be reduced by removing and destroying infected plant parts
- Pruning infected shoots
- Fungicides such as;
- Manco-zeb
- Thiovit Jet
- Nimrod



White Powderly mildew attacks the tender part of the plant and if it becomes severe, it attacks even fruits.

Fire Blight

- It attacks and quickly kills apple branches and sometimes the entire tree.
- It leaves no visible lesions or spores but dead leaves and branches.
- The disease is spread at the beginning of the rainy season by rain splash or by insects especially bees.

Fire blight management

- Spraying with copper based fungicide after defoliation can reduce vegetative growth later and therefore the spread of fire blight.
- Infected branches should be cut off about one foot below the disease lesion before infection spreads to the main trunk and be burnt.
- Do not use the same tool to cut infected stems and pruning of healthy trees.
- Fire blight can be chemically controlled with antibacterial sprays before and during flowering, use Copper fungicide sprays

Harvesting apples and handling

This is the final operation of the season in the orchard.

- Harvesting needs maximum attention and preparation along with appropriate planning to ensure pre and post harvest longevity.
- Apple fruits are perishable though can stay for some good time before deterioration.
- Poor harvesting and poor handling nullifies fruit quality.
- There should be recommendable harvesting management systems and strategies to ensure optimum handling, storage and transportation of fruits.

Apples are preferably due for harvest when the following have been noticed;

- Attainment of full internal maturity
- Sufficient and appropriate size
- Attractive color/change of color
- Right flavor and aroma

During harvesting, pedicel cords should be left at the fruit as their removal can be an entry point for pathogens.

Picking/harvesting fruits should be done in soft bags.

NARO

KAZARDI

TEMPERATE FRUITS

Over the last 12 years, 24 varieties have been introduced for evaluation for adaptability and fruit yield in Uganda. So far, two varieties have been released and promoted in the country (KAZARDI, 2010). However, powdery mildew has continuously become a critical challenge to apple production in Uganda. In addition, temperate crops being new in the country, management challenges are still affecting the enterprise. However, research on different management options in relation to yield is on-going and it will come out with best options and recommendations that will enhance fruit productivity in Uganda. The main activities of this project include but not limited to:

- Developing technologies, practices and strategies (agronomic, pest and disease protection, post harvest handling and processing, marketing) for enhancing production of temperate fruits
- Developing a strategy for multiplying and availing quality planting materials to farmers timely and at affordable prices.
- Building capacity of community members for economic production of temperate fruit in the zone and other suitable areas in the country.
- Building capacity of community members in production of quality and quantity planting materials.

Orchard establishment and management

Site selection

Site selection is one of the moist important managerial decisions that an orchard a manager for orchard longevity. Discrepancies in site selection are reflected in reduced orchard performance, yield and profitability of the life of the orchard. This involves planning and organizing the location of a garden/fruit orchard. The most common planting site is homestead gardens. Good site selection leads to:

- Orchard security due site selected based on proximity
- Orchard longevity-limited destruction/dame to our fruit trees
- High yields-due to good sites with good and fertile soils
- Ease of monitoring and supervision due to their proximity

Considerations during site selection

- Proximity-distance from home
- Soils (good, fertile and well drained)
- Terrain (preferably sloping and not in a valley or lowland vulnerable to water logging)
- Drainage (good)
- Surrounding environment (a forest, homesteads, a school, busy roads or other social infrastructure)

Land preparation

Land preparation for horticultural crops (apple in particular) has to be done in a special way to ensure longevity and good crop establishment. It involves activities like;

Land clearing-removal of vegetation from the site using pangas, slashers, sickles, axes, hoes and other available tools to attain a debris free site.

Chapter 13
MBARARA ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (MBAZARDI)

13.1 Background

The Institute is responsible for carrying out research and disseminating livestock, crop, fishery and forestry research technologies in the South Western Agro-ecological Zone. The Institute mission is to undertake agricultural research and disseminate appropriate technologies for improving productivity in the South Western Agro-ecological Zone (SWAEZ).

13.2 Institutional changes and their impact on delivery of the mandate

The institute evolved from a stock Farm in 1996 to raise quality breeding stock. In 2000 it became an Agricultural Research and Development Centre (ARDC). Its main focus was to enhance access of research technologies to rural communities, thus serving a bigger livestock community rather than a dairy farm. In 2005, it finally became Mbarara Zonal Agricultural Research and Development Institute (MbaZARDI). Several infrastructural improvements have been made. Currently the institute has an administration block with office space, a resource center/library, conference hall, screen houses, rehabilitated farm roads, store, laboratory, main gate.

In terms of human resource, the Institute is headed by a Director under whom are ten scientists, eight technicians, one research assistant and twelve support staff including five drivers, three accountants, auditor, a Human Resources Officer, a Communications Officer and an Administrative Assistant. Under the ATAAS program, two staff members managed to go for PhD studies, one staff went for masters training while few more staff went for individual short term trainings.

13.3 Top successful interventions

1. Enhancing fruit growing in south western region.
2. Enhancing animal feeds using pasture grass conservation and preservation.
3. Improved cassava varieties restore hope to farmers in south western Uganda.
4. Development and promotion of improved banana technologies for improved productivity in the South West Agro-Ecological Zone (SWAEZ).

13.3.1 Enhancing fruit growing in SWAEZ

Background

South western Uganda is a livestock dominated community with high levels of malnutrition and fruits would be a quick source of income and food for livelihood diversification. The South western dry land was noted to be affected by climate change and unreliable weather in a baseline study conducted in 2010. The fruit project was a direct demand from the community. This led to a needs assessment exercise which ranked fruits as the fourth priority enterprise making it a priority enterprise for the zone.

The intervention

In 2012, citrus and mango orchards were set-up. Among the orange varieties disseminated was Washington navel, Valencia and Hamlin. On-farm farmer managed trials were used to evaluate improved fruit varieties suitable for the zone. The initial fruit germplasm was obtained from national crops resources research institute (NaCRRI) in Namulonge in 2006, evaluated on station. The project evaluated 27 varieties of mango on station and four of the promising lines of Keitt, Zillate, Tommy artkins and Bire were taken on-farm in Sembabule and Kiruhura districts.

Success factors

The mango verities evaluated had unique attributes i.e. fast growth. The varieties produced fruits in 2 years compared to local varieties after 5 years. The mango and orange project worked with several partners who included District Production Officers who were in charge of participatory farmer identification, supervision and technical backstopping while the World Bank through ATAAS funded the project evaluation and dissemination process. MbaZARDI on the other hand was in-charge of carrying out adaptive Research, conducting on-station and on-farm research as well as collection of data on field performance.

Beneficiaries

Mr. Kisasa Joseph and Mr. Matsiko Musa were some of the farmers whose incomes increased. By 2014, they obtained 300-500 fruits per tree per season from trees planted in 2011. These measureable changes were observed over a period of 3 years. Technology up scaling was first done in 2010 and is still on-going. Mango varieties have been disseminated as far as Sembabule (Rwebitaba S/C) and Kiruhura district (Buremba local government) benefiting the immediate communities. Other areas where the tech has been disseminated include Nyendo, Masaka for Sembabule produce and Rushere, Buremba for Kiruhura produce.

Outcome

Fruits from improved mango varieties offered better prices given the high market demand) and more incomes compared to local ones i.e. 500/= per fruit, they improved food security and nutrition as well as providing employment to the farmers who took it up as a business venture. With more players like NAADs,

the sale of seedlings became a lucrative business venture. The project increased tree cover in the region thus contributing to environmental conservation.

13.3.2 Improved cassava varieties restore hope to farmers in south western Uganda

Background

After several reports of vast devastation of cassava gardens by brown streak virus (BSV) and cassava mosaic in the region, MbaZARDI intervened by promoting cassava varieties that are tolerant to the above mentioned viruses. Cassava brown streak disease had risen to 90% yet farmers were not aware of this. Intervention was as a result of community complaints in the zone though the disease had first been reported in central Buganda region.

The intervention

Under the East Africa Agricultural Productivity Project (EAAPP), MbaZARDI commenced promotion of improved and disease-free cassava varieties in the region. In 2008, MbaZARDI multiplied varieties like TME 14, 204, MH 97/9610067 and AKENA. In 2010, cuttings of these varieties were given out after level add "as demonstrations so that farmers could have access to the planting materials." These were later affected by Brown streak virus and farmers were advised to uproot them including those on-station.

To avert this situation, MbaZARDI team of scientists, in collaboration with Cassava project at National Crops Resources Research Institute (NaCRRI), Namulonge, introduced cassava varieties that are tolerant to cassava mosaic and brown streak diseases. In 2012 NASE 14 was brought in by EAAPP project. In addition to being tolerant to cassava brown streak disease, NASE 14 is also high yielding, sweet, tasty and early maturing.

Beneficiaries

A total of 55 acres were plated on station and on farmer-managed trial fields. The key beneficiaries of the project were vulnerable groups of HIV victims and malnourished children, over 3000 farmers 2 prison farms. It was later in 2013 rolled out on demonstrations in the districts of Rakai, Ibanda and Lyantonde. In Rakai alone, 5 acres were planted at the Datic and 13 acres at Mutukula Prisons farm. A 15 acres demonstration field was planted at Kiburara Army Prisons Government Farm in Ibanda.

The project ended after multiplying 1864 bags of cassava cuttings which were later distributed to 13 districts namely; Mbarara, Mitoma, Rakai, Rubirizi, Ntungamo, Kiruhura, Sheema, Sembabule, Buhweju, Lyantonde, Ibanda, Bushenyi, and Isingiro. The stem cuttings were supplied alongside information materials and training of the beneficiaries. The technology is still being used and it is estimated to have over 1 million beneficiaries.

Success factors

The successful development and dissemination of the technology was driven by factors like availability of land in addition to the fact that is a key food crop in the area. The fact that NASE 14 is tolerant to cassava Brown streak virus disease was also an important factor.

This intervention was made a success through support from partners like, Farmers (for seed multiplication and EAAP (for funding). District Local Governments and District Agricultural Officers helped in identifying the farmers, site selection and mobilization/ supervision. NARO provided technical back stopping, guidance and training on management of the varieties. Information on the project was disseminated beyond the targeted agro-ecological zone. The key dissemination partners were the District Local Government, NAADS, Transporters, Management Advisory committee, Prisons/farm manager and Operation wealth Creation while farmers in the zone provided land in addition to mobilizing labour.

Outcome

The community was boosted in terms of food security and income. Due to the increase in price cassava cuttings from 10, 000 to 20,000 per bag, some farmers started multiplying cassava stems commercially. The certified cassava seed/cuttings multipliers had ready market provided by National Agricultural Advisory Services (NAADS).

"I couldn't ever imagine that there are cassava varieties that cannot be attacked by cassava mosaic virus disease. After planting this demonstration garden and inviting my neighbors' to regularly visit me, we have now hopes that our food security needs are catered for. We can now look to the future of our children without fear of losing our cassava gardens. Thanks to NARO and technology up scaling" said one cassava farmer in Rubirizi district.

13.3.3 Enhancing animal feeds using pasture grass conservation and preservation

Background

Due to the changing weather, feed and pasture quantity and quality has reduced. The cattle corridor of the south western Agro-ecological zone in Uganda is among the communities that were greatly affected by lack of feed/pasture. In 2009, MbaZARDI embarked on a project dubbed; "Pasture Conservation and Preservation", which aimed at addressing this challenge. The project noted that many farmers were lacking feeds for their animals especially during the dry months. Researchers then embarked on the process

of improving animal health through good feeding and management. Precisely, 80% of the farmers in the region were suffering from limited feeds during drought periods causing a reduction in milk production.

The intervention

The intervention focused on preservation and conservation of grass during dry season i.e. silage and hay. Planting of pasture grasses like Cloris gayana, providing pasture seed, proper cutting, feeding and conservation of pastures were also emphasised. This came after several consultations from National Livestock Resources Research Institute (NALIRRI) on adaptive research and pasture development. In 2011, NARO started dissemination and extension of the technology. Mbarara ZARDI's role was production of viable pasture seed with over 70% germination rate in the region, building the capacity of farmers and technical backstopping. Information on the project was disseminated using brochures, radio talk shows, Orumuri Newspaper, publications/conference papers and video documentaries.

Success Factors

The major factor responsible for successful development of the technology was availability of funds and human capacity. Dissemination was enabled by factors like increased productivity and group marketing.

Various partners were involved in the project i.e. NAADS in up-scaling the technology, capacity building and co- funding the project. This intervention attracted funding from Netherlands Development Organisation (SNV) for 50-100 farmers to ensure dry season availability of hay. While East African Agricultural Productivity Programme (EAAPP) helped in pasture seed multiplication and capacity building of the farmers/stakeholders. Government and political leaders helped to provide support through increased publicity, funding and easing dissemination. The technology was spread beyond the zonal districts to as far as Kapchorwa and Sironko (Buginyanya) districts.

Outcome

Three years after introducing and disseminating the technology people's incomes increased and others could afford cars. Animals were now more assured of feeds leading to increased milk sales. A case in point is the Kiruhura farmers who realized the highest pasture and milk sales. Economic impact was observed by farmers paddocking their animals; this led to limited animal movement hence reduction of conflicts. The pasture conservation project led to a tractor scheme where pasture farmers were given tractors for pasture production enhancement by the President of Uganda under cost-sharing by districts on 10th March 2017.

Fig. 37 Martin Tusienge (Agroforestry and fruits volunteer) creates a trap for fruit flies at one of the mango farms established in 2012 and 2013 in Kiruhura Distict.



MUKONO Zonal Agricultural Research and Development Institute



Chapter 14
MUKONO ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (MUZARDI)

14.1 Background

Mukono Zonal Agricultural Research and Development Institute (MuZARDI) is mandated to conduct adaptive Research and technology dissemination in the Lake Victoria Crescent Agro-ecological zones. It was established by the NARS Act of 2005. It covers 21 districts of Central Uganda which include: Mubende, Mityana, Luwero, Kyankwanzi, Mukono, Kayunga, Nakasongola, Nakaseke, Masaka, Kalangala, Buikwe, Kalungu, Lwengo, Mpigi, Kampala, Bukomansimbi, Gomba, Butambala, Buvuma, Wakiso and Kiboga. Mukono ZARDI had a successful transition from a DFI to ARDC and it is now a semi-autonomous zonal Institute.

The institute is mandated to coordinate and conduct applied and adaptive research, and disseminate technologies, specific to South–western agro-ecological zones.

14.2 Institutional changes and their impact on delivery of the mandate

MuZARDI evolved from a District Farm Institute (DFI) to an Agricultural Research and Development Centre (ARDC) and finally to a Zonal Agricultural Research and Development Institute (MUZARDI) serving 21 districts. The Institute formerly had a few staff but currently it has several staff in different disciplines like Crop entomology, agronomy, rural sociology, livestock health, aquaculture, agro-forestry, pathology, soil science, socio-economics and several support staff. Staff capacity includes (scholars), 7 Masters, 8 bachelors degrees and 5 Diploma holders. These are also categorized into NARO employed and project staff.

14.3 Top successful interventions as identified by MuZARDI

1. Improving Market access for Pineapple Chain Actors using the Participatory Market Chain Approach (PMCA) in Uganda
2. Increasing the capacity of smallholder farmers to produce and market leafy green vegetable crops in Uganda
3. Urban and Peri-urban farming for enhanced income, food security and nutrition
4. Enhancing Nutrition in Primary schools

14.3.1 Improving Market access for Pineapple Value Chain Actors using the Participatory Market Chain Approach (PMCA) in Uganda

Background

Pineapple contributes over 20% of the world production of tropical fruits and 70% of it is consumed in fresh form in the main producing countries (Coveca, 2002). In Uganda, the fruit has gained commercial importance especially in Luwero and Kayunga districts. It is currently the most widely grown fruit in Uganda with the current production of 1,600MT fresh pineapple (FAOSTAT, 2009). Uganda's pineapples are sweeter and less acidic; so they have a competitive advantage compared to other countries in the East African region. However, its production and marketing is limited by quality of planting materials, high perishability, inadequate management skills and product development. There was need to address these challenges to improve the competitiveness of the pineapple value chain using innovative research approaches.

The intervention

NARO through Mukono Zonal Agricultural Research and Development Institute (MUZARDI) implemented and coordinated a 3-year research and development collaborative project with three partner organizations; NaCRRI, Agri-net Uganda Ltd and VEDCO in Bushenyi, Kampala, Iganga and Luwero districts. Project partners employed the Participatory Market Chain Approach (PMCA) as a proven and innovative methodology to establish a platform of 56 actors and build their capacity to more efficiently and sustainably participate in the pineapple value chain.

Beneficiaries

The project worked directly with 56 market chain actors and their family members; estimated at 336 indirect beneficiaries. The actors consisted of farmers, traders, processors, extension workers, NGO, CBOs and researchers. The approach assisted actors to identify and implement viable market opportunities which led to joint pro-poor innovations. The participatory processes ultimately stimulated interest, trust and collaboration amongst members of the market chain. Various pineapple value chain partners including SNV Uganda, NAADS, Bushenyi District Local Government (DLG), ABi-trust, UIRI, EnvAlert, UNBS, RUCID, NOGAMU Agri-net Uganda Ltd and VEDCO engaged in knowledge sharing and learning processes. As a result of these interactions, four pineapple products namely

RUCID pineapple juice, slynyas and chips and BRISK pineapple juice were improved for the local market.

Six market chain actors (MCAs) were trained in collaboration with UIRI in pineapple pulp processing, while 54 MCA's were trained in pineapple juice processing, conducting market research and conventional sucker multiplication. NARO linked Sarmalina Beverages Ltd (BRISK) to Lusanja Organic farmers' group in Luwero. The group supplied 300-500 pineapples per week culminating in a gross income of 0.75 million shillings.

Success Factors

A cross section of stakeholders along the commodity chain contributed to the success. The rich interaction, information sharing and learning, technical and financial resources, greatly contributed to attaining the set goal.

14.3.2 Urban and peri-urban farming for enhanced income, food security and nutrition

Background

Urban and Peri-urban (UAP) farming refers to the production of food in and around towns or cities. It is usually done in small areas due to limited and costly land in such areas. Over 50% of the world population is currently estimated to live in urban areas. However, food security in urban areas remains a challenge, particularly for the urban poor. Given that land is limited for city and town dwellers, intensive integrated resource management, innovations and strategies are vital for optimizing productivity of any agricultural enterprise. It is on this basis that NARO came up with innovations and interventions to improve the livelihoods of urban and Peri-urban farmers.

The intervention

MuZARDI spearheaded this initiative from problem identification, proposal development through to its implementation. As a result, innovations such as home gardening (also known as backyard or kitchen gardening) were introduced to urban and peri-urban farmers. Trials were conducted by MUZARDI to establish the most appropriate micro-gardens for enhanced productivity and profitability of selected vegetables including tomatoes and Nakati. Micro-gardens include food towers, sacks, buckets, wooden boxes and ridges to mention but a few. This initiative stands out because it can be done in the backyard or any small space hence making every available space productive.

This intervention was implemented in partnership with District Officials, the Agricultural Department of Kampala City Council Authority (KCCA). Other partners included NGOs like Parents Empowering Children and Youth Uganda (PEYCU), Reach One Touch One Ministries (ROTOM) and Camp Green International in three districts; Kampala, Wakiso and Masaka. These partners mainly focused on extension and creating a knowledge school. MUZARDI coordinated resource mobilization, information material development, distribution and farmer training in key aspects of urban farming.

Beneficiaries

Urban and Peri-urban farmers mainly women, elderly persons, pupils and students in the project areas were the main targets. Dissemination activities were done both within and outside the target districts. Over 1300 urban farmers have benefited from this technology both directly and indirectly. Establishment of demonstrations as well as production and distribution of information materials for instance during trainings and exhibitions were the major approaches employed during dissemination and outreach activities. Spillover effects from this initiative reached as far as Kiboga, Jinja, Lira, Mukono and Lwengo districts.

Success Factors

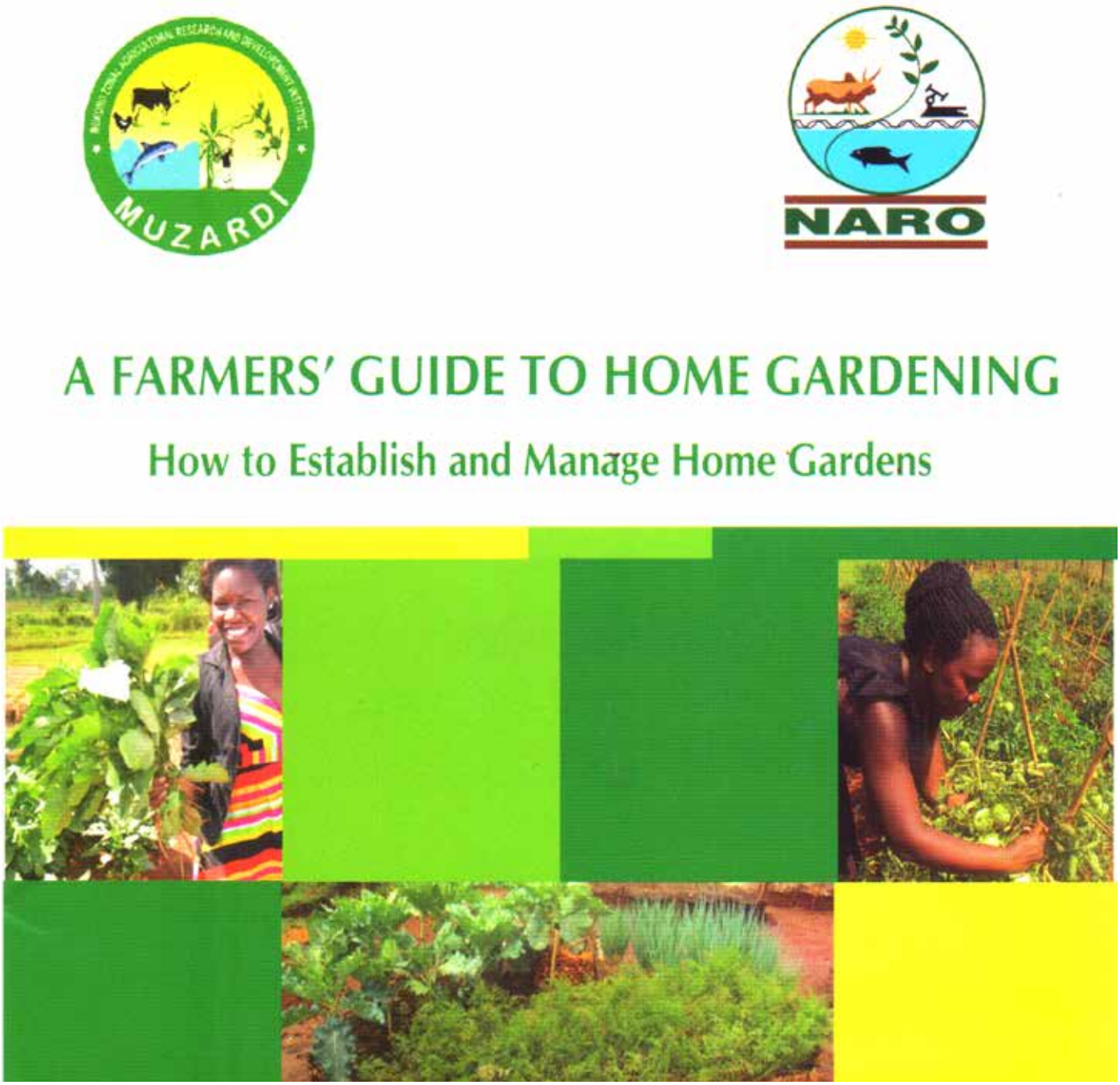
The intervention was mainly successful due to a number of factors including but not limited to availability of funds, willingness/good will from partners to receive advice, team work, demand by the community and use of schools as dissemination channels. Like any other intervention, implementation came along with a number of bottlenecks like inadequate funds.

Outcome

As a result of this intervention, Urban and peri-urban farmers are able to grow vegetables for improved nutrition, food security and income all year round. There is access to home produced food hence reducing food insecurity incidences and providing cash for purchasing other food supplies. Agriculture teachers, students and pupils also gained knowledge during training activities. A case in point is Ms. Babirye Harriet, an urban farmer from Entebbe, Wakiso district who is a beneficiary of this intervention. She lives on a 100 x 80ft plot of land but in spite of the limited space available to her; she practices home gardening in various forms. She grows tomatoes on 20 x30ft, has a food tower, hanging and potted gardens of various vegetables including colewort (sukuma wiki), spring onions, green pepper and eggplants. Apart from providing food and nutrition for her family, she also earns about Ugx. 280,000/= (USD77) monthly from the sale of products from her garden.

Impacts of the project range from social, economic to environmental. For instance, some farmers were able to share their produce with their neighbors, while others sold the extra thereby boosting their income. Farmers were also taught how to separate organic waste from inorganic waste, leading to improved waste disposal in the target areas.

Fig. 38 Farmers guide to home gardening



14.3.3 Increasing the capacity of smallholder farmers to produce and market leafy green vegetable crops in Uganda

Background

The increasing demand for high-quality horticultural goods at local, national and regional levels offered a big opportunity to farmers to increase their income and improve their livelihoods. But this remains a theory until smallholder farmers are supported to produce larger quantities and quality horticultural products and are able to reach favorable markets. This called for market players to come together to address the challenges of poor coordination and linkages among different actors in the leafy vegetable market chain to enhance interaction, promote knowledge sharing and enhance social learning by engaging actors.

The intervention

MuZARDI embarked on the Horticultural Collaborative Research Support Project (HortCRSP) to identify and implement activities to address challenges of production and marketing of leafy Vegetables. MuZARDI generated technological, institutional and commercial innovations, and built the capacity of market chain actors (farmers, traders and processors) to help identify market opportunities and produce competitive products.

Beneficiaries

The project that was carried out in Buikwe and Mukono Districts was implemented in partnership with the Rural Agency for Sustainable Development, Makerere University, Uganda Christian University, Buikwe and Mukono District Local Governments and the University of California, Davis. Three groups were

formed following themes like Seed Production and Processing, fresh Leafy Vegetable Production and Leafy Vegetable Processing. An innovation platform for interaction and sharing experiences and knowledge was formed and this brought together about 54 actors in the indigenous leafy vegetable market chain.

Outcome

The process triggered commercial and institutional innovations including; formation of "Nkokonjeru seed farmer group - a community based seed group as well as Nakati flour, Nakati Baghia and composite Nakati peanut paste developed and branded for the local market. The seed group focuses on production, processing and supply of quality indigenous leafy vegetable seed. At the community level, the farmers collectively package their seed in small packs which are labeled for the local market. Currently, the group supplies seed of leafy vegetables to seed companies (SIMLAW) and is working with CABI to have their seed business certified.

Challenges

Through its span, the project faced challenges like identifying feasible and practical innovations and keeping the Actors on the platform active. These were overcome through seeking for viable opinions from the actors and advocating for continuous linkage and interaction among actors.

Fig.39 Urban agricultural practices



14.3.4 Improving nutrition among primary schools in central districts of Uganda

Background

Food and good nutrition are basic needs that one needs to have to survive. Approximately 300 million children stay hungry in the world. Organizations like World Food programme observed that food attracts hungry children to school. "One successful method to ensuring that children attend school on a regular basis is through school feeding programs". School feeding programs have proven a huge success because not only does the attendance increase, but in areas where food is scarce and malnutrition is extensive, the food that children are receiving at school can prove to be a critical source of nutrition. School meals have led to improved concentration and performance of children in school. *(WFP report).* In Uganda several primary school pupils almost go hungry with sometimes a cup of porridge or nothing to eat the entire day. It is upon this basis that a school outreach programme was started to contribute to food security, nutrition and to provide skills to the young.

The intervention

MUZARDI began coordinating an outreach programme seven years ago that provides technical training in modern crop management. The programme has been implemented in partnership with district local governments, both the Education and Agriculture departments and school managements. The key objective of the programme was training the young generation in modern farming practices and improving nutrition among the school going children. Participating schools were selected basing on a criteria; including all religious denominations, availability of land, private and boarding and Universal primary education.

Beneficiaries

The programme was implemented in Mukono, Kayunga, Buikwe, Luwero and Kalungu where five schools were selected per district. The participating schools provided land where crops were grown and labour. This encouraged the pupils to practically participate in the planting of crops. Technologies of bananas (Mbwazirume, Kisansa, M9 and Mpologoma), fruit trees of Pawpaws and mangoes and vegetables such as Nakati, Bugga, jjobyo, sukuma wiki and egg plants were disseminated. Over 7500 pupils and parents have been reached.

Outcome

Nutrition of participating schools was improved as lunch was now served to pupils who never used to have lunch especially for UPE schools. The Head teacher Kazansaya primary school reported that pupils could now get a cup of porridge and teachers' lunch was organised since food was available. Pupils could also share a meal when more bunches of bananas were harvested. The district local government in Kalungu formed a club of participating schools where they hope to involve other schools that were not part of the programme. This will make the program reach more schools in the districts. District local government staff as a result of the programme in Buikwe began incorporating a similar programme in their budgets for funding from both government and potential donors. It was observed that parents who visit the school gardens are now taking up the challenge to learn from what their children teach them, hence making the project a community program. In that way suckers from the planted banana gardens are also obtained and given to parents who in the end improve their household food security.



Chapter 15
NABUIN ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE –NABUIN ZARDI

15.1 Background

Nabuin is one of the 16 Public Agricultural Research institutes under the National Agricultural Research Organisation established by National Agricultural Research (NAR) Act (2005) stationed in Lorengedwat sub-county, Nakapiripirit district.

The institute is mandated to conduct & manage adaptive & applied agricultural research & facilitate development & dissemination of appropriate agricultural technologies that address the specific needs of the North-Eastern Dry Agro-ecological zone of Teso & Karamoja.

The zone comprises of 15 districts of Nakapiripirit, Moroto, Abim, Napak, Kaabong, Amudat, Serere, Soroti, Amuria, Katakwi, Bukedea, Kaberamaido, Ngora, Kotido & Kumi.

Nabuin started as a government institute in early 1963, to serve the then greater Karamoja district with knowledge & extension services in agriculture. However, during the 1979 political unrest & subsequent years, the centre was vandalized as its entire infrastructure was completely destroyed & therefore ceased operations.

15.2 Institutional changes and their impact on delivery of the mandate

Following various reforms in Agricultural Research, NAR Act (2005) re-established Nabuin as a semi-autonomous ZARDI catering for the Northern & Eastern Agro-ecological zone of Karamoja & Teso. Nabuin resumed its operations from Serere (former District Farm Institute) because of insecurity & lack of infrastructure at its current station in Lorengedwat, Nakapiripirit district. However, in 2010 Nabuin ZARDI opened a main office in Moroto district to operate closer & develop its infrastructure at Nabuin station. In 2015, Nabuin ZARDI moved all its operations to Nabuin station in Lorengedwat sub-county, Nakapiripirit district.

Its transformation from a District Farm Institute status to a ZARDI widened its scope to include Teso & Karamoja sub regions, serving 15 districts while shifting operations from Serere to Nabuin station has enabled Nabuin ZARDI to address the problems (such as drought) of Karamoja better. The change also attracted more funding opportunities as well as increased staffing (10 staff in 2007 to 33 staff). Infrastructure has been upgraded to include construction of laboratories, solar powered water supply, staff houses, screen houses, stores & offices all of which greatly contribute to generation of more agricultural technologies.

Nabuin ZARDI comprises of scientists, technicians, Admin Assistants, Finance Officers, Internal Auditor, Accounts Assistants, Human Resources Officer, Drivers, Development Communication Officer & support staff. Of these 4 staff are PhD scholars (3 males & 1 female), 1 staff (male) pursuing Master's degree, 1 staff pursuing Diploma in Agricultural Technology, multiple short courses in data analysis, management and agronomic practices. The institute also facilitates inter-institute induction and mentorship programs to further build staff capacity and increase performance on the job.

15.3 Top successful interventions as identified by Nabuin ZARDI

1. Seed multiplication increases incomes.
2. Increased awareness of cover crops for improved soil fertility and crop yields.
3. Improved availability & quality of forage for all year round animal feeding.

15.3.1 Multiplication and production of quality seed

Background

The entire Teso and Karamojong sub-regions had very limited supply of quality seeds. The seed companies such as Victoria seeds, NASECO and Simlaw were not active in the area to supply farmers with quality seeds. Worse still, about 80% of seed availed by government and NGOs (FAO) were being used for food not for planting. This resulted in food insecurity, famine and starvation. The above situation justified the intervention so as to reverse the trend.

The intervention

Nabuin ZARDI came in to address the challenge by multiplying seeds such as maize (MM3, VP Max and Longe), beans (NABE 15, NABE4 and Tapara beans) & sorghum (Seso3 & Epuripur). In 2013, thorough consultations were conducted with the relevant stakeholders including communities, opinion leaders, district local governments, OPM and NGOs which identified the gap for intervention and an implementation plan was drawn. Identification of the existing farmer groups to participate in the farmer field school, establishment of demos, training communities, Agricultural Extension Staff and staff of partner NGOs on seed multiplication technology were conducted. Farmers then replicated the technology in their fields

to produce quality seeds for planting. As a result, farmers started to produce their own quality seed other than over reliance on seed companies notes Dr. Okullo Paul, Director of research – Nabuin ZARDI. NARO empowered farmers in the region by providing planting materials (particularly breeder seeds that were difficult for local farmers to access).

Beneficiaries

Multiple platforms and approaches like radio talk shows, face to face explanations, brochures and on-station demonstrations were employed to disseminate the intervention within Moroto, Napak, and Nakapiripirit districts and Ike land. As a result, over 60% of the farming communities in Karamoja & Teso sub-regions benefited from the intervention.

Success Factors

Key success factors include high demand by farmers, participatory approach in the research process, availability of land for setting demonstration sites in different locations, adequate funding, political security provided by Ugandan government, strategic networks.

Outcome

Self-reliance in seed production and increased food availability brought about abundance of quality seed. Improved wellbeing, higher incomes from seed multiplication, diversification of the farming system (reduced reliance on cattle keeping as source of livelihood) were also attained. In addition, there was improved vegetation cover, and food security among the farming communities. This was made possible by higher incomes realised by lead farmers and ability to meet basic needs. Employment opportunities sprouted as group members took up seed multiplication as full time job (mechanization and commercialization of seed production).

15.3.2 Increased awareness of cover crops for improved soil fertility and crop yields

Background

Research shows that 50% of farmers obtained extremely low yields (1-2 sacks per acre) of cereal crops. This is attributed to degraded soils brought about by the limited vegetation cover, which exposes fields to soil erosion during rainy season and wind erosion during the dry spell. This resulted into persistent food insecurity characterized by famine, low household income and poor nutrition in the entire Karamoja and Teso sub-regions. In 2009, Nabuin ZARDI identified the need to generate a technology that would conserve the soil as well as improving its agricultural productivity during a priority setting meeting with stakeholders (district local governments, farmers, NGOs).

The intervention

The development and multiplication of suitable varieties of cover crops (jack beans, velvet beans and tephrosa) was initiated in 2010. The process involved collection of germplasm from Bulindi ZARDI and forests, laboratory analysis of soil samples drawn from the different areas of Teso and Karamoja perceived as degraded. Demonstration gardens (both on-station and in communities) were established. In order to come up with suitable/recommended species, soil fertility samples were analysed. This intervention was considered to be affordable and environmentally friendly compared to use of inorganic fertilizers. Capacity building and training sessions of both extension services providers and farmers was conducted. Rigorous publicity and dissemination activities were also undertaken to ensure wide adoption of the technology.

Beneficiaries

Although the intervention targeted farmers in Karamoja and Teso regions covering districts like Ngora, Kaberamaido, Kotido, Amuria, Nakapiripirit and Jinja, the benefits spilled over to more districts. It's estimated that 70% of the farming communities in Karamoja and Teso sub-regions benefited from this intervention from its inception to date.

Success Factors

Notably, adequate time allocated to the research process, community participation throughout the technology development process. In addition, strong and strategic partnerships, and access to free radio airtime which made reaching farmers in distant locations easy greatly contributed to this success. Other factors include affordability by resource poor farmers, and uniqueness in the sense that it improves soil fertility as well as crop yields better than the expensive inorganic fertilizers.

Outcomes

This intervention exposed the community to a change of attitude from bush burning to planting of cover crops. This led to improved soil fertility, soil conservation and increased productivity. Improved nutrition and well-being among farming communities due to high quality and better yields of crops was noticed. Farmers in Teso sub-region started having more meals while their counterparts in Karamoja sub-region now boast of 2 meals a day instead of only one they used to have before the intervention. Higher incomes were registered from sale of seeds to NAADS among others. e.g. Odongo James in Amuria got 500,000 UGX from selling 1 sack (100 kgs) of beans with a kilogram of beans going at 5,000 UGX. Improved biodiversity in

project sites as a result of increased vegetation cover was recoded.

15.3.3 Multiplication of quality of forage species for all year round animal feeding

Background

Karamoja region is known to be an agro-pastoralist area and the principle way of life in the region is pastoralism. The region has limited or no pasture for animals during the dry season and as a result cattle keepers move from one place to another in search of pasture (nomadic pastoralism) in Karamoja and Teso sub-regions. Movements lead to loss of animal weight, reduced milk yield, poor quality milk and meat and death. In additional, there is growing demand for milk and meat in the region but production capacity remained low due to poor quality pasture. Therefore, there was need for a technology to improve both the quality and quantity of milk and meat production in the two sub-regions.

As has been the case in earlier interventions which are demand driven, this particular gap was identified during the NARO priority setting exercise of 2007 by multiple stakeholders. The process involved identification of appropriate pasture species for the agro-ecological zone, establishing pasture multiplication gardens, evaluation of performance both on-station & on-farm with the communities, preservation (harvesting, simple drying & packing and finally training farmers how make hay and to feed animals with hay. The technology is handy for the region because it avails animals with adequate nutrients all year around.

Beneficiaries

Various dissemination activities were rolled out in surrounding districts of Moroto, Napak, Nakapiripirit, Katakwi, Amuria since inception to date. As a result of this intervention, over 3,000 livestock keepers in Teso & Karamoja sub-regions have and continue to feed their cattle all year round.

The intervention



Fig. 40 Baling of dried hay using a box and strings.

Success Factors

The enormous success registered by this intervention is owed to adequate funding, overwhelming demand by communities, strategic collaborations and networks, political security provided by government, multiple technology dissemination approaches used among others. Wide adoption was supported by regular radio talk shows, developing information materials, farmer field schools, and exhibitions during agricultural shows (Karamoja and Source of the Nile agricultural trade show).

Outcome

After introducing this technology to the communities, livestock rearing system is changing from nomadic to semi-intensive method; beneficiaries started producing pastures for commercial purposes unlike in the past, body growth and improved wellbeing accruing from regular intake of both quality meat & milk. Farmers are registering improved levels of income brought about by sales from meat, milk & feeds, reduced animal mortality rates hence more animals available for sales & therefore better profits. Ultimately, there is reduced degradation of rangelands due to shift from nomadic way of keeping animals to semi-intensive method (reduced pressure on rangelands) and employment opportunities to community based trainers in Kotido district being paid by CARITAS Kotido.

Ngetta Zonal Agricultural Research and Development Institute



Chapter 16
NGETTA ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (NGETTA ZARDI)

16.1 Background

Ngetta Zonal Agricultural Research and Development Institute started way back in the 1930s and was used as a settlement and re-orientation site for war veterans during the post-world war II period. Later in the 50s, the colonial government transferred its management to the department of agriculture for purposes of teaching farmers around the center better farming practices with more focus on cotton production. The director of the institute; Dr. Laban Turyagyenda explains that after independence, government upgraded it to a district farm institute under the ministry of agriculture serving farmers in the then Lango district.

The mandate of NgeZARDI is to undertake adaptive and applied research in all aspects of crop, livestock, fisheries, and agroforestry and disseminate improved agricultural technologies of specific importance to the Northern agro-ecological zone.

To achieve this mandate, the institute develops and promotes demand driven and market responsive technologies and ensures efficiency and effectiveness in collaboration with stakeholders under its programs namely; Crop Research and Development, Livestock and Aquaculture Research and Development, and lastly Natural Resources Research and Development.

16.2 Institutional changes and their impact on delivery of the mandate

With coming into force of the NARS Act of 2005, Ngetta ARDC became a zonal Agricultural Research and Development Institute. Ngetta sits on over 700 acres of land and has undergone several transformations in naming, core research mandates and activities. The institute also boasts of a satellite station located at the former Kitgum ARDC on the outskirts of Kitgum town. As a public agricultural research institute, Ngetta ZARDI is a semi-autonomous institute under the supervision and guidance of a management committee. Under this arrangement, the institute is mandated to manage and carry out applied and adaptive research in all aspects of crops, livestock, fisheries, and agroforestry. The institute disseminates improved agricultural technologies of specific importance to the Northern agro-ecological zone. The ZARDI operates in 16 districts, eight of which are in in Lango sub-region, including Amolatar, Alebtong, Apac, Dokolo, Kole, Lira, Oyam and Otuke, while eight in Acholi sub-region (Agago, Amuru, Gulu, Kitgum, Lamwo, Nwoya, Pader and Omoro). The main station is based in Lira district 5 km from lira town along Kitgum road.

16.3 Top successful interventions as identified by Ngetta ZARDI

1. Controlling citrus leaf spot disease/citrus canker disease.
2. Domestication of shea nut tree.
3. Commercialization of Pigeon pea.
4. Commercialization of Sweet potato.

16.3.1 Controlling citrus leaf spot disease (citrus canker disease)

Background

Citrus leaf spot is a devastating foliar disease caused by bacteria that makes pre-mature leaves and fruits drop off the plant. It is spread by wind rain and people carrying infection on their hands, clothes or tools. Fruits can be attacked at all growing stages. In 2010, the region was attacked by an outbreak of Citrus Canker, one of the Citrus Leaf Spot diseases and there was no available intervention to help farmers. The disease being a recent entrant among diseases in the Northern Agro Ecological Zone (NAEZ), farmers lacked management options for the disease. Yield loss due to citrus canker was between 50 and 100%. Disease was first detected in Uganda in an orchard in Lira district in 2010 and then spread to all citrus growing areas in the region. Several measures were recommended including nursery and orchard inspections, quarantines, protective copper sprays and the on-site burning of infected trees to eradicate or reduce disease spread. These strategies were based on experience in controlling other crop diseases with similar epidemiology. Methods at the time were ineffective, costly and many farmers abandoned citrus growing due to the disease and ineffective control measures.

The intervention

Working with the Horticulture and Oil Palm program at NaCRRI and with funds from Agricultural Technology and Agri-business Advisory Services project (ATAAS), Ngetta ZARDI embarked on a strategy to rehabilitate diseased orchards of those farmers involved in orange farming. The intervention was in response to farmers' appeals. Ngetta ZARDI developed a technology: phyto-cultural practices using chemical strategy. None was existing before for combating Citrus Leaf Spot and Citrus Canker. During the technology development process, on-station trials were carried out in three orchards, with 90-100% of trees infected at the beginning of the experiment. They evaluated control measures for citrus canker. Complete severe bark horning of all

infected trees in the orchard at the beginning of the dry season (December) manifested. copper sprays (Copper oxychloride fungicide) were later applied and insecticide (Pyrinex) at a concentration of 0.2%. This aimed at restoring health to orchards which had been devastated with citrus canker. The disease is caused by bacterium Xanthomonas.

After validating the results, Ngetta ZARDI recommended Phyto-cultural practices including complete back horning and judicious spraying of copper based pesticides to control Citrus Canker.

Beneficiaries

A total of 22 farmers in Ngetta sub-county were supported. All are market oriented farmers with at least 6 acres of citrus each. So far, 120 people have been trained and eight farmers received technical expertise.

Success Factors

This intervention was unique because it had never been used elsewhere in the country hence making it an innovation. The technology was adopted and now being used by everyone in the region due to deliberate efforts to popularize it by NgeZARDI and partners.

16.3.2 Domestication of the Shea nut tree

Background

For most people of the northern parts of Uganda, especially women, who have the responsibility to supply the daily food intake for their families, the shea tree provides a good source of food – the shea fruit. This is especially so, because the ripening of the fruits coincides with the lean season of food production. Shea nut is known to be naturally rich in Vitamins A, E, and F, as well as a number of other vitamins and minerals. Vitamins A and E help to soothe, hydrate, and balance the skin.

The shea tree grows naturally in the wild in the dry Savannah belt of West Africa from Senegal in the west to Sudan in the east, and onto the foothills of the Ethiopian highlands.

In Northern Uganda, it grows in almost all the districts both in Lango and Acholi sub-region. In the recent past, farmers from other parts of the country like central and eastern sub-regions have started to demand for the seedlings. Once the shea tree survives the first five years of its early stages of germination and growth, it grows slowly and takes about 30 years to reach maturity and from here, it can live for up to 300 years. In the absence of any hazards, including tree felling, it can bear fruit for 200 years. The shea tree has no capacity for propagation regeneration, and therefore, can only be grown by seed.

The intervention

To address the seedling challenge, the breakthrough by the scientists at Ngetta ZARDI to modify the shea tree have until now not been successful. “We are also encouraging farmers to protect the wild growing shea nut trees from bushfires as a means of conserving their species from destruction. Reducing the maturity period of the crop from 20 to 7 years is a huge incentive to farmers in the shea nut industry,” explained Gloria Mutoni. Mutoni, an agro-forestry technician working at Ngetta ZARDI noted that farmers will soon be availed with tissue cultured shea nut seedlings, a move that we believe will be a great move in the right direction regarding the growth of the shea nut industry. The seedlings can be accessed by all interested farmers from the research institute at a pocket friendly fee of shs.5000 per seedling.

Success Factors

All the district local governments were encouraged to enact by-laws with punitive measures of all culprits caught cutting down this precious tree. Nursery beds with capacity of about 50,000 seedlings were also established.

Outcome

The shea nut tree has many uses, both economic and cultural benefits. The economic importance of the shea tree cannot be over emphasized, especially in the face of the unstable world market price for cocoa and the need to find suitable substitutes for cocoa in the confectionery and cocoa butter industry. The mature kernel contains about 61% fat which when extracted is edible, and can serve medicinal as well as industrial purposes. Research shows that the shea tree is the second most important oil crop in Africa after the palm oil tree. After the oil is extracted, the residue serves as excellent fuel, and can also be mixed with mud for plastering traditional mud huts. There is untapped capacity for producing copious amounts of sap that can constitute an important source of raw material for the gum and rubber industry. It is estimated that about one million shea trees are in Uganda, and these can potentially yield 300 tons shea nuts worth about UGX 50m to sh100 million per year.

16.3.3 Commercialization of Pigeon pea

Background

In northern Uganda pigeon pea is eaten either as grain or mashed into a sauce, taken with millet bread or sweet potatoes and spiced with Shea nut oil (moo yao). Pigeon pea is essentially a smallholder crop, grown on poor soils in drought-prone areas, where its ability to tolerate dry spells and harsh conditions can be a key factor in household food security. Pigeon pea, through nitrogen fixation and leaf fall, also provides substantial quantities of nutrients into the soil, benefiting subsequent crops grown in the same field. Traditional varieties are generally intercropped

with food crops such as maize, sorghum, beans, and cowpea, and non-food crops such as cotton. Low input requirements make the crop particularly suitable for the smallholder farming system.

The intervention

Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI) in partnership with International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) implemented a project on "Enhancing Productivity of Pigeon pea in Uganda" with funding from EC-IFAD in the Northern Agro-Ecological Zone (NAEZ). The main objective of this project was to promote pigeon pea cultivation among smallholder farmers in Uganda. When the project started 2012, the two pigeon pea varieties, SEPI-I (KAT 60/8) and SEPI-II (ICPL 87091) that were released in 1999 had been contaminated and pure seed could not be got. Currently, four medium-duration varieties (ICEAPs 00540, 00554, 00557 and 00850) through Farmer Participatory Varietal Selection (FPVS) trials were identified and are in their final year of National Performance Trials (NPT), from which two of them were released.

Feedback from farmers who participated in the selection of the new lines revealed that these new varieties took shorter time (5 months) from planting to harvest unlike the traditional types that takes 9 months. In addition, these new lines take a much shorter timer to get ready when cooking. Many farmers indicated that they got two harvests a year and as a result got twice as much income from the two harvests. Women reported that they spent less time in the food preparation and also less fuel/ firewood used in cooking new pigeon pea lines. This gives the women more time to rest or attend to other household chores.

Beneficiaries

With these new varieties, more farmers are getting interested in growing pigeon pea for commercial purposes because of the demand for the new varieties. This has been possible because NgeZARDI together with Integrated Seed Sector Development purified SEPI 1 and provided foundation seed for farmers. In Alebtong district, 460 kg of foundation seeds was bought by Note Ber Famer groups in Angetta and Abukamola Parishes in Omoro sub-county for seed multiplication. Each area (village) was assigned for multiplication of a particular variety. The total area of seed multiplication was 75 ha, and a total of 60 MT of pigeon pea seed was produced. With the rate of 4,000/= per kilogram, a total of 240 million was raised. The market for pigeon pea has also grown with buyers coming from as far as India and Kenya making it more viable than before. In 2015 season a kilogram of pigeon pea ranged from 4,000/= to 5,000/= in the local markets. There is also a steady growing market for crop after the introduction of the new Pigeon pea varieties that have bold and cream grains. With proper organization, farmers should be able to earn a lot more from the sale of their pigeon pea to international markets.

Outcome

With the introduction of these new varieties there has been a diversification in the way pigeonpea is prepared and consumed. The aspect of value addition of the product has provided alternatives to consumers. Through Ngetta ZARDI, farmers are now marketing pigeon pea splits and flour. The flour is used to make porridge, mandazis or bagiya. This provides alternative ways to consume pigeon pea. The buying and selling pigeon pea grain and other by-products (split and flour) is slowly turning into a viable business venture for not only the farmers involved in growing pigeon peas, but also youths and other people who live in urban centers.

16.3.4 Commercialization of Sweet potato

Background

Sweet potato ranks third in importance as a staple food after bananas and cassava in Uganda. Ugandans consume an average of 85 kilograms of sweet potatoes per year, the third-highest level of any country in the world. Back in the day farmers used to request for sweet potato vines from a neighbor and get it free of charge. However, Agriculture is now being taken as a business thus demand for quality planting materials is increasing.

The intervention

Ngetta ZARDI has been implementing commercialization of sweet potato vine multiplication in areas with long dry periods in collaboration with National Resources Institute and the University of Greenwich for the last three years. The farmers involved are in districts of Gulu, Lira, Apac and Arua. The demand for vines in these districts is created by lack of planting material at the start of the rain season that is triggered by long dry season of about 4 months starting in late November up to March and worsened by stray animals during this time. This creates a situation in which by the time the rains return, there is lack of planting material for the farmers. This gap provided a business opportunity for vine multipliers in Northern Uganda who were trained through the commercialization of sweet potato growing initiative.

Before this initiative, it would take 10 years for new varieties to reach the farmers as a result most farmers were growing local land races leading to low production. Ngetta ZARDI boosted the sweet potato production system in project areas in northern Uganda by introducing improved new sweet potato varieties such as NASPOT 8, NASPOT 10, NASPOT 11, NASPOT

12, NASPOT 13 and New Dimbuka. These varieties that were released by NARO to boost sweet potato growing fight food insecurity whilst providing nutritional value as well to Ugandans. Vine multipliers conserve the vines during the long dry spells in the low lands/ wetlands and start selling these vines to other sweet potato farmers for planting at the onset of rains. The bulk of the sales are from June to September. Through planting sweet potato for vine multiplication in the lowlands, a constant supply of clean planting materials is available to farmers all year round and also an avenue for brisk business for the vine multipliers.

Beneficiaries

Ngetta ZARDI identified and trained farmers in sweetpotato vine multiplication and agronomic practices to increase production. Areas covered included Bungatira and Unyama sub-counties in Gulu, Cegere in Apac and Mandiba in Arua districts. Through participatory variety evaluation and selection, farmers selected and adopted the new varieties.



Fig. 41A. Women selling sweet potato vines;

There are a number of women most of whom are widows and single mothers who are directly employed in growing and selling sweet potatoes as a business. They grow the sweet potato for sale, enabling them to have control of the harvest of the roots and the vines as well. This means that they are able to make a lot more money because they control the process right from the garden to the market.

In Arua, women selling sweet potato vines and roots are found in Obatini Junction while in Gulu they are located along Diplomat Street. In Gulu, are about 20 women who have come together and are earning from sweet potato as a business. They sell sweet potato vines to customers from as far as Kitgum, Amuru and Agago. A bundle of sweet potatoe vines is being sold at 5,000/=, while in Arua it's going for 3,000/= a bundle.

The business has now spread to the districts of Kitgum, Nwoya, Amuru, Adjumani, Moyo, Nebbi,Yumbe, Maracha, Koboko, Kitgum, Kole, Congo and South Sudan besides the initial 4 districts where this project is operating.



Fig. 41B. Women selling sweet potato and vines

Beatrice Akello is a sweet potato farmer in Gulu district; she too has been able to put up a brick house from returns got from the selling potato vines and roots. (The house is not yet complete but she is hopeful to roof it soon). Currently she is living in a mud and wattle hut with her family and believes that the quality of life that her family is heading to is getting much better due to the benefits of her labour as a sweet potato vine multiplier. The hut that Beatrice and her family live in is quite small and congested but with the new building almost complete all this will be history for the family, as they move from a mud and wattle grass thatched hut to her new brick and cement house.



Fig. 42B Before engaging in sweetpotato; B. After joining sweetpotato trading



Rwebitaba Zonal Agricultural Research and Development Institute

Chapter 17

RWEBITABA ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE (RWEBIZARDI)

17.1 Background

Rwebitaba Zonal Agricultural Research and Development Institute (Rwebitaba ZARDI) is one of the Public Agriculture Research Institutes under the regulation of the National Agricultural Research Organization (NARO).

It is mandated to undertake applied and adaptive agricultural research for the Western Highland agro-ecological zone.

The districts the institute serves include, Kyegegwa, Kyenjojo, Kabarole, Kamwenge, Kasese, Bundibugyo and Ntoroko.

The institute has two stations; Rwebitaba Tea Research Centre (TRC) located at Rwebitaba in Kyenjojo District which is 21 Km from Fort Portal town on Fort Portal-Kampala road with sole mandate of undertaking tea research. This centre sits on 69 hectares of land with over 300 different tea clones, tea seedlings and a field gene bank. Rwebitaba TRC, was established in 1960 as a branch of the Tea Research Institute of East Africa (TRIEA). TRIEA was the main tea breeding station before the collapse of the East African Community in 1977, which led to the closure of research activities in Uganda. TRIEA operations ended in 1978 leaving a lot of on-going research at Rwebitaba in the hands of Government of Uganda. The second station, sitting on over 200 hectares of land, is located at Kyembogo, off Kijura road in Kabarole district 8 Km from Fort Portal town where livestock and other crop research take place.

17.2 Institutional changes and their impact on delivery of the mandate

Following the establishment of the National Agriculture Research System (NARS) ACT 2005, the National Crops Resources Research Institute (NaCRRI) took over the administration of Rwebitaba in 2007 in order to revive tea research at Rwebitaba. To-date considerable research materials left by TRIEA have been recovered through rehabilitation of tea and field gene bank, improvement of infrastructure, provision of basic facilities and equipment, and initiation of priority on-station and on-farm research experiments. From July 1, 2011 NARO declared Rwebitaba a semi-autonomous Institute for the mid-western agro-ecological zone and has since inherited the activities of NaCRRI. Rwebitaba ZARDI runs four programs; Tea research Program, Crops Research program, Livestock and Fisheries Program and Livelihood and Farming Systems program.

17.3 Top successful interventions as identified by Rwebitaba ZARDI

1. Rwebitaba ZARDI boosts tea production in Uganda
2. NARO develops protocol for traceability of honey from Uganda

17.3.1 Rwebitaba ZARDI boosts tea production in Uganda

Background

A few years ago Tea companies based in Uganda used to cross the borders and part with over 8,340 US dollars (approximately 30 million Ugandan shillings) 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 as to produce quality tea that was marketable both locally and globally. This ostensibly expensive endeavor 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.

The intervention

Since Rwebitaba Zonal Agricultural Research and Development Institute (ZARDI) implemented a program on quality tea production through early stage appraisal for seed system in Uganda. The country's Tea industry has been significantly boosted. 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.

Beneficiaries

For example, between 2013 and 2016, the tea program at Rwebitaba ZARDI availed a total of 4 million cuttings of priority tea clones, namely; 6/8, 31/8, 108/82, 100/5 and 303/577 .Ten nursery operators and 6 large scale tea farmers in Kabarole and Kyenjojo districts benefited from this initiative. They in turn were 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.

NARO-Rwebitaba ZARDI has trained lead farmers,

extension officers and agricultural officers from all the thirteen tea growing districts of Uganda. Seven of these have been zoned for tea production trials, namely; Nebbi, Zombo, Kamwenge, Ntungamo, Kabale, Kisoro and Rubanda. The intervention is expanding with more trials being established in Kabale for possible upscaling in tea production innovations.

Outcome

There is 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.

Fig. 44 Tea Establishment in the field



17.3.2 NARO develops protocol for traceability of honey from Uganda

Background

As plant pollinators, honey bees play a very important role in agricultural and non-agricultural crop production. In addition, honey bee products hold important nutritional, medicinal, cosmetic and economic value to society.

Honey from Uganda is widely known for its superlative quality yet most beekeepers have been selling their honey without niche marketing. This has been a huge constraint in the value chain since it was difficult to ascertain the physico-chemical profile of Ugandan honeys.

The intervention

Under the developing innovative tools and technologies for increased beekeeping productivity in Uganda project, NARO designed an internationally acceptable protocol for traceability of honey from the country. In addition, NARO designed protocols for value addition and quality assurance.

Experiments conducted in the study involved investigations into the genetic variation in ten agro-ecological zones of Uganda which revealed the presence of two honey bee races, namely; *A.m. adansonii and A.m. scutellata*. The former is more widespread in the northern and eastern parts of the country while the latter is more widespread in the southern and western parts of the country. This was the first exhaustive population genetics research on bees in Uganda and the results are recommended for consideration while planning beekeeping activities in the country.

Outcome

Given the impactful project results, the NARO Competitive Grant Scheme tasked the project Principal Investigator (PI), Dr. Robert Kajobe to coordinate the development of a follow up proposal on commercialization of NARO bee products for possible funding.

Annexe 1

NATIONAL COFFEE RESEARCH INSTITUTE (NACORI)

Top successful interventions | NaCORI
Accelerated promotion of elite seed that can withstand drought and other hostile environments.
Better coffee management using the coffee management calendars | 2009
Black Coffee Twig Bore (BCTB) controlled using the BCTB management Kit (Phytosanitary with limited use of chemicals) | 2014
Coffee Inter-Cropping Systems: Coffee-Banana/legumes intercropping system. 1.2 million households growing Robusta coffee adopted the intercropping system | 1996
Development of crop management and commercialisation packages for the oil palm industry in Uganda.
Harmonisation and massive dissemination of extension materials such as training manuals on all aspect of coffee along the value chain.
Molecular diagnostic tools for coffee wilt disease.
Phytosanitary packages for tea wilt management | 2011
Release of seven novel varieties (Kituuza Robusta 1-7series). The varieties are resistant to coffee wilt disease | 1997-2009
Three tea varieties with higher yields and resistance to tea wilt disease released | 2015
UBIC – Common Concerns about GM Crops

List of Partners | NaCORI
Africa Coffee exporters (Kyagalanyi)
Café Africa
Centre for Agriculture and Bioscience International (CABI)
CIRAD (French Agricultural Research Centre for International Development)
European union (EU)
Farm groups e.g. Twekembe in Ntenjeru and Jjongoza in Rakai
International Center for Insect Physiology and Ecology (ICIPE)
International institute of tropical agriculture (IITA)
Makerere university
National agriculture advisory services (NAADs)
UGACOF
Uganda coffee alliance
Uganda coffee development authority (UCDA)
United States Agency for International Development (USAID)
University of Michigan

List of information materials available | NaCORI
Managing The Black Twig Borer (BCTB)
Recommended Shade tree systems for the diverse coffee agro-ecologies of Uganda
Coffee Management Season Calendar: Mid-Northern Robusta coffee agroecosystem
Coffee Management Season Calendar: Central and Mid- Eastern Robusta coffee agroecosystems
Coffee Management Season Calendar: West-Nile Arabica coffee agroecosystem
Coffee Management Season Calendar: Mt. Elgon Arabica coffee agroecosystems
Mass propagation of Robusta coffee Wilt Resistant varieties using tissue culture

Annex 2

NATIONAL CROPS RESOURCES RESEARCH INSTITUTE (NACRRI)

Top successful interventions | NaCRRI
Adding proteins on every Ugandan's plate: A case of beans
Cassava value addition
Development and dissemination of upland rice
Development and promotion of stress-tolerant maize varieties
Developing seed system for indigenous vegetables
Establishment of a Biosciences information hub
Grafting technology for mango and citrus earning millions as household income
NARO successfully stimulates a paradigm shift in the soybean sub sector in Uganda
Promoting uptake of stress-tolerant and nutritious sweet potato varieties
Reversing the prevalence of cassava mosaic disease by reducing its incidence from 64% in 1994 to 17% in 2013, attributed to 77% adoption of improved varieties

List of Partners | NaCRRI Bean Projects
Alliance for a Green Revolution in Africa (AGRA)
Bukinda women's cooperative society
International Center for Tropical Agriculture (CIAT)
Farm Africa organization
Farmer groups
Gatsby Foundation
Kabayizi women's group
Local government
National Agricultural Advisory Services (NAADS)
Nyarugulu women's group
USAID

List of Partners | NaCRRI Soybean Project
Alliance for a Green Revolution in Africa (AGRA)
Consortium for enhancing University Responsiveness to Agribusiness Development (CURAD)
Makerere University
Ministry of Agriculture Animal Industry and Fisheries MAAIF
Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)
Soybean Africa

List of Partners | NaCRRI Cassava Projects
Cornell University
East African Agricultural Productivity Project (EAAPP)
Farmers Groups and Extension Service Providers
International Institute for Tropical Agriculture (IITA)
Ministry of Agriculture Animal Industry and Fisheries (MAAIF)
Next Generation (Next Gen) Cassava Project Partners
PARIs, NARs, Regional and local Universities
Virus Resistant Cassava for Africa (VIRCA PLUS) Project Partners

List of Partners | NaCRRI Sweet potato Projects
International Potato Centre (CIP)
Harvest Plus
North Carolina State University
Uganda Multi-Sectoral Food Security and Nutrition Project
PARIs, NARs, Regional and local Universities
Extension agents and model farmers

List of Partners | NaCRRI Maize projects
International Centre for Maize and Wheat Improvement (CIMMYT)
International Institute for Tropical Agriculture (IITA)
Water Efficient Maize for Africa (WEMA) Project partners
NARO Institutes
Seed Companies
Local, regional and International Universities

List of Partners | NaCRRI Rice projects
Africa Rice
Farmers and extension service providers
International Rice Research Institute (IRRI) Philippines
Japan International Cooperation Agency (JICA)
NARO Institutes
Seed Companies

List of Partners | Uganda Biosciences Information Center (UBIC)
Academic Institutions
East African Agricultural Productivity Project (EAAPP)
International Service for the acquisition of Agri-biotech Applications (ISAAA)
Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF)
Ministry of Education and Sports
Ministry of Science, Technology and Innovation
Ministry of Water and Environment
NARO institutes
National Curriculum Development Center
National Association of Science Teachers of Uganda
Open Forum for Agricultural Biotechnology (OFAB)
Program for Biosafety Systems (PBS)
Science Foundation for Livelihoods and Development (SCIFODE)
Uganda Biotechnology and Biosafety Consortium (UBBC
Uganda National Council for Science and Technology (UNCST)
Uganda Science Education Progam (USEP)

List of information materials available | NaCRRI
Avocado production guide
Bean recipes - Best food choices for adventurous cooks
Bean varieties
Citrus production guide
Cucumber production
Eggplant production farmer's guide
Improved bean varieties and their management
Inspection and certification of cassava planting material
Management of avocado diseases
Management of citrus diseases
Management of mango diseases
Management of passion fruit diseases
Management of Sweet potato virus disease (SPVD)
Mango production guide
Manual for improved mango production
NaCRRI; our products and services
Namulonge Agricultural and Animal Production Research Institute (NAARI) annual report 1996/97
Orange-fleshed sweet potato for Africa
Orange-fleshed seed potato for combating Vit-A deficiency
Passion fruit production guide

Pineapple production guide
Precooked beans: for improved health, food and nutrition security and wealth creation
PRiDe Project Newsletters
PRiDe Project; Promotion of rice
Reaching and engaging end users (REU) with orange-fleshed sweet potato in eastern and southern Africa: executive summary
Rice cultivation handbooks - PRiDe
Rice diseases and insects
Soybean production and development in Uganda ; A case of paradigm shift in an African university
Soybean production guide in Uganda
Soybean utilization guide
Sweet potato production and management
Tomato production
UBIC – Common Concerns about GM Crops
UBIC – Facts and Figures on crops under Biotech Research in Uganda, 2015
UBIC – Quotable Quotes about Biotechnology in Uganda, 2016
UBIC- Top Ten Facts about Biotech and Biosafety in Uganda, 2016
Upland rice cultivation guide

Annex 3
NATIONAL FISHERIES RESOURCES RESEARCH INSTITUTE (NAFIRRI)

Top Successful Interventions | NaFIRRI
Diversification of cultured fish species: Release of African (male) catfish | Mid 1990s.
Domestication of the Nile Perch.
Fish disease identification mechanisms and development of simple management plans.
Growing live feeds production
Increasing aquaculture productivity and production in Uganda through quality fish seed development, multiplication and distribution
Increasing pond production and profitability for small-scale fish farmers: Innovative fish feeds.
Managing water pollution caused by heavy metallic ions
Release of African carp | 2000, Kisinga and Mpongo | 2016
Successful control of water hyacinth on Uganda's major water bodies
Transformation of fisher communities into the first cage aquaculture park in Uganda.
Use of solar lamps for fish growing to accelerate fish growth.

List of Partners | NaFIRRI
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Auburn University, USA
Directorate of fisheries
European Union
Fisher Fork
Fish Farmers/Uganda women fish network
Government of Uganda
Masese cage fish farmers
McGill University, Canada
Research partnerships with local, regional and international scientists e.g. universities and research institutions
Source of the Nile fish farm
UgaChick
Uganda fish processors and exporters association
USAID
World Bank

List of information materials available | NaFIRRI
The Status of the fish stocks, the environment and socio-economics of Kabaka's Lake | 2001
Aquatic ecology monitoring: Water quality, fish, fish catch, sanitation and disease vectors | 2014
Control of Kabira weed (Salvinia molesta) on Uganda's water systems | 2016
Development of Best Practices for Cage Fish
Farming to Increase Fish Production in Uganda | 2016
Fishing effort and fish yield over a 15-year period on Lake Victoria, Uganda: Management implications | 2016
Guidelines for selection and zoning of sites for establishment of cage fish farming and aquaculture parks in Uganda | 2016
Operational Manual for Cage Fish Farming | 2016
Pollution in Northern Lake Victoria (Uganda): Implications for management | 2016
Regional action plan to manage fishing capacity on Lake Victoria | 2009

Annex 4
NATIONAL FORESTRY RESOURCES RESEARCH INSTITUTE - NAFORRI

Top successful interventions | NaFORRI
Biological control of Eucalyptus pests
Construction and renovation of Research buildings at NaFORRI
Cypress aphid control in Uganda: a successful case of classical biological control.
Development of a bioenergy saving stove currently being piloted in Nakasongola district
Hydrogel Technology
Integration of Calliandra into smaller holder dairy production systems
Introduction and screening of eucalyptus clones for different agro-ecologies in Uganda.
Grafting technology for mango and citrus earning millions as household income
Introduction of Tropical Fruit farming in Eastern Uganda
Propagation and domestication of medicinal plants Prunus africana and Waburgia ugandensis
Propagation and grafting of shea butter trees on farm; Shortened maturity period from 40 to 15 years.

List of Partners | NaFORRI
Biodiversity International (formerly IPGRI)
Center for International Forestry Research (CIFOR)
Central American and Mexico Coniferous Resources (CAMCORE)
College of Agricultural and Environmental Sciences, Makerere University
Common Wealth Scientific and Industrial Research Organization (CSIRO
International Center for Tropical Agriculture (CIAT)
International Crops Research Institute for the Semi-Arid Tropics - (ICRISAT)
International Food Policy Research Institute (IFPRI)
International Forest genetic conservation and improvement initiatives
International Institute of Tropical Agriculture - (IITA)
MONDI Forest Company, South Africa
National Environmental Management Authority (NEMA)
National Forestry Authority (NFA)
Oxford Forestry Institute (OFI)
World Agroforestry Centre (formerly ICRAF)

List of available information materials | NaFORRI
Development of strategies for the conservation and sustainable use of Prunus Africana to improve the livelihoods of small-scale farmers
Eucalyptus hybrid clones for fast growing and high yielding plantations
Famine Foods for Uganda
Forest conservation and management
Forest Products and services
Incest reference collection
Top–cleft: an appropriate technique for grafting shea butter trees in Uganda for early fruiting
Tree improvement and germplasm

Annex 5
NATIONAL LIVESTOCK RESOURCES RESEARCH INSTITUTE (NALIRRI)

Top successful interventions | NaLIRRI
Breeding enhances indigenous goat meat productivity
Conservation of indigenous cattle genetic resources
Crossbreeding of the SEAZ cattle with Boran for increased meat productivity
Development of the anti-tick vaccine.
Fodder conservation technologies to support year round livestock forage availability
Integration of Calliandra into smaller holder dairy production systems
Introduction and screening of eucalyptus clones for different agro-ecologies in Uganda.
Improving feed availability in smallholder dairy production systems
Improving indigenous chickens through crossbreeding: The SAARI Crossbred chickens
Inventory of major honeybee pests in Uganda documented
Nakyesasa Dairy Research and Business Hub combats National Pasture Seed Scarcity
Selective breeding improves SEAZ traction capacity, spurs agricultural productivity

List of Partners | NaLIRRI
Astel Diagnostics
District local governments
International Center for Tropical Agriculture (CIAT)
International Livestock Research Institute (ILRI)
MAAIF
National Agricultural Advisory Services (NAADS)
National Animal Disease Diagnostic and Epidemiology Centre (NADDEC)
National Animal Genetic Resource Centre & Databank (NAGRC&DB)
NARO Institutes
NGOs/CBOs
World Bank
UgaChick
Uganda fish processors and exporters association
USAID

List of available information materials | NaLIRRI
Acaricide resistance and how the challenge is being addressed | 2016
Addressing Animal Nutritional Constraints in Uganda: The Contribution of the Livestock Nutrition Research Programme | 2015
Bee forage identification, establishment, qualities and management
Brachiaria hybrid cv. Mulato: a dry season forage for smallholder dairy farming systems | 2015
Calliandra calothrysus (Calliandra), a source of protein supplement for dairy cattle | 2016
Cattle rubber mats improve cow health and milk yield | 2016
Climate smart agricultural technologies and innovations in Ngora district | 2014
Common improved dairy cattle breeds for milk production | 2016
Controlling ants in beekeeping
Early detection of Bovine Brucellosis to facilitate deployment of strategic control measures | 2016
Economics of zero grazing dairy cattle production system | 2016
Effects and control of wax moth in bee industry
Enhancing household income through improving beef productivity of short horned Zebu in Uganda's extensive grazing areas
Establishment and management of Alfalfa (Medicago sativa) fodder | 2016
Establishment and management of Calliandra (Calliandra calothyrsus) fodder | 2015
Establishment and management of Lablab (Lablab purpureus) fodder | 2015
Establishment and management of Napier grass (Pennisetum purpureusm) fodder | 2016
Establishment and management of Rhodes grass (Chloris gayana) fodder | 2016
Feeding a calf from birth to weaning
Gender-targeted forage chopper for smallholder dairy farmers | 2015
Genetic diversity of Theileria parva strains in Uganda. Implications for Muguga cocktail vaccine efficacy in ECF control | 2016
Hay production and utilization | 2016
How to become a successful dairy farmer
How to make low cost feed rations | 2016
Honey Bee Pest Management
Honey Harvesting and Processing
Increasing hive colonization
Lablab purpureus (Lablab), a valuable fodder crop for dairy cows | 2016
Maize-forage legume intercrop for food, fodder production and income generation | 2016
Milk processing technologies for small-scale producers
Mubende, a small East African goat. Superior genetics from Uganda | 2016
Nutrient feed block supplement for goats and cattle | 2015
Silage and hay production for smallholder dairy farmers
Silage making for small-scale farmers | 2016
Sweet potato silage making - audio videos (Luganda and English)
Sweet potato Vine-Based Partial Milk Substitute Technology for dairy calves | 2016
Tick control technologies in Uganda | 2016
The Dairy Research and Business Incubation Center (DRABIC), Nakyesasa
Tips to a profitable zero grazing dairy cattle enterprise | 2016
Together we can stop the menace of Taenia solium cysticercosis in Uganda.
Water harvesting and management for livestock and crops | 2015
Watusi Ankole longhorn cattle | 2016

Annex 6
NATIONAL AGRICULTURAL RESEARCH LABORATORIES (NARL)

Top successful interventions | NARL
Banana bacterial wilt effectively prevented from decimating Uganda's banana industry
Development and promotion of Highland banana (Matooke) hybrids in Uganda
Hand cranked maize Sheller
Introduction of the Fertilizer Optimizer Tool for soil fertility management
Manual forage chopper
Motorised maize Sheller for commercial farmers
NARO develops a lightweight rice sheller to empower women farmers and processors
Promotion of Sustainable Land Management (SLM) systems to prolong land productivity in Uganda (Fanya juu/ fanya chin)
The Uganda soils Information System
Water Treadle pump

List of Partners | Agricultural Engineering and Appropriate Technology Research
Africa Rice
Global Affairs Canada (GAC)
Farmers
International Fertilizer Development Center (IFDC) Private fabricators
Lira Rice Promoters Association
Local governments of Butaleja and Lira
NGOs

List of available information materials | NARL
Improved maize variety factsheet
KABANA 7H: New matooke variety
KIWANGAZI (M9, KABANA 6H): a new matooke variety
Maize postharvest handling and management guide
NARO Lightweight rice thresher leaflet
NARO Lightweight rice thresher operational manual
New procedure in developing adjustment algorithm for harmonizing historical climate data sets
Overview of Banana research program
Physical effectiveness of soil and water conservation technologies: adapt of effects of climate better reduce surface runoff and soil less on your plots . Policy brief
Physical effectiveness of soil and water conservation technologies in drought prone areas of western and central Uganda
Puro Laboro me Uganda
Soil and water conservation factsheet
Surface runoff harvesting tank factsheet
Training manual for Handling small pelagic fish in Uganda
Update on Banana bacterial wilt control
Working drawings and templates for private fabricators

Annex 7
NATIONAL SEMI ARID RESOURCES RESEARCH INSTITUTE (NASARRI)

Top successful interventions | NaSARRI
Adoption of animal traction weeding technologies improves the lives of small holder farmers in eastern Uganda.
Application of herbicides and fertilizers reduces production cost of sunflower and time.
Development and adoption of resilient groundnut varieties with improved nutritional and income – generating attributes.
NaSARRI commercialises sorghum the 'originally poor man's crop'

List of Partners | NaSARRI
Alliance for a Green Revolution in Africa (AGRA)
Animal Traction Partners
CGIARs
Department For International Development (DFID)
EU-IFAD
Farmers
Feed the Future
ICRISAT India and Malawi
Local Government
Media houses (Etop Radio, Etop newspaper, New Vision, Monitor)
Guru Nanak
New Mexico State University
NGOs/CBOs
Peanut Mycotoxin Innovation Lab (PMIL)
SAAINCO
Soroti Catholic Diocese Integrated Development Organization (SOCADIDO)
Tropical Legume Phase III (TLIII)
University of Georgia
Vision Terudo
VSF International

List of available information materials | NaSARRI
Groundnut leaf minor
Groundnut production guide for Uganda: Recommended practices for farmers
Groundnut seed production manual for Uganda
Increased production using animal traction
Management of aflatoxins in ground nuts
Semi-arid regions crops research yields high dividends for resource poor farmers: a case of sorghum in Uganda
Seven steps to train your oxen how to weed
The Eagle project overview (Sorghum)

Annex 8
ABI ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE (ABIZARDI)

Top successful interventions | AbiZARDI
Enhanced fish production in West Nile region through pond and cage aquaculture
Evaluating high-yielding forage cultivars
Evaluation of local varieties of Bambara nuts and beans alongside improved varieties from Brazil and Nigeria
Introduction and promotion of goat rearing in West Nile: The Mubende goat story
Mangoes commercialized in West Nile region
Promotion of Napier grass, Rhodes grass (Chloris Gayana), and Lablab grass (Bracharia Mulato)
Provision of fish seed in the West Nile region
Soil fertility management for improved agricultural production in West Nile region of Uganda
Physical effectiveness of soil and water conservation technologies: adapt of effects of climate better reduce surface runoff and soil less on your plots . Policy brief
Physical effectiveness of soil and water conservation technologies in drought prone areas of western and central Uganda

List of Partners | AbiZARDI
Academic institutions (Makerere University, Muni University, Nile University, Uganda Martyrs University, Agricultural colleges
District Local governments, Farmer Associations and farmer groups of Arua, Koboko, Nebbi, Maracha, Yumbe ,Moyo, Adjumani, Pakwach and Zombo Districts
Government institutions (Uganda Prisons Services Arua, NARO institutes, MAAIF, Uganda Registration Services Bureau (URSB), Uganda Biosciences Information Centre (UBIC), Aquaculture Research and Development Center, Kajjansi)
Media houses (Radio Pacis, Arua One FM, The New Vision, Daily Monitor, Uganda Radio Network, Radio Maria, Voice of Life FM, Nile FM, Green Chronicles, The Science Times, Agribusiness Digest, and Environmental Link)
NGOs (ZOA, DAR, Uganda National Agro- Input Dealers Association (UNADA), WelthungerWilfe, CEFORD, UCA (Nebbi), Nile Pro Trust, West Nile Private Sector Organistion (WENIPS, Self Help Africa (Nebbi), , World Vision, Solar Now, RICE WEST NILE, PALM CORP, SNV, VODP, K.K Nature Harvest (Koboko), MunguYiko (Arua), AgriPro Focus, Nile Crocodile Ltd, Kati farms)
Programmes/Projects (NAADS, Operation Wealth Creation, Integrated Seeds Sector Development (ISSD), The World Bank (ATAAS), JICA, Project for Restoration of Livelihood in Northern Uganda (PRELNOR), CIAT, IITA, AGRA, UNHCR, Promotion of RICE Development (PRIDE), FAO, EAAP, NUSAF, ICRA, RUFORUM)

List of available information materials | AbiZARDI
AbiZARDI at a glance
Cassava Value Added Products
Status of research on Bambara nuts (Vigna subterranea) in Uganda
The case of one-cow dairy farming for urban and land constrained areas for increased incomes and food security
West Nile farming systems and livelihoods at a glance

Annex 9
BUGINYANYA ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE – BUGIZARDI

Top successful interventions | BugiZARDI
Alternative low-cost control options of livestock ailments to transform farmers' lives in South East Agro-Ecological Zone (SEAEZ) of Uganda
Bringing back the glory through Arabica coffee production
Development of strategies for the conservation and sustainable use of Prunus africana to improve the livelihoods of small-scale farmers
Development of Uganda hybrid maize
Domestic wheat production: a solution to Uganda's import dependence
Goats breeding projects for eastern high land areas
Performance of Toggenburg, Boer and their crossbreds with indigenous goats in south eastern Uganda
Potato value chain as a driver of improved livelihoods in Mt. Elgon area
Promotion of Soil and water conservation practices in Buluganya Sub-county, Bulambuli District – Uganda
Strategies for management of maize lethal necrosis in eastern Uganda

List of Partners | BugiZARDI
Academic institutions
Alliance for a Green Revolution in Africa (AGRA)
Austrian Development Association
Congregations Around Richmond Involved to Assure Shelter (CARITAS)
CHAIN UGANDA
Eco Trust
Eden
Farmer Groups and Associations
Food for the Hungry
German Technical Cooperation (GTZ)
Idda Tujje
Integrated Seed Sector Development (ISSD)
International Fertilizer Development Center (IFDC)
International Fund for Agricultural Development (IFAD)
International Potato Centre - CIP
Japan International Cooperation Agency (JICA)
KAWACOM
Kenya Agricultural and Livestock Research Organisation (KALRO)
Kenya Plant Health and Inspectorate Services
Link Environmental Protection (LEP)
Local Governments
National Animal Genetic Resource Centre & Databank (NAGRC&DB)

National Forestry Authority (NFA)
National Potato Association of Kenya
National Union of Coffee Agribusiness and Farm Enterprises (NUCAFE)
Operation Wealth Creation (OWC)
Private Sector Foundation
Self Help Africa
Uganda Coffee Development Authority (UCDA)
Uganda National Seed Potato Producers Association
VECO Uganda
Volunteer Efforts for Development Concerns (VEDCO)
World Vision

List of available information materials | BugiZARDI
Arabica coffee establishment
Barley production
Coffee berry disease a threat to Arabica coffee in Uganda
Critical steps in pre-harvest management of potato in field for best storage quality
Dry season livestock feeding
Fact Sheet on Fall Army Worm
Hay and silage making
Improved Potato harvesting Techniques
Management of Maize Lethal Necrosis
Management of weeds in rice
Soil fertility management in eastern Uganda
Sustainable land management for increased productivity
Temperate fruit production
Wheat production

Annex 10
BULINDI ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE (BUZARDI)

Top successful interventions | BuZARDI
Adapting to climate change; the case of Kyabigambire farmers in LACZ
Cage fish farming; A new way to reap big from a unit volume of water
Cassava multiplication and distribution in the LACZ
Imparting skills in improved apiary management
Pasture seed multiplication
Promotion of improved groundnuts in the Lake Albert Crescent Zone of Uganda
Promotion of NERICA varieties in the Lake Albert Crescent Zone

List of available information materials | BuZARDI
Bulindi ZARDI newsletter
Cassava production, best practices for the Lake Albert crescent region of Uganda
Insect pests of honey bees in the Lake Albert Crescent Zone of Uganda and their management
NARO-CGS Apiculture project

Annex 11
KACHWEKANO ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE (KAZARDI)

Top successful interventions | KaZARDI
Enhancing apple growing in SWHAEZ region
Enhancing goat productivity at KaZARDI
Enhancing production of quality seed potato through private partnerships
KaZARDI released eight elite potato varieties
Promotion of farmer run screen-house technology
Goats breeding projects for eastern high land areas
Performance of Toggenburg, Boer and their crossbreds with indigenous goats in south eastern Uganda
Potato value chain as a driver of improved livelihoods in Mt. Elgon area
Promotion of Soil and water conservation practices in Buluganya Sub-county, Bulambuli District – Uganda
Strategies for management of maize lethal necrosis in eastern Uganda

List of Partners | KaZARDI
Deepa Industries Limited
Food and Agriculture Organization (FAO)
Integrated Seed Sector Development (ISSD)
International Fertilizer Development Center (IFDC)
International Potato Centre - CIP
Kabale Seed Processors and Producers
Ministry of Finance
MPs and Local Government
NANDOS
National Agricultural Advisory Services (NAADS)
Uganda National Seed Potato Producers Association (UNSPPA)

List of available information materials | KaZARDI
Farming systems and livelihood analysis of the south western highlands agro-ecological zone: A report
Goat housing structure at KaZARDI
Highlights about KaZARDI
Potato growing brochure
Screen house technology

Annex 12

MBARARA ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE (MBAZARDI)

Top successful interventions | MbaZARDI
Bruchids Uganda project: Development and promotion of improved community based storage technologies for bruchids management in selected food legumes under small-holder farming system.
Development and promotion of improved banana technologies for improved productivity in the South West Agro-Ecological Zone.
Development and promotion of improved rice technologies for better productivity in the South West Agro-Ecological Zone.
Enhancing animal feeds using pasture grass conservation and preservation.
Enhancing fruit growing in south western region
Improved cassava varieties restore hope to farmers in south western Uganda
Improving feeds and water quality in catfish culture systems
Improving Tea (Camellia sinensis) production
Soil Fertility and Water Management in the SWAEZ
Uganda morphological genetic diversity assessment and agronomic performance of Ugandan and Nigerian cocoyam accessions under upland conditions

List of Partners | MbaZARDI
Agricultural Technology and Agribusiness Advisory Services (ATAAS) Project
District Local Governments
Government of Uganda
National Agricultural Advisory Services (NAADS)

List of available information materials | MbaZARDI
A Farmer's Digest Booklet; NARO-NAADS partnership activities in SWAEZ
An overview of MbaZARDI
Crops research, Field diagnosis and management of the xanthomonas wilt of banana in east and central Africa
Crops research programme at MbaZARDI

Annex 13
MUKONO ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE (MUZARDI)

Top successful interventions | MuZARDI
Enhancing adoption of agro-forestry technologies with high market demand in the LVCAZ
Enhancing Nutrition in Primary schools
Fish farming promoted in the LVCAZ
Improving Market access for Pineapple Chain Actors using the Participatory Market Chain Approach (PMCA) in Uganda
Improved pastures and feeds for pigs, dairy cows and poultry
Increasing the capacity of smallholder farmers to produce and market leafy green vegetable crops in Uganda
Promotion of modern apiary technologies in LVCAZ
Smallholder integrated crop management (ICM) research planning: A case for Mukono and Kayunga districts
The Participatory Market Chain Approach a means of promoting agriculture in Uganda
Urban and Peri-urban farming for enhanced income, food security and nutrition

List of Partners | MuZARDI
ABI trust
Agricultural Department of Kampala City Council Authority (KCCA)
Camp Green International
Department of Food Sciences and Technology Makerere University
District Local Governments (Kampala, Wakiso, Buikwe and Masaka)
East African seeds
Lusanja Organic farmers' group
National Agricultural Advisory Services (NAADS)
Parents Empowering Children and Youth Uganda (PEYCU)
Reach One Touch One Ministries (ROTOM)
Rural Agency for Sustainable Development
Rural Community in Development (RUCID)
Sarmalina Beverages International
SIMLAW seed company
Uganda Christian University
University of California, Davis
Volunteer Efforts for Development Concerns (VEDCO)

List of available information materials | MuZARDI
A famer's guide to Home gardening
Grow vegetables a better way (Cabbage)
Home gardening options for urban and peri-urban vegetable farmers in Uganda
Making Nakati Peanut butter
Nakati seed production and processing

Nakati (Solanum aethiopicum) seed production
Processing protocol for leafy green vegetables

Annex 14

NABUIN ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE – NABUZARDI

Top successful interventions | NabuZARDI
Improved availability & quality of forage for all year round animal feeding
Popularized use of cover crops for improved soil fertility and crop yields
Seed multiplication increases availability of seeds for planting and incomes/ multiplication and production of quality seeds for planting

List of Partners | NabuZARDI
Alliance for a Green Revolution in Africa (AGRA)
Agro input dealers
Bulindi ZARDI
District Local Governments
Farmers/ Farmer groups
Food and Agriculture Organization (FAO)
Gulu University
Guru Nanak
Integrated Seed Sector Development (ISSD)
International Crops Research Institute for the Semi-Arid Tropics - (ICRISAT)
Kamtec
Lutheran World Federation
Lusanja Organic farmers' group
National Agricultural Advisory Services (NAADS)
Makerere University
Media (Karamoja FM)
Ministry of Agriculture Animal Industry and Fisheries (MAAIF)
Mount Meru
Mukwano Group
Operation Wealth Creation
Political & Opinion leaders
World Bank
World Food Programme

List of available information materials | NabuZARDI
Acacia Senegal the wonder tree for semi-arid zones
Developing and promoting hay based technologies for drought resilient livestock production in Karamoja Uganda
Fostering extensive crop production in Karamoja dryland
Hay production and utilization for drought resilient livestock production
How to make hay
Nabuin ZARDI organizational brochure
Promotion of Chloris gayana for hay making
Recommended cassava varieties for the Nabuin zone
Soil research in Nabuin zone
Status of Brosellosis in Karamoja sub region
The potential of aquaculture in Karamoja sub regions

Annex 15

NGETTA ZONAL AGRICULTURAL RESEARCH DEVELOPMENT INSTITUTE – NGEZARDI

List of Partners | MuZARDI
Top successful interventions | NgeZARDI
Development of protocol for rehabilitation of diseased fruit orchards. Introduced two disease tolerant varieties
Domestication of the shear nut tree. Reducing maturity age for Shea nut tree from 25 to 5-7 years | Work Started 2011
Introduction of Boer goats, Friesian and Jersey cows for cross breeding and distribution to farmers | 2002
Introduction and promotion of orange and mango cultivars to ensure use of clean planting materials
Introduction of disease tolerant cassava varieties Akena, TME14, TME 204 during outbreak of cassava mosaic in Lango sub-region | 2004
Multiplication and demonstration plots of citrus and mango varieties: Washington Navel, Hamelin, Tangerine
Processing disease resistant and high-yielding coffee seedlings for distribution to farmers
Production and distribution of quality foundation seed (Rice, cassava, and soy)
Promotion of coffee growing in Northern Uganda
Variety selection and introduction of drought tolerant and groundnut rosette disease resistant improved groundnut varieties (Egola 1, Serenut 1, 2, 3, 4 varieties).

List of available information materials | NgeZARDI
Bracharia mullato- Management Practices, Facts and Figures
Citrus canker: Signs and symptoms
Cassava brown streak: signs, symptoms and Management
Conserving Shea tree (Vitellaria paradoxa) through propagation
Domestication and promotion of (Vitellaria paradoxa) Shea nut tree in Northern Uganda
Field identification and management guide for major citrus diseases
Fish Pond Management
Fish predator control
Growing high yielding varieties of pigeon Pea
Handbook on Labour saving technologies for Rice & Maize
Hatchery operators Manuel-Catfish Farming
Low land rice production
Management of common of pests in beans
Mango Establishment
Ngetta ZARDI Profile
Pigeon Pea seed production
Selected fast growing tree species suitable for northern Uganda
SLM- Interventions and areas
Soils: Existing threats in Northern Uganda
Upland rice production

Annex 16

Rwebitaba Zonal Agricultural Research Development Institute (RwebiZARDI)

Top successful interventions | RwebiZARDI
NARO develops protocol for traceability of honey from Uganda
Rwebitaba ZARDI boosts tea production in Uganda

List of Partners | RwebiZARDI
District Local Governments
National Agricultural Advisory Services (NAADS)
Makerere University
Ministry of Agriculture Animal Industry and Fisheries (MAAIF)
Tea Estate Companies in Uganda
The Uganda National Apiculture Development Organisation (TUNADO)
Uganda Tea Association (UTA)

List of available information materials | RwebiZARDI
Best performing tea clones in Uganda
Bring tea into bearing
Tea field establishment
Tea growing in Uganda
Tea nursery management
Tea pest and disease prevalence, incidence and severity in Uganda
Tea value addition
Tea value added products from priority clones for product diversification and marketing from selected tea clones

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