DESCRIPTION OF SELECTED TECHNOLOGIES GENERATED IN THE EAAPP PHASE I PROGRAMME

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DESCRIPTION OF SELECTED TECHNOLOGIES GENERATED IN THE EAAPP[1] PHASE I PROGRAMME

FINAL REPORT

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[1] Eastern Africa Agricultural Productivity Project (EAAPP)

Foreword

The conceptualization of the Eastern Africa Agricultural Productivity Programme (EAAPP), stemmed from the recognition by New Partnership for Africa Development (NEPAD) that in order for Africa to achieve its Millennium Development Goals of halving hunger and poverty by 2015, there was need for a sustained economic growth of about 6 percent annually for a period of 12 years. For countries in Eastern Africa and indeed the other regions of Africa, that largely depend on agriculture, this meant generating and sustaining growth of the agricultural sector. It also meant identifying sub-sectors that had the greatest potential to drive growth and reduce poverty. That potential lies in commodities that have a large production base and a large and growing demand in the region. NEPAD through its Comprehensive Africa Agriculture Development Programme (CAADP) recommended that African countries should devote at least 2% of their GDP to agricultural research and development (R&D). It also called for greater focus on improving agricultural productivity and increasing the effectiveness of technology generation and dissemination.

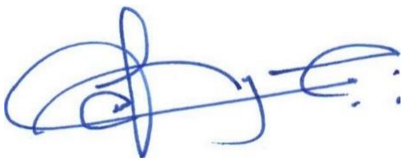
To promote this objective, the Forum for Agricultural Research in Africa (FARA) was tasked to identify specialized Regional Centres of Excellence (RCoE), to spearhead the application of cutting-edge science for improving the livelihoods of African smallholders, pastoralists and low-income consumers. FARA was also given the mandate of strengthening and integrating National Agricultural Research Systems (NARS) at the sub-regional level and increasing collaboration between NARS, International Agricultural Research Centres (IARCs) and Advanced Research Institutes (ARIs) with special attention to networking.

Based on the subsidiarity principle, FARA delegated these responsibilities for Eastern and Central Africa to the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), which has robust research networks covering eleven countries in the sub-region. Through its medium term operation plan (up to 2015), ASARECA provided a stronger platform for regional collaboration within the sub-region and also contributed to resource mobilization and allocation to joint research, dissemination and training programmes.

The EAAPP was designed to complement ASARECA's activities by scaling up investments at country level that are in line with the regional approach, and have the capacity to generate both national and regional benefits. EAAPP invested in regional approaches to agricultural research, through supporting the strengthening of four Regional Centers of Excellence (RCoEs) in agricultural research in Eastern Africa, and upscaling of technologies for **four** key commodities **- Dairy, Wheat, Cassava and Rice**. The different countries were identified as the appropriate hosts for the key commodities under EAAPP based on comparative advantage in the region in terms of the broader dimensions of commodity productivity.

It was expected as part of the EAAPP design that each RCoE would assist other countries in the region in the development of robust agricultural commodity (dairy sector for Kenya, Rice for Tanzania, and Wheat for Ethiopia and Cassava for Uganda) value chains based on the smallholder model. Although the RCoEs were hosted in different countries, EAAPP was structured to provide funding for each country's RCoE to participate in the activities of RCoEs hosted by other countries participating in the programme. It was also the expectation of the project that outputs from the four RCoEs would be shared across the sub-region. The effectiveness of the regional perspective of the project was entrusted to ASARECA which coordinated implementation (i.e. through regional planning, review, M&E and sharing of results) of the programme.

The EAAPP Phase I that was approved in 2009 has successfully generated several Technologies, Innovations, and, Management Practices (TIMPs) through much focused engagement of research teams in the commodity value-chains under the RCoE in the respective countries. This compilation provides a brief of selected technologies for each agricultural commodity value chain. The documented technologies have been adopted across borders and have manifested tangible impacts at farm level. Further information about this document is available at http://www.asareca.org/eaapp.



Professor Francis Wachira
Interim Executive Secretary of ASARECA

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BACKGROUND TO THE EAST AFRICAN AGRICULTURAL PRODUCTIVITY PROGRAMME (EAAPP)

The East African Agricultural Productivity Programme (EAAPP) was conceived as a Regional Agricultural Research for Development initiative. The EAAPP Programme Development Objective was to: enhance regional specialisation in agricultural research; enhance collaboration in agriculture training, and technology dissemination; and facilitate increased transfer of agricultural technology, information and knowledge across national boundaries. EAAPP was at inception stage envisaged to run for a ten-year period and in two phases. Phase I, approved in 2009, focused on capacity building with the establishment of the Regional Centres of Excellence (RCoEs) through construction/improvement of infrastructure and human resource development; technology generation and dissemination; and improving seeds and breeds availability.

EAAPP is a regional partnership of the governments Ethiopia, Kenya, Tanzania and Uganda with ASARECA and the World Bank. Under EAAPP, the four countries undertook to establish Regional Centres of Excellence (RCoEs) for agricultural research by investing in commodities identified by ASARECA as being of sub-regional importance to mitigate food insecurity. **A Regional Center of Excellence** under the EAAPP was defined to be a leading agricultural technology programme with established research, dissemination and training capacity that distinguishes it as a leader in the region and beyond.

Kenya is the centre of excellence for dairy, Uganda for cassava, Ethiopia wheat and Tanzania for rice. The countries have pledged to manage investment in these commodities to benefit the sub-region. By playing a convening role for EAAPP, ASARECA seeks to enhance collaboration of the National Agricultural Research Systems (NARS) to contribute to the AU/NEPAD's CAADP Pillar I, which focuses on revitalizing, reforming and expanding Africa's agricultural research, technology dissemination and adoption.
ASARECA uses its expertise in coordinating regional research for development, extension, training and education to facilitate spillovers of technologies and innovations that will be generated through EAAPP. Specifically, ASARECA plays the following roles in EAAPP:

Convening role: ASARECA facilitates strategic meetings for the four countries to develop operational frameworks for RCoEs; define the responsibilities of each RCoE to the sub-regional stakeholders; define the mode of operation of the RCoEs individually and in relation to others; define outputs and the manner in which they will be shared amongst participating countries and other countries in the sub-region, and facilitates the development of regional strategies for the four commodities.

Networking and information sharing: ASARECA facilitates information sharing platforms to enable sharing of benefits and spillover of technologies and innovations developed by individual RCoEs to other participating countries.

Technical backstopping: ASARECA has over the years developed in-house expertise for out-scaling agricultural technologies, innovations and best practices; and puts this expertise at the disposal of the RCoEs.

Monitoring and evaluation: Regional M&E activities focus on tracking the extent to which EAAPP is making spillovers happen across the sub-region.

Policy harmonization: ASARECA facilitates rationalization and harmonization of policies, procedures and regulations aimed at creating common standards in the participating countries. This is attained by establishing the status of policies and procedures affecting the four commodities; analysing and developing policy options and advocating for and supporting implementation of the options.

Capacity building:ASARECA organizes and facilitates regional training workshops for RCoE managers to equip them with the tools and skills to transform the RCoEs into more effective research institutions

Training role: ASARECA collaborates with institutions and organizations that have expertise for training agricultural extension workers in undertaking the training.

Management and coordination: ASARECA has pledged to ensure the highest level of professionalism in managing EAAPP affairs and resources. EAAPP is like a new baby in the house. ASARECA is paying deserving attention to this new-born. We will do all it takes in collaboration with the RCoEs to see the baby grow and live a complete lifespan.

Achievements of EAAPP Phase 1:
An external evaluation of EAAPP in early 2015 Titled: *End Of Phase 1 Evaluation of the East African Agricultural Productivity Programme – EAAPP. Final Report,* noted the following achievements:

1) Seventy-five Masters students and 36 PhD candidates have been fully funded under the project. Similar numbers of men and women registered for Masters programmes in Tanzania and Uganda but only 2 in Ethiopia. There were only seven female PhD students out of 36 across the four countries. A further 50 students have received partial funding from the project.
2) 138 new technologies have been developed by the regional centres of excellence. Many are new varieties of cassava, rice, wheat and forage crops. Twenty-three new technologies have been disseminated across national boundaries including: two Tanzanian rice varieties released in Kenya and Uganda, and undergoing National Performance Trials (NPT) in Ethiopia; four clones of Napier grass from Kenya recommended for dissemination in Uganda; botanical seed of cassava with enhanced carotene sent to Ethiopia, Tanzania and Kenya; assisted reproductive technologies from Kenya sent to the other countries.
3) EAAPP M&E surveys show an increase in adoption of new varieties, breeds, and other selected management practices by farmers from 35 percent to 53 percent (2010-2014) in project areas.
4) EAAPP M&E estimates of land planted with improved cultivars are 2,755 ha in 2010, increasing to 12,807 ha in 2014. This is attributed to the substantial increase in production of planting material and farmer awareness in EAAPP project areas. Large increases are reported in Ethiopia, Kenya (cassava, rice, wheat) and Uganda (cassava).
5) ASARECA has facilitated harmonized NPT protocols for cassava, rice, wheat and pasture seeds under the project. It has coordinated a draft EAAPP intellectual property (IP) rights policy. On livestock, progress has been made in: drafting animal breeding policy and breeding rules in Kenya, now being used as a guide for other EAAPP countries; developing regional guidelines on procedures for movement and trade in heifers and germplasm; drafting a National Animal Breeding Policy in Ethiopia; development of a protocol for import and export of compounded dairy feeds and forages in Tanzania; developing regional guidelines for import and export documentation and procedures for dairy.
6) The harmonised Results Framework developed by ASARECA/EAAPP is a very useful tool which focuses on process and output indicators, and tracks progress at national and regional levels. Overall the M&E systems are very well designed and managed, providing timely results for project management

In this report, 27 Technologies are presented as examples of new technologies that were developed by the RCoE and have been successfully scaled-up across the EAAPP participating countries. SSAVA

1.0 CASSAVA

1.1 High Yielding Cassava Varieties

Description of the technology

Six technologies in form of cassava varieties were developed under the regional center of excellence for cassava in the EAPP project. The six varieties with appreciable attributes in terms of yield and resistance to diseases are as indicated in Table 1.

Table 1: Cassava varieties developed

Variety	Yield (t/Ha)	Maturity (Months)	DMC (%)	Taste	CBSD	CMD	Mealiness
NASE 14	23.3-33.0	12	34.5	Sweet	Tolerant	Resistant	Mealy
NASE 15	21.7-38.8	12	35.0	Sweet	Tolerant	Resistant	Mealy
NASE 16	17.5-23.3	15	30.0	Sweet	Tolerant	Resistant	Mealy
NASE 17	23.8-37.5	12	34.0	Sweet	Tolerant	Resistant	Mealy
NASE 18	26.7-31.7	12	34.1	Sweet	Tolerant	Resistant	Mealy
NASE 19	18.3-28.7	12	28.0	Bitter	Tolerant	Resistant	Mealy

Cassava remains an important household food and income security in Africa. The crop's productivity is constrained by numerous pests and diseases. In particular, farmers in Eastern and Central Africa have been constrained by the pandemic of cassava mosaic disease (CMD) and re-emergence in greater magnitude of cassava brown streak disease (CBSD). These two viral diseases, combined with abundant whitefly and other pest populations can decimate the crop causing up to 100% yield loss. Under EAAPP, the RCoE for Cassava focused on development and dissemination of resistant/tolerant cassava varieties, which are viewed as a major option to manage these biotic constraints. Picture

Photograph 1: Disease free multiplication field of cassava variety NASE 14 in Busia District, Eastern Uganda

Cassava varieties resistant to pests and diseases are those that can produce reasonable yields in presence of pests and pathogens, compared to their susceptible counterparts. These varieties were developed through rigorous screening and evaluation in high diseases/pest pressure zones. Six varieties with resistance to CMD and tolerant to CBSD presented in Table 1 above were developed and released. These varieties (NASE 14 to 19) were officially released in June 2011for farmers' use by Ministry of Agriculture Animal Industries and Fisheries (MAAIF) of Uganda. The varieties have since then been adopted in all the EAAPP implementation countries in Eastern and Central Africa. The use of the varieties under recommended agronomic practices guarantees increased productivity.

Photograph 2: Appreciable harvest from high yielding cassava

Scaling up approaches used to promote technology

Cassava is a key crop in all the countries that participated in the EAAPP. It is a mandate crop for the National Agricultural Research Institutes with increasing focus on aspects of productivity and value addition among others. Pest/disease resistant cassava varieties are targeted to benefit farmers and small and middle scale industrialists. The approaches used for scaling up use of disease resistant varieties include use of on-farm trials, participatory variety selection with through intense involvement of farmers, foundation stock multiplication by research teams at Research Institutes and secondary multiplication of plant materials by grassroots level actors including NGOs and CBOs. Based on experiences in the region, successful scaling up and promotion of cassava elite varieties intense involvement of stakeholders including especially the key actors along the cassava value chain such as a) cassava farmers; b) Researchers; c) Extension staff; d) Seed companies; e) Opinion leaders; f) Cassava processors; and, g) Transporters. The critical and essential factors for successful promotion and adoption of the technology/innovation included a) Robust researcher-extension-farmer linkage; b) Adequate facilitation of personnel involved in the promotion processes; c) Availability of pest/disease resistant varieties; and, d) Accessibility of planting materials

Current situation with reference to use of technology and future scaling up strategies

High yielding cassava varieties developed and released in Uganda (mainly NASE elite varieties) are being grown in Ethiopia, Kenya and Tanzania. They have contributed to a significant increase in production, stimulated by the demand for cassava flour as a cheaper substitute for wheat flour in products such as *enjera*. The wide adoption of cassava varieties is in part attributed to the participatory variety selection processes, which enable participating farmers to make their selection and start multiplying varieties of their interest. In addition, through secondary multiplication stakeholders such as NGOs & Local Governments organize and work with farmer groups through whom diffusion of technologies are made easier and faster. Cassava research teams in all the EAPP participating countries proactively engage with farming communities. In Uganda for instance, about 70% of households grow cassava and approximately 48% have adopted new cassava varieties.

Challenges encountered in the dissemination of the technology/innovation, adoption and scaling up/out include

a) Low rate of cassava "seed" multiplication; b) Bulkiness of planting material; c) Perishability of planting material; d) Unstable weather conditions; e) Poor rural road network, restricting coverage; f) Inadequate information on best practices; g) Inability of some farmers to communicate (read or write) in a common language etc. There is consensus among stakeholders that these challenges are not insurmountable and can be addressed through a) Use of rapid and tissue culture multiplication techniques; b) Timely planting; c) training to empower stakeholders in best practices; and, d) Production and dissemination of user friendly information & dissemination materials to target stakeholders.

Lessons learnt about the best ways to get the technology or innovation to reach and be used by the largest number of users include the following;

a) Participatory, technology development which is pivotal to successful uptake by the end users
b) Media plays critical role in awareness creation on new innovations
c) Information to be disseminated should be translated into different local languages

Gender considerations in connection to development and use of the technology

Varietal development culminates with On Farm Trial (OFT) and Participatory Variety Selection (PVS) where women, men, and youth participate as members of farmer groups in the validation of varieties and multiplication of selected varieties. The process considers individuals and is not based on opinion leaders or key informants; this in part presents opportunity for marginalized groups particularly rural women and children to effectively engage on the subject. Equal opportunity was therefore, given to different groups in terms of gender categorization in all stages of cassava varietal development. This participation spins-off with interest from all parties to further participate production, processing, and marketing, unless regulated by social and/or cultural practices.

Photograph 3: Women participate significantly in the cassava value chain

Additional documentation that may be useful in describing the technology

Disease free cassava planting materials can be accessed through the National Agricultural Research Systems (NARS) of the respective countries: NaCRRI (Uganda), KALRO (Kenya), EIAR (Ethiopia) and Naliendele/Kibaha (Tanzania). For the varieties to give optimum yields, the farmers should ensure they embrace good agronomic practices. At a minimum, the following should be adhered to:

- Clean seedbeds on well-drained soils are preferred for planting at the onset of rains
- Planting is at a spacing of 1m x 1m, giving a plant population of 10,000 plants/ha
- Weeding should be done regularly, especially as the weeds appear
- Gap filling is necessary where establishment is poor, but should be done within the first month of planting
- Off types and diseased plants should be removed as soon as they are seen
- Unfamiliar disease/pest symptoms should be reported to the NARS personnel or the nearest extension agents for remedial advice

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1.2 Botanical Seed of Cassava with Enhanced Beta Carotene

Description of the Technology

To boost cassava germplasm base in the EAAPP partner countries, open pollinated seeds harvested from both beta-carotene-rich and elite germplasm at Namulonge Crops Resources Research Institute (NaCRRI), in Uganda were collected and distributed to Ethiopia (4,594 seeds), Kenya (5,480 seeds) and Tanzania (5,501 seeds). These sexual seeds were generated from elite parents that were characterized by high levels of beta-carotene content, virus resistance and yield. Seedlings from these crosses were established in Kenya, Tanzania and Ethiopia, where they were separately evaluated for adaptation and key agronomic traits. Currently, selections from these introduced seeds are either at preliminary or advanced yield evaluation stages. Outstanding clones from these selections will upon satisfactory evaluations be officially released in the respective countries for commercial production.

Genetic stocks that combine CMD and CBSD resistance are being developed by inter-mating 33 CBSD tolerant clones that survived the six-year culling exercise undertaken at NaCRRI during the period 2005 and 2012. Progeny (botanical seeds) generated from these crosses has been shared with Kenya, and Tanzania, and are currently under evaluation in clonal and or advanced yield trials. Outstanding clones from these selections will upon satisfactory evaluations be used as progenitors. During the period 2010 to 2015, research activities were undertaken to: 1) combine virus resistance and beta carotene; 2) increase levels of beta carotene in cassava through inbreeding; and 3) implement genome-wide studies for purposes of identifying markers associated with beta carotene content.

In terms of technologies generated, when CBSD tolerant clones were crossed to beta carotene clones, the resultant progeny (F_1s) were characterized with beta carotene levels ranging from 0 to 10.9 with a mean of 3.7 $\mu g\ g^{-1}$; from these, up to 69 individuals with beta carotene content of 5 μgg^{-1}, were selected for advancement and/or recombination. Furthermore, through inbreeding, up to 591 clones were generated; beta carotene content of this population ranged from 0 to 13.45 µg/g with a mean of 4.9 µg/g. Thirdly, through genome wide studies, markers that can be used for selection of beta carotene have been identified.

Photograph 4: Left: Variability observed in beta carotene populations developed at NaCRRI with root colour pigmentation ranging from white to deep yellow; Right: root morphology of beta carotene clones; root dry matter content of these roots ranges from 9.7 to 31.2%, with a mean of 24.3%

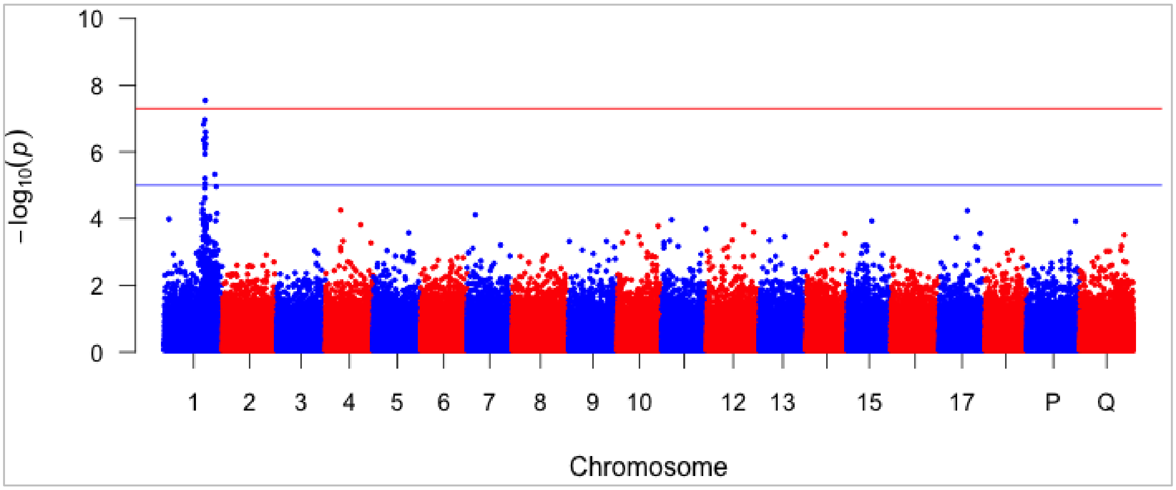

Figure 1: Manhattan plot displaying markers associated with beta carotene in cassava on chromosome 1. This analysis was based on 179 310 SNP markers and root colour pigmentation

Table 2: F_1 seedlings generated by inter-mating parental lines that combine CBSD and CMD resistance and/or tolerance

Family Code	CBSD root incidence in Parental clone	Harvest Index	No. of Sexual seeds
TZ P/138	0.0	0.42	178
TZ P/64	26.9	0.30	384
TZ P/69	-	-	454
TZ P/100	-	-	677
TZ P/177	-	-	428
TZ P/90	0.0	0.20	354
TZ P/122	-	-	305
TZ P/66	-	-	693
TZ P/170	0.0	0.28	655
TZ P/73	3.8	0.43	307
TZ P/74	0.0	0.20	240
TZ P/80	8.3	0.13	318
TZ P/160	0.0	0.61	1004
TZ P/110	-	-	924
TZ P/65	0	0.23	818
TZ P/61	-	-	340

CBSD field data from 2013 evaluation plots at NaCRRI. Of the 23 parental lines, seeds were only sourced from 16 parents. Equal proportions of these seeds will be shared with Tanzania and Kenya for field evaluation for combined CBSD and CMD resistance

Scaling and current situation of the cassava botanical seed

This technology is high-end science towards a downstream that is focusing on an innovative seeding process for cassava. It has potential for reducing bulky planting materials/cuttings to use of non-vegetative seed. There's evidence of scaling up the high end science from Uganda to other East African countries but the technology is still at testing stage and has not been made available for scaling-up to downstream users.

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1.3 Cassava Improved Seeds

Description of the Technology

The cassava improvement programme yielded four new varieties that were released in Tanzania and are in use beyond the counties boarders. A brief description of each variety is as indicated below.

i. ***Kachaga*** is one of the cassava improved seed variety. Kachaga is charactericed by;

- Early maturity (harvesting 8months),
- High yielding (12-17 tons/hectare) while local varieties are yielding 5-10 tons/hectare,
- Bitter and diseases /pest tolerant.

The technology aimed in addressing unavailability of planting materials, Diseases and pest attack and Low yield per unit area.

ii. ***Mkombozi*** is one of the cassava-improved seed. Mkombozi is characterized by:

- Early maturity (harvesting 8 months),
- High yielding (12-17 tons/hectare) compared to local varieties which yield 5-10 tons/hectare,
- Sweet and diseases /pest tolerant

The technology aimed to address unavailability of planting materials, diseases and pest attack and low yield per unit area

Photograph 5: Mkombozi variety

iii. ***Kiroba*** is one of the cassava improved seed. Kiroba is characterized by:

- Early maturity (harvesting 8 months),
- High yielding (20 tons/hectare) compared to local varieties which yield 5 - 8 tons/hectare,
- Sweet and diseases /pest tolerant

The technology aimed to address unavailability of planting materials, diseases and pest attack and Low yield per unit area

Photograph 6: Kiroba variety grown at Mangopachanne village at Mtwara district, Tanzania

iv. ***Naliendele*** is one of the cassava-improved seed. Naliendele is characterized by:

- Early maturity (harvesting 8 – 12 months),
- High yielding (20 tons/hectare) compared to local varieties which yield 5 - 8 tons/hectare,
- Sweet and diseases /pest tolerant

The technology aimed to address unavailability of planting materials, diseases and pest attack and Low yield per unit area

Scaling up approaches used to promote technology

The improved cassava varieties have been made available to individual farmers and researchers and research institutions have made effort to ensure that the seed remains true to time. The critical and essential factors for successful promotion and adoption of the technology/innovation include capacity building on improved varieties and agronomic practices, availability of enough planting materials (seeds), access to credits and incentives and improved marketing systems for cassava and the associated products.

There is overwhelming demand for seed among smallholder farmers and supply is further constrained by the low multiplication rate of planting material. The multiplication rate, which is at the ratio of 1:10 this, results in inadequate rate of supply of improved planting materials.

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2.0 DAIRY

2.1 Sahiwal Breed Improvement

Description of the technology

Although local Zebu cattle are adapted to the semiarid environment, their productivity is low. Development of crossbreds which can guarantee improvement in body size and milk production within existing production systems provide a promising approach of increasing production efficiency and competitiveness of cattle with other species in the different production systems in Semiarid areas. The local Zebu cattle females were mated by Sahiwal sires and the resulting crossbred females, which were 50% Sahiwal and 50% Zebu, were bred to a different Sahiwal sire to produce crossbred females, which were 75% Sahiwal and 25% Zebu.

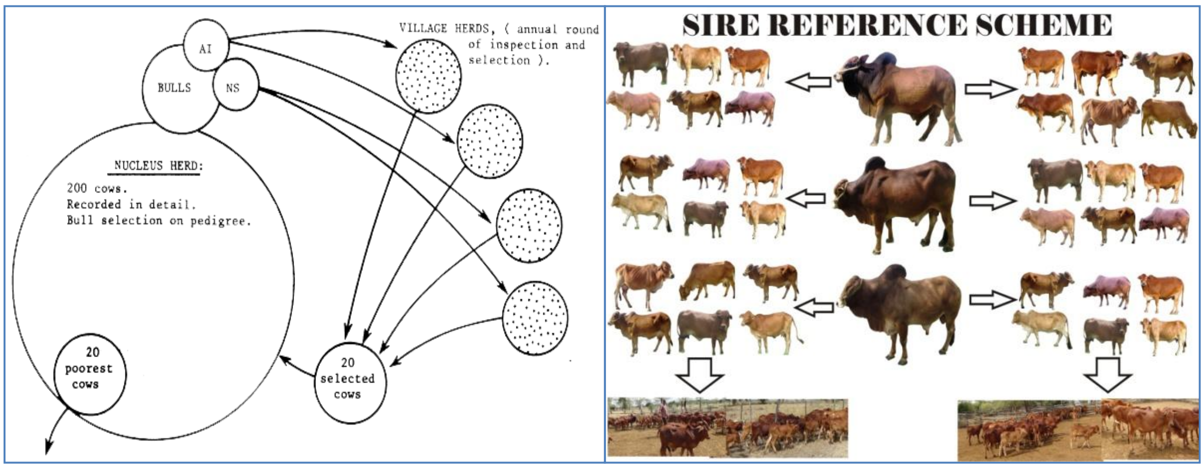

Figure 2: Sire reference schemes were adopted as a rapid means of creating genetic links among Sahiwal multipliers to create tandem breed improvement across herds

After attaining sexual maturity, the crossbred females were bred to a different Sahiwal sire to produce crossbred females, which were 87.5% Sahiwal and 12.5% Zebu. In the fourth generation, the crossbred females were mated to a Sahiwal sire to produce crossbred females with 93.75% Sahiwal inheritance and 6.25% Zebu inheritance.

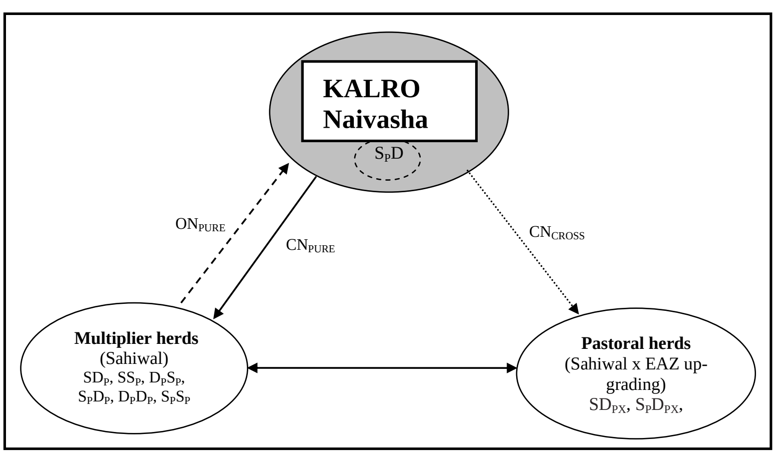

Figure 3: breeding structure and main mating groups schema

The breeding structure and main mating groups as shown in the schema. The selection groups are defined respectively as; SS, SD, DS and DD, Sahiwal sires of sires, sires of dams, dams of sires and dams of dams in the nucleus; SPD, mutliplier-born sires to breed dams in the nucleus; SDp and SSp nucleus born sires to breed dams and sires in multiplier herds, DpSp, SpDp, DpDp, and SpSp are multiplier born dams and sires to breed sires and dams for this sector; SPPX and SPDPX nucleus and pastoral born Sahiwal sires mated to EAZ cows for the upgrading program, DPXDPX are crossbred cows back crossed to Sahiwal sires to produce crossbred cows.


Photograph 7: Mass calving at KALRO Naivasha

Sahiwal is a breed of Zebu cattle, which is loved for its ability to give high quality milk with high butter fat content. It is resistant to tick borne diseases and thrives in arid and semi-arid areas where pure exotic breeds find it difficult to cope.

Among small-scale farmers, the breed is used for milk production, while in ranches; it is used primarily for commercial meat production. The biggest advantage of the Sahiwal is its higher milk production compared to the Boran; its weaners are healthier and heavier (60 – 75 kg). Mass calving at KALRO Naivasha has been a result of on-centre hormonal treatments. This formed the basis for developing standardized protocol for on-farm ART supported bull and AI schemes in the region.

Physical characteristics

Sahiwal's colour ranges from reddish brown to red, with varying amounts of white on the neck, and the underline. In males, the colour darkens towards the head, neck, legs, and tail. The tail ends with a black switch. The breed is also known for drooping ears. The hump is massive, but in the female, it is nominal. At the KALRO multiplication centers (Naivasha and Perkerra), adult females weigh 460 kg and males weigh 680kgs, though higher values for males have been documented.

According to research conducted by KALRO, the breed is a good milk producer – compared to other local breeds and is capable of an average of about 8-10kgs per day, with a fat content of 4.5 %, within an average lactation period of 10 months. Sahiwal has larger teats compared to other Zebu breeds, making milking easier.

They produce small calves (average weight of 27kg) without difficulty or requiring assistance. Sahiwal is also relatively resistant to tick-borne diseases, though not as much as Boran. These characteristics make the Sahiwal attractive to the arid and semi-arid lands of Kenya, Eastern Africa.


Photograph 8: Technical support to one of the bulls' schemes in Olipikidong'oi

Cross breeding

Sahiwal is an excellent grazer, able to use pastures in arid and semi-arid areas, making it a good alternative for farmers who are not interested in zero grazing or want to have both milk and beef. Crossbreeding with Fresian, Jersey or Ayrshire increases the milk production potential of its heifer.

Box 1: Sahiwal cattle breed in Kenya

Kenya has enormous genetic resources of Sahiwal cattle that is used as source of breeding stock and semen for the country and Africa.

Photograph 9: Redish brown Sahiwal

A Sahiwal-Friesian cow gives higher milk yields compared to a purebred Sahiwal, yet it does not eat as much as the Friesian breed. The breed is also resistant to most of the common cattle diseases compared to the Friesian. According to research conducted by KALRO, the Fresian-Sahiwal cross gives average milk yields of 15-18kgs per day. Calves grow faster and so heifers can be served early.

Feeding

Sahiwal thrives on natural pastures - including Kikuyu grass (*Pennisetum clandestinum*), star grass (*Cynodon plectostachyum*) as well as raised fodder grasses like Boma Rhodes (*Chloris gayana*), Foxtail grass (*Cenchrus Ciliaris*) and Fodder Sorghum, among others. It is advised that the cows be grazed rotationally in paddocks to give grasses time to re-grow. Water and mineral licks should be provided as the farmer desires. Sahiwal cows kept for milk production can be supplemented with a protein legume and concentrate for more milk production.

Health management

Ticks pose a major risk to cows in pasture areas. Dip or spraying with acaricides once a week is recommended to prevent tick bone diseases. To prevent internal parasites, animals should be dewormed at least once in every three months or as is necessary depending on the helminth feacal egg count.

In addition, routine vaccinations against diseases like Foot and Mouth, Anthrax, Lumpy Skin Disease (LSD), and other epizoonotic diseases should be done as recommended by veterinarians. For instance, East Coast Fever (ECF) vaccine is now available and given once in the animal’s lifetime for Anthrax vaccinations should be given twice a year.

Scaling up approaches to promote technology

The Sahiwal breed has during the period of implementation of the EAAPP been shared across borders. For instance, two farms in Kenya sold 154 bulls to buyers in Tanzania. Low input external production systems in Kenya**.** Records are available to tress the pedigree. This is part of ensuring that the breed standards are maintained. The animals selected for cross boarder trading were part of breeding programme with inspection that requires detailed pedigree and performance records on each animal during inspection.

Current situation with reference to use of technology and future scaling up strategies

The crossbred females with 93.75% Sahiwal inheritance have demonstrated potential for increased productivity. They have an increased milk yield (1543kg/ lactation; Calving Interval 446days; Age at first calving 41 months). They can survive in various ecological zones ranging from the Afro-alpine moorlands to the very arid areas including the highly fertile humid and sub-humid agricultural areas of the highlands, the semiarid and arid range areas, and the fertile coastal strip. This makes the bred suitable for use in various parts of Eastern Africa where the Zebu have been reared for centuries by smallholder farmers.

Gender considerations in connection to development and use of Technology

This technology is designed to increase milk and milk products as well as beef productivity. Milk and milk products as well as beef are major sources of protein in Africa. Availability of proteins is very critical among childbearing mothers and children under 5 years. This is a key gender consideration in the breeding programme for the Sahiwal since it is largely intended to increase milk and meat production.

Contact details of the generators and promoters of the technology

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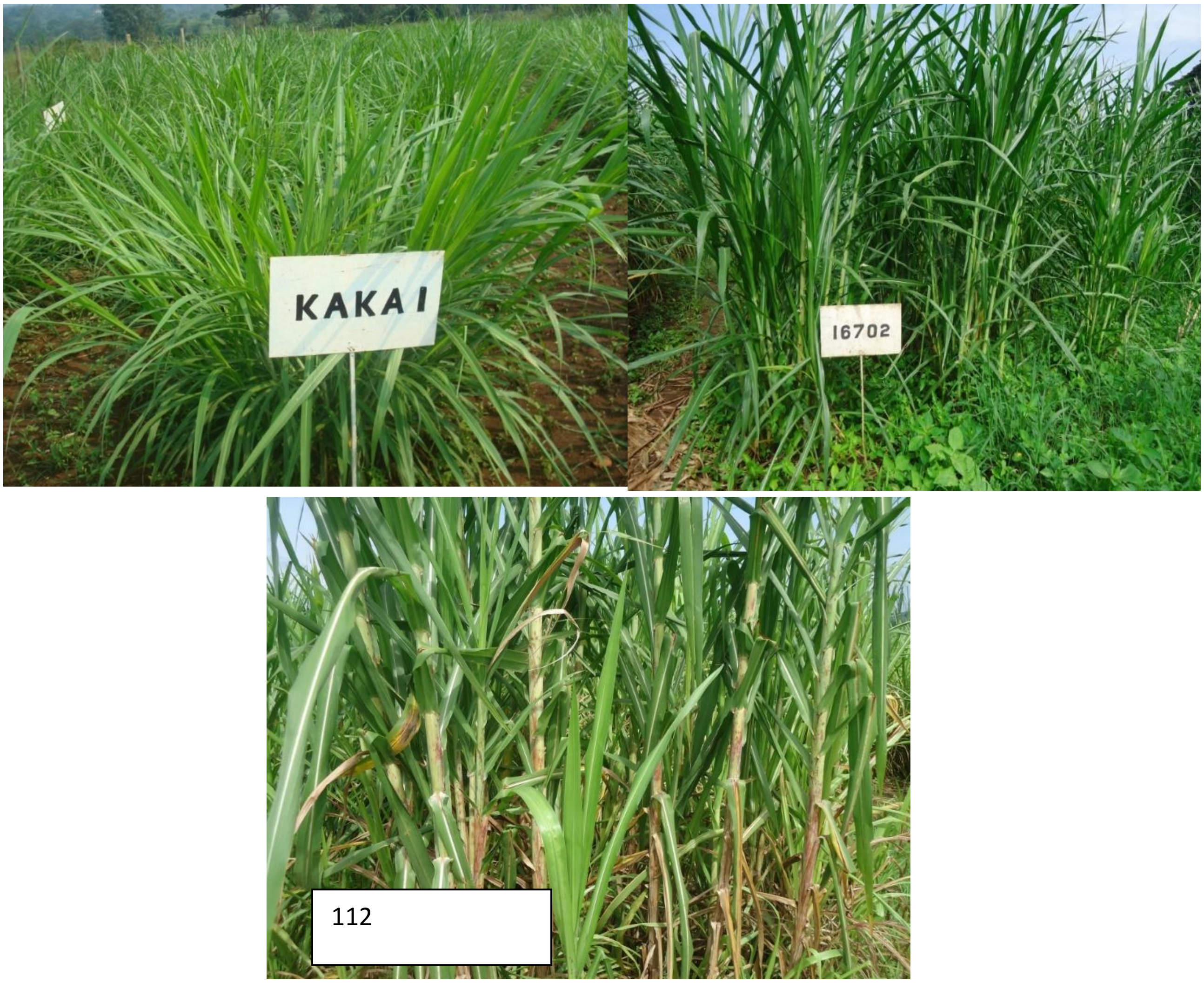
2.2 Napier Grass Accessions Tolerant to Napier Stunt Disease

Description of the technology

Efforts to generate technologies against Napier stunt disease have yielded four technologies in form of tolerant varieties that were developed and are now available for uptake pathway and being used in the region.



Photograph 10: Photos showing the different Napier varieties developed

Napier grass (*Pennisetum purpureum* Schumach) also known as elephant grass, contributes 60-80% of the forages in smallholder dairy systems in Eastern and Central Africa (ECA). The grass, whose herbage dry matter yield (DMY) ranges between 16 and 30 t/ha/year is grown by over 80% of smallholder farmers in ECA. Indirectly, some farmers earn cash incomes from selling napier grass fodder to dairy farmers. The grass is also being used as a trap crop in the integrated management of stem borers (*Chilopartellus*) of maize and sorghum.

Photograph 11: Napier grass accessions tolerant to Stunting & Smut Diseases

Napier grass production in ECA is threatened by Napier stunt disease (NSD), caused by 16SrXI group phytoplasma (*Candidatus* Phytoplasma *oryzae*) (Nielsen et al., 2007). Studies conducted in Uganda have shown that all locally available napier grass accessions are susceptible to NSD. Affected shoots become pale yellow in colour and seriously dwarfed. Often the whole stool is affected, with yield reductions of 40-100% and eventual death of the plants. Consequently, the disease has reduced feed availability for livestock, increased price of napier grass in the worst affected districts, forcing some farmers to sell off their livestock. This challenge inspired the development of tolerant varieties described in Table below 2:

Table 3: Descriptors of Napier grass accessions tolerant to Napier stunt disease when compared to the local variety, *Pennisetum purpureum*

Descriptor	**Napier grass accessions tolerant to Napier stunt disease**				**Local variety *Pennisetum purpureum 99***
	Kakamega 1	**Kakamega 2**	**112**	**16702**	
Plant height (cm)	156.54	158.8	155.73	153.23	164.1
Average Dry matter yield (tonnes/ha/year)	31.88	33.6	31.88	32.38	24.4
Average Crude protein content (%)	7.3	7.3	7.7	7.4	7
Average Neutral Detergent Fibre (%)	59.7	58.8	58.2	58.6	59.8
Tiller count	37.92	37.26	40.24	32.07	56
Weeks to first harvest for use as fodder	12	12	12	12	14
Internode length	9.54	9.72	9.14	7.742	10.56
Tolerance to Napier (1-5), at 7th harvest (14 months after planting)	1	1	1	1	2
Colour of flower	bright yellow, turning brown	light yellow	light yellow	light yellow	light yellow

Scaling up approaches used to promote technology

This technology was conceived and developed in Kenya but has now crossed boarders and is widely used in Eastern Africa. In Uganda, planting materials were distributed to farmers in major districts where smallholder dairy cattle production is a major enterprise. AS indicated in Table below, the volume of seed produced and disseminated for Napier is greater than for the other forages. To ensure sustainable production, a team of scientists and extension staff were trained in basic agronomic practices. The scientists and extension workers designed and implemented tailor-made short course which have to date resulted in training as well as creating awareness to 14,906 (78,651 women) trained on Napier stunt disease control, use of alternative forages and seed multiplication within and outside Uganda. Other approaches that have been used to promote the technology include (a) Scientific conferences and workshops involving key stakeholders; (b) Agricultural Shows; (c) Media (Newspaper articles, TV and radio programmes); (d) Farmer manuals, leaflets, brochures and newspaper articles produced and disseminated to stakeholders; and, (e) scholarly reference/ resource materials in form of books published.

To meet demand for high-yielding, disease resistant fodder from smallholder dairy farmers in East Africa, scientists from the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI) worked together to select and distribute smut-resistant varieties of Napier grass.

Table 4: Quantity of forage seed produced and distributed (2012-2915)

Forage species	On-station	On-farm	Total produced
Chloris gayana (kgs)	2,600	750	**3,350**
Clitoria ternatea (kgs)	150	0	**150**
Brachiaria splits (sacs)	156,000	20,000	**176,000**
Lablab purpureus (kgs)	4,500	2,000	**6,500**
Napier grass accession tolerant to Napier stunt disease (cuttings)	25,000,000	15,000,000	**40,000,000**

On-station *refers to NaLIRRI and ZARDIs*
On-farm: *Established (for seed production) by the farmers who received planting materials from NaLiRRI and ZARDIs*

Current situation with reference to use of technology and future scaling up strategies

The varieties are now widely used within Eastern Africa and continue to spread in the Lake Victoria crescent. The model for technology diffusion has been farmer-to-farmer extension approach with farmers continuing to multiply and sell the new accessions to other farmers. The fodder availability has increased in the region by over 20% due to use of tolerant Napier grass accessions. The process of scaling up and use of Napier tolerant varieties remains of interest to scientists and is not only a business of down-stream actors. To meet demand for high-yielding, disease resistant fodder from smallholder dairy farmers in East Africa, scientists from the Kenya Agricultural Research Institute (KARI) and the International Livestock Institute (ILRI) have continued to work together to distribute smut-resistant varieties of Napier grass. In 2012, ILRI provided the Brazilian Agricultural Research Corporation, Embrapa, with Kakamega I and II to enable researchers to use them to develop higher yielding and more nutritious resistant varieties.

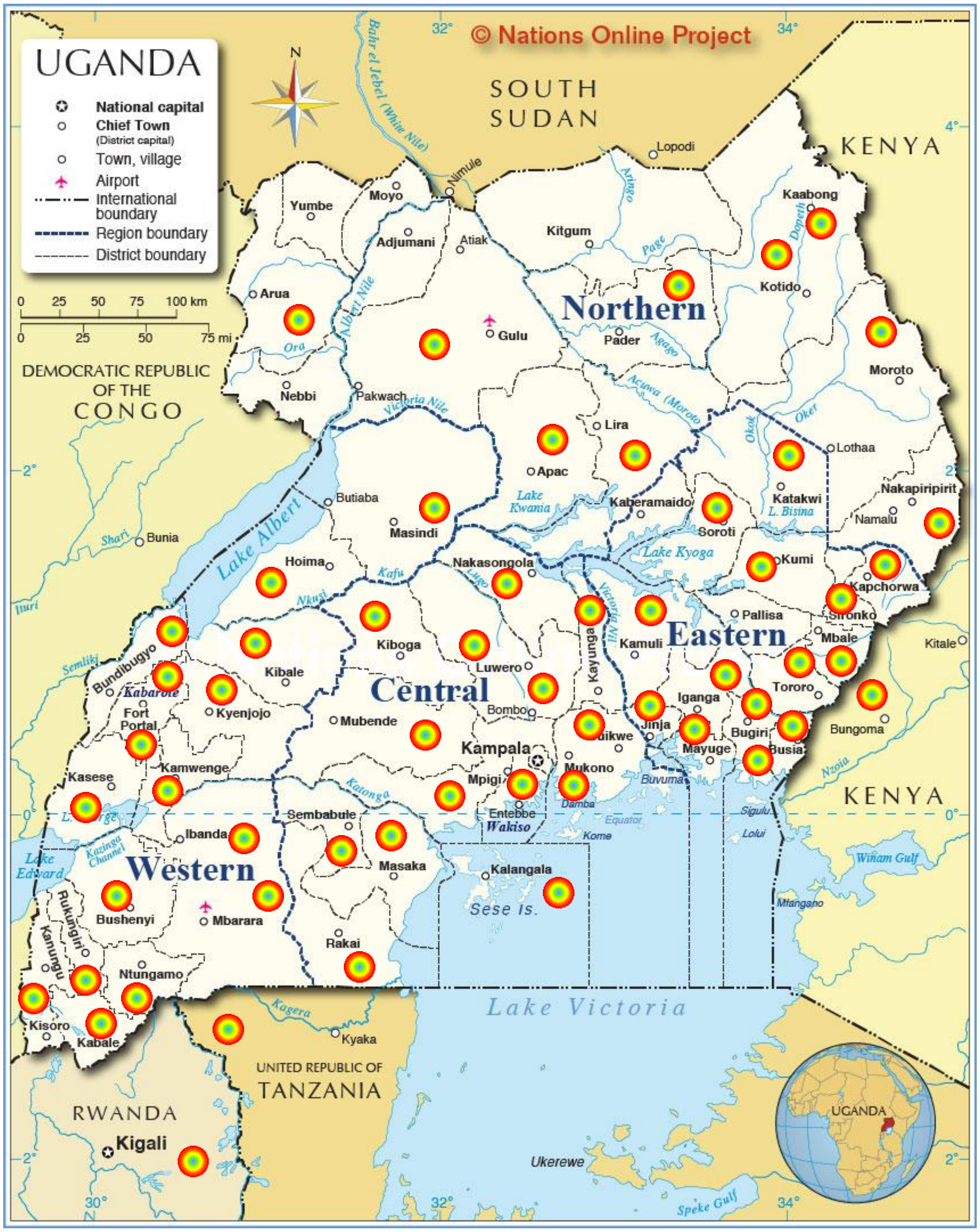


Figure 4: Map showing districts where forage seed has been distributed by various organizations

Gender considerations in connection to development and use of the technology

During the development of the technology, women were involved in this research. This technology is well suited for zero grazing and provides comfort for women farmers. Other attendant technologies facilitate easy access to this grass for example chopping The activities that link the processing of the forage provide for gender-disaggregated roles. The men can fetch form the field while the women and children can participate in chopping and feeding animals as they attend to other household tasks. Increased milk production arising from adequate feeding translates into better household nutrition with increased milk consumption by children and childbearing mothers.

Photograph 12: Family members participate in feeding

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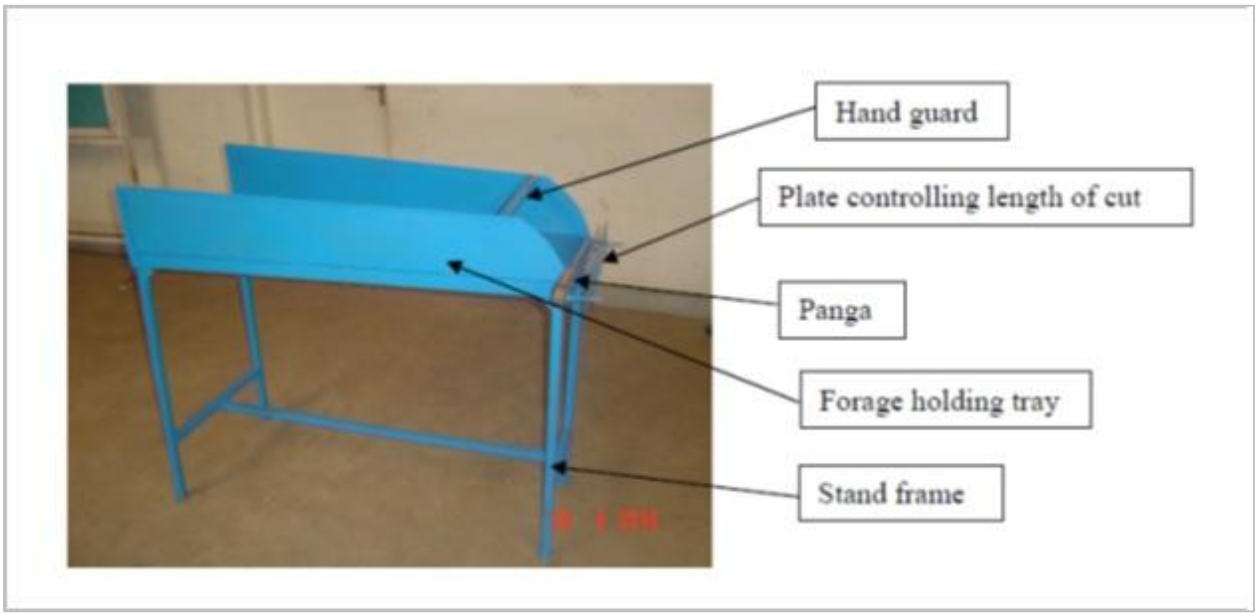
2.3 Forage Chopper

Description of the Technology

The zero-grazing livestock production system is characterized by high feed requirements and high labour demands. Forage processing for zero-grazing animals requires planting and caring for forage just like the other seasonal crops, and then harvesting, transporting home, chopping and feeding it to the animals. Forage materials for zero grazing animals require chopping for ease of consumption by the animal and increased palatability. These activities are predominantly carried out by women, often assisted by their children. The high labour demands, coupled with a lack of sufficient land for forage production and forage scarcity for dry season feeding, means that available forage must be efficiently used, and waste minimized. Hand tools and head porterage are factors in the labour demands of forage production and transportation to often distant cattle stalls. Hand chopping is the common practice among majority of farmers. Additional to low output capacity and lack of uniformity in length of cut, the method is tedious, time consuming and quite dangerous to the operator. The forage chopper has been developed to address some of these constraints.



Photograph 13: Components of a forage chopper

The manual forage chopper (fixed knife) is an all metal machine with a mild steel sheet holding tray for holding un-chopped forage. Towards the front end of the holding tray is a hand bar for preventing the operator's hand from reaching the chopping end. This is targeted to minimize accidents that were related to the traditional hand chopping method where farmers reported cases of cut off or hurt fingers. The chopping tray rests on a four-legged stand. At the front end of the machine is the chopping slot. Within the chopping slot is fitted a removable panga. The panga can be fitted on either left or right hand side of the chopping slot depending on the operator's convenience. Adjacent to the chopping slot is an adjustable plate controlling the length of cut that can be set within the range of 1 – 3 inches of cut.

Among the constraints faced by the smallholder dairy farmers is the drudgery associated with forage processing. Secondly, there is a need to promote efficient utilization of fodder, which entails forage chopping for conservation of forage, especially for dry season feeding, as well as to reduce forage wastage in the rains. The forage chopper has proved very effective in reducing the chopping accidents related to the traditional hand chopping, eliminating the cutting off or hurting the operator's fingers. Secondly, the forage chopper has effectively improved the user labour efficiency, easing the forage processing activity, which has allowed farmers either to reassign roles or time to engage in other productive activities.

Scaling up approaches used to promote technology

The forage chopper has been evaluated on a number of smallholder dairy farms in Eastern Africa. There is increased use by smallholder zero grazing dairy farmers and this is in part largely due to convening events organized for purposes of promoting the technology, including among others on-farm demonstrations, Shows e.g., Agricultural shows and World Food Days, and, Farmer field days. On-farm evaluations have been used to allow assessment by users and potential-users. On-farm demonstrations have provided opportunity to researchers and users to interact and learn more about the use and maintenance procedures needed for effectiveness and efficiency.

Traditional hand chopping

Photograph 14: Risk of traditional hand chopping lessened by increased adoption of forage chopper

Current situation with reference to use of technology and future scaling up strategies

Technology adoption and use in the EAAPP participating countries 600 (200 per country) smallholder farmers have been reached but the effective uptake and use is for about 150 smallholders zero grazing dairy farmers. The relatively slow uptake is attributed to challenges with essential factors that include: (a) Initial cost of the machine; (b) cost of repair and maintenance of the machine; (c) Availability of after-sale services; (d) Availability of the machines and (e) Availability of fodder. Through interaction with farmers using the machine, researchers have had opportunity to look at issues to be considered for further scaling-up. In an effort to reduce the cost of the machine, other materials have been considered for fabrication. Either a combination of wood and timer or the promotion of wooden models.

Gender considerations in connection to development and use of the technology

East African women have long played a key role in the domestic care of local cattle. The introduction of zero grazing animals increased women's tasks within the livestock sector. Given the increased burden, it was imperative to enhance women's access to appropriate technologies and necessary information regarding new forms of livestock husbandry. The processing of forage is predominantly carried out by women, often assisted by children. Hand chopping is the common practice but it is associated with low output, lack of uniformity in length of cut, method is tedious and quite dangerous to operator. Forage chopper would reduce women's labour burdens in forage processing and empower them by freeing their labour for other income generating activities.

Photograph 15: The machine is user friendly and appreciated by women

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Lead organisation and the scientist

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2.4 Treadle Pump

Description of the Technology

The large-scale irrigation schemes of the past have lost favour because of their social environmental and financial costs. Consequently, current project planners are seeking the participation of farmers in designing and managing irrigation plans in addition to re-dress on issues of social equity and environmental sustainability. For all the countries in Eastern Africa, environmental degradation is on the increase due to both population pressure on the already available well-watered land and wetland encroachment as a means to obtain assured moisture for crop production. Over 80% of the population is rural while 90% is engaged in agriculture, whose productivity has been on the decline (low input/low output system due to unpredictability of rainfall and long dry spells). This has resulted into increased poverty levels and thus, depriving farmers the purchasing power to acquire recommended technologies. Motorized pumps for example, have high running and maintenance costs, which could be a dis-incentive to production hence, the treadle pump innovation. The pump is a simple human powered device that can be locally manufactured and maintained at low cost in rural settings. The pump has a wooden base, two cylinders, two wooden pedaling boards, suction and delivery pipes and operator support pipes. A vertical support pipe is fitted with a pulley that carries two pumping pistons. The head of each of the pistons is fitted with a pair of leather cups.

This is a positive displacement pump, whereby water is pushed by a force applied by the legs through two pistons. The principle is based on suction lift using a cylinder and piston to draw water from a source below ground level, for example a river or shallow well. The pump was originally developed as a hand pump for domestic water supply, but skillfully adapted for use in irrigation but is still used for watering animals especially in zero grazing systems.

Photograph 16: Components of a treadle pump

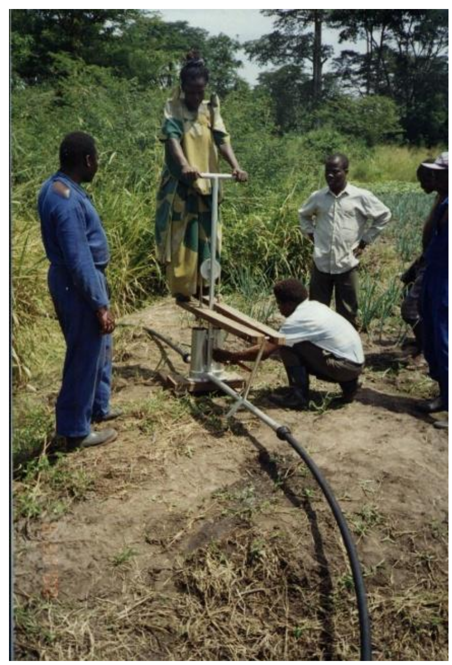
Two types of treadle pumps are available and many modifications have been made to make them suit local operating conditions. The two main types of pumps are designed to do different tasks and so they are not directly comparable. Secondly, there is not enough information available on all the design modifications to enable effective comparisons to be made between pumps of the same type. There are differences in design, e.g., the materials used, dimensions of components and the standards of workmanship and in the methods of testing.

Increased agricultural productivity through use of improved technologies is a key to reducing poverty in many developing countries. During the dry season, majority of farmers cannot grow crops, resulting in a shortage of essential foods like vegetables and fruits. During the same period, livestock do not have enough pasture and water and crowd around very limited watering points. The treadle pump can effectively and cheaply transmit water from a source to irrigate the crops and water animals. Other advantages are:

- The pump can be used to lift water for household use
- Locally produced and therefore spares available
- Cheaper than motorized pumps, easy to operate and maintain
- Environmentally friendly
- Can be operated by both women and men

Scaling up approaches used to promote technology

Dissemination, scaling out/up approaches that were used as part of scaling up and promotion of technology include on-farm evaluations, on-farm demonstrations, Shows e.g., Agricultural shows, World Food Days and Farmer field days. The on-farm evaluations presented opportunity of users to assess the machines through a joint undertaking. Using on-farm demonstrations facilitated researchers and users to interact and learn more about the use, maintenance and repair of the machine.



Photograph 17: On-farm evaluation of the treadle pump in Luwero

Current situation with reference to use of technology and future scaling up strategies

Over 350 smallholder farmers have been reached but the effective uptake and use is for about 200 smallholder farmers. Users have highlighted the following demerits of the treadle pump technology:

1) The pump can only be used where the water table is high, i.e., 3m and above. Below 3m it is more difficult to suction the water. The limit is set by atmospheric pressure.
2) The maximum discharge is limited to $10m^3/hr$. This limit is set by the human leg muscle. About $6m^3/hr$ can be comfortably discharged.
3) The pump can command/irrigate a limited area (0.1-0.2ha) at ago
4) The maximum head that can be generated is 5m. therefore a sprinkler, apart from micro, cannot be operated, but drip and surface methods can be used
5) Treadling for hours on a daily basis is very strenuous and laborious
6) To manufacture the pump you need a well-equipped workshop
7) Operation is labour intensive; a minimum of 2 persons

8) Zimbabwe and Niger models too heavy to be moved by one individual
9) The ApproTec pump is light and portable thereby making it prone to theft
10) Pump may not be suitable for pumping drinking water because of lubricants and the leather.

To address the issue of water source, the researchers have been promoting both roof and surface run off water harvesting.

Gender considerations in connection to development and use of the technology
The treadle pump was designed taking gender into consideration. Despite the demerits listed above, **Error! Bookmark not defined.**women, men and youth can comfortably operate the machine.

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2.5 Attached Moldboard Plough

Description of the technology

It is animal drawn improved Moldboard plough that is attached to the wooden parts of Ethiopian traditional plough, ***'Maresha'***, such as beam (*mofer*) handle (*erf*), one wooden wing (deger) and metal tying unit. The cutting edge or shear is replaceable when it wores out. It makes deeper and wider furrows and completes land preparation with lower input of draft power and tillage frequency than ***Maresha.*** Unlike the previous efforts made to introduce moldboard ploughs, this one easily diffused into the user community, because of its light weight, and basic similarity to the local plough except the ground engaging part. This equipment was extensively tested at different parts of the country under heavy, medium and light soil using the local oxen as the draft unit. The implement does not require extra draft power and skill compared to the local plough and was tested by women in certain areas as well. The implement was tested with farmers at Wolencheti, Bofa, Siraro, Melkassa, Holleta, Baher Dar and Bako.

Photograph 18: Beam (*mofer*) handle (*erf*) moldboard plough

Table 5: Specifications and Working Features

Overall dimension, mm			**Weight, kg**		**Working depth, mm**	**Working area, mm^2**
Length	**Width**	**Height**	**With attachments**	**W/o attachments**		
660	310	243	16	5	125	33390
Field capacity, m^2/hr		Draft, kg	Unit draft, kg/cm^2	Labour requirement		Price, Birr
434		106	0.33	**1**		366

Scaling up approaches used to promote technology

Smallholder farmers are the major beneficiaries of the technology, which has now spread to various parts of Eastern Africa. The implement was multiplied by the Melkassae Agricultural Mechanization Research Centered, and have been distributed to different farmers with support from Regional Agricultural Research Centers, Private entrepreneurs and Big and small manufacturers. The Agricultural Mechanization Center alone though limited to batch production for demonstration purposes, has distributed over 500 ploughs. The following factors/conductions are essential for promotion of improved small-farm implements.

a. Large-farm machineries developed for large-scale farm sizes are very expensive and not suitable for small and patchy sized farms of smallholder farmers. On the other hand, there is need of improved farm implements for efficient and improved land preparation to increase productivity and production of wheat and other crops. Therefore, this is an opportunity for small-farm implements to be successfully disseminated to smallholder farmers with small farm size.

b. Previous and existing agricultural development policies and strategies for increased productivity and production have been and will be favourable for development and promotion of improved small-farm implements.
c. Knowledge and techniques are available with researchers on small-farm implements.
d. The extension system is very eager in dissemination of improved small-farm implements for smallholder farmers because large-farm implements do not fit to and are expensive in small sized farms.

Current situation with reference to use of technology and future scaling up strategies

The plough technology is now being picked up by private small enterprises and demand has increased due to the interest of some successful farmers asking for improved implements. In addition, small and micro enterprises are trained on the manufacturing skill of the implement, have entered the business, and are manufacturing the implement on contractual and demand basis. Nonetheless, unavailability and escalating price of manufacturing materials may make the technology inaccessible to the poor and low-income farmers unless the credit and other cash access systems are put in place.

Gender considerations in connection to development and use of the technology

The design of the project to develop the implement took into consideration both the needs of men and women. Early in the demonstration stage, women were actively involved and were equipped with skills on how to use the implement. Several women farmers own the plough and they have found it user-friendly. Proper land preparation makes easy the planting and weeding operations that are primarily the task of women and school-age children. Therefore, envisaged that adoption of 'Erf' and 'Mofer' attached Moldboard Plough will reduce the workload on women, and school-age children to allow them to engage in other productive activities.

Additional documentation that may be useful in describing your technology

- Strengthen the development and use of suitable small-farm implements technology.
- Governments have to facilitate the development and dissemination of the implements and give direction for extension system to focus on dissemination of the implements in addition to other technologies.

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2.6 Fodder Conservation (Tube Silage)

Description of the technology

There is increased interest for zero grazing and with this comes the challenge of adequate feeds throughout the year. Tube silage in one of the technologies used by small scale in pastures and fodder conservation. It involves harvesting of fodder at the optimum nutrient level, chopping and putting it into polythene bags while compacting to remove oxygen. This method preserves fodder for a longer period while minimizing wastage at peak of production. The tubes are available at different sizes and are easier to handle and store.

Photograph 19: Fodder Conservation Using Silage Tubes in Uganda

Dairy farming business in Kenya frequently suffers a set back every time there is a dry season due to lack of adequate fodder for dairy animals. Ironically, the prices of milk are at their highest during the dry spells. This interferes with the profitability of dairy enterprise. However, with a constant supply of silage, the dairy farmers can triple their income for the same period of milk production. Today this has been made possible by the use of tube silage making technology, which was introduced in the country by an American farmer's cooperative called Land O' Lakes, some years back and latter taken over by extension services. Currently this silage making technology has become popular than ever before as a result of climate change which has led to frequent fodder shortages.

Box 2: Material requirements for the tube silage making technology

- Fodder – Napier, maize or sorghum can be used.
- Black polythene tubes, two and a half metres, gauge 1000.
- Mollasses-20 litres
- Chaff cutter or a machete
- Canvas
- Sack
- Medium sized bucket
- 5litres plastic container for mixing
- Watering can
- sisal twine
- water
- 2 people to provide labour for application of the technology. Make the silage in the store where it will remain until ready for use

The process entails the following steps

- Harvest the fodder and keep it for two days to wilt.
- Chop the fodder into to 2.5cm length pieces.
- Measure one bag of well compressed fodder (about 70kgs) and spread it on the canvas.
- Mix 1 litre molasses with 3 litres of water and sprinkle the mixture over the fodder then mix thoroughly.
- Pleat the black polythene tube lengthwise, tie firmly with the sisal twine at 30cm distance from the cut edge, fold back the edge and tie once again to exclude the air.
- Turn the polythene bag inside out.

- Roll down or fold back the top of the polythene bag.
- Put into the polythene bag the mixture of fodder, molasses and water.
- Compress the mixture firmly to exclude all the air. A man in clean gum boots can stand inside the bag and compress the fodder down thoroughly using the feet.
- Repeat the steps until the polythene bag is full, approximately 450kgs weight. Hold the top of the polythene bag firmly excluding the air. Tie the bag firmly with a sisal twine excluding the air in order to encourage the growth of fermentation bacteria. Place a weight at the top to exclude the air which if allowed will make the mixture to rot due to activity of rotting bacteria.
- A bag of soil approximately of about 40kgs has been used successfully by farmers to weigh down the top.
- Wait for 21 days for completion of the fermentation process before use. Temperatures of 40º-42º are recommended during the fermentation process and a silage thermometer can be used for measuring. The silage made using this technology is sweet smelling and brown when ready.
- Mix the high quality silage with Napier or hay when feeding the dairy animals for maximum benefit.
- The amount of fodder to be fed per dairy cow depends on milk production .This dairy industry technology has come at the right time to the right people.

Scaling up approaches used to promote technology

The silage making technology is spreading at a high rate among the smallholder dairy farmers. This technology was shared in the region through exchange visits, brochures, and leaflets and uploaded in the websites. Some innovative youths have identified the technology as a business opportunity, and are giving the service of making the tube silage for a fee. Tube silage making technology is simple, cost effective and ideal for smallholder dairy farmers. Tube silage making technology has two major advantages. First, the technology ensures constant milk production by the dairy cows throughout the year, due to a regular supply of dairy animal feeds, leading to good returns from the dairy enterprise. Secondly, it promotes conservation of excess fodder allowing harvesting at the optimum stage, preventing overgrown fodder and ensuring high quality fodder for the dairy cows at all times. These merits of the technology make it appropriate for smallholder farmers.

Photograph 20: Compacting silage during ensiling

Gender considerations in connection to development and use of the technology

The technology is gender friendly and is in particular it is suitable for women farmers because it assure o availability of cattle feed frees women engaged in zero grazing to attend to other household tasks.

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2.7 Crop Residue Blocks

Description of the technology

Crop residue blocks are compacted feed blocks made from locally available crop residues (maize stover, rice, oats and wheat straws, and sugarcane tops) enhanced with mineral and nutrient supplements. The following crop residue feeding blocks have been developed and used by farmers:

- Cashew nut waste,
- Coconut cake crop residue,
- Maize Stover-Sugarcane tops based feed block,
- Wheat & oats straw based feed blocks
- Yeast treated rice feed block were developed.

An example of process of formulating crop residue crop using Maize stover is as described below.

Maize stover was obtained from fields at the Kenya Agricultural and Livestock Research Organization (KALRO). Purified bentonite clay was purchased from Athi River. Biochar was made at the centre (KALRO), with maize stover as biomass/feed stock materials. The Biochar Kiln was purchased from the African Christians Organization Network (ACON), an NGO in Western Kenya, Bungoma County. Maize stover was pulverized using a small-scale feed pulverizer, obtained from Tinga engineering company in Nakuru. They were then pulverized into small particles and store

Photograph 21: Small-scale biochar making kiln at KARI Muguga South

Mixing and moulding

Urea (10 kg) was mixed with minerals (common salt 3kg and mineral premixes 2kg) in a large container. A solution was made up using 40 litres of water. Then 20kg of molasses was added and the mixture stirred thoroughly with a wooded stick until all the urea and minerals was completely dissolved. The specified amount of maize stover (40 kg) was placed on the ground in a heap on a polythene paper. Then 10 kg of cement was added into it and this mix was thoroughly mixed using shovels and forks. Where bentonite was the treatment, 10 kg was added into this mix, while 5 kg of biochar was added where the latter was the treatment. The mix was then sprinkled with the mixed solution of “molasses-mineral/salt-urea” using a water sprinkler, and carefully kneaded until a uniform paste of good consistency was prepared, and stored overnight. Small amounts of the paste were progressively stacked into a feed block making machine, and compressed into a block. The blocks were allowed to cure in shaded area for three weeks prior to feeding trial.



Moulding process **Experimental feed blocks**

Photograph 22; Demonstrating use of biochar to mass produce feeding blocks

Animal feeding

Two feed blocks were offered to each animal as a basal diet twice a day, one in the morning at 830hrs and one in the evening at 230hrs. No feed supplementation was done during the experimental period. Animals were adapted to the new housing and feeding conditions for 14 days before faecal collection. Dung was collected from each animal for seven days at 800hrs. Daily faecal output was weighed and sub-sample for dry matter (DM) determination. A 10% sub-sample was bulked per animal over the collection period and stored at -5ºC.

Photograph 23: A dairy steer feeding on the experimental feed block in a feed box

These crop residue feed block technology was shared across the region during shows/exhibitions and conferences. The same technology was shared through brochures, extension manuals and leaflets and uploaded into project websites. The advantages of densified feed blocks as expressed by farmers were that they are balanced and improved supply of nutrients; reduced feed wastage thus efficient in delivery of nutrients and reduced expenditure on labour.

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2.8 Homemade Feed Rations for Dairy Animals

Description of the technology

Dairy ration options for zero-grazing dairy production system were formulated using PCDAIRY WIN05 software package. The software consists of eight feed formulation modules. The feed rations were formulated for specific regions based on the locally available feed resources
Some of the rations formulated included:

The KALRO Naivasha dairy rations were:

- Rhodes grass hay + Lucerne hay + Wheat bran + Cotton seed cake + Soya bean cake + Molasses + Stock lime + Yea sac (Conventional; concentrate supplementation during milking)
- Rhodes grass hay + Lucerne hay + Wheat bran + Cotton seed cake + Soya bean cake + Molasses + Stock lime + Yea sac (TMR)
- Maize stover + Lucerne hay + Wheat bran + Cotton seed cake + Soya bean cake + Molasses + Stock lime + Yea sac (Conventional; concentrate supplementation during milking)
- Maize stover + Lucerne hay + Wheat bran + Cotton seed cake + Soya bean cake + Molasses + Stock lime + Yea sac (TMR).

KALRO Ol Joro Orok dairy rations were:

- Green maize stalks silage + Lucerne hay + Wheat bran + Soya bean meal + Stock lime + Molasses + Yea-sac
- Green maize stalks silage + Lucerne hay + Wheat bran + Lupin seed meal + Stock lime + Molasses + Yea-sac
- Napier grass hay + Lucerne hay + Wheat bran + Soya bean meal + Stock lime + Molasses + Yea-sac
- Napier grass hay + Lucerne hay + Wheat bran + Lupin seed meal + Stock lime + Molasses + Yea-sac.

For the KALRO Ol Joro Orok feeding trial, Lucerne hay was included at 40 % of forage intake (dry matter basis), molasses at 0.5 % of concentrates intake (as fed basis), and Yea-sac at 0.05 % of concentrate intake (as fed basis).

Photograph 24: Homemade feed rations

The technology is being disseminated throughout East Africa. A total of 150 feed rations have been formulated using locally available resources. Use of this technology has resulted in increased milk yield by 20% at on station and 15% on-farm. Use of these homemade feed rations reduces costs by 10%.

The technology is gender friendly and is an efficient approach for waste management. Nonetheless, there is still a lot to be done in terms of refining and standardizing the technology.

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2.9 Early-Calves Weaning Diets

Description of the Technology

Early calve weaning diet was formulated to reduce the cost of rearing calves at the expense sale of milk. It was designed to serve asing diet/ milk replacer for smallholder diary production systems. During the first to second week, separate the calf from the mother or dam and start feeding her by hand. Feeding should meet the calves' nutrient requirements; aim at reducing deaths, encouraging rumen development and maintaining a as a daily growth rate of approximately 0.4 to 0.5kg.

Second week: Colostrum feeding continues for about four to five days. Though up to this time, the rumen of the calf is not yet well developed but has a groove formed that help deliver milk straight from the oesophagus to the abomasum (true stomach), restricting solid feed to pass.

Photograph 25: A farmer with his calves in Kikuyu, Kiambu

Milk feed increases as the body weight surges such that the calf consumes milk equivalent to 10 per cent of its own body weight. This continues for up to about week six.

Calves are the foundation on which the future of any dairy enterprise is built. If good replacement heifers are to be found, the management of calves must be effective.

Calf management starts even before she is born to the time she is weaned. With good feeding regime and routine practices, death cases are reduced even at the time when she is being born.

The calves remain healthy, grow fast into replacement heifers and start production early, hence rapidly contributing to genetic improvement and overall growth of the farm.

A few days before birth, the pregnant cow, which at this time shows the signs of calving, should be put into a maternity paddock, separate from other cows.

The paddock allows for closer monitoring and should be kept clean with fresh water provided.

During calving down, provide assistance when necessary to avoid difficulties and deaths at birth. After birth, first ensure that the calf is breathing. If having difficulty in breathing, assist it by removing mucus from nostrils.

If still not breathing, hold the calf by the rear limbs upside down, swinging it several times. Next tie and cut then disinfect the umbilical cord using iodine or solution of copper sulphate.

Feeding the Calf

During the first to second week, separate the calf from the mother or dam and start feeding her by hand. Feeding should meet the calves' nutrient requirements; aim at reducing deaths, encouraging rumen development and maintaining a daily growth rate of approximately 0.4 to 0.5kg.

This weight, however, varies with breeds. The feeding strategy, however, changes depending on the start of weaning.

First week of birth: After the calf is able to stand, allow it to suckle colostrum at will from the mother. The suckling should be assisted by directing the muzzle towards the udder if the calf is not able. Colostrum absorption is highest within 12 hours after birth and very low after 24 hours.

As such, the calf must suckle colostrum immediately after birth, most recommended within an hour or two. Excess colostrum can be stored or fed to other calves when still fresh.

Generally, colostrum has antibodies that pass immunity to the calf hence protect it against diseases the mother might have been exposed to. It is also a rich source of nutrients as it has high amount of energy and protein compared to milk.

Second week: Colostrum feeding continues for about four to five days. Though up to this time, the rumen of the calf is not yet well developed but has a groove formed that help deliver milk straight from the oesophagus to the abomasum (true stomach), restricting solid feed to pass.

It is for this reason that the calf remains dependent on liquid diets like whole milk or milk replacer for growth and nutrition and should be fed clean and warm at body temperature of 37C at 10 per cent body weight which translates to about four liters per day in at least two feedings. Milk here should be given through nipple suckling, bottle feeding or early introduction to bucket feeding.

Third week: Between two to three weeks of age, introduce high quality roughage. This can be supplemented with concentrates preferably calf starter pellets. Where hay is used, it should be of high quality, fine texture and mixed with legumes.

Milk feed increases as the body weight surges such that the calf consumes milk equivalent to 10 per cent of its own body weight. This continues for up to about week six.

Week 6: The amount of milk here is reduced and the calf is encouraged to consume dry feeds, including concentrates until weaning time at week nine.

Water

Even though water is the largest component of milk, calves should also be served fresh water. Lack of drinking water slows down the rate of digestion and development of the rumen lengthening the time for safe weaning. Water intake increases with age and after sometime the animal should have free access.

Weaning

This means withdrawing milk and the calf now becomes fully dependent on other feed sources. At this point, the calf has attained twice its birth weight.

Mostly, dairy calves are weaned at about nine to 12 weeks of age. It is possible to wean early at about five to eight weeks if more milk was fed and calves were introduced to pre-starter and starter feeds early in life. Early weaning, however, requires that a specific feeding programme be adopted, like using low levels of milk and high energy, high protein pelleted concentrates to stimulate rumen development.

To reduce stress on calves, weaning should be done gradually. Reduce the twice a day milk feeding to once a day to allow the calf's digestive system to adjust to the new diet.

Table 6: Chemical composition (%) and energy (MJ kg^{-1} DM) of experimental diet (Early calves' weaner diet (EWD)

Component	Amount
Energy	11
Crude protein	23
Crude fibre	9.10
Calcium	0.90
Total phosphorus	1.50
Crude Fat	3.05

The cost of rearing a dairy calf up to 105 days was reduced by approximately threefold. With early calve weaning diet, farmers to save 9 kg of milk per cow per day. Therefore, for a 105-day calf-rearing period, the total milk saved (due to feeding of EWD) was 945 kg. At US$ 0.65 per kg of milk, the total savings would be valued at US$614. Therefore, with this EWD technology, farmers can save 945 kg of milk (valued at US$614) for home consumption and/or for sale for increased cash incomes, thus reduce poverty levels.

Scaling up approaches used to promote technology

This technology is available for scaling up but requires refinement, to fit particular context.

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2.10 Assisted Reproductive Technologies (ART)

Description of the technology

These are reproductive technologies that are used in faster improvement and multiplication of livestock germplasm. The ARTs shared in the region were Multiple Ovulation and Embryo Transfer (MOET) Technologies, Hormonal Synchronization and use of Artificial Insemination. **Hormonal synchronization ensures that cows come on heat at the same time.**

The breeding programme involves a nucleus herd situated at KARLO Kiboko and the commercial population with farmers. Bulls and dams were selected and purchased to obtain the effective breeding population, i.e., 5 bulls and 10 females. To optimize the breeding programme, increased selection and shortening of generation intervals of the breeding population was initiated. Multiple ovulation and embryo transfer (MOET) was incorporated to produce more animals as selection candidates.

Photograph 26: Jersey x Zebu up-grading ART supported program in Katakwi, North eastern Uganda

Through snowballing, the foundation breeding stock was selected from farms in the project sites on the basis of the following traits for both males and females: Milk yield, body size, fertility – calving interval and regular oestrus (bulls were selected based on dam performance and full-sib female information), Longevity, conformation (udder size and size of milk veins, leg shape) and age at the time of 2nd and 3rd calving. Due to lack of pedigree and performance recording, visual observation and the farmers' knowledge were relied on to select the animals. Own performance, full-sib, half-sib, sire and dam information were considered where available when selecting the breeding stock. Discretion was used to ensure the breeding males and females selected were not from the same locality to avoid possible inbreeding. It was, therefore, assumed that inbreeding for the base population was zero. The breeding stock bought from the farmers and KARLO Kiboko ranch and then uniquely identified, and kept at KARLO Kiboko for further screening, and for MOET, ES & AI or mating.

Organization of the mating system

First approach

Donor females were super ovulated and semen from the selected males used to inseminate them, while ensuring animals used were not from the same location to avoid possible inbreeding. The embryos were extracted after 7 days (morula and blastocyst stages) and transferred to recipients (surrogate mothers), who carried them, to term. Each donor yielded 5-6 viable embryos per cow per MOET session. Cows were synchronized so that they were in oestrus at the same time then inseminated artificially or using natural mating (ES & AI/Mating).The resultant male and female offspring were selected for breeding based on the traits of the foundation stock. MOET, ES & AI/Mating continued with these animals and new genetic material introduced whenever there is an opportunity for superior breeding animals.

Second approach

Through artificial insemination (AI), semen from the selected males was used to inseminate farmers' stock after oestrus synchronization, with restriction to avoid inbreeding. Individual farmers and the CBO's were trained on the management of a breeding programme as well as good animal husbandry practices (i.e., health management, animal nutrition, feeds and feeding, housing and animal welfare). In case of use of natural mating, the CBO's were trained on use of bull rotation schemes. Stocks were vaccinated against prevalent diseases as part of a strategy to enhance success of the breeding programme.

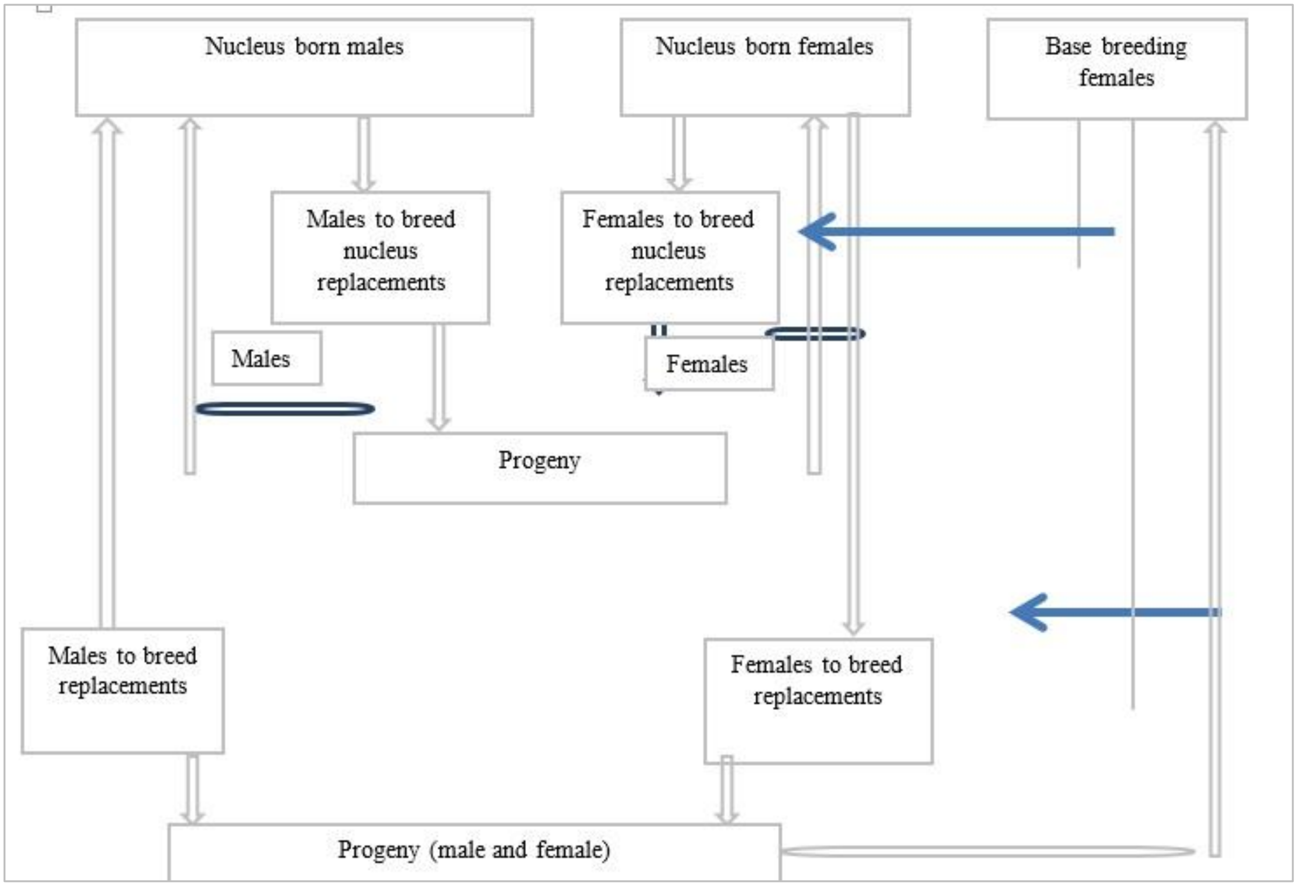

Figure 5: Open Nucleus Breeding Plan for the SEAZ (Kamba genotype)

Optimization of the breeding scheme

Multiple Ovulation Embryo Transfer (MOET)

The MOET was performed in 4 phases. Steps involved in MOET were selection of donor cattle, selection of recipient cattle, superovulation of donors, synchronization of donor and recipient cattle, artificial insemination of donor cattle, flushing of donor cattle, searching for and grading embryos and transfer of embryos into the receipients.

Oestrus synchronization, artificial insemination and natural mating

Three protocols were used to synchronize oestrus in the project SEAZ cattle.

Oestrous synchronization and artificial insemination (ES & AI).

The two procedures were carried out on 30 SEAZ cattle in a process similar to that of the recipient program for MOET. The only additional step was insemination of the cows 12 and 24 hours after they showed standing heat.The semen used was from bulls that were also used in the MOET program.

Oestrus synchronization and natural mating

Rectal examination was done in 45 SEAZ cows selected from the KARLO Kiboko herd. Sixteen cows in 2 groups were synchronized using Prostaglandin (estroPLAN®), the protocol used intramuscular injection of 2ml hormone and 10 ml Catasol on day 0 then a repeat of the same on day 11. One day after the last injection they were separated from the rest of project cows and selected bulls introduced to them and herded separately for 4 weeks during which the cows coming in heat were mated.

Oestrus synchronization, artificial insemination and natural mating

Oestrus in 19 cows was synchronized using, Prostaglandin (estroPLAN®) and Gonadotropin releasing hormone GnRH (Gonabreed®) hormones. Administration of 1ml GnRH was done on day 0; 2ml estroPLAN® was given on day 7, then 1ml GnRH was repeated on day 9 then timed insemination or natural mating carried out after 8 hours. Insemination was done twice twelve hours apart.

Nutrition of the SEAZ herd

All the cows and bulls were grazed on natural pasture within the KALRO Kiboko ranch and at least allowed nine hours of grazing on a daily basis. When the pasture was insufficient, they were supplemented using hay. Cattle on the MOET programs were also supplemented using concentrate feed and minerals. Donors were fed on 2 kg concentrates per day during the 29 day MOET program. The recipients were fed on 1 kg concentrate per day, one week before the transfers and continued for a further three (3) weeks for the recipients that received embryos. Water was provided in troughs inside and outside the cattle boma.

Reproductive parameters

The reproductive parameters studied in the superior or improved Zebu cattle and the foundation cows of the nucleus included length of oestrus cycle (days), length of oestrus(hrs) and behaviour, calving interval, calving ease, hormonal profiles, age at puberty, age at first parturition, gestation length, conception rate and parturition percentages, weight of calves at birth and weight at puberty. Sperm quality including motility, semen concentration, semen volume, were studied during semen collection and processing.

Scaling up approaches used to promote technology

These ART technologies were shared in Uganda, Tanzania and Ethiopia.

This technology marks an important milestone in the livestock sector and depicts the importance of translating research findings into applicable knowledge. For increased adoption, there is need to domesticate the technology at farm.

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2.11 Napier Tissue Culture Protocol for Mass Production of Disease Free Planting Materials

Description of the Technology

This technology relates to development of Napier grass tissue culture protocol and micro-propagate disease tolerant planting materials. It was developed when Napier grass accessions identified to be tolerant to stunt and smut diseases were collected and established in a screen house at KALRO biotechnology. The accessions included six non infected accessions (K75, K33, K38, K62, K72 and K82) from KALRO Alupe that had been identified to be tolerant to stunt disease through field screening, two accessions (Ouma 3 and South Africa L3) from KALRO Kakamega that had been identified to be tolerant to stunt disease through confined field screening at ICIPE; and two (Kakamega 1 and Kakamega 2) tolerant to smut disease from KALRO Muguga (FCRI).

The culture media comprised of Murashige and Skoog Medium (MS) powder supplemented with vitamins, 20 g/litre of sucrose and 2 mg/l BAP and dissolved in distilled water and at pH 5.7, 3 g of phytagel was added per liter of medium, boiled, and then dispensed into universal bottles of Kilner jars. The medium was sterilized by autoclaving at 121^{o}C. The medium was then allowed to solidify and stored at room temperature until it was required for use. Several young, green and non-woody auxiliary shoots of the desired Napier grass accessions from the greenhouse were excised with single edged razor blade and subjected to a protocol for surface sterilization procedure. The leaves were cut off and the stems cut to about 5 mm of the shoot – auxiliary explants (nodal sections) closer to the base with a ridged cross-section. Twenty (20) to 25 nodal sections were placed in each 500 ml conical flask. The explants were then washed in running tap water to get rid of large debris followed by washing in sterile distilled water. The prepared nodal sections were then soaked in broad spectrum fungicide solution for 30 minutes and transferred into a laminar flow cabinet. The explants were sterilized with a solution of 1.5% sodium hypochlorite for 20 minutes and later drained. The explants were then soaked in 80% ethanol for 5 minutes and washed with sterile distilled water 3 times to get rid of all the chemicals. Using sterile tweezers and a large, sterile scalpel blade, dead bleached tissues were aseptically cut off. Explants were gently pressed onto each nutrient MS medium bottle. The bottles were capped tightly and sealed with parafilm. The cultured explants were transferred into growth room, with controlled light, alternating 16 hrs light and 8 hours darkness at 27°C. Contaminated cultures were discarded. The non-contaminated plants that sprouted were multiplied through the process of

Photograph 27: Process of tissue culture from laboratory to acclimatization in the greenhouse

micro-propagation. A series of sub-culturing of any shoots that sprouted was done in fresh media to multiply and root. Data was taken on the number of shoots surviving, contaminated or dead.

Acclimatization and transfer of plantlets to soil

Emerging micro-propagated plants were transferred to the greenhouse. The process followed here included filling pots with vermiculite, removing the parafilm from the culture vessels and the lids.

Using fingers the gel was gently broken with care being taken not to damage any roots. The cultures were then taken to sink; fingers were spread over the top of the plants and warm water run over the media so that the gel floated on top of the water. The gel was poured out. Warm water was run onto any gel remaining allowing it to be broken up and washed off the plant roots by the force of the water from the tap. Plantlets were then returned to potting bench and transferred to the vermiculite containing pots. The plants were watered thoroughly until water run out of the bottom of the pots. Pots were placed in seed trays, covered with good fitting humidity bags to maintain moisture and placed on the bench in green house. The humidity bags were sprayed with fungicide in order to control possible attacks of fungus gnats. One week after potting the humidity papers was split on one side to start to acclimatize the plants to the green house conditions. After a further one week the humidity paper was removed totally. After a further three days plants were scooped out with the adhering vermiculite and transferred to pots containing sterile soil. Fungicide was sprayed on the sterile soil during acclimatization and fertilizer was to be added every two days in a week. These were watered till they become fully acclimatized to the green house conditions.

Scaling up approaches used to promote technology

Mass propagation of tissue culture Napier grass is possible in order to sustain the current demand of tolerant/resistant varieties/accessions. To obtain a high number of plants, the mother plants should be free from diseases. This technology is appropriate and can be undertaken to scale as part of commercialization at community level. This has not been possible in the course of implementation of the EAPP project and more needs to be done with a view to actualize commercial production.

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2.12 Bull semen from Kenya to other countries

Description of the Technology

Reproductive assisted technologies (RAT) are used for breed improvement and adaption where the females are synchronized using hormones and later inseminated using semen

Photograph 28: The technology was developed farmers taking into consideration contextual issues

Scaling up approaches used to promote technology

Approaches included training of farmers on animal husbandry especially signs of heat, heat detection and disease control in groups

Current situation with reference to use of technology and future scaling up strategies

Most of the inseminated cows have calved down and the crosses(F1s) are bigger in size and grows faster compared to the indigenous cattle. Use of value chain and innovation platform approaches will be the future scaling up strategies

Gender considerations in connection to development and use of the technology

During farmer selection and training gender aspects were considered where men and women especially female headed households keeping cattle were included in the exercises.

Additional documentation that may be useful in describing your technology

Authors to provide source/reference to actual communication products; and at least 4 photographs from which a suitable 1 -2 will be selected.

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2.13 Cassava Based Napier Grass Silage for Increased Milk Yield

Description of the Technology

Pasture grasses are the main sources of feed for livestock in East Africa. Use of Napier grass/ cassava leaves and tubers in silage making has shown to be an alternative to the conventional silage made from Napier grass/gliricidia and maize bran. Silage conservation is an option for providing high quality feed for the dry season. To address the low dairy productivity experienced during the dry season, the silage technology was adapted for coastal Kenya to conserve excess forage towards the end of the rainy season. Farmers in the region are encouraged to grow Napier grass in leucaena or gliricidia alleys to improve the quantity and quality of forages. Molasses is the recommended source of carbohydrate in silage making. However, it is not readily available in coastal Kenya. A technology was therefore developed for the region where maize bran is used instead of molasses. over dependency on maize for food has led to scarcity

Photograph 29: Farmers being trained on how to prepare Napier grass for silage making

Scaling up approaches used to promote technology

This technology demonstrates the importance of engaging farmers to use available feeds to maximize milk yields. Supplementing Napier grass silage with gliricidia or cassava leaves increased the crude protein (CP) in the silage from 71 for no supplement to 103 and 115 g/kg DM for gliricidia and cassava leaves respectively. Improved milk yields from the area following implementation of cassava based Napier grass silage technology has attracted milk processors who are now organizing milk collection channels and providing ready market for milk produced. Different approaches for uptake pathways have been used to scale up and promote the technology.

Photograph 30: A farmer pounding cassava roots in preparation

Refinement of this technology will be necessary in the process of dissemination to ensure that it is tailored to the local context.

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3.0 RICE TECHNOLOGIES

3.1 Two Tanzanian Rice Varieties Released in Kenya: Txd306 and Komboka; and Txd 307 and Komboka in Uganda

Description of the Technology

Variety TXD 306

Developed and released in Tanzania in 2002, TXD 306 commonly known as SARO 5 grows well in lowland rainfed and irrigated ecosystems in temperature ranging from 28°C to 35°C and average rainfall ranging from 800 - 1000 mm. The irrigated ecosystem is the most favourable because water availability is assured throughout the growing season.

Photograph 31: Rice crop with a good harvest

TXD306 has the following traits:

- High tillering ability with a range of 30 to 50 tillers per hill compared to traditional varieties (10-15 tillers per hill)
- Medium height (95-100 cm)
- Strong culm (resistant to lodging)
- High yielding potential ranging from 5.5 to 7 tha^{-1}
- Medium maturing, it takes 130-135 days to mature compared to local varieties that take up to 150 days;
- Aromatic, a character most preferred by consumers, hence highly acceptable.

Variety Komboka

This variety was released in Tanzania in 2012. Kombaka grows well at 0-1250 m.a.s.l under under irrigated and rainfed lowland ecosystems. It has a medium height (105-110 cm), medium maturity period (123 days) and it is a high yielding variety ranging from 5.5 to 6.0 tha^{-1}.

Variety TXD 307

This variety was released at Chollima Agro-scientific Research Centre in Tanzania. High tillering ability, medium height, strong culm, high yielding potential ranging from 5 to 7 tha^{-1}, medium maturing and aromatic

Scaling up approaches used to promote technology

In Tanzania, these varieties have reached almost all rice growing areas especially those under irrigation. TXD 306 and Komboka, and TXD 307 and Komboka have been released in Kenya and Uganda, respectively following evaluation trials that were conducted in these countries.

The scaling up approaches includes the use of demonstration plots through farmer groups and use of private companies to produce seed for farmers.

Current situation with reference to use of technology and future scaling up strategies

In Tanzania these varieties are widely grown in irrigated and rainfed lowland ecosystems. They are highly acceptable due to its yield advantage (up to 7t/ha) over traditional varieties (1.5-2 t/ha). They use high dosage of fertilizer (80kgN/ha, 20kgP/ha) compared to traditional varieties which use the maximum of 60kgN/ha and mostly without the use of P fertilizers. They are moderately tolerant to most diseases of economic importance such as Rice Yellow Mottle Virus (RYMV), Blast and Bacterial Leaf Blight (BLB). Their milling quality is moderate to high depending on soil fertility management and time of harvesting.

Scaling up of these varieties has not taken place in Kenya until the process in place to accredit seed laboratory at Tanzania Official Seed Certification Institute (TOSCI) to ISTA and OECD is finalized.

Gender considerations in connection to development and use of the technology

Farmers of all groups (men, women and youth) were involved in evaluating the varieties in the field and eventually participatory variety selection before they were officially released. Women are more concerned with household food security, while men and youth interest in rice farming is to generate income. Therefore, they adopt the use of these high yielding varieties to meet their need.

Additional documentation that may be useful in describing your technology

Inventory of technologies and RRCoE reports are available at ASARECA

Leaflets, brochures are available at RRCoE headquarters and at the Ministry of Agriculture Livestock and Fisheries.

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3.2 Demand-Driven Rice Varieties for Enhanced Yield Under Small Scale Farmers Conditions

Description of the technology

The germplasm was collected from the three major rice growing regions of Kenya comprising central, western and coast; and also acquisitions from IRRI, CIAT-Colombia, AfricaRice Centre, Mali, Tanzania, Uganda and Japan. These were screened for local adaptability and then characterised. The promising lines were selected for hybridization, wider multi-environment trials and regional sharing.

Photograph 32: Rice crop with a good harvest

The promising lines were entered into National Performance Trials by KEPHIS and under the regional harmonized materials and technology sharing, two varieties from Tanzania (TXD306 and IR05N221) were released in Kenya after one season testing. Both varieties were popular because of grain quality and aroma.

From breeding activities, 700 lines were acquired. Through selection after screening and characterization, 300 crosses were made that resulted in about 800 populations. Selections and MET resulted in nomination of 6 elite lines to National Performance Trials of which two were released and two are in the NPT.

The seed system for one of the released variety is being developed to unlock its commercialization. The TXD306 seeds are yet to be obtained from Tanzania, calling for some understanding to enable the project develop the breeder seeds and unlock its production by farmers.

The demand for NERICA1, TXD306 and IR05N221 seeds by farmers and seed companies is great, but unfortunately, the breeder seed is not yet available and there is urgent need to make seed available. For NERICA1, due to aroma the demand for seed cannot be met and more effort in seed production is therefore required. The breeder seeds for NERICAs 1, 4, 10, 11 and Dourado precoce were developed to basic seeds. There is need to develop the certified generations for commercialization by farmers and thus lead to improved productivity.

Photograph 33: SARO5 promotion demonstration

The seed packaging was changed from polythene bags of 1, 5 and 10 kg to Khaki envelopes and sealed with a gunny sealer. This improved seed aeration, and seed viability previously at one and half years.

Although some lines are in NPT, there are many good promising lines that have been developed and can be entered into NPT for variety release.

Table below shows the roadmap for released varieties seed certification for commercialization. It is clear from the table that there is need to step up certified seed production in volumes to meet the demand and scope of regional coverage.

Current situation with reference to use of technology and future scaling up strategies

A lot of work has been undertaken and many technologies made that require incubation and finally availing to farmers to spur the desired positive change toward self-rice food sufficiency. The polished elite lines need to be released for their eventual commercialization.

The popular released varieties under the phase one of the project need to be availed to farming community through finishing their seed production and linking up with the seed merchants for seed production and distribution to farmers.

Seeds of popular varieties released through regional collaboration were still unavailable and there is urgent need to formalize availing these to farmers. There is also need to promote them widely for faster adoption and hence increased productivity. There is also need to develop and package extension materials in form of manuals, brochures, pamphlets and posters.

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3.3 NERICA Rice Varieties in Uganda

Description of the technology

Under EAAP, National Crops Resources Research Institute (NaCRRI) released five irrigator rice varieties New Rice for Africa (NERICA) to farmers, and collaborated with interested organisations and seed companies to inspect and made applications for the new rice varieties. The varieties include Nerica 6, Komboka, WITA9, Agoro and Okile — are tolerant to the yellow mottle virus disease that causes premature yellowing of leaves.

NERICA 6 is highly tolerant to yellow mottle virus; it came in as an upland variety but it also did well in lowland areas because one of its parents is a lowland variety. Komboka, an aromatic rice ranked best during testing, was first released in Tanzania in 2011 and in Kenya a year later.

WITA9 performs well in most areas, including upland, and Agoro is high-yielding, early maturing and strongly aromatic. Okile rice variety is high yielding and has good grain characteristics. The new varieties have a short maturity period of between 105 and 110 days, compared with the earlier varieties that take between 130 and 150 days.

Ugandan farmers have been growing Kibimba rice varieties popularly known as K-Series or paddy rice and Supa, whose production has declined by half to between two and three tonnes per hectare. The development of the new rice variety involved screening of more than 300 lines that had been crossed at various international rice research institutes in China, the Philippines and Nigeria. From 2002 to 2013, Uganda's National Agricultural Research Organisation released nine rice varieties, all upland varieties.

Photograph 34: A farmer checks on the progress of rice growing in his garden

The Nerica 4 variety dominates and is appreciated for its hardiness, high yields and shorter maturation period of between 90-100 days compared to traditional varieties that take between 120-140 days. Nerica with off-springs, 1 to 10, have also been released, with seed multiplication by private seed dealers expanding their availability to farmers.

A farmer checks on the progress of rice growing in his garden. Over time, Ugandan farmers have adopted better yielding varieties boosted by research

Scaling up approaches used to promote technology

NaCRRI is working in collaboration with the Tilda rice scheme to multiply and distribute the seeds to farmers.

Current situation with reference to use of technology and future scaling up strategies

Over the last few years, Uganda has been experiencing a remarkable rice boom supported by good farming practices, premium market prices, and favorable policies that have stimulated large private investment in the rice sector.

The growth of Uganda's rice production has contributed to greater food security and a reduction in rice imports. For instance, according to the Ugandan government, rice imports dropped between 2005 and 2008, which helped save the country about US$30 million in foreign exchange earnings.

The area sown to rice nearly doubled from about 80,000 hectares in 2002 to about 150,000 hectares in 2011. Similarly, paddy production jumped from about 120,000 tons in 2002 to more than 220,000 tons in 2011.

Photograph 35: Evidence of increased yields

The rice industry in the country has rapidly moved from improved seed to production to processing and to the markets over the last few years.

Gender considerations in connection to development and use of the technology

The introduction of improved upland rice varieties has vastly expanded rice production in Uganda – reducing imports by a third. For many women farmers, the change is not only bringing a valuable new crop, but also more bargaining power with their husbands. Introduction of the NERICA-4 rice variety has challenged the traditional dichotomy where men produce high-value cash crops and women produce low-value food crops. In Uganda, rice is a high-value food crop produced by both men and women.

This totally changes the usual gender dynamics. With the production of this high-value crop, women are recognized as being contributing partners in a joint endeavor – and not just as free family labor, helping the husband with his commercial crop.

Photograph 36: Women prefer upland rice varieties as compared to paddy rice

The benefits from rice production come at significant costs to women and children, who take on the most burdensome tasks related to its cultivation. During the rice's most vulnerable stage, they spend 12-13 hours per day for over a month scaring off huge swarms of red-billed Quelea weaverbirds, which can destroy a field in a single day. The most effective control method is to run up and down the fields making noise and throwing rocks. Women describe feeling like "slaves to the rice" during this period, exhausted and unable to perform other tasks, while their children have to miss school.

Weeding also falls to women and children. It is backbreaking work and must be done three times per season (compared to just once for other crops) to ensure good yields.

Photograph 37: The NERICA-4 variety is appreciated for its hardiness, high yields, and shorter maturation time (compared with traditional rice varieties)

Many women seem to be think that despite the new labor burdens associated with growing upland rice, they have become more independent and have gained decision-making power in their households vis-à-vis their husbands," says Bergman Lodin. She quotes a female focus group participant as saying, "In the past, he was the one to decide, since he was the one to grow income generating crops. Now, we have decision power!"

The findings indicated that female-headed households are experiencing equal yields per hectare as are male-headed households. But their overall yields are lower, because men have more access to land and can therefore

Gender inequities in access to land remain to be resolved, offering a challenge to researchers engaged in promoting greater gender equity in land rights and policies – and their enforcement. Further research also needs to focus on interventions that can decrease the high labor burdens of upland rice production. The use of protective netting, natural predators, or a specially-developed quelea virus are examples of areas under investigation to control bird pests. Different forms of planting and land management, the use of weeders, and use of indigenous ground cover plants between rice rows and during fallow periods are being researched to inhibit weed growth.

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3.4 Rice Motorized Seed Dresser

Description of the technology

This technology was developed to facilitate smallholder rice farmers in dressing of their seed. The technology is also applied in seed dressing under small holder wheat farming. Lack of mechanization seriously limits productivity and competitiveness of rice based systems in Sub-Saharan Africa (SSA). At the same time, the continent is littered with wrecks of imported agricultural machinery, abandoned because of inappropriate designs, lack of spare parts or costly maintenance Mechanization is crucial but its introduction requires careful analysis of successes and failures and discussion of lessons learned. Machines do not only hasten field operations but also provides a high quality product, making it more attractive to local traders and consumers. Mechanization is essential for rice production and processing. For farmers to intensify their cropping, they need to mechanize the manual labour-intensive operations. In order for rice growing farmers to realize the benefits accrued from mechanizing rice production, all levels of production from land preparation to harvesting should be mechanized. Farmers realized the fact that mechanizing rice production operations leads to labour and time saving at the same time profitable. Full mechanization of main rice production activities from land preparation to harvesting can be 10 times labour saving compared to manual. However, for rice mechanization to be successful local manufacturers and suppliers of implements should ensure they supply quality and reliable materials that will not discourage resource poor farmers.

Photograph 38: The motorized seed dressed is not bulky and covers limited space

During EAPP phase I, a motorized seed dresser was developed with a view to ensure that seed planted is clean seed. This technology is available for adoption nonetheless, there is limited information about the process of development as well as future scale up efforts

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4.0 WHEAT TECHNOLOGIES

4.1 Improved Bread Wheat and Durum Wheat Varieties in Ethiopia

Description of the Technology

The major wheat production constraints in Ethiopia and in other eastern African countries include biotic - rusts, septoria, fusarium and weeds, and abiotic stresses - low moisture, waterlogging, low soil fertility, frost, heat and salinity. Use of improved varieties that are resistant/tolerant to biotic and abiotic stresses is economically viable, user friendly and environmentally safe. The wheat-breeding program of Ethiopia has been developing high yielding varieties possessing good quality traits with resistance to major diseases.

Photograph 39: Improved wheat variety tolerant to biotic and abiotic stresses

A number of bread and durum wheat varieties have been released for mid-altitude-optimum-production environments, highland-high-rainfall environments, low-altitude moisture deficit areas, and for irrigated heat stress environments. However, only a few old bread wheat varieties are currently under cultivation mainly due to fast break down to rust diseases. Durum wheat varieties are not as vulnerable as bread wheat to rust diseases and many old cultivars are still under cultivation. List of 28 bread wheat and 33-durum wheat varieties that are still under production and newly released ones are given in Tables below. Their year of release, performance in major characteristics, adaptation environment, and breeder and maintainer of each variety is given.

Scaling up approaches used to promote technology

Users of the technology/innovation?

- Small holder farmers in each agro-ecology are the major beneficiaries of the technology
- Large-scale public agricultural enterprises (previously called state farmers)
- Emerging private farmers in Ethiopia are also beneficiaries
- The currently flourishing agro-industries in the country

Critical and essential factors and explain their importance

e. Previous and existing agricultural development policy and strategy have been favourable for promotion and development of improved varieties for increased productivity and production of wheat.

f. Strong research, extension and farmer's linkage, and strong interest of seed enterprises that led to smooth technology generation, dissemination, multiplication and production by respective actors, research, MoA & RBoA, seed enterprises, and small-scale farmers, and agricultural development enterprises involved in the wheat production. Research centers have not been only developing the technology (varieties) but also involving in initial technology (breeder and pre-basic seeds, in some cases basic seeds) increase for seed enterprises to start basic and certified seed production, and for small amount distribution to nearby farmers.

Moreover, the research has been involving in pre-demonstration and popularization activities every time new varieties are released. Large up-scaling/demonstration by the extension system of MoA follows the pre-demonstration by research centers.

g. Bread wheat is one of the major strategic crops for food self-sufficiency and poverty alleviation and considered high priority crop by the government of Ethiopia, and other countries in the region.

h. The uptake of durum wheat varieties by farmers and the seed enterprises has been slow (see reasons under section C.6 below). However, the following opportunities exist for the scenario of the slow uptake by the extension system, the seed industry, producers and the agro-industry in the country to change.
   - Neither the country will afford continuous supply of hard currency for import of the crop by the flourishing number of agro-industry in the country, nor will the increasing demand for high quality products by consumers allow the blending of durum wheat with bread wheat for macaroni/pasta making.
   - presence of market in neighbouring and other countries for possible export
   - existence of vast land for international standard quality durum wheat production
   - presence of well experienced small scale farmers and agricultural development enterprises in wheat culture
   - the flourishing large-scale private agricultural development enterprises and agro-industries in the country and in the region

Current situation with reference to use of technology and future scaling up strategies

Challenges (if any) encountered in respect to further dissemination of the technology/innovation, adoption and up/out scaling

- Dissemination of existing and upcoming new varieties of bread wheat has no problem.
- The uptake of durum wheat varieties by farmers and seed enterprises, however, has been slow due to poor linkage of the producers with market (agro-industry); the industry has been importing durum wheat from abroad and has been buying hard bread wheat from within the country for blending with the imported durum wheat.

Recommendation for addressing the challenges

- The recommendation to use the opportunities available (section B.5) for expansion of durum wheat production is to create, in the first place, government awareness on the technologies available in durum wheat to supply raw material for local industries, and on the opportunities that even available for export.
- Use government influence in bringing together and creating stakeholders' forum (SF) in which all actors of the value chain participate and plan research activities, pre-extension, up-scaling, seed production, quality grain production and supply and marketing of seed and grains with the responsibility of all actors of the value chain determined with rules and regulations developed to make sure that every actor fulfil its responsibility.

Lessons learnt about the best ways to get technologies or innovations used by the largest number of people

- Close collaboration and working together of research, extension, farmers, seed enterprises, private seed and grain producers, and NGOs working on agricultural development
- Use of individual farmers, farmers-researchers-extension groups (FREGs), and farmers' training centers (FTCs) in gender disaggregated participatory on-farm adaptation trials, pre-demonstration and up/out-scaling activities

- Gender disaggregated training given to farmers, development agents, MoA subject specialists, and private farmers and seed producers on improved wheat varieties and associated technology packages during dissemination activities

Gender considerations in connection to development and use of the technology

- all dissemination activities and trainings of farmers and other stakeholder have been gender disaggregated
- selection of host farmers of technology dissemination have been gender disaggregated even though the number of male farmers usually outweighs

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4.2 Small Thresher-Implements

Description of the Technology

It is a non-cleaning type engine driven (8 hp) thresher consisting feeding tray, concave-drum assembly and top cover. It threshes teff, wheat and barley and shells maize as well. It is provided with two replaceable concaves with different grate openings (12 mm for maize and 6 mm for others) and corresponding pulleys of 360 mm and 180mm in diameter.

Photograph 40: The multi-crop thresher

Table 7: Specifications and Working Features

Overall dimension, mm			Losses, % (*maize, $^{+}$other, $^{\times}$all)			Threshing eff., %
Length	**Width**	**Height**	**Unshelled***	**Damaged^{+}**	**Total$^{\times}$**	
2930	790	1500	1.44-4.92	0.61-0.59	1.91-5.51	95.1-98.6
Output, kg/hr			Power reqt., kw	Energy reqt., kwh/ton	Labor reqt., man-hr/ton	Price, Birr
Shelling		Threshing				
1466-3060		122-494	1.91-2.68	1.56-11.85	0.64-16.02	

Modified IITA Multi-Crop Thresher

The threshing units of the original IITA thresher are peg type, which is effective in threshing smaller cereals like tef and wheat but resulted in higher grain breakage while shelling maize. The drum is now modified to accommodate replaceable bar and peg types for efficient threshing and shelling. It was also improved for ease of operation and transportation.

Photograph 41: Modified IITA Multi-Crop Thresher

Table 8: Specifications and Working Features

Overall dimension, mm			Losses, % (for maize)			Output, kg/hr
Length	Width	Height	Unshelled	Damaged	Total	
1950	1440	1450	0.16	0.19	0.35	2385.1
Shelling eff. %	Cleaning eff., %		Fuel (lt/hr)	Power requirement (hp)	Labour requirement	Price, birr
88.66	99.87		1.56-11.85	10	2	23431

Scaling up approaches used to promote technology

Users of the technology/innovation

- Small holder individual farmers are the major beneficiaries of the technology
- Farmers in areas where using combine harvester not possible due to an accessibility and unaffordable high prise for small-farm size.

Essential factors for successful promotion and adoption of the technology/innovation

These implements were multiplied by the Melkassae Agricultural Mechanization Research Center, the Regional Agricultural Research Centers, and Private entrepreneurs, big and small manufacturers and have been sold to few farmers in the country. The Agricultural Mechanization Center has been involved in giving threshing service on request basis. The Regional Agricultural Mechanization Research Centers, especially the Oromya and BaherDar Agricultural Mechanization Research Centers, Selam Vocational School Amyo Engineering and one or two others have been involved in manufacturing and scaling out of these equipment mainly to farmers' operators who give rental service to the vicinity once they are done with their own. As threshing is a difficult operation and weather dependent, farmers are very much interested to use these stationary threshers, wherever combine harvesters are not available. As grain mills diffused readily into the user community, diffusion of threshing technology has not been difficult, in areas where this technology was introduced.

Threshing in time with minimum loss is the primary target of all farmers. The threshing work is important on wheat, which is one of the important crops supported by EAAPP. This technology is now being picked up by private small enterprises and demand has risen due to the interest of some successful small-scale farmers. Besides, small and micro enterprises, are trained on the manufacturing skill of the implement, have entered the business, and are manufacturing the implement on contractual and demand basis. So we can say that this implement has entered the market chain in Ethiopia. The following factors/conductions demand for promotion of improved small-threshing implements.

Large combine harvesters developed for large-scale farm sizes are very expensive and not suitable for small and patchy sized farms of smallholder farmers. In moving from combine harvesting one small farm to another small farm mix up seeds of different varieties that farmers could not maintain the purity of own seeds of self-pollinated and self-fertilized crops like wheat. This has been forcing farmers to see the hands of seed enterprises for seeds of self-pollinated crops as they do for hybrid varieties every year. Moreover, big combine harvesters have been spreading weeds seeds from farm to farm, reason for wide spread infestation of the same grass weed species in all wheat fields in Arsi and Bale zones in Oromia regional state of Ethiopia. Moreover, there are several wheat production areas with hilly and steep slopes that cannot be accessed by combine harvester. Therefore, there is an opportunity for efficient small-threshing implements with minimum threshing loss to be successfully disseminated to smallholder farmers with small farm size.

Knowledge and techniques are available with researchers on small-threshing implements.

The extension system is very eager in dissemination of improved small-threshing implements for small holder farmers for true-to-type seed and reduced weed seed spread and for areas not accessible for combine harvesters.

Current situation with reference to use of technology and future scaling up strategies

Challenges

1) Ploughing is an important activity under taken in crop production operations. It is time consuming and needs care to get pure seed and quality grain that fetches high market price. Small-threshing implements have been picked up by private small enterprises and demand has increased due to the interest of some successful farmers asking for improved implements. Yet the question of unavailability and escalating price of manufacturing materials and engines may make the technology inaccessible to poor and low-income farmers unless credit and other cash access systems are put in place.
2) There is less tradition of extension system on dissemination of farm implements.
3) DAs and farmers in most places have less knowledge on small-threshing implements and dissemination may take time.
4) Less availability of the implement at right time and place with affordable prices may slow the pace at which the dissemination and adoption of the implement take place
5) Lack of credit to own the implement may reduce farmers interest in exercising and adopting the implement

Lessons learnt

- The implements are stationary and can be easily controlled by anyone who can legitimately join the labour force including young people and women.
- Use FTCs and FREGs in demonstrating technologies to a wider number of people at a time.
- Importance of organizing training for extension staff, subject matter specialists, farmers in collaboration with MoA and NGOs.
- Importance of farmers' field days and workshops with participation of farming communities, agricultural expertise, police makers, politicians and NGOs.

Gender considerations in connection to development and use of the technology

- These implements are engine operated and needs minimal human power input and can be easily controlled by anyone who can legitimately join the labour force including children and women. We can see now some women entrepreneurs who own such machines and give service to farmers at a modest price per quintal in and around the country. Now a substantial number of women farmers are owners of this implement in the country.
- Trainings in all demonstration activities have been gender disaggregated
- Efficient and handy-threshing implements are, therefore, important to reduce workload on women and get quality seed and grain in small farm sized, in areas not accessible, and by combine harvesters.

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4.3 Motorised Wheat Thresher for Smallholder Farms

Description of the Technology

This technology was developed to aide smallholder wheat producers to thresh their wheat as wheat farming in Kenya is mainly dominated by large scale farmers with most of the farm operations mechanized. The technology can be both manually and motorised.

Photograph 42: The motorized wheat thresher is user friendly

There is however, limited adoption of this technology owing to the fact that it has just been developed. There is need for the scientist and extension officers to appreciate and popularise this technology.

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4.4 King Bird Wheat Variety with Ethiopia

Description of the technology

This wheat variety was developed in Kenya and has adult plant resistance to UG99. It has been shared in the region for variety testing and releases in respective countries.

In Ethiopia, the variety was acquired through Material Transfer Agreement and was timely because the local varieties had succumbed to UG99. The gt race TKTTF, virulent for the SrTmp gene present in Ethiopian cv. Digalu and first detected in 2012, caused significant yield losses in Digalu during the 2013 and 2014 seasons. No suitable replacement varieties with significant seed volume were available, and alternate solutions were sought. EIAR, through CIMMYT-Ethiopia, introduced 5 tonnes of adult plant, rust resistant wheat cv. Kingbird from Kenya. Kingbird was evaluated for agronomic performance at seven locations vs. three checks in 2014, and was also evaluated for stem rust reaction in single-race nurseries (TKTTF, TTKSK, TRTTF and JRCQC). With support from USAID/CIMMYT, seed was concurrently multiplied on 37 ha producing 80 tonnes of seed that was distributed to farmers in 2015.

The variety has not reached farm level but is a promising technology for increased yields. Information on scale up and uptake is therefore not available.

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