ASARECA

Transforming Agriculture for Improved Livelihoods

annual report 2011

Pooling regional resources to feed populations

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Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
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Contents

Communication from Dr Lala Razafinjara, Chairman, Board of Directors

2011 was an eventful year for the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). It is the year during which ASARECA received the new Republic of South Sudan, bringing the number of ASARECA member countries to 11.

This is the year when most ASARECA projects initiated in 2008–2009 ended. These projects yielded over 107 technologies, innovations and management practices (TIMPs). These TIMPs will play a critical role in natural resource base management. Specifically, they will improve the genetic profile of crops and animals; reduce biotic constraints such as pests, weeds, and diseases that decrease yields; and provide affordable high quality seeds for the farmers. We learned many lessons from the completed projects and ASARECA, through the guidance of its Board of Directors, pledges to turn these lessons into opportunities to make agriculture in Eastern and Central Africa (ECA) more attractive.

The celebratory mood reached a climax when ASARECA held its First General Assembly from 14–16 December 2011 at the Imperial Resort Beach Hotel, Entebbe, Uganda

2011 was therefore, a celebration of achievements scored in generating several agricultural TIMPs and knowledge products. The celebratory mood reached a climax when ASARECA held its First General Assembly from 14–16 December 2011 at the Imperial Resort Beach Hotel, Entebbe, Uganda. The theme of the General Assembly: "Feeding Our Region in the 21st Century" was a befitting way to put into context the current

wave of rising food prices, the increasing effects of climate change and a host of other challenges affecting agricultural productivity in the region.

The General Assembly produced important recommendations that will shape the future of ASARECA. The recommendations cover strategic areas such as stronger collaboration with national governments, non-governmental organisations (NGOs), the private sector and universities to increase investment in science and technology; promoting participation of targeted technology users; focusing on scaling out best practices; creating awareness and promoting innovations for climate change; strengthening engagement with stakeholders in policy advocacy and dialogue to solicit political will and supportive policies for agricultural development; and strengthening collaboration with regional economic communities to influence political support to the Comprehensive African Agriculture Development Programme (CAADP) process.

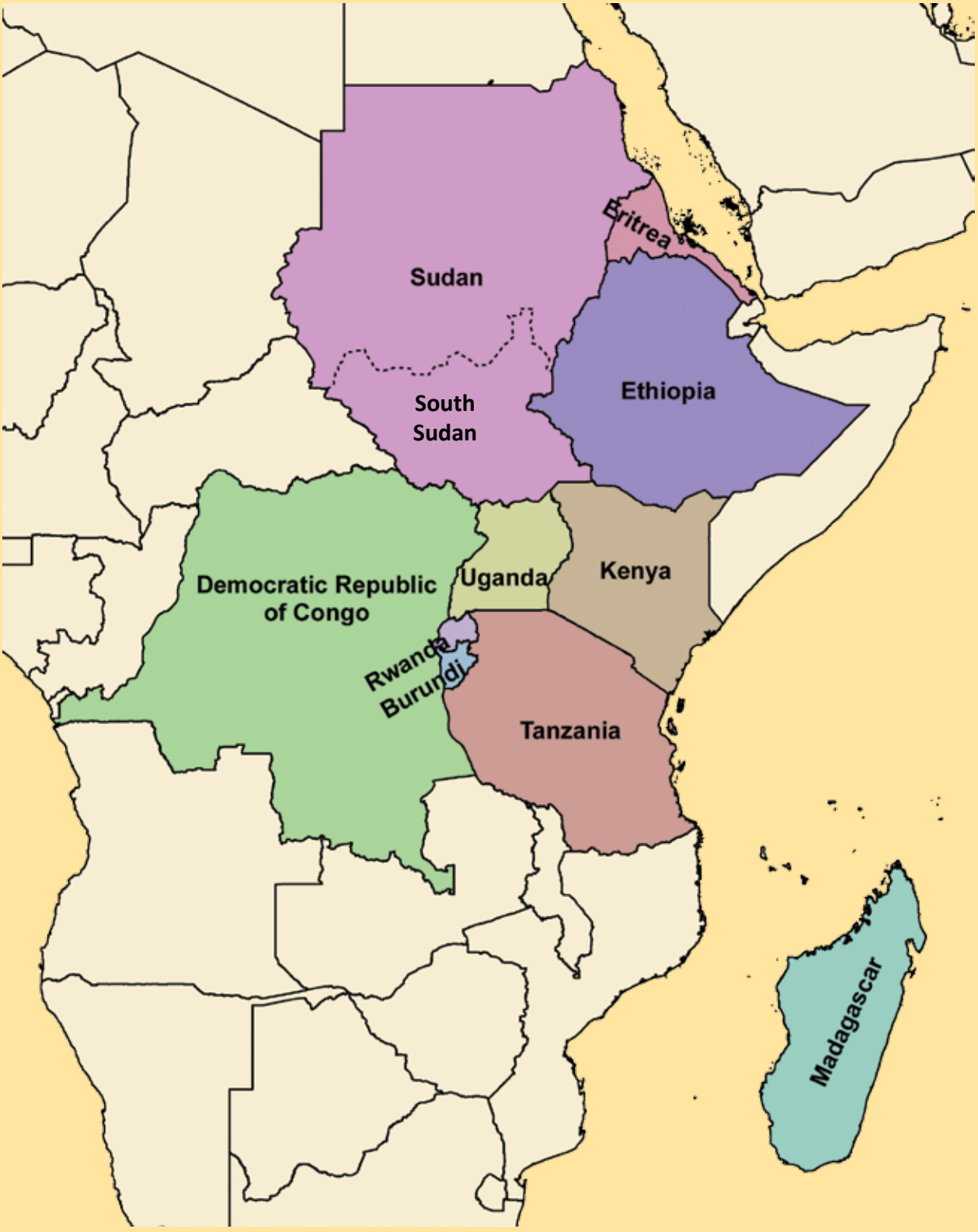
ASARECA also continued to use its vantage position as a regional collaboration icon to boost the progress of the East African Agricultural Productivity Project (EAAPP). ASARECA convened priority setting, planning and budgeting workshops for regional centres of excellence for cassava, rice and wheat. Besides this, ASARECA continued to respond to the demand for capacity development in the region by providing opportunities to both individuals and institutions, through training on agricultural innovation systems to its own staff, principal investigators and national focal persons, students and other stakeholders.

These and other highlights in this Annual Corporate Report, accord representatives of the 11 ASARECA member countries pride in driving an organisation that is truly for our people.

Dr Razafinjara Lala
Director General, Centre National de Recherche Appliquee au Developpement Rural (FOFIFA) Madagascar
Chairman, Board of Directors, ASARECA

Dr Seyfu Ketema and Uganda's agriculture minister, Tress Buchanayandi, launch activities towards ASARECA General Assembly in 2011

Association for strengthening Agricultural Research in Eastern and Central Africa (ASARECA) member countries



Communication from Dr Seyfu Ketema, ASARECA Executive Director

A total of 56 lines of striga resistant sorghum varieties were generated using molecular marker breeding technology. By the end of the year, four of these varieties were ready for release in Sudan

2011 was an opportune time to showcase evidence of returns on investment made in ASARECA. The returns are there to see. 2011 also marked a new chapter in putting the enormous experience gathered from years of coordinating regional agricultural research into new energy. Therefore, confident of the path trodden to improve livelihoods in the sub-region, ASARECA convened the historic First General Assembly to provide a platform for sharing ideas; formally introduce ASARECA to its regional stakeholders; and to welcome patron ministers to interact with the ASARECA community. The General Assembly provided a great opportunity to showcase, share and celebrate work done by ASARECA and partner national agricultural research institutes (NARIs). The highlights of this work include those discussed below.

Scientists supported by ASARECA successfully transformed nine transgenic maize lines with drought tolerance genes. The team of young scientists drawn from the region and led by Prof Jesse Machuka, converged at Kenyatta University in 2009 and embarked on a plot to insert drought tolerance genes into farmer preferred maize varieties in the region. The scientists were drawn from the NARIs of Ethiopia, Sudan, Kenya and Tanzania, and outstanding students fresh from completing their Masters degrees. The nine transformed lines are: two Ethiopian lines, three Kenyan lines, two Sudanese lines, and two Tanzanian lines. One of the Sudanese genes was named the "ASARECA gene".

ASARECA and partners developed a pen-size diagnostic kit for *Taenia solium* in pigs. The kit is more sensitive for detecting infected pigs and humans than the traditional diagnostic

tests which rely on palpation of cysts under the tongue of a live pig. The traditional method is promoted as a potential screening test that farmers could perform themselves. However, its sensitivity is only 16%, which is very low.

A total of 56 lines of striga resistant sorghum varieties were generated using molecular marker breeding technology. By the end of the year, four of these varieties were ready for release in Sudan. The researchers chose to use molecular markers to improve precision and enhance the effectiveness of breeding for striga resistance.

ASARECA made significant progress in promoting in vitro and cryopreservation of cassava and sweet potato in the sub-region. As a result, 360 cultivated and landrace cassava accessions have been collected and DNA from 179 accessions have been sent for molecular characterisation. A total of 449 accessions of sweet potatoes were collected and 210 samples have been sent for molecular characterisation.

ASARECA and partners successfully developed a genetic linkage map for field resistance to cassava brown streak disease (CBSD). The map forms grounds for understanding the genetic basis of CBSD tolerance in cassava cultivars. This in turn could facilitate rapid and efficient breeding of improved varieties. Marker assisted breeding has the potential to drastically increase the efficiency of breeding and reduce the time taken for breeding products to reach farmers. ASARECA promoted the production of quality seed for African indigenous vegetables (AIVs) to improve nutrition and generate income for smallholder farmers in ECA. Several production models were tested to scale out the production of quality seed. This, ASARECA hopes, will open up this sector to markets.

ASARECA and the Rwanda Agricultural Board (RAB) supported banana farmers in Rwanda to produce high quality wine banana, post-harvest handling and processing. Through this, some groups in Rwanda are reporting tremendous progress in processing.
ASARECA and partners have highlighted policies and actions that governments and multi-stakeholders need to undertake to build specific adaptive capacity in some of the most affected areas. These include mainstreaming climate change in national planning and budget processes to enable research and investments in climate smart technologies and innovations for smallholder farmers.

A total of 34 young scientists from the NARIs of Burundi, Rwanda and Sudan who ASARECA sponsored to undertake Masters degrees in the most acclaimed universities in East Africa completed their studies. In Rwanda for example, the scientists are deployed in strategic positions.

ASARECA could not have achieved these outcomes without support from our partners and well-wishers. In this context, I thank the Directors General of the 11 member NARIs for their dedication, guidance and deployment of scientists, other professionals and national resources, which ensured the successful implementation of the ASARECA projects. I acknowledge and thank the Board of Directors that guides our work. I also thank the development partners for their commitment and dedication to improve livelihoods of our people in the sub-region through their guidance and financial support. These include African Development Bank, UK Department for International Development, Canadian International Development Agency, European Union, International Development Research Centre (Canada), Swedish International Development Cooperation Agency, United States Agency for International Development, and the World Bank Multi Donor Trust Fund. I also thank scientists and professionals from the national and international institutions who execute the activities. Last, but not least, I thank all the ASARECA Secretariat staff for their dedication, commitment and enduring hard work; they are much appreciated.

Dr Seyfu Ketema
Executive Director, ASARECA

ASARECA at a glance

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is a sub-regional not-for-profit association. It was established in 1994 by 10 member countries, which were represented by their national agricultural institutes. The 10 member countries are: Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda.

Vision

Regional leader in agricultural research and development for improved livelihoods in eastern and central Africa (ECA)

Goal

Enhanced sustainable productivity, value addition and competitiveness of the sub-regional agricultural system

Purpose

Enhanced utilisation of agricultural research and development innovations in ECA

Mission

To enhance regional collective action in agricultural research for development, extension and agricultural training and education to promote economic growth, fight poverty, eradicate hunger and enhance sustainable use of resources in ECA

ASARECA adds value to the work of the national agricultural research systems (NARS) in the sub-region through:

- Identification of shared goals and the promotion of economies of scale and scope through collaboration, specialisation and sharing of results.
- Identification of sub-regional public goods that would be under-produced in the absence

of shared goals and a regional mechanism.
- Sharing of knowledge and experiences with institutional innovation for more effective agricultural research for development, extension and agricultural training, and education.

ASARECA sees improved delivery and impact of scientific knowledge, policy options and technologies as powerful instruments to drive the sub-region towards meeting the Comprehensive African Agriculture Development Programme (CAADP), which is the agricultural agenda of the African Union's New Partnership for Africa's Development (AU/NEPAD).

ASARECA is positioned to contribute towards achieving the vision of AU/NEPAD by using strong partnerships at all levels. It serves as a forum for promoting regional agricultural research for development. It is a forum for strengthening relations among NARS, international agricultural research institutions, universities and other advanced research centres. ASARECA links agricultural research to political dialogue through the East African Community (EAC), the Common Market for Eastern and Southern Africa (COMESA), and the Forum for Agricultural Research in Africa (FARA) and AU/NEPAD.

Working to deliver on the CAADP agenda

The ASARECA strategic plan is aligned to CAADP and its implementation guidelines, the Framework for African Agricultural Productivity (FAAP). The ASARECA operational plan has set forth good corporate governance and management structures, systems and directions for the implementation of the CAADP agenda.

ASARECA is working with the CAADP country teams set up by COMESA to identify key areas of intervention to accelerate the country round table processes in the member countries. Using the rich network of national agricultural research institutes (NARIs), ASARECA is working with AU/NEPAD, COMESA and FARA to identify priority investment areas, especially in research, and to facilitate implementation. ASARECA contributes directly to CAADP Pillar IV and supports the other three pillars through its seven programmes, which enhance regional collective action in agricultural research for development in the member countries.

ASARECA sees improved delivery and impact of scientific knowledge, policy options and technologies as powerful instruments to drive the sub-region towards meeting the Comprehensive African Agriculture Development Programme (CAADP)

The seven programmes are: (1) Staple Crops, (2) High-Value Non-Staple Crops, (3) Livestock and Fisheries, (4) Agro-Biodiversity and Biotechnology, (5) Natural Resource Management and Biodiversity, (6) Policy Analysis and Advocacy, and (7) Knowledge Management and Up-Scaling.
The programmes are implemented through partnership and collaboration with the NARS in member countries, the Consultative Group on International Agricultural Research (CGIAR), universities and other advanced research centres.

Highlights of 2011

A. Responding to the need for demand driven agricultural technologies

Nine drought tolerance genes for maize ready, more transformations underway

Research on drought tolerant maize brought excitement to the ASARECA community as 2011 drew to a close. Scientists funded and coordinated by ASARECA successfully transformed nine transgenic maize lines with drought tolerance genes. The team of young scientists drawn from the region and led by Prof Jesse Machuka, converged at Kenyatta University in 2009 and embarked on a plot to insert drought tolerance genes into farmer preferred maize varieties in the region. They were drawn from the national agricultural research institutes of Ethiopia, Kenya, Sudan and Tanzania and from outstanding students fresh from their Masters degrees. The scientists constituted a core PhD research team under the project, "Genetic Engineering of Maize for Drought tolerance in Eastern and Central Africa (GEMADOT)."By the end of 2011, the researchers had successfully transformed the nine lines: two Ethiopian, three Kenyan, two Sudanese and two Tanzanian:

- Ethiopian maize lines transformed with the IPT gene. The IPT gene enables maize plants to withstand drought by enabling

maize cells to produce an enzyme called IPT. This enzyme instructs maize leaves to delay aging (or senescence) during drought.

- Ethiopian temperate maize line (A188) with a CBF1 gene. The CBF1 gene enables maize cells to synthesise an enzyme called CBF1. When this enzyme senses dehydration it commands an army of other proteins to protect maize cells against the drought stress.
- Three Kenyan maize lines transformed with the PARP gene. The PARP gene enables maize cells to reduce the production of an enzyme called PARP. Under drought conditions, this enzyme instructs maize cells to conserve energy.
- Sudanese maize genotypes with drought tolerance gene, annexin P35. This gene facilitates release of the enzyme annexin which enables maize to defend itself against drought. This enzyme helps the maize plant protect its cells against dangerous oxidants called reactive oxygen species (ROS). These oxidants are chemically reactive molecules that regulate cell behaviour. However, during times of stress such as those caused by drought ROS over-accumulate and may damage cells. During drought stress, annexin defends the maize by stopping ROS from over-accumulating. This is a first time invention and the gene has been named the "ASARECA Drought gene". A manuscript of this work was submitted to a journal for publication.
- Two Tanzanian maize lines with the XvPrx2 gene isolated from *Xerophyta viscose*. This gene facilitates the introduction into maize cells of molecules called peroxiredoxins. These molecules enable the maize cells to reduce the amounts of the lethal ROS that accumulate in maize cells during drought, ensuring survival of plant cells. Using this approach, ASARECA hopes that maize cells, and therefore, the whole plant, will survive better during severe drought stress periods. A manuscript of this work is awaiting submission to a journal for publication.

Seven transformed lines (ASARAnxzm35, Annat1, NHX1, XvPrx2, XvSAP1, IPT and CBF 1), and maize with the silenced PARP1 gene using amiRNA1, miRNA3, were regenerated and the first transgenic seeds produced. The next step is to conduct further experiments to generate the data that regulatory agencies require to allow confined field trails to be carried out. This will be done in the first phase of GEMADOT. Enough seeds have been produced to enable this experimentation. The new varieties are products of farmer preferred varieties common to the tropics.

Transformed plants show more tolerance of water deficiency, and can return to full recovery after completely drying up. The plants may wither, but revive after 24–72 hours of rehydration.

Maize is the most important staple food crop in Eastern and Central Africa (ECA) with 80%of rural and urban populations depending on it as a source of calories. According to FAO, from 2006 to 2009, maize production in ECA decreased

Transformed plants show more tolerance of water deficiency, and can return to full recovery after completely drying up. The plants may wither, but revive after 24–72 hours of rehydration

The transgenic maize greenhouse at Kenyatta University, Nairobi

from 15.7 million tonnes to 14.7 million tonnes. The current maize yield stands at 1.3 tonnes per hectare compared to the potential of up to 7.0 tonnes per hectare as projected by the Maize and Wheat Improvement Center (CIMMYT). Drought is the single most important abiotic stress factor responsible for reduced maize productivity. Seventy per cent of maize yield in ECA is lost due to drought.

The ECA region is prone to drought, making farming extremely risky, especially for resource poor small-scale farmers. Drought has been exacerbated by climate change. The ability of smallholder farmers to cope with drought therefore is greatly hampered by lack of crop varieties that do well in insufficient and erratic rainfall conditions. This has sadly exposed many farmers to the devastating effects of drought including crop failure, leading to hunger and poverty.

It is against this background that in 2009 ASARECA, Kenyatta University and the participating national agricultural research institutes (NARIs) initiated the project. The project is managed by the ASARECA Agro-biodiversity and Biotechnology Programme. It was funded through a basket of funds (the Multi-donor Trust Fund) to the tune of US$350,000, managed by the World Bank. In 2012, the scientists will continue to engineer 17 maize varieties adapted to the region. The project team estimates that it could take up to 15 years to release a genetically modified crop plant for farmer uptake. Products from this research initiative are projected to be ready for commercial release as early as 2017 provided research continues at the current pace. The phases for the development and commercialisation of a genetically modified crop include:

1. Gene discovery
2. Transformation, regeneration and evaluation
3. Contained greenhouse tests
4. Confined field tests
5. Open field tests
6. Commercial release

Stages 1, 2 and 3 were accomplished in 2011.

Pen-size diagnostic kit for *Taenia solium* ready for validation

ASARECA and partners developed a pen-size diagnostic kit for *Taenia solium* in pigs. The kit is more sensitive for detecting infected pigs and humans than the traditional diagnostic tests which relied on palpation of cysts under the tongue of a live pig. The traditional method was being promoted as a potential screening test that farmers could perform themselves. However, its sensitivity was only 16%, which is very low. Besides, standard laboratory-based serologic tests were not suitable for use in the field. The pen-size kit, however, is easy to use, requires no sample preparation and provides rapid diagnosis.

Taenia solium is a zoonotic parasite carried in the small intestine of human beings during the adult stage of its life cycle. Both human beings and

Pigs need to be vaccinated against *Taenia solium*

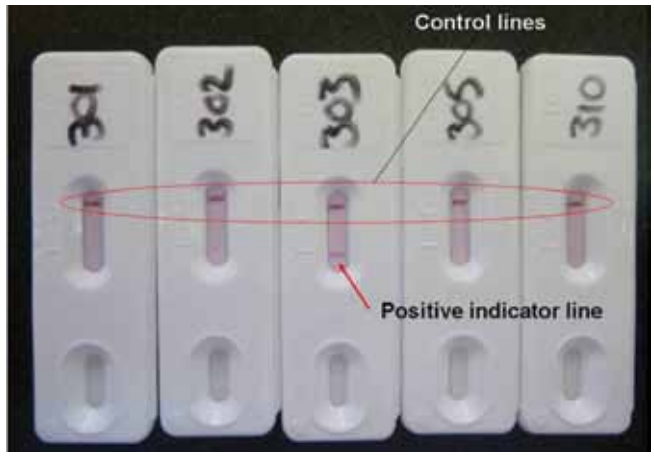
Both human beings and other hosts (primarily pigs) can be infected by the larval form of the parasite, leading to cysticercosis

other hosts (primarily pigs) can be infected by the larval form of the parasite, leading to cysticercosis. Human and porcine cysticercosis are devastating infections. In human beings, cysticercosis affects the nervous system causing neurocysticercosis, which can result in life-threatening neurological disorders, including epilepsy. In areas endemic to *T. solium*, studies have found that the leading cause of epilepsy is neurocysticercosis. People in these areas have therefore condemned piggery, leading to loss of the economic benefits accruing from piggery. Studies supported by ASARECA, conducted in Burundi, Democratic Republic of Congo (DRC), Kenya, Tanzania and Uganda, showed a high prevalence of porcine cysticercosis in the sub-region, with some rural areas enduring up to 50% prevalence.

The threat to public health is therefore real. To calm the fear of these threats while preserving piggery as an economic activity, ASARECA in collaboration with the International Livestock Research Institute (ILRI), the University of Edinburgh (UK), and Astel diagnostics (Uganda) set out to determine the risk factors of *T. Solium* cysticercosis/taeniasis; develop and evaluate a pen-size diagnostic test kit for the disease in pigs; and evaluate the efficacy of *T. solium* recombinant vaccine in pigs in ECA.

This pen-size diagnostic kit has the potential to significantly improve the pig industry which is undergoing rapid expansion in the sub-region. In Uganda, for example, estimates indicate that the number of pigs has increased tenfold over the last decade. However, while the numbers are rising, pig-borne zoonotic diseases (especially T. solium) are also becoming more prevalent. Studies in western Kenya, for example, indicate that 50% of pigs going into the food chain are infected with the disease. This means that about 7% of all pork meals could be unsafe.

The most effective way to stop infected pork from entering the food chain is to identify the infected pigs before slaughter. The infected pigs can be treated with anthelmintics and returned for slaughter after a suitable time. Unfortunately, no reliable method is available to detect the infected pigs as they do not show any clinical signs.



Pen-size diagonistic kit for *Taenia solium*

T. solium taeniasis is acquired by eating infective larvae of the parasite from infected meat. Raw or inadequately cooked pork provides the route for taeniasis transmission. The larval form of *T. solium* cysticercosis can infect both humans and pigs if the hosts ingest infective eggs of the parasite. Water and foods contaminated with faecal material from a human carrier of the adult tapeworm are the major sources of cysticercosis transmission. Several factors have been found to facilitate the occurrence of cysticercosis. These include open sewers, poor personal hygiene, free ranging pigs, and lack of safe drinking water.

The World Health Organization (WHO) estimates that at least 50 million people are infected globally with *T. solium* and more than 50,000 deaths occur from this condition each year. In India alone, the annual cost to society (agriculture and health) of porcine cysticercosis is estimated to be about US$150 million. WHO lists porcine cysticercosis as both a neglected tropical disease and a neglected zoonotic disease. It is endemic only in developing countries of Africa, Asia and Latin America where it affects the nutritional and economic well-being of poor smallholder farming communities by rendering pork unsafe food, hence affecting its market. The International League against Epilepsy has called neurocysticercosis the main cause of acquired epilepsy in the world.

56 striga resistant sorghum lines move towards release

A total of 56 lines of striga resistant sorghum varieties were generated using molecular marker breeding technology. By the end of the year, four of these varieties were ready for release in Sudan. Through the project, "Fighting striga: Resistance genes deployed to boost sorghum productivity", ASARECA supported the Agricultural Research Corporation of Sudan (ARC), the University of Nairobi, the National Agricultural Research Institute of Eritrea, the Rwanda Agricultural Board, the International Crops for Research Institute for the Semi-Arid Tropics (ICRISAT), to develop and use molecular markers to improve precision and enhance the effectiveness of breeding for striga resistance.

This study has used modern biotechnology tools to identify and map quantitative trait loci (QTL) associated with striga resistance. This has improved the precision with which these QTLs are being exploited through map-based cloning

The type of molecular markers used to develop the striga resistant sorghum lines are referred to as the simple sequence repeats (SSRs) or micros-atellites. Others prefer to call them diversity array technology (DArT)

Sorghum at KARI Katumani

Sorghum for drylands at a demonstration site at KARI Katumani

for resistance genes to breed varieties that farmers prefer and that the market demands.

Molecular markers are readily detectable proteins or pieces of DNA. They are typically detected as a band on a gel, and show differences that a scientist to identify individuals which differ genetically. Molecular markers are used in genetic fingerprinting, forensic science, paternity, quality control, diversity analysis, introgression of genes from other genomes, gene location, marker assisted breeding, comparative mapping and synteny and gene mining.

The type of molecular markers used to develop the striga resistant sorghum lines are referred to as the simple sequence repeats (SSRs) or microsatellites. Others prefer to call them diversity array technology (DArT).

Striga resistance genes were introgressed from the donor parent N13 into farmer preferred sorghum backgrounds Tabat, Wad Ahmed and AG8 from Sudan; Hugurty from Eritrea; Ochuti from Kenya; and IS8193 from Rwanda using marker assisted selection. Fifty-six superior striga resistant BC3 lines were generated. Currently, 22 lines are being evaluated in Sudan, Eritrea, Kenya, Uganda, Tanzania and Rwanda for agronomic performance and striga resistance with the aim of releasing them for commercial use in the sub-region. These lines have incorporated between one and five striga resistant QTLs successfully using marker assisted backcrossing.

The six countries that have evaluated the striga lines are at different stages of evaluation. The Sorghum Program in Sudan has moved ahead of the others and tested its materials on farm in multiple locations. The Program is ready to present the results to the national variety release committee for commercial release of at least four lines, whose productivity is comparable to that of the recipient parent. The new varieties combine the strong resistance to striga displayed by the donor of striga resistant genes, N13 strain of sorghum and the superior yields of farmer preferred varieties across Sudan.

Sorghum is ranked second, after maize, as the most important cereal staple crop in the ASARECA region. Its unique viable food grain serves many of the world's most food insecure people. Unlike other cereals grown in Africa, sorghum it is drought resistant and can also withstand periods of water-logging.

However, the production of sorghum in the sub-region is constrained by striga, a parasitic weed also referred to as the "witch weed". Baseline studies show that depending on the level of striga infestation, and without intervention, yield losses can go as high as 100% with only striga flowers being visible and not a single sorghum plant. Improvements brought by the new varieties can see yields recover by as much 84%.

Striga resistant sorghum has mechanical barriers which thicken the root walls, making it impossible for striga to penetrate the plant. As a result, while striga may be able to germinate, it cannot penetrate the root, and so withers.

Until the recent breakthroughs, striga was an intractable problem because of its unique coping abilities. A single striga plant can produce up to 50,000 seeds that can lie dormant in the soil for up to 20 years. When cereals are planted, the seeds sense the cereal root and seeds are stimulated and attach to the host. The striga then starts to suck nutrients and water which it uses to synthesise its own food as it chokes its host. Although striga eventually develops roots, they are just anchor the parasite in the soil; these roots can neither suck water nor nutrients. Instead, striga uses a special hooking mechanism called a haustorium to attach to the host and suck both nutrients and water. Sorghum mono-cropping, practised widely by farmers in the hot tropics, exacerbates infestation.

The new sorghum varieties are able to keep striga away. The parasite is eventually isolated until it withers.

Conserving cassava and sweet potato germplasm for posterity

ASARECA made significant progress in promoting in vitro and cryopreservation of cassava and sweet potato in the sub-region. Conservation biotechnology refers to applying the tools of modern biotechnologies to conserve germplasm.

It involves conserving germplasm in form of test tube plantlets, artificial seed, and cryopreservation. Using these tools, 360 cultivated and landrace cassava accessions have been collected and DNA from 179 accessions have been sent for molecular characterisation. A total of 449 accessions of sweet potatoes were collected and 210 samples have been sent for molecular characterisation. After molecular characterisation, duplicates will be removed and only unique germplasm will be conserved using conservation biotechnology techniques.

The genetic erosion already being experienced in the sub-region signals the urgent need to conserve biological diversity. Genetic erosion may cause a permanent reduction in the number, evenness and distinctness of alleles, or combinations of alleles of agricultural importance in this region. Cassava and sweet potatoes are key agricultural enterprises for food and economic development, whose genetic resources are being lost due to both human activities and natural disasters.

Studies have demonstrated that the genetic resources of sweet potato and cassava germplasm can be conserved in both field and in vitro gene banks for exchange, evaluation and use in the long term. Field maintenance offers several advantages over in vitro conservation. These include ease of operation, less need for specialised staff, cheaper equipment and less sophisticated techniques. It also allows the agronomic evaluation of germplasm for use in breeding and varietal improvement.

This system, however, has several drawbacks as it requires extensive land, high labour cost, disease build-up, poor ecological adaptation, the danger of theft of genetic material, bulkiness of propagating material for transport, and quarantine restrictions. Due to this limitation, ASARECA, through the Agro-biodiversity and Biotechnology Programme, initiated the project to pilot conservation biotechnology to promote the long-term ex situ conservation and sustainable utilisation of cassava and sweet potato plant genetic resources for the benefit of present and future generations.

Through this study, cultivated and landraces of cassava and sweet potatoes have been collected, conserved using conservation biotechnology techniques and are being characterised. To breed and identify genes responsible for resistance to cassava brown streak disease (CBSD), a genetic linkage map for resistance to CBSD is being developed. The project came to an end in 2011, but there is need to mobilise resources to continue conserving and characterising cassava and sweat potato germplasm for use to improve cassava for traits demanded by the market using conservation biotechnology.

Fighting CBSD, the cassava enemy, through genetic means

ASARECA and partners successfully developed a genetic linkage map for field resistance to CBSD. The map lays the groundwork for understanding the genetic basis of CBSD tolerance in cassava cultivars. This in turn could facilitate rapid and efficient breeding of improved varieties. The map was developed through marker assisted breeding since

Farmer displays cassava infected with CBSD—it is so hard it cannot be used even as animal feed

conventional methods of breeding are known to be relatively inefficient. Marker assisted breeding has the potential to drastically increase the efficiency of breeding and reduce the time taken for breeding products to reach farmers.

CBSD is the main viral disease that limits the production of cassava in the sub-region. It causes losses of up to 74% and, in some cases, total root loss. Cassava productivity in ECA is, on average, nearly 10 tonnes per hectare, which is 3times less than the yields recorded in Asia. In response, ASARECA, through the Agro-biodiversity and Biotechnology Programme in partnership with the International Institute for Tropical Agriculture (IITA), started a project to breed cassava varieties resistant to the disease.

DNA from the progenies was successfully extracted and SSR genotyping of the progenies resulting from the crosses between Nachinyaya × AR37-80 and Kiroba × AR37-80 were done during the year. DNA was extracted using a modified Dellaporta method. Nachinyaya and Kiroba are the resistant cassava varieties while AR37-80 is the highly susceptible cassava variety. Nachinyaya, Kiroba and AR37-80 cassava materials were screened as parents of the mapping populations for specified markers. This process identified markers that are polymorphic among mapping populations and have been used to develop preliminary genetic linkage maps.

The project has also been able to make available all the cassava SSR primer pairs. This activity was necessary because several thousand SSR markers are available for cassava. Some of these markers are published, some are not but are available, and several target the same SSR, yet have different names. Therefore there was an urgent need to "curate" or harmonise the SSRs in cassava, identify duplicates and avail them in a user friendly format in a web-enabled database.

Vegetables with potential to boost household income and nutrition

African indigenous vegetables (AIVs) have the potential to improve nutrition and generate income for smallholder farmers in ECA. However, even as markets for AIVs begin to emerge, farmers still rely on seed saved from a previous crop or seed obtained from informal markets. Often, such seed is of poor quality, and characterised by germination and purity rates below 50%. Poor germination rate means that farmers realise low yield per unit area, while low purity implies that the seed contains impurities such as inert matter and seeds that are not true to type (seed of mixed varieties).

In response to this, ASARECA with partners in the sub-region initiated a project, "Scaling up farmer-led seed enterprises for sustained productivity and livelihoods in Eastern and Central Africa". The partners include: the Centre for Agricultural Biosciences International (CABI), the Kenya Agricultural Research Institute (KARI), Kenya Seed Company Ltd. (KSC) and Technical Adoption through Research Organisation (TATRO) in Kenya. Others are: Horticultural Research and Training Institute Tengeru (HORTI-Tengeru), Tanzania Official Seed Certification Institute (TOSCI), INADES-Formation, Tanzania, and the World Vegetable Centre, Regional Centre for Africa, (AVRDC-RCA).

The aim of the project was to test different models to establish viable farmer-led enterprises for production and marketing AIV seed. The project was implemented in Kenya and Tanzania, focusing on farmer-led seed enterprises. Ways to improve the delivery of reliable, high quality seed of AIVs and maximise participation of both men and women in the value chain were tested.

Farmers extract seeds for indigenous vegetables

Farmers and researchers share information on growing high quality amaranthus vegetables

The two countries were selected because they provided contrasts in terms of private sector involvement in seed production and seed policy environment. For example, while in Tanzania it is permitted to produce quality declared seed (QDS), in Kenya, only certified seed can produced and sold in labelled packages.

Three farmer-led seed enterprises models were tested. One of the models was the seed company-mediated or the contract farming model. This model was tested in both countries: in Bungoma District in Kenya and in Arumeru District in Arusha, Tanzania. The second model was referred to as the research-mediated model in which small-scale farmers formed a community based organisation to work closely with researchers to produce and market quality seed. In this case, a farmer community based organisation known as TATRO worked with KARI to produce seeds that met the inspection and certification requirements of the Kenya Plant Health Inspection Services (KEPHIS). This model was tested in Siaya, Bondo, Kisumu and Butere/Mumias districts in Kenya. The third was based on production of QDS which was acceptable under the seed policy and standards of Tanzania. This model was tested in Dodoma and Mpwapwa districts in Tanzania.

During validation of the models, a capacity building programme for farmers and other stakeholders was initiated. At the beginning of the project, a baseline study was conducted to determine the pre-adoption socio-economic situation and production practices of participating farmers and to identify training needs. Based on training needs identified during the survey, a training curriculum for training of trainers course was carried out for 19 farmer trainers (7 women) in Kenya and 10 farmer trainers (3 women) in Tanzania. The curriculum is comprehensive and provides farmers with the technical skills to produce quality AIV seeds under the three models and to do so as business enterprises.

The Training of Trainers graduates conducted season-long farmers (seed growers) training in the identified project sites in both countries. In Kenya 611 farmers (246 women), stockists, field assistants and marketing agents were trained.

Through testimonials from participating farmers in Kenya and Tanzania, the project has made significant contributions towards improving people's livelihoods

In Tanzania a total of 360 farmers (137 women) farmers producing quality declared seeds of AIVs were trained.

The trained seed growers (farmers) used the knowledge gained to produce quality seeds and increased income from selling the seeds. In Kenya the farmers contracted by the Kenya Seed Company produced a total of 1854 kg of *Amaranthus dubius*, 11,365 kg of African nightshade, 6430. kg of *Crotalaria* and 3728. kg of Jute mallow seeds. Using the recommended seed rate, the seed is enough to plant 3708 acres of *Amaranthus dubious*, 45,460 acres of African nightshade, 12,859 acres of *Crotalaria* and 7455 acres of Jute mallow. The buying price for *Amaranthus dubious* and African nightshade was US$ 1 and US$ 8.13 per kg of seeds respectively whereas both Crotalaria and Jute mallow were sold at U$ 6.25 per kg of seed. This translated to a total gross income of US$ 165,093. Of this, US$ 53,995 was income from seeds produced by women. In Tanzania the contracted growers in Arusha earned about US$ 39,973 (US$ 11,372 of which was from sale of seeds produced by women) after selling 1864 kg seeds of African eggplant, 1644 kg of seeds of *Amaranthus hybridus* and 1337 kg of African nightshade seed at approximately US$ 10, US$ 3 and US$ 13 respectively.

The overall mean purity and germination rate of the seeds ranged from 92.3–99.0% and 92.3–99.0% respectively. The QDS growers sold their seeds in small quantities (as low as 2 g). This was equivalent to a mean selling price of US$ 70.97, US$ 1.77 and US$ 61.29 for 1 kg seed of African eggplant, *Amaranthus hybridus* and African nightshade respectively. Total gross income from selling QDS was US$ 10,470, with US$ 3,647 being income from seed produced by women. The seeds produced by the contract farmers can be used to plant 9322 acres, 3288 acres and 5349 acres of the three crops respectively. Similarly, the QDS is enough to plant 369 acres, 5194 acres and 43 acres of African eggplant, *Amaranthus hybridus* and African nightshade.

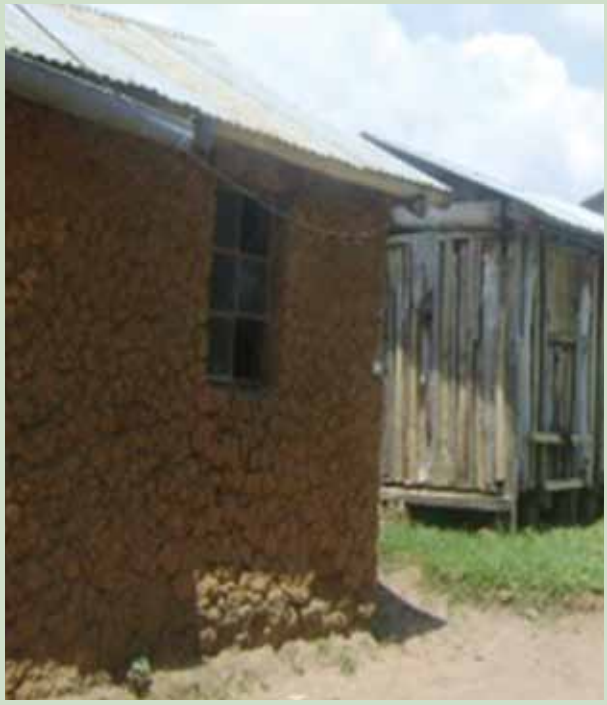
Through testimonials from participating farmers in Kenya and Tanzania, the project has made significant contributions towards improving people's livelihoods. Besides crop diversification, significant changes in household incomes emerged through income earned from the seed business. This has enabled the farmers to meet basic needs and even to pay school fees, build semi-permanent houses, engage in small-scale businesses and even buy motorcycles.

The project demonstrated that farmer-led seed enterprises have potential for higher income earning opportunities at both the farmer and community levels. The success of farmer-led seed enterprises models on AIVs was based on building good partnerships with a wide range of institutions/organisations to identify, establish and train seed growers groups.

Under the research-mediated model, descriptors for Amaranthus and spider plant were developed, a key milestone towards official release as new varieties in Kenya.

Testimonials from African Indigenous Vegetable farmers

Mr. Hosea Orone a contract seed grower in Bungoma, Kenya
I have been able to build a permanent house for my sister using income that I earned from selling jute mallow, Crotalaria and nightshade seeds. The project has enabled me to earn extra cash which I use to finance my other projects.



Before

After

Catherine Atii, a single mother of six
I used to be a casual labourer at the Kenya Seed Company. My income then could barely keep my family going. After I attended the ASARECA project training courses, I developed an interest in growing AIV seeds. I was able to sell my seed and raise enough capital to start a grocery shop. Now, I am better off than I was before. I can now comfortably pay school fees for my children.

Mr and Mrs Boazi Sebai, registered QDS growers from Ngh'umbi village in Kongwa District, Tanzania
During the 2010/2011 season, my family spent TSh 80,000 (US$ 47) to produce quality Amaranthus seed in our ¼ acre plot. In the end, we harvested 300 kg of Amaranthus seed and sold it at an average price of TSh 2500 per kg, earning a total of TSh 750,000 (US$ 440). We own a half-acre plot and, apart from AIVs, we also grow cabbage, Chinese cabbage and tomatoes. Using proceeds from AIVs and other vegetables, we are now building a permanent house.

Tosio Ekakoro, a farmer from Teso Kenya
I have benefited from the Kenya Seed Company. I now own a motorcycle from the proceeds I received after selling nightshade seed. I am also able to pay school fees for my children.

Empowering farmers to process fruits for better earnings

Post-harvest losses of fruits and vegetables in Rwanda and Tanzania are as high as 70% or more. In response to high demand to reduce the losses in the two countries, ASARECA in September 2009, in collaboration with institutions from the two countries, initiated a project titled "Processing for Commercial Exploitation of Selected Tree-Fruits and Vegetables in Tanzania and Rwanda".

Fruits often sold fresh in local markets are perishable, leading to large losses for farmers and traders

The aim of the project is to introduce key interventions that would reduce post-harvest losses. These interventions are: promoting validated technologies for value addition of selected fruits and vegetables; improving knowledge on production, pre- and post-harvest handling and processing; establishing standard and safety assurance regulations for the processors and addressing issues concerning rudimentary processing facilities; reducing malnutrition among the vulnerable groups; and championing lobbying for favourable marketing policies.

Working in collaboration, the implementers set out to validate, adapt and promote appropriate

The aim of the project is to introduce key interventions that would reduce post-harvest losses

value addition technologies and strengthen linkages between producers, processors, business service providers, markets and regulatory agencies. The implementers are Sokoine University of Agriculture, Mikocheni Agricultural Research Institute, and the Community Food Processing and Training Centre, Morogoro, all in Tanzania; and the

Processed fruits on display at Nane Nane show in Tanzania

Dried amaranth prepared by trainees

Rwanda Agricultural Board and Kigali Institute of Technology in Rwanda.

The technologies were generated to meet on-farm, storage, market and nutritional requirements to promote quality and safety assurance along the value chain.

By the close of 2010 a total of 35 processors—20 in Tanzania and 15 in Rwanda—had received training in post-harvest processing. They in turn trained other interested people organised in clusters of 7–10 on pre-and post-harvest processing, who in turn have trained more than 5 neighbours each. The Food Science Department of Sokoine University developed several formulations for fruit and vegetable products and these were promoted for commercialisation by all those who received training. These included ready-to-drink and nectar (concentrated) juice formulations and solar dried products. Some of the products were: ready-to-drink pure mango juice, mixed mango and passion fruit juice; pure passion fruit and pure pineapple; passion fruit nectar juices;

Nana Nane show in Tanzania

Processed and packaged fruit juice

Drying in progress inside a walk in solar drier—these driers are being promoted

Nane Nane show in Tanzania

solar dried mango chips; mango bars; pineapple jam; and solar dried amaranth. The Tanzanian component also promoted, three amaranth soup recipes using solar dried amaranth powder.

All these products are being promoted for commercialisation in Tanzania and Rwanda. In Tanzania 3 clusters each comprising 10 processors are ready to market their juices and solar dried products in international supermarkets as soon as the registration of their products is completed. Rwanda promoted passion fruit and pineapples because the country does not produce mangoes. Also, due to the rudimentary processing facilities, Rwanda produced more of the fruit nectar than the ready-to-drink juices.

Case study

Opening up a global dream for Rwandan rural banana processors

Christine Murebwayire, 1of the 20 members of COPROVIBA cooperative, is confident that her cooperative is set to become one of Rwanda's most acclaimed rural farm based enterprises. She is the coordinator of the cooperative.

Recently, Christine received a presidential handshake from the country's leader, Paul Kagame, in recognition of her entrepreneurial excellence and for producing quality locally made products.

Only three years ago, Christine and colleagues, Celestine Gatabazi, Alfred Mweyaneza, and 17 others, were a team of undeveloped rural banana wine brewers. They used rudimentary methods such as foot stamping to extract juice from crudely ripened banana.

ASARECA delegation arrives at the model farm

Today, Christine and her colleagues have climbed many of the steps up the development ladder. They are considered role models for the potential that rural farmers and entrepreneurs hold to turn around livelihoods in Rwanda. COPROVIBA cooperative in Ngoma District in the Eastern Province of Rwanda, is producing up to 1200 crates of wine a week (4800 crates a month or 57, 600 crates a year), up from a mere 200 crates a week (800 crates a month or 9600 crates a year) in 2009. Selling each crate at Rwf 5000 (Rwf 629.36 is equivalent to US$ 1), the cooperative today earns Rwf 6 million a week (Rwf 24 million a month) from wine sales. In 2009, they earned only Rwf 1 million a week (Rwf 4 million a month).

Banana wine production in Rwanda has huge potential to propel the benefits of banana

Several factors have contributed to this impressive growth. However, one outstanding factor to the turnaround is the openness of the founders to new ideas. Cashing in on this, in 2010 ASARECA and the Rwanda Agricultural Board (RAB) initiated a project to enhance sustainable productivity, value addition and processing of banana among banana farmers, processors and traders.

While banana is the second most important food and cash crop in Rwanda, covering about 25%


Murebwayire gets a handshake from President Paul Kagame

of the country's arable land, its potential has not been fully exploited to reap commensurate economic benefits. Individual farmers, peri-urban and rural entrepreneurs, cooperatives and associations are making efforts to add value to banana to produce products such as wine, juice, flour and confectionaries, but their efforts are limited. Informed by this, the project, titled "Improved Banana Technologies for Market and Income Generation in Rwanda", targeted the Eastern Province, the leading banana belt.

Before the project

According to Christine, the banana wine production process starts from the garden. "Once the quality of the banana crop is poor, the quality of the product as well could be compromised," she notes.

Like other wineries, COPROVIBA originally ripened bananas by burying them in the ground and covering them with leaves to generate the heat necessary for ripening. Another option was to hang the banana in a house and use smoke to raise the room temperature. These very basic methods meant waiting for up to eight days for the bananas to ripen. Even then, the ripening was 86% not uniform. Besides, these rudimentary methods had no precise method of ensuring that soil particles did not drop into the juice. At the time, most processors used their feet to stamp the ripe banana to extract juice. "Our processing capacity was low. We could only crush 500 kg a day. Besides, the method was unhygienic and unhealthy," Alfred Mweyaneza, the vice president of the COPROVIBA admits.

Bursting bottles

The juice would be fermented for up to 15 days in 20-litre jerry cans. Determining the desired sugar levels, fermentation or brewing limit was more or less by discretion. "We lacked both the equipment and skills to determine where fermentation stops," Christine recollects. The implications were unpleasant. First, it would not be possible to standardise the brand sugar level. Secondly, many times fermentation continued in the bottles leading to build up of pressure. "We frequently received reports of bottles bursting while being transported to the depot, or even in front of the customer. It was such an embarrassment," Christine recalls.


Healthy FHIA varieties supplied by RAB

The methodology also meant that hygiene and sanitation were difficult to maintain. "Once hygiene and sanitation are compromised, there is the likelihood of contamination by microorganisms, leading to shorter shelf life of the products," notes Jean Bosco Shingiro, the lead project implementer. Indeed, according to Christine, the customers often complained about the poor quality of the wine. It was hard for the cooperative to build a loyal clientele.

Wine in beer bottles

The small-scale capacity of most cooperatives meant that they had limited capital to invest in bottling and branding. Most wineries used Heineken beer bottles bought from bottle hawkers. Once the wine was considered ready for consumption, it was measured using a calibrated jug and poured into the bottle, before it was sealed and branded manually. The wines were sold mainly in the capital city, Kigali, at Rwf 5000 per crate (and retailed at Rwf 400 per bottle). "Our capacity was limited, so we produced only 150 to 200 crates per week and earned 750,000 to 1,000,000 francs a week depending on the production level," Christine narrates.

ASARECA and RAB intervene

Reading into these trends, ASARECA and RAB intervened to raise the quality of the banana products. The intervention targeted the Eastern Province, the leading banana area.

According to Dr Fina Opio, the Manager Staples Crops Programme, the priority was to address hygiene, banana quality and processing issues through training on pre- and post-harvest handling. The project also facilitated access to and sharing of information on best banana farming practices, and juice wine handling innovations.

RAB initially provided select cooperatives with FHIA 25 banana varieties. The variety is resistant to banana xanthomonas wilt (BXW) and is the best for juice and wine. As a result of training and information sharing, most cooperatives were motivated to buy the FHIA 25 plantlets from RAB.

Wine at a local store

Over 200 farmers get disease free varieties

For COPROVIBA, the training was the beginning of total transformation. "It changed our perception towards quality, standards and growth. Since then, we have witnessed rapid growth," says Celestine Katabazi, the production manager. Besides their core production roles, the cooperative now trains banana farmers and other processors.

In 2010 the cooperative selected and trained 200 organised farmers to produce additional plants on their personal farms. All the beneficiaries took part in a learning tour of the model farm. As the number of offshoots from the mother plant multiplied, individual farmers got plantlets for their farms. In addition, the COPROVIBA on-farm agronomist visits the farmers helping them to implement best practices. This has had a significant impact on the dissemination of BXW free plantlets, especially FHIA 25.

The trickle down effects of technical support from the project have greatly increased banana production. To date, the farmers supply 3 tonnes of banana every 2 weeks to the cooperative. The cooperative buys banana from the farmers at Rwf 80 per kg. A bunch of 100 kg can therefore fetch Rwf 8000.

Ripening room leads to better quality

ASARECA also built a ripening room for COPROVIBA with a capacity of 4 tonnes of banana per ripening session. During ripening, the room is moderately heated, expediting the rate of ripening. The period of ripening has been reduced from eight to three days. The good quality of banana, uniform heat application and uniform room conditions have led to uniform ripening and high quality juice.
Hygiene has drastically improved with the elimination of rudimentary methods such as burying, foot stamping, adulteration with soil, contamination by microorganism's etc. Moreover, the cooperative has bought large trunks for heating the juice to eliminate any contamination. To manage the expanded volumes and to regulate fermentation conditions, the cooperative now uses 210 litre tanks placed in a restricted room.

According to Katabazi, the improvements have led to 80% growth in production and improved working conditions. From only 200 crates a week (800 crates a month) in 2009, by the end of 2011 the cooperative had the capacity handle 4 tonnes of banana a week. The cooperative also had the capacity to bottle 1200 crates of wine a week. The production is projected to improve in 2012.

ASARECA Board members get a glimpse of the wine brewing process

To date, the cooperative is proud of other improvements like in-house quality testing and increased shelf life of their wines. Previously, they could not tell how long the wine would last on the shelf, but now they are certain it lasts up to two years. The wine is sold all over Rwanda through a network of distributors located in each of the six provinces. The distributors pick the wine from the main depot based in Kigali. The transportation, distribution and marketing have become a big enterprise with potential to expand further with the growth of the sector.

Aware of the looming potential, the cooperative has moved to acquire a standards license from the Rwanda Bureau of Standards. It is now in the process of attaining a quality mark. These processes are part of positioning the cooperative for product and market expansion. "We are

exploring penetrating the Kenyan and Tanzanian markets. We have a potential client in New York. He has asked us to improve the packaging and branding," Christine reveals. As a follow-up, the cooperative has engaged a consultant to study the cost of transporting wine to New York.

The story of COPROVIBA serves to illustrate that supporting emerging agro-based small-scale enterprises has the potential to improve rural livelihoods and set off a value chain that can spur growth of African economies. According to the RAB Deputy Director General, Dr Daphrose Gahakwa, the Rwanda Government has set up mother gardens for BXW resistant varieties as part of the efforts to make banana more productive.

Other cooperatives that benefitted from ASARECA and RAB training, information sharing and networking have improved their production, hygiene and sanitation and marketing as summarised below.

Ihumure cooperative

Ihumure cooperative in Umutsama hydromel has eight members. According to Focus Hakizumwami, the president of the cooperative, the training and exposure enabled them to open up to innovations to improve hygiene and sanitation. They also got basic skills to carry out tests on processes such as fermentation and conduct basic laboratory analysis. As a result, their sales have grown from a mere 602 crates in 2009 to, 763 crates in 2010 and 5295 in 2011. The cooperative employs 23 people and acts as a training centre for banana stakeholders in the locality. The cooperative pays Rwf 3000 per year for health social security for members and their families. Each member currently earns a dividend of Rwf 200,000 francs a year.

COOPROTRABA

COOPROTRABA used factory savings to build a factory house at Rwf 30 million, bought a pick-up truck at Rwf 10 million and some land at Rwf 2 million.

Agasaro

Members of Agasaro have used the profits from the banana business to set up side businesses as a diversification strategy. The side businesses include goat rearing, clothing boutiques and buying vehicles for the transport business.

Ineza

Using factory savings, Ineza breweries bought land and provided 50% funds to build a permanent factory building.

Testimonies

Etienne Ndayambaje: I have built a permanent house that cost about 600, 000 francs. The cooperative pays health social security for my family.

Hakizumwami Focus. I am the President of Ihumure cooperative. I have built a permanent house for my family. I am able to pay tuition fees for all my four children who are in primary to secondary schools.

Case study

Turning climate change risks into opportunities

Until recently, Anthony Mwangi Kieti, a farmer from Machakos in Kenya, thought his homeland was nothing but useless undulating topography. Mwangi's location has suffered rampant runoff, which has washed away fertile top soil leaving the area barren. To survive, Mwangi and village folks in Mwania watershed resorted to keeping goats, some of which are resilient to the harsh environment. They would sell the goats for food from other markets.

But since Mwangi visited demonstration farms set up by the Kenya Agricultural Research Institute (KARI) at the research centre, and on-site at Kalie watershed, a year ago, his vision has changed completely. He now sees a huge potential to grow food, practise agroforestry, feed livestock and mint money from this once barren land.

KARI scientist explains water management practices for crop husbandry

This life-changing visit was made possible through the project "Integrated management of water for productivity and livelihood security under variable and changing climatic conditions in ECA", established by ASARECA and partners to confront effects of climate change. Through the project, KARI set up the demonstration farms to sensitise farmers on the advantages of pursuing proper agronomic practices and making the best use of available rain water to increase productivity of their land.

How it works

According to Kwena Kizito, the lead investigator of the project, researchers use the demonstration plots to illustrate to farmers how to control runoff by establishing benches or check dams, terraces, tight ridges and other water conservation techniques. The farmers are also exposed to a cocktail of accompanying agronomic practices such as crop rotation, mono-cropping, the use of fertilisers, early sowing of seed etc. The farmers learn the benefits of using certified seed and following weather forecast advisories to manoeuvre variable climatic conditions.

"When we visited Kalie watershed, I saw that bare land which was once worse than mine had been turned green and the crops were doing very well. I realised that my own land had the potential to produce just anything I want," Mwangi says with finality.

In 2011 Mwangi swung into action. He injected KSh 30,000 (KSh 85.78 is equivalent to US$ 1) to top up the KSh 40,000 he received from ASARECA through KARI, to cut 3 by 2 square foot benches from the top to the foot of the hill. He had two objectives: one, to stop runoff, and two, to collect and optimise harvested water. The land between the benches became terraces on which he dug several holes, scooping out and putting a side stones. "I mixed the soil with compost manure in the ratio of 2:2 tins. I plan to plant trees, fodder crops and Napier grass when the rainy season starts," he said, towards the end of 2011.

A farmer in Machakos, Kenya tends a tree nursery; the trees will be planted as part of the efforts to regenerate degraded land

Thanks to the ASARECA/KARI sensitisation, Mwangi is aware that the trees will modify the environment by cooling it. He knows that foliage from the trees will add value to the land, making it fertile. He also knows that the undergrowth that is beginning to sprout from this once bare land will in a few months cover the entire hill and clean the water which flows into the Mwania River, which runs down to the south of Mwania hill. "It won't be long before the hill becomes an enterprise," Mwangi announces. "My dairy cow and goats will no longer go short of feeds. This land will be a source of medicine, honey, timber and firewood."Under Mwangi's leadership, members of Mwania watershed, covering about 900 hectares, have already planted over 3000 Bravaria and Nsena seedlings, and over 500 seedlings of natural trees. They are looking to plant 20,000 trees by the close of 2012.

In the neighbouring homestead, Gladys Mwasia planted certified maize seed following advice from KARI. She dug several benches on the gentle slope on her piece of land. "The benches slowed down runoff by about 70%. I prepared the soil for cultivation by making tight ridges and applying compost manure. I followed the weather advisories and planted maize just before the rains started," she explains. That year, Gladys harvested 2500 kg of maize in the first season and 3000 kg in the second season, her best maize harvest ever.

Mwangi and Mwasia are true life testimonies of the potential to increase agricultural productivity and household income in the region through efficient use of water. The testimonies represent what scientists and farmers can do together to pre-empt climate change. But more exciting, they are initial signs that integrated management of water initiatives, if well pursued, could transform land perceived as "waste" into production hubs.

This ASARECA project, worth US$1.7million, is implemented in partnership with KARI (the lead institution), the Ethiopian Institute of Agricultural Research (EIAR), Rwanda Agricultural Research Institute (ISAR), National Center of Applied Research and Rural Development (FOFIFA), Madagascar, Malagasy Company in Hydraulic Studies and Applications (SOMEAH), National Agriculture Research Institute (NARI), Eritrea. The project is receiving technical backstopping from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Although the project only started in April 2011, by the end of that year the results were promising.

According to Kizito, a researcher from KARI, the project sites in each country have been purposely chosen to take into account the emerging challenges of climate change. "In Kenya, we have two

sites: Mwania watershed in Machakos District and Kalie watershed in Makindu District. The two sites are similar, except that Makindu is warmer than Machakos. Makindu demonstrates the potential of drylands, because it is one of the regions worst hit by climate variations. Makindu represents what the climate in Machakos will be if the effects of climate change if not mitigated," says Kizito. "We have seen good results, from outputs on farmer's fields and their responses to what we have been demonstrating."

In all the countries, the project is implemented through a platform of actors, who have a role of improving the livelihoods in the region. In Kenya, the actors include the Kenya Forest Service; the ministries of Gender, Agriculture and Livestock; local non-governmental organisations (NGOs); and farmer organisations.

In all the countries, the project addresses water productivity issues at two levels: farmer and watershed. In Kenya, an area of about 10 km2 is being used to address the issues at watershed level. "That is the basic unit from which we thought we could draw basic lessons that could be scaled out by the government and development practitioners," says Kizito.

"We have been able to harness water in what used to be wasteland, convert wasteland into arable and good pasture with good grass species, forage trees. This is now an ideal learning site for Kenya and the rest of the sub-region," Kizito asserts. "We are telling the farmers that since they are committed to farming, let them do it correctly. If they are not committed, then they have no business in farming. He notes that most farmers are now realising bumper yields, despite a marginally good season.

This woman in Makindu District in Kenya walks for over five miles to look for water

In Kenya about 60 farmers dug over 2000 pits after the training on pasture establishment and rehabilitation of wastelands using "tumbukiza" pits. This has released over 70% of the household from food insecurity.

Project researchers have underscored that even if the region experiences only one rainy season in a year, if the water is well harnessed it can be used to produce enough food for the communities. The researchers also emphasise that integral agronomic practices (intercropping, mono-cropping, the use of fertilisers, spacing, timely planting, crop rotation, the use of certified seed, correct weeding, etc.), are part and parcel of the broader response to climate change. The project is also mainstreaming the use of weather forecasts into agricultural planning.

According to Caroline Kimeli from the Ministry of Agriculture, 192 plots were established to demonstrate the benefits of using inorganic fertilisers, applying manure, using certified seed, seed priming etc. The project is testing three cropping systems: maize only; maize rotated with cowpea; and maize intercropped with cow pea.

The plots provide farmers with learning models that have enabled them to shift from traditional crops that are unable to cope with variable climatic changes and diversify to crops that can weather the changes. As a result, Lazarus Musimi, a farmer, confesses, "We have learnt that cowpea, pigeon pea, green gram; water melon; fodder crops; and Napier grass are excellent for this kind of weather."

Weather forecasts

The project has also mainstreamed weather forecasts into the planning and execution of the agricultural calendar. "Our work is to down scale weather forecasts to farmers to enable them prepare land, select seed varieties. Our advice also enables farmers make decisions based on anticipated rainfall amounts," notes Jackson Mwangagi, an official at the Kenya Metrological Department.

To track progress and inform future work, ASARECA is measuring the progress of the interventions by measuring the runoff at the lowest point of the watershed. "We have constructed two monitoring units to measure the impact of the interventions upstream. We are due to install two more units to measure the sediments taken off the soil," says Reuben Ruto, a researcher at KARI Katumani.

Reclaiming degraded Ethiopian hills for productivity

In Ethiopia, promising work is underway in Adulala and Kechema watersheds. In Adulala, all the hills have long been degraded by human activities leading to accelerated soil erosion and consequently decline in the yields of crops such as teff, wheat, barley, field pea, field bean, haricot bean, maize etc. However, farmers in the watershed are hopeful. In 2011 the project started mobilising and sensitising communities on the benefits of reclaiming the hills through re-vegetation.

The communities were taught how to dig benches to cut down runoff and to dig holes to plant trees. The project also provided 100,000 seedlings of different species of trees to plant on the hillsides. An additional 20,000 seedlings to replace those that withered was also provided.

Newly developed varieties of wheat in Ethiopia which are designed to check food insecurity in the drylands

Teff in Ethiopian drylands

The response was overwhelming. The farmers took up the tree planting initiative and committed to maintain the trees. Teff seed was sown on the hills to add organic content to the soil. Today, what you see is unbelievable! The hills have been totally reclaimed with a thick undergrowth of grass and different species of trees. Runoff has been reduced tremendously, freeing the slopes and valleys for cultivation. Besides, the farmers have organised regulated harvesting of grass to feed livestock. The hill has also contributed to cooling the mini-climate of the area.

The project has also empowered 8women and 14 men belonging to the Gara Amsalu Beekeeping Association to upscale investment in beekeeping. The project helped the farmers acquire modern beehives. The hives will be expanded and transferred to the reclaimed hills to facilitate pollination and ecosystem enhancement.

According to Fitih Ademe, the project head for Ethiopia, "We are emphasising to the farmers that they have several water conservation and agronomic options to improve productivity."

At Kechema watershed, the project has facilitated several farmer trials to test the different wheat and teff varieties for adoption. Three varieties of teff including the fast maturing and high yielding CR-37with a capacity to produce 25 kg per hectare; Gemedins with long panicles leading to high yield and better grain; and the local and slow maturing variety, are being tested. Farmers and researchers are already learning lessons and generating data from these trials.

A water bench like this stops runoff and is used also to grow Napier grass for feeding livestock

Beekeeping in the drylands of Ethiopia

The farmers are also trying out three varieties of wheat, Quame and Asasa and Udea. They have already accepted these varieties following observed high yield, early maturity, high forage yield, dominance against weeds, and ability to withstand smut disease. Farmers have also observed the Udea variety and have concluded that it is susceptible to smut, matures late and is unable to compete with weeds, leading to low yield.

Other countries picking up

In Madagascar, the project is being implemented in Avaratrambolo, Manjakandriana District, and Ankazomiriotra, Betafo–Antsirabe District. These districts are characterised by high population growth, expansion of agriculture into fragile lands, high levels of land degradation and lack of control on use of available water. Betafo and Manjakandriana districts have flat valleys and convex hills with an altitude between 1000 and 1400 metres above sea level. The major crop, rice, can be grown twice a year due to the cold period. It is common for farmers to plant off-season crops after the rice harvest. Most of the hillside land is steep slopes, with low fertility and is highly susceptible to erosion.

In Rwanda, the project is implemented in Bugesera and Nyamagabe districts. Bugesera has less rain and gentle topography, while Nyamagabe receives more rain and has steeper slopes than Bugesera. Agriculture in the two districts is for subsistence and largely is characterised by low landholding size due to high population density. Bugesera District is experiencing reduction in land productivity due to the shortage of water and low soil fertility. Nyamagabe District suffers from soil erosion and acidity. The households in the districts are generally food insecure mainly due to low and erratic rainfall. Despite the tremendous potential for crop and livestock farming, the current productivity levels of the systems remain low.

In Eritrea, the project is implemented in Amadir and Molqi watersheds in the Sahelian rainfall zone. A 190 m3-capacity check dam and 5.4 km of terraces were constructed around Amadir dam in Eritrea after sensitisation and training by the project. Another 334 m3-capacity check dam and 9.5 km of terraces were constructed around Molqi dam to control soil erosion and prevent siltation of both the dams. As a result, farmers in these two watersheds now enjoy a continuous supply of clean water. Besides, over 600 seedlings have been planted around the homesteads to conserve the environment and generate income for the farmers. Farmers also dug about 6000 "tumbukiza" pits in Amadir and Molqi to harvest water and establish woodlots. The woodlots have since taken off and are intended to provide raw materials for the cottage "carving" industry planned for the two watersheds, besides conserving the environment. Amadir and Molqi receive rainfall from the south-western monsoons.

Climate, rainfall and topography are highly varied. The country is periodically subject to severe droughts which result in extreme food deficit years. Seventy per cent of the topography is characterised by inaccessible mountainous terrain and arid/semi-arid areas with sparse vegetation. The current institutional capacity and resource levels for agricultural research are inadequate to realise essential research tasks and outputs, or to meet the needs of producers on a national scale. As a result, food security and poverty alleviation are major concerns of the government.

Although most ECA countries have adequate water resources, they face an economic water scarcity. Less than 25% of the water from rivers in the region is used by human due to inadequate investments in water control structures and management systems. In fact, countries in Africa store only about 4% of annual renewable flows. The region heavily depends on rainfed agriculture which, unfortunately is increasingly at the mercy of climate change. This mix constitutes part of the main reasons why Africa is unable to respond to its food and market deficits.

Despite being naturally rich in water, the irrigated area in ECA totals slightly more than 3.5 million hectares, with Sudan and Madagascar accounting for marginally over 80% of it. Ethiopia, the most populous country in the region, with less than 40%of the arable land currently under cultivation, has a potential irrigable area of about 2.63 million hectares, but only 12% of this is currently under irrigation.

The project was inspired by evidence that investment in agricultural water can contribute to agricultural growth and reduce poverty directly by encouraging intensification and diversification of agriculture. This has the potential to cause increase in employment. Upgrading rainfed agriculture through better management of rainwater, soil moisture, and supplemental irrigation offers the potential to increase food production and reduce poverty, especially for sub-Saharan Africa.

Integrated watershed management links production, conservation and livelihood objectives of people with a stake in a given watershed. It provides a framework for integrating technical, economic and social knowledge in identifying constraints, and in supporting planning and decision making to achieve sustainable solutions.

According to Dr Hezron Mogaka, Manager of the Natural Resources Management and Biodiversity Programme at ASARECA, emerging positive results from all the participating countries indicate clearly that climate change presents a series of challenges; however, communities can unearth hidden opportunities from it. Evidence exists that with prudent management of water resources, use of right varieties, improvement of soil health and value addition, communities such as the Mwania residents have at hand adaptation strategies that work to their advantage.

"ASARECA will, in the medium to long-term, continue to work closely with key partners to promote climate smart water management options," says Dr Mogaka.

B. Enhancing agricultural productivity through policy options

Study refutes misconceptions about drylands

Pastoralism has been blamed for environmental degradation and loss of biodiversity in the drylands of ECA. It has also been alleged that pastoral rangelands are unmanaged and therefore over-exploited. Another common misconception is that pastoral economies lack economic potential, and lack prospects for the pastoral lands and the peoples therein. For these and other reasons, governments in the Horn and East Africa have historically neglected pastoralism.

In some cases, where governments have intervened, the policy, legal and institutional interventions have undermined the abilities that pastoralists have used for years to manage risks and cope with livelihood shocks. It is now apparent that despite many constraints to their rangeland management practices, where pastoralists are still able to move their herds effectively, and where their traditional systems of governance remain strong, rangelands tend to be in good environmental condition.

In addition, statistics show that pastoral livelihoods in the drylands contribute greatly to national economic activity, although these contributions are often not well documented. It was against the backdrop of several challenges and opportunities that a study was undertaken on "Natural Resource Management and Biodiversity Conservation in the Drylands of Eastern and Central Africa". The study focused on livelihoods and biodiversity in areas used for pastoralism in northern Tanzania, southern and northern Kenya and southern Ethiopia. The study was based on the five assumptions discussed below.

First, biodiversity may be best conserved by supporting the livelihoods of the pastoralists who manage this diversity. **Second,** there is inadequate understanding on how policies influence the ability to benefit from the mutual interaction between pastoralism and biodiversity. **Third,** there is need for a trans-regional approach to understanding and influencing dryland conservation and pastoral livelihoods. **Fourth,** dispersed information already exists on pastoral areas, which could be mobilised to define policy constraints and identify solutions. **Fifth,** a wide range of stakeholders, from local communities to government decision makers, should be engaged to develop new insights and frameworks to generate new policy dialogue.

Engaging different stakeholders was seen as a means to improve both the extent to which policies were likely to be equitable, and the likelihood that policies will be implemented.

Targeted communication

Using the project communication guidelines developed by ASARECA, key results of the study were analysed and the communication plan was tailored accordingly. The communication plan identified targeted communications in four areas, namely: communication to other researchers; communication to policy/decision makers; communication with local communities/ stakeholders; and communication to the general public. The communication plan singled out the policies that affected pastoral livelihoods and biodiversity and prepared to develop relevant policy options for the related ministries. Policy bottlenecks were identified, such as funding or capacity constraints at local government level, and communication was targeted accordingly in the plan. As laid out in the plan, the findings and recommendations of the study were presented to key stakeholders from Ethiopia, Kenya, Tanzania and Uganda at national and regional dialogue meetings held in October 2011. The stakeholders were drawn from national ministries, pastoralist civil society organisations, research bodies and regional government organisations.

In light of the information presented by the study, the stakeholders made several specific recommendations: climate change and climate variability were found to be serious challenges for livelihoods in drylands, as was the biodiversity crisis. The results also indicated that maintaining mobility was key both for adaptation strategies and for biodiversity maintenance. Clear demand for regional alert systems was expressed.

Land tenure is a key factor for mobility maintenance, especially regarding the support of communal tenure in drylands. Participatory approaches are fundamental to guaranteeing the ownership of development measures by local communities. Access to social services such as veterinary, health and education was considered to be key for communities living in dryland areas; the ecosystem services provided by sustainable livelihoods should pay for the increased cost of the service delivery by the state. Access to banking and financial services in remote areas, as shown by those associated with mobile telephones, has proven to be key to facilitating the marketing of products. Social and infrastructure services should also pay special attention to women's empowerment, including specific marketing of products produced by women.

The potential of radio broadcasting in local languages was highlighted as a powerful tool for building capacity of dryland inhabitants, particularly pastoralists. Participants of the dialogue meetings expressed a clear mandate to involve parliamentary representatives of pastoralists in discussions about drylands. While members of parliament have often shown an inadequate understanding of dryland issues, they usually have little time to participate in capacity building events. It is the mandate of the dialogue meetings to stimulate grassroots organisations, local leaders and elders to exert pressure on their members of parliament so that the capacity of the policymakers is built through the information available as a result of research carried out by institutions capable of delivering reliable knowledge. The study was considered

Donkeys are a common feature in degraded lands

a good example of the type of knowledge they should receive. Communication activities targeting policy makers will be developed and implemented in the next phase of the project. The project report and several related policy briefs are available on the ASARECA website, www.asareca.org.

Strategies for adapting to climate change

Agriculture drives the economies of 10 countries of ECA and accounts for 43%of their gross domestic product annually. In Burundi, DRC, Ethiopia, Sudan and Tanzania, agriculture accounts for more than 50% of gross domestic product; in Eritrea, Kenya and Madagascar, it accounts for less than 30%. Extreme weather patterns have, however, become common and threaten to change the way economies in the sub-region will fare. Climate change is already affecting ECA and is manifested through prolonged droughts in parts of Ethiopia, Kenya and Tanzania in 2011; and devastating floods in parts of Kenya, Tanzania and Uganda. Climate change definitely will have far-reaching consequences on the poor and marginalised groups, especially those who depend on agriculture for livelihoods and have a lower capacity to adapt.

Weather-related crop failures and livestock deaths in addition to loss of property are already causing economic losses and undermining food security in ECA. Feeding the increasing populations in the sub-region, which has one of the highest population growth rates in the world (averaging 3.7%), requires radical transformation of agriculture.

A grim reality that looms large in the 10 countries is that more than 70%of the population live in severe poverty and are directly dependant on climate-sensitive resources for their livelihood. A major challenge therefore is how to increase agricultural production among these resource poor farmers without exacerbating environmental problems and simultaneously coping with climate change.

Informed by this grim situation, since 2009 ASARECA (through the Policy Analysis and Advocacy Programme), has collated data on rainfall patterns, cropping systems, population trends and policy preparedness in the 10countries. The studies, conducted in collaboration with the International Food Policy Research Institute (IFPRI), under the project "Strategies for Adapting to Climate Change in Rural Sub-Saharan Africa: Targeting the Most Vulnerable" were meant to inform decisions on how to cope with climate change. In 2010 ASARECA and IFPRI finalised the analysis of key strategies for climate change adaptation for the 10ASARECA member countries.

Predictive analysis

Current data on agriculture and economic development were reviewed using technical modeles used to anticipate changes in climate towards 2050. The models demonstrate that the impact of climatic conditions and population growth on agricultural production; and global supply and demand for food and attendant rise in food prices are real.

All the models predicted that the 10 ASARECA countries would experience increased rainfall and a rise in temperatures. Increase in temperature has a powerful knock-on effect. It causes increased evaporation, which reduces the moisture in the soil, leading to higher plant water requirements; therefore an increase in temperature would be unfavourable to the region. The models also predict that rainfall will be more erratic, further disrupting predominantly rainfed agricultural production systems with coffee predicted to be the most affected. Results from climate change scenarios show a general increase in maize yields in most parts of ECA and yield losses in large parts of DRC, Ethiopia, Tanzania and northern Uganda.

However, the results show that sorghum yields will decline across ECA, while there will be gains in western DRC, and in the highlands of Ethiopia, Kenya, Tanzania and Sudan. These changes point to possible expansion in the crop production zones for staple crops and livestock. The merits of this change include enhancingthe food security of communities in the new production areas although adverse impacts are also likely in the sense that farm gate prices might collapse, thus undermining household incomes and climate change resilience. There are environmental concerns if the new lands being opened involve cutting down natural forests and cultivating fragile savannah grasslands. All this will require technological advancement in terms of better adapted varieties, and soil and water management practices.

In some countries, climate change will present opportunities to grow crops in areas where they could not have previously grown. Such areas are those which are too cold for certain crops today, but which will be warmer due to climate change making them suitable for those crops.

The signals from the models and scenarios will inform future policy directions on the importance of climate change adaptation in the region. ASARECA and partners have contributed to the growing awareness of the potential adverse effects of climate variability and change both in regional institutions and national governments. This has resulted in various initiatives aimed at addressing climate change issues.

At the regional level, EAC recently published a climate change policy (EAC 2011). The policy is aimed at, among other things, guiding the region on climate change actions and establishing a climate change fund to support adaptation and mitigation activities. The policy also establishes research institutions of excellence in technology development for climate change adaptation, and mainstreaming of climate change in national development processes.

This study is also augmenting individual country efforts, recognising the national level activities underway. For example, the 10 countries have ratified the United Nations Framework Convention on Climate Change (UNFCCC). They have also each drafted a National Adaptation Programme of Action (NAPA) and a host of other strategies focusing on climate change.

ASARECA and partners have highlighted policies and actions that governments and multi-stakeholders need to undertake to build specific adaptive capacity in some of the most affected areas. These include mainstreaming climate change in national planning and budget

Goats in drylands

ASARECA and partners have highlighted policies and actions that governments and multi-stakeholders need to undertake to build specific adaptive capacity in some of the most affected areas

processes to enable research and investments in climate smart technologies and innovations for smallholder farmers.

Others strategies are:

- Developing and promoting drought-tolerant and early-maturing crop varieties. Most countries have areas that are classified as arid or semi-arid, hence the need to develop such varieties.
- Strengthening rural infrastructure to increase access to markets.
- Reviewing and enforcing climate smart land policies.
- Capacity building to implement actions on climate change. The capacity covers training inthe management of modelling for climate change, crop modelling and remote sensing, and managing early warning systems. These initiatives are already underway in Burundi, Eritrea, Ethiopia and Madagascar.
- Promoting rainwater harvesting as an important adaptation strategy, either small scale with small check dams or large scale with large dam projects. This is already underway in many countries with ASARECA interventions.
- Other measures that are common to ECA countries that are being promoted include conservation and restoration of vegetative cover in degraded and mountain areas; reduction of overall livestock numbers through sale or slaughter; cross-breeding, zero-grazing, and acquisition of smaller livestock such as sheep, goats; adoption of traditional methods of natural forest conservation and food use; and promoting community-based management programmes for forests, rangelands, and national parks.
- Rehabilitation of degraded agricultural lands is ongoing in Eritrea, Ethiopia, Kenya, Sudan and Uganda. These activities include using adaptable land management practices and planting tree species to prevent soil erosion and improve the microclimate, transforming steep slopes into cultivable land, and reclaiming degraded lands through terracing. In the drier areas, sowing grasses and legumes to enrich the rangelands is underway to ameliorate livestock feed shortages.
- Improved coordination and implementation of climate change polices by harmonising policies and institutional frameworks affecting climate change adaptation across different approaches and strategies. Examples of how this can work are already underway in Eritrea, Ethiopia, Kenya, Sudan, Tanzania and Uganda.

C. Catalysing agricultural research through capacity development

Case study

Supers stars: Rwanda Government deploys SCARDA scientists to drive research

Hungry for well trained senior scientists to drive agricultural research in the country, the Rwanda Government has deployed fresh MSc scientists returning from various universities in East Africa, in the most strategic and priority research positions. The scientists have a couple of urgent roles: one, confront food insecurity and malnutrition; two, boost farmers' incomes by orienting them to the market.

Leonidas Dusengemungu has been appointed the national head of Innovation Platforms in Rwanda. He is also backstopping the national extension team to drive the national crop intensification programme for the five priority crops: maize, cassava, wheat, Irish potato and bean. **Gafishi Kanyamasoro** has been tasked to develop and deliver to the Rwandan people local inbred lines of maize adapted to high altitude areas. Currently, Rwanda is importing maize seed for its high altitude areas from Kenya. **Uwizera Mathilde** is now head of the National Soy Bean Programme. "My brief is to conduct research and extension in soybean," says Mathilde. "This involves producing quality soybean, promoting soybean inoculated through farmer field schools and linking farmer cooperatives to oil processors." **Cyamweshi Rasangama** has been appointed the Director of Natural Resources Management and Mechanization in the western agricultural zone. He has been tasked to initiate

research related to soil conservation and formulate fertiliser use recommendations for the priority crops. **Wilson Dufitumukiza** is the chief of the National Tea Research and Extension Programme for Rwanda. **Maximillan Manzi** is the Director for Livestock Research and Extension in the Eastern zone. "I am tasked to champion research on reproduction physiology for indigenous cows and cattle genotypes in Rwanda, conduct research on embryo transfer and artificial insemination," he notes.

"The appointments reflect cornerstone research areas in Rwanda. That means RAB is confident that these scientists are best suited to lead efforts to transform our agriculture," said Dr Vicky Ruganzu, a senior researcher working with RAB and the ASARECA focal person for Rwanda.

Until 2008, these scientists were only junior researchers with first degrees. This meant that they could only do as much as their limited education, training and exposure and skills could offer. In 2008 ASARECA sponsored 34 young mid-level scientists from ECA to undertake leadership and mentorship training; and an array of master's degree courses in Plant Breeding, Soil Science, Agricultural Information and Communication Management, Research Methods, Range Management, Agricultural Extension, and Breeding in various universities. Through the project, "Strengthening Capacity for Agricultural Research and Development in Eastern and Central Africa" (SCARDA-ECA), ASARECA teamed up with the Forum for Agricultural Research in Africa (FARA) and the Regional Universities Forum (RUFORUM), to place the students in acclaimed universities in ECA. The universities are Makerere University in Uganda; the University of Nairobi, Jomo Kenyatta University of Agriculture and Technology and Egerton University all in Kenya; Sokoine University of Agriculture in Tanzania; and the Sudan Academy of Sciences.

The students were selected from the Agricultural Research Corporation (ARC) in Sudan, Institut des Sciences Agronomiques du Burundi (ISABU) and Institut des Sciences Agronomiques du Rwanda (ISAR, now RAB). These countries were chosen following an institutional assessment of the national agricultural research system, which indicated that lack of adequate human resource capacity was a major weakness in delivering research outputs to meet the needs of the poor. The scientists successfully completed their courses and in 2010, returned to their countries early 2011 and are making priceless contributions. Two years down the road ASARECA has started the process of following up the students. Below are highlights:

Leonidas Dusengemungu

Dusengemungu is now incharge of in nolvation platforms nationally

Dusengemungu was sponsored to study Agricultural Extension and Education at Makerere University. Before the scholarship, Dusengemungu was the head of Technology Transfer Unit at Rubona Station, ISAR. During his MSc studies, Dusengemungu was introduced to the innovation platforms of FARA which are considered a model for participatory research on the continent. With this level of exposure, Dusengemungu was set to influence the perceptions of farmers in the watersheds (area fed by a common water stream/source) to optimally use the land. His academic research on "Capacity for Sustaining Agricultural Innovation Platforms in Rwanda: A Case Study of the Research into Use (RiU) Project", analysed the needs of farmers, processors and extension workers in Rwanda.

When Dusengemungu completed his studies in 2010, he was immediately posted to Rubona Station and appointed the head of the Outreach Programme of ISAR. This put him at the helm of "taking" all agricultural and associated technologies ranging from agroforestry, horticulture, livestock etc., to the farmers.

He started off with 24 mature technologies waiting to be transferred. With a team of eight social scientists under his docket and working closely with the natural scientists, Dusengemungu swung into action, creating innovation platforms for technology adoption.

After an interim appointment to head of the Crop Directorate for the Western Province on 1 July 2011, in February 2012 Dusengemungu was appointed National Head of Innovation Platforms. He started three innovation platforms for beans and maize; rice; and coffee and is due to start the banana and pineapple platforms. In addition, Dusengemungu supports other innovation platforms on water productivity supported by ASARECA.

"In the west, I started a platform for fishing which brought together traders, fishermen, the police, district leaders and the army to agree on how to conserve fish in Lake Kivu which were becoming extinct. We agreed to shut the lake for two months to let the fish restock and thereafter, open it for two months," he explains. "At first it was like a one-off initiative, but it has been adopted as a more or less permanent measure to replenish the lake because the community has seen the benefit.

While still studying at Makerere University two years ago, Dusengemungu's dream was to clinch an opportunity to implement his study findings. Today, his hands are overflowing with the opportunity, perhaps, a little more than he ever dreamt of. His country is hungry for people who can tame knowledge and exposure to touch the lives of the farmers.

Gafishi Kanyamasoro

Gafishi explains the process of transforming the yellow maize variety into the the farmer preffered white

Maize under transformation from yellow to white

Gafishi started his research career in 1996 in the Western Province of Rwanda after graduating from an agricultural college in Congo. With a "Level A", equivalent of advanced diploma, he was deployed in Nyagatare and Rwerere stations as a manager. About this time, he found extra time off his schedule to study for a bachelor's degree in Rural Development. The opportunity to undertake MSc studies in Plant Breeding at Makerere University under SCARDA opened up a whole new world to him. His academic research on "Determination of the hetoritic groups of maize inbred lines and the inheritance of their resistance to the maize weevil *Sitophilus zeamais"* was spot on with the future he was preparing for.

"Immediately I returned to Rwanda in March 2011, I was appointed researcher and posted to Tamira Station as a station manager and researcher in maize. In July the same year, I was posted to the northern zone, considered to be the best maize yielding area in the country, and named the focal person on the Maize Programme in the entire zone," he explains. That means I was in charge of maize research stretching from Rwanda's border with Uganda to the outskirts Kigali city."

Today, Gafishi's roles have expanded. "I am in charge of maize in all high altitude areas of Rwanda. I have been tasked to develop inbred lines of maize for all high altitude areas in the country. Most of the country is high altitude, so you can gauge the extent of this assignment," he notes.

"We have made tremendous progress in turning the yellow variety into white. We have advanced to a critical stage where we have made selections for the OPVs"

Currently, Rwanda is importing hybrid maize for high altitude from Kenya. The government, however, wants inbred varieties adapted to the Rwandan highlands to be developed urgently to improve maize production. Gafishi is also conducting breeding experiments to develop a farmer preferred white open pollinated (OPV) variety of maize from the only variety adapted for the highlands, which unfortunately, the farmers do not like because it is yellow.

"We have made tremendous progress in turning the yellow variety into white. We have advanced to a critical stage where we have made selections for the OPVs," he notes.

Gafishi attributes these stellar achievements to enhanced capacity and the exposure offered by the MSc course. "When I was a technician, all I could do was evaluate imported germplasm," he notes.

Rwanda has an acute shortage of maize breeders. Currently, there are only three maize breeders in the country: Gafishi, who is in charge of the highlands; Alfonse Nyagatare, who is in charge of the mid-altitude area; and the National Director for Crop Production. "So, when I say 'we' when referring to the western zone, I am referring to myself as the team leader and lead researcher, two extension staff and one technician," he explains.

The effects of Gafishi's work spill over to neighbouring farmers in DRC and Uganda. "They come to seek seed, advice and training and we support them," he notes."I am very satisfied with what I am doing. My country has confidence in me and that is the best motivation one can ever get."

Cyamweshi Rasangama

After his first degree in Soil Science, Cyamweshi worked in ISAR as a junior researcher, moving from one station to another until 2006. He also worked as a focal person for the International Center for Tropical Research (CIAT)/Tropical Biology and Fertility project. "At the time, because of limited exposure and knowledge base, it was hard to undertake and produce any research output. In fact, I cannot mention any research output to my name that I did at that time," Cyamweshi confesses.

Today, however, Cyamweshi has many research milestones directly linked to his name, thanks to the empowerment he received through an MSc in Soil Science at Makerere University. "I can now do any form of research, and when I interact with researchers the world over, I feel comfortable," he notes. "The SCARDA scholarship recognises the problems of research capacity in the true African context."

Cyamweshi's research, "Optimizing phosphorus availability for bean production on high altitude andisols(volcanic soils)", enriched his knowledge base further, positioning him well for challenges of any type.

On returning to RAB in early 2011, Cyamweshi was appointed a researcher in soil conservation and posted to the western agricultural zone. He was tasked to initiate research related to soil conservation and formulate fertiliser use recommendations for priority crops: maize, wheat, rice, potato and beans. "I did not have a technical team to work with. In the whole province covering five districts, I was the only soil researcher," he notes.

Following these recommendations and other concerted efforts, today the government distributes fertiliser to farmers at the beginning of the planting season on a 50–50 cost sharing arrangement. The farmer's contribution to the cost is taken after harvest.

"At the beginning of every cropping season, I send my extension staff to sensitise farmers on planting time, and other farming best practices, distribute seed and orient them towards the market. The fertiliser comes in when they are adequately prepared," says Cyamweshi.

Since June 2012, Cyamweshi's scope of work was expanded. He was appointed the Director of Natural Resources Management and Mechanisation in the western agricultural zone. That means coordinating all the activities to do with extension. The extension activities are grouped in productivity deliverables. In extension, he has been able to deliver the following:

Increasing arable area under erosion control by 13%
Cyamweshi championed efforts to produce guidelines to control soil erosion and increase arable land by 13% by June 2012. The team has established 2697 ha of radical terraces and 8047 ha of progressive terraces in the western region as of June this year. Besides, the team has mobilised farmers and local authorities to ensure the facilities are well maintained.

Increasing area under small- and medium-scale irrigation
The team is working to increase arable land under irrigation by 300 ha. The team has established small-scale irrigation using damsheets which RAB has installed on farm in a cost sharing arrangement. The technique involves collecting runoff water to sustain year-round vegetable production.

Making marshlands more productive
The team has been working to develop marshlands using effective irrigation to increase the area of arable land in Western Province. To date, more than 20% of three identified catchments have been protected and soil erosion control activities are ongoing. To ensure that this is sustainable, water users' associations to follow up established best practices and innovations have been established.
Integrated agroforestry and forestry land use systems

The team initiated integrated agroforestry and forestry land use efforts to manage the land use. To date over 207,000 trees have been planted in the intervention areas covering 95 ha. In Karonji, one of the districts, the total number of Eucalyptus and other trees planted has surpassed 1,700,000 in an area of over 1100 ha.

Kitchen gardens for nutrition
According to Rwanda's Health Ministry, about 16,000 families countrywide are undernourished. To ratify the situation, the extension team has trained farmers to establish and maintain kitchen gardens for year-round vegetable production. They established pilot kitchen gardens to serve as models and provided the farmers with quality vegetable seeds for amaranth, nightshade, egg plant, carrot, onion and spinach. Besides, performance contracts for building 50 kitchen gardens per cell were signed by sector agronomists and the district authority. The performance contracts were evaluated in August and results are due to be released.

Mitigation of climate change
To reduce vulnerability to climate change, the team is working with the Rwanda Environment Management Authority to produce 3,300,000 seedlings of *Alnus acuminate* to be planted on 500 ha of land. Two species of bamboo have also been planted in a nursery to produce 1500 seedlings.

The group has also established nurseries to produce economic seedlings. To date, 450,000 seedlings of tamanilo and maracuja plants, and 150,000 seedlings of avocado are in nurseries.

Uwizera Mathilde
Before the MSc, Uwizera had a BSc and was a researcher and the Head of Biotechnology at ISAR. When the opportunity arose to undertake a master's degree, she decided to do research on "Co-deployment of legume nodulating bacteria and *Arbuscular mycorrhizae* fungi for improved bean in acid soil".

Mathilde gets into action in one of the bean fields in Rwanda

"Beans are a staple crop in Rwanda. Reducing organic fertiliser use for beans is critical in cutting the cost of production. That is what motivated me to research into the application of microorganisms for nitrogen and phosphorus fixation in acidic soils," says Uwizera.

After her studies, Uwizera was appointed the head of the National Soybean Programme and tasked to conduct research and extension in soybean. This meant she had to lead efforts to produce quality soybean, promote soybean inoculated through farmer field schools and link the farmer cooperatives to the soybean oil processors. Her thesis became immediately handy when she was appointed Coordinator of the Nitrogen Fixation Project for smallholders. Uwizera is directly supervising a team comprising two plant breeders, one soil scientist, one biologist and agronomist; two extension staff and three technicians.

Maximillan Manzi
With a first degree in Veterinary Medicine, Maximillan Manzi was the head of the Livestock Research Unit at ISAR, before he went for an MSc in Range Management at the University of Nairobi in Kenya.

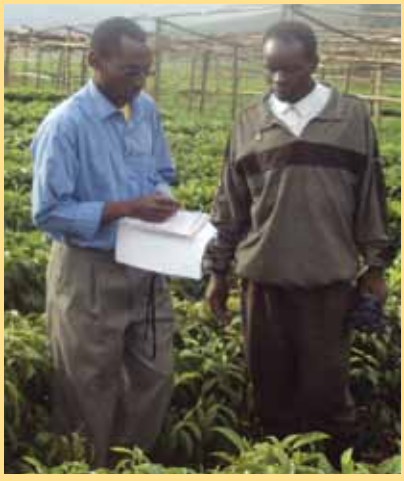
During his MSc studies, Maximillan chose to do his research on "Factors affecting pre- and post-weaning growth of crossbred cattle in Songa Research Station in Rwanda" to improve his capacity in breeding and genetics. He benefitted from frequent study tours to the International Livestock Research Institute (ILRI), a centre of excellence for livestock research in Africa. This exposed him to practical skills, especially in data management. "Before the training, I was implementing breeding activities with difficulty because of knowledge limitations. After the training, especially in breeding

and genetics, my skills improved drastically. I now have the capacity to plan and implement breeding activities in Rwanda with ease," he asserts.

On returning home, Maximillan briefly worked at ISAR as an animal breeder. Soon after, he was appointed the Director of Livestock Research and Extension in the Eastern zone, putting him at the top of livestock sector in the country. "I monitor and coordinate activities of 26 livestock staff engaged in livestock nutrition, health and breeding," he notes. "I am tasked to champion research on reproduction physiology of indigenous cows and cattle genotypes in Rwanda; conduct research on embryo transfer and artificial insemination; and maintain a system for collecting, documenting and analysing goat and cattle breeding data at Karama/Bugesera and Karama/Nyagatare Research Stations."

Wilson Dufitumukiza

Before undertaking the SCARDA sponsored MSc in Soil Science at Egerton University, Dufitumukiza was an assistant researcher in the Tea Research Programme of ISAR. With a BSc then, his brief was to identify constraints to tea production in Rwanda.



Wilson Dufitumukiza conducting research evaluation in the field

Once he received the MSc scholarship, Dufitumukiza made the best use of the well equipped soil laboratories and field sites at Egerton for his research on the "Effect of lime and NPK fertiliser formulations on soil chemical properties, tea yield and leaf total polyphenols in Gisovu, Rwanda". When he completed the studies, he was appointed a researcher and tasked to conceptualise and implement participatory tea production research and extension projects.

In April 2012, he was appointed the head of the National Tea Research and Extension Programme for Rwanda. This put him at the helm of promoting public–private partnerships nationally, regionally and internationally to improve tea production and conservation. He is charged with ensuring that technical capacity for tea research and development is boosted. He is also involved in the tea policy and strategy formulation.

It is only two years since the scientists completed their master's degrees. The scope of work Rwanda has entrusted to these scientists is testimony to the hunger for qualified people to take charge of agricultural research for development in the country. This scenario is similar in all countries that were unable to develop local talent due to conflict. The stories also highlight what capacity development can do to optimally deliver agricultural research outputs. The scientists have the potential to become world class researchers who can move research, not only in Rwanda, but in the rest of Africa. Given the ASARECA orientation to produce agricultural technologies which can be shared throughout the region, enabling these scientists to undertake PhD studies would be a strategic investment.

D. Powering technology linkages through information and communication

First General Assembly offers platform for knowledge sharing

ASARECA held a successful First General Assembly from 14 to 16 December 2011 at the Imperial Resort Beach Hotel, Entebbe, Uganda. The theme of the meeting was: "Feeding our region in the 21st century".

The first in the history of ASARECA, the objectives of the General Assembly were to: create a forum for developing a shared vision and shared goals to enhance sustainable agriculture to bring about economic growth and improved livelihoods in the ECA region; introduce ASARECA and its strategic regional objectives, challenges, opportunities and successes to the patron ministers and members of the general assembly; provide an enabling environment for the general assembly to play its oversight role; and to receive from the patron ministers and the general assembly, recommendations and strategic guidelines for ASARECA work.

True to the solid foundation of ASARECA built on strong partnerships and collaboration, the General Assembly brought together over 270 delegates representing: national agricultural research institutes (NARIs) and national agricultural research systems (NARS); sub-regional associations for agricultural research; extension, agricultural training and education related associations; farmer associations; associations of processors of agricultural products; associations representing agricultural service providers; associations of agricultural products; associations of agricultural businesses and related marketing agents; consumer associations; organised women's groups and youth groups working in agriculture-based associations and NGOs; investors and donors; international research centres belonging to the Consultative Groups on International Agricultural Research (CGIAR); universities and advanced research institutes; and academies of science among others.

Delegates discussed topical issues such as the emerging impacts of the Comprehensive African Agricultural Development Programme

(CAADP) as a planning and partnership platform to accelerate growth and poverty reduction; gaining control over high volatile food prices; governance and policy imperatives for transformation of agriculture; harness livestock resources for food security; gender mainstream agricultural research and development; the role of farmers; universities; NGOs; agricultural extension; and the private sector in agricultural research and development.

In a demonstration that regional partners respect and have faith in ASARECA leadership, they made a series of recommendations that could expand ASARECA influence and interactions in the sub-region. Some of the highlights of the recommendations are discussed below.

Agricultural development—Challenges and opportunities

ASARECA should work with national governments to increase investment in science, technology and innovation, particularly advances in biotechnology, and information and communication technologies; support approaches that encourage participation of targeted technology; strengthen the mechanisms for member countries to tap into existing opportunities; increase focus on scaling out of best practices; increase efforts towards regional market integration; and address food price volatility.

Climate change

ASARECA should: increase focus on climate change; support member countries to generate reliable weather data and play a key role in raising awareness on climate change to minimise post-harvest losses; and address the issue of access to food.

Policies and political commitment

ASARECA should: strengthen its engagement and that of its stakeholders in policy advocacy and dialogue to solicit political will and formulation of supportive policies for agricultural development; lobby for government support to smallholder farmers; and strengthen collaboration with regional economic communities to influence political support to the CAADP process.

Addressing the disconnect between agricultural research in the NARIs and faculties of agricultural sciences

ASARECA should: strengthen national institutional frameworks that coordinate and consolidate agricultural research in NARIs and training in faculties and schools of agriculture and related disciplines; support universities to undertake reforms that make them more relevant to current and future needs, while championing the establishment of a new generation of agricultural universities that integrate agricultural research and university training.

Contribution towards CAADP

ASARECA should: strengthen its collaboration with regional economic communities to garner political support for the CAADP process and ensure that all stakeholders fully participate in the process through increased support for their capacity building.

Supporting farmers and their organisations

ASARECA should assist farmer organisations to build their capacity and that of their partners to engage in post-production activities in the value chain, like value addition, marketing and enterprise development and develop entrepreneurial skills such as record keeping, business planning, market intelligence, negotiation, and monitoring and evaluation; create an innovative platform and network for information and knowledge management, including indigenous knowledge and information sharing to promote continuous learning and adaptation among the different stakeholders.

Strengthening extension

ASARECA should: commission studies to understand the underlying bottlenecks to

technology adoption and review and critique the extension approaches and their relevance in different contexts.

Supporting NGOs

ASARECA should: encourage and support genuine NGOs that play a supportive role to functions of ASARECA and create platforms for their networking and partnerships with research/training institutes; and broaden its "concept of NGOs" to embrace civil society organisations to tap into the contribution of professional associations in agriculture-related disciplines.

Supporting the private sector and its strategic partners

ASARECA should empower the private sector by: building its capacity to lobby and advocate for favourable policies, for example tax exemptions on agricultural goods and products and increased access to finance for agriculture; commissioning research into strategic entry points for greater interaction between the private sector and farmers that could trigger economic transformation within the agriculture subsector; and providing access to an inventory of available technologies and their suitability in the different areas within the region.

Dealing with emerging issues underlying food insecurity

ASARECA should: strengthen its efforts to engender agricultural research and enhance equity to boost food production; strengthen centres of excellence and build their capacity by recruiting outstanding scientists and developing infrastructure to produce and exploit appropriate technologies for diverse cultures; and support member countries to invest in rainwater harvesting.

A complete publication of the proceedings of the General Assembly: Feeding our region in the 21st century: First ASARECA General Assembly. Volume 1: Proceedings: ASARECA: Entebbe, Uganda: 2012; is now available.

Getting African information online

"In Africa in general and Uganda in particular, the impact that research and innovation can have on agricultural and rural development and natural resources management is limited because most of the information and knowledge generated is not easily accessible and used," said Dr Emily Twinamasiko, the Director General of the National Agricultural Research Organization(NARO), Uganda.

Among the initiatives that ASARECA carries out to address the challenge of access to information generated by agricultural research and development in ECA, is the FARA supported Regional Agricultural Information and Learning Systems (RAILS) project. The project was established to promote learning, access and sharing of agricultural information among individuals and organisations involved in agriculture in Africa. Under this project an online Africa-wide portal, www.erails.net, was established. In 2011, ASARECA held a three-day regional Training of Trainers (TOT) workshop for 17 members (11 men; 6 women) of the ASARECA RAILS and the Dissemination of New Agricultural Technologies in Africa (DONATA) projects on use of this portal. The workshop drew representatives from eight ASARECA countries—Burundi, DRC, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. By the end of the workshop, each participating country had developed the homepage for their country portal. In addition, several websites were easily created on the national portals. The participants are expected to serve as eRAILS trainers in their own countries. Follow up country workshops were organised in Kenya, in the same year, by alumni of the TOT, and several more websites were created on the Kenyan portal.

The portal, www.erails.net, aims to become the African portal for agricultural information. The ASARECA/RAILS project is working to ensure that it has websites of or links to all the institutional and individual websites in the agriculture sector in Africa.

Annexes

Annex 1: Financial and Auditor's Report

Independent auditors' report to the board of directors of ASARECA

We have audited the financial statements of ASARECA set out on pages 9 to 25 which comprise the statements of financial position as at 31 December 2011, statements of revenue and expenditure, statements of changes in fund reserves and statement of cash flows for the year then ended, together with the summary of significant accounting policies and other explanatory notes, and, have obtained all the information and explanations which, to the best of our knowledge and belief, were necessary for the purposes of our audit.

Respective responsibilities of the directors and auditors

The Association's directors are responsible for the preparation and fair presentation of these financial statements in accordance with ASARECA guidelines. This responsibility includes: designing, implementing and maintaining internal controls relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or error, selecting and applying appropriate accounting policies, and making accounting estimates that are reasonable in the circumstances. Our responsibility is to express an opinion on these financial statements based on our audit.

Basis of opinion

We conducted our audit in accordance with International Standards on Auditing. Those standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance as to whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on our judgment and include an assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, we considered internal controls relevant to the association's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by directors, as well as evaluating the overall presentation of the financial statements. We believe that our audit provides a reasonable basis for our opinion.

Opinion

In our opinion, proper books of account have been kept by the Association and the financial statements, which are in agreement therewith, give a true and fair view of the state of affairs of the Association at 31 December 2011 and of its surplus and cash flows for the year then ended in accordance with the accounting policies described in Note 1 of the financial statements and comply with the ASARECA guidelines.

Basis of Accounting and Restriction on Distribution and Use

Without modifying our opinion, we draw attention to Note 1 to the financial statements, which describe the basis of accounting. The financial statements have been prepared to comply with the Financial Management Policies and Guidelines of ASARECA. As a result, the financial statements may not be suitable for another purpose. Our report is intended for ASARECA and its partners. However, upon release by ASARECA, its distribution is unlimited.

Signed by
Partner, Delloitte and Touche
Certified Public Accountants (Uganda)

Statement of Financial Position on December 31, 2011

	Notes	2011 US $	2010 US $
ASSETS			
Non-current Assets			
Property and Equipment	2	203,407	126,008
		203,407	**126,008**
Current Assets			
Cash at Bank	3	8,051,162	6,689,721
Accounts Receivable - NARI Membership	4 (a)	201,787	222,549
Accounts Receivable - Donors	4 (b)	175,707	136,089
Accounts Receivable - Project Sub-grantees	4 (c)	1,730,939	2,975,813
Accounts Receivable - Others	4 (d)	259	558
		10,159,854	**10,024,730**
Total assets		**10,363,261**	**10,150,738**
RESERVES AND LIABILITIES			
Capital Reserves			
Investment in Fixed Assets		203,407	126,008
Capital reserve fund		920,216	823,078
Accumulated Operating Surplus		3,317,693	3,204,192
		4,441,316	**4,153,278**
Liabilities			
Accounts payable - donors	5 (a)	5,201,821	5,473,469
Accounts payable - others	5 (b)	470,961	308,847
Accruals and provisions	5 (c)	249,163	215,144
		5,921,945	**5,997,460**
Total reserves and liabilities		**10,363,261**	**10,150,738**

The financial statements on pages 9 to 25 were approved by the Board of Directors on **29 March 2012** and were signed on its behalf by:

Dr. Seyfu Ketema
Executive Director, ASARECA

Mr. Techalew Negash
Head of Finance, ASARECA

Statement of revenue and expenditure for the year ended December 31, 2011

	Notes	2011 US $	2010 US $
REVENUE			
Income from donations	6 (a)	14,422,743	15,115,141
Membership Contribution	6 (b-i)	50,000	50,000
Other earned income	6 (b-ii)	199,912	212,406
Total revenue		**14,672,655**	**15,377,547**
EXPENDITURE			
Governance & secretariat management	7(a)	2,149,564	1,626,385
Programme management support	7(b)	2,079,555	2,011,247
Technical programmes and networks	7(c)	10,232,897	11,477,509
Total expenditure		**14,462,016**	**15,115,141**
SURPLUS FOR THE YEAR		**210,639**	**262,406**

Statement of changes in fund reserves for the year ended December 31, 2011

	Capital Reserve fund US $	Accumulate Operating surplus US $	Total Reserve Fund US $
At 1 January 2010	846,495	3,023,889	3,870,384
Investment in fixed assets - 2009	(105,520)	-	(105,520)
Gain on Disposal of Assets	3,412	-	3,412
Surplus for the year	-	258,994	258,994
Capital charge transferred to capital fund	78,691	(78,691)	-
Investment in fixed assets – 2010	126,008	-	126,008
At 31 December 2010	**949,086**	**3,204,192**	**4,153,278**
At 1 January 2011	949,086	3,204,192	4,153,278
Investment in fixed assets – 2010	(126,008)	-	(126,008)
Gain on Disposal of Assets	3,921	-	3,921
Surplus for the year	-	206,718	206,718
Capital charge transferred to capital fund	93,217	(93,217)	-
Investment in fixed assets – 2011	203,407	-	203,407
At 31 December 2011	**1,123,623**	**3,317,693**	**4,441,316**

Annex 2: Publications list/knowledge resources

Electronic newsletters

	Date	Issue	Title
1.	21 January	1	Trends of staple food and input prices: a global and regional overview
2.	4 February	2	From food aid to food assistance: issues, lessons and implications
3.	18 February	3	Gender perspective in adaptation to climate change-induced water stress
4.	4 March	4	Mitigating effects of volatile food prices on low- and middle-income countries
5.	18 March	5	Lessons learned: World Bank's new strategy in Africa
6.	1 April	6	Regional integration in Africa: implications for food security
7.	15 April	7	The urgent actions needed to prevent recurring food crises
8.	29 April	8	Enhancing the impact of policy research in eastern and central Africa
9.	13 May	9	Out grower schemes: why big multinationals link up with African smallholders
10.	27 May	10	Food price shocks: food security implications and the opportunities in Africa
11.	10 June	11	2011–2012 national budgets: measures by East African countries to tackle food prices, food security and other issues in agriculture
12.	24 June	12	Volatility of agricultural markets: causes and options for policy solutions
13.	8 July	13	Agricultural investment: business models and opportunities for smallholders
14.	22 July	14	Influencing change: mainstreaming gender perspectives in agricultural re search and development
15.	5 August	15	Agricultural research investment trends in Eastern and Central Africa
16.	19 August	16	Sustainable land management: bye law development and implementation
17.	2 September	17	Formulating a national framework for biotechnology and Biosafety policy
18.	16 September	18	The new harvest: agricultural innovation in Africa
19.	30 September	19	Achieving gender equality in development: so much done, so much to do
20.	14 October	20	Emerging trends: a case for reconsidering policy action and priorities
21.	28 October	21	How international price volatility affects domestic economies and food security
22.	April	Issue 2	The AgriForum Newsletter
23.	October	Issue 3	The AgriForum Newsletter

7.1.1. Journal articles

1. Abdalla HM, Gamar YA. 2011. Climate change: selection of sorghum genotype with wide adaptation, AG-17, for rain-fed areas of Sudan. *International Journal of Agricultural Science*1(3):144–155.
2. Cooper PJ. M., et al., 2011. Adding value to field-based agronomic research through climate risk assessment: A case study of maize production in Kitale, Kenya. *Experimental Agriculture* 47(2):317–338.
3. Dawoud DA, Ahmed EA, Babiker AGT. 2011. Performance of striga resistant African cultivars under Sudan conditions. *Sudan Agricultural Research Journal* 17: 65–72.
4. Donatha Damian Tibuhwa. 2011. Morphology and taxonomy of *Sarcoscypha ololosokwaniensis* sp. nov.: A new *Ascomycota* species from Serengeti National Park-Tanzania. *Journal of Yeast and Fungal Research* 2(1):1–6.
5. Farrow A, Musoni D, Cook S, Buruchara R. 2011. Assessing the risk of root rots in common beans in East Africa using simulated, estimated and observed daily rainfall data. *Experimental Agriculture* 47(2):357–373.
6. Gathenya M, Mwangi H, Coe R, Sang J. 2011. Climate- and land use-induced risks to watershed services in the Nyando River Basin, Kenya. *Experimental Agriculture* 2011 47(2): 339–356.
7. Hansen J, Mason SJ, Liqiang Sun, Tall A. 2011. Review of seasonal climate forecasting for agriculture in sub-Saharan Africa. *Experimental Agriculture* 47(2):205 –240.
8. Jarvis A, Lau C, Cook S, Wollenberg E, Hansen J, Bonilla O, Challinor A. 2011. An integrated adaptation and mitigation framework for developing agricultural research: Synergies and trade-offs. *Experimental Agriculture* 47(2): 185 –203.
9. Mbuya K, Nkongolo KK, Kalonji-Mbuyi A. 2011. Nutritional analysis of quality protein maize (QPM) varieties selected for agronomic characteristics in a breeding program. *International Journal of Plant Breeding and Genetics* 5(4):317–327.
10. Kipkoech A, Okeyo-Owour, JP, Mogaka H (eds). 2011. Towards implementation of Payment for Environmental Services (PES): A collection of findings linked to the ASARECA funded research activities. VDM Verlag Dr Muller GmbH & Co. KG - Germany
11. Ogero K, Gitonga NM, Ombori O, Ngugi M. 2010. Cassava production and limitation of propagation through tissue culture. In: p 148–155. Mwangi M, ed., Contributions of agricultural sciences towards achieving the Millennium Development Goals. FaCT Publishing, Nairobi, Kenya. Available at: http://www.m.elewa.org.
12. Osbahr H, Dorward P, Stern R, Cooper S. 2011. Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. *Experimental Agriculture* 47(2):293–316.
13. Ouma R, Mude A, Van de Steeg J. 2011. Dealing with climate-related risks: Some pioneering ideas for enhanced pastoral risk management in Africa. Experimental Agriculture 47(2):375–393.
14. Rao KPC, Ndebwa KK, Oyoo A. 2011. Climate variability and change: farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental Agriculture* 47(2): 267–291.
15. Stern RD, Coe R. 2011. Assessing and addressing climate-induced risk in sub-Saharan Africa rainfed agriculture: Lessons learnt. *Experimental Agriculture* 47(2):395–410.
16. Stern RD, Copper PJM. 2011. Assessing climate risk and climate change using rainfall data—A case study from Zambia. *Experimental Agriculture* 47(2):241–266.
17. Tinzaara W, Karamura E, Kubiriba J, Byabachwezi M, Tushemereirwe W, Opio F. 2010. The Integrated approach for the management of banana xanthomonas wilt in East and Central Africa. Proceedings of the African Crop Science conferences, Cape Town, South Africa, 27 September to 2 October 2009, 9: 691–696.

18. van de Steeg., et al., (2009). *The influence of current and future climate-induced risk on the agricultural sector in East and Central Africa.* ILRI Research Report22. ILRI [International Livestock Research Institute], ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], and ICRISAT [International Crop Research Institute for the Semi-Arid Tropics].

7.1.2. Books & Book Chapters

1. Admassu H, Getinet M, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Ethiopia. Country chapter in IFPRI-ASARECA research monograph forthcoming
2. ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa]. 2011. ASARECA Gender Mainstreaming Strategic Plan 2010–2013: Together we can find solutions for improved livelihood and sustainable agriculture. ASARECA, Entebbe, Uganda.
3. ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa]. 2011. PAAP Advocacy Strategy. ASARECA, Entebbe, Uganda.
4. Baramburiye J, Kyotalimye M, Thomas T, Waithaka M. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Burundi. Country chapter in IFPRI-ASARECA research monograph forthcoming.
5. Barun G. 2011. Introduction: Engaging with the challenges for mainstreaming gender in agricultural research and development. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
6. Barun G, Ssendiwala E, Waithaka M, eds. 2011. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
7. Bashaasha B, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Uganda. Country chapter in IFPRI-ASARECA research monograph forthcoming.
8. Bissrat Ghebru B, Araia W, Ogbazghi W, Gebreselassie M, Thomas T. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Eritrea. Country chapter in IFPRI-ASARECA research monograph forthcoming.
9. Chiche Y, Tesfaye A. 2011. Towards gender mainstreaming in an agricultural research system: Organizational assessment of gender aspects in Ethiopian Institute of Agricultural Research (EIAR). In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
10. Draft book on Management and Utilisation of *Prosopis* spp. in arid and semi-arid areas drafted.
11. Draft paper to be a chapter in a book on: Agricultural Innovation Triangles.
12. Dusengemungu L, Rucibigango M, Mukakalisa S, Badege P, Mukankubana D, Nyiraneza C, Mbanda J. 2011. Influencing change in the Institut des Sciences Agronomiques du Rwanda (ISAR) through gender analysis in participatory research. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.

13. El-Dukheri I, Abdalla I. 2011. Promoting participatory research and gender analysis within the Agricultural Research Corporation (ARC), Sudan: *Influencing change. In: Gurung B, Ssendiwala E, Waithaka M, eds. Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
14. Kabanyoro R, Turyamureeba G. 2011. Mainstreaming participatory research and gender analysis in National Agricultural Research Organization (NARO), Uganda. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
15. Kanyeka EK, Lwezaura D, Lema N. 2011. Influencing change: Gender mainstreaming in national agricultural research system in Tanzania. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
16. Kinkela SS, Bahandi CA. 2011. Gender issues and perspectives in agricultural research and development projects in the Democratic Republic of Congo. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
17. Makokha O, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Kenya. Country chapter in IFPRI-ASARECA research monograph forthcoming..
18. Nelson G, ed. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Eastern and Central Africa. IFPRI-ASARECA research compendium forthcoming.
19. Ngugi JN, Nyonges DJW, Gathaara V. 2011. Experiences and lessons learned in the mainstreaming of gender analysis and participatory research in national agricultural research systems: The case of Kenya Agricultural Research Institute (KARI). In: Gurung B, Ssendiwala E, Waithaka M, eds. I*nfluencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
20. Ramiaramanana D, Randriambolanoro L, Bodovololona R, Razafimandimby S. 2011. Challenges for gender mainstreaming in Centre National de Recherche Appliquée au Développement Rural (FOFIFA), Madagascar. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.
21. Ssendiwala E, Waithaka M. 2011. Influencing change: Project evaluation. In: Gurung B, Ssendiwala E, Waithaka M, eds. *Influencing change: Mainstreaming gender perspectives in agricultural research and development in Eastern and Central Africa.* CIAT Publication 373 CIAT [International Center for Tropical Agriculture], Cali, Colombia, ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa], Entebbe, Uganda.

22. Taha A, Thomas T, Waithaka M. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Sudan. Country chapter in IFPRI-ASARECA research monograph forthcoming.
23. Tenge N, Mutabazi A, Thomas T. 2011. Assessing the Vulnerability of Agriculture to Climate Change in Rwanda. Country chapter in IFPRI-ASARECA research monograph forthcoming.
24. Waithaka M, Thomas T, Kyotalimye M, Nelson G. 2011. Overview in Assessing the Vulnerability of Agriculture to Climate Change in Eastern and Central Africa. IFPRI-ASARECA research monograph forthcoming.

7.1.3. Manuscripts & Research Draft Papers

1. Adikini S, Tripathi L, Beed F, Tusiime G, Magembe EM, Kim DJ. Development of sensitive and specific molecular tool for detecting *Xanthomonas campestris* pv. Musacearum. Plant Pathology.
2. Mwakaje AG, Manyasa E, Wawire N, Ongare D, Muchai M, Masiga CW, Nikundiwe A, Mugoya C. Socio-economic mapping and livelihood study in Tanzania with a focus on Serengeti Mara Ecosystem.
3. Mwakaje AG, Manyasa E, Wawire N, Ongare D, Muchai M, Masiga CW, Nikundiwe A, Mugoya C. Income generation and governance challenges by local Communities in Protected Areas: The Case of Serengeti Mara Ecosystem (SME).
4. Mbwaga A, Kayeke J, Ebiyau J, Okalebo J, Mekonnen Sime, Alemu Tirfesa, Dafalla Ahmed, Elfaith Abdel. Integrated striga management options for increased sorghum productivity in striga infested areas of Eastern and Central African (ECA) countries.
5. Amutete G, Wambugu GM, Mwangi JM, Masiga CW, Mugoya C, Muchai M. Implications of land use systems on avifaunal diversity in the Maasai-Mara Ecosystem.
6. ARIM. Economics of rice-legumes spatial planting methods.
7. ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa]. 2011. Natural resource management and biodiversity conservation in the dry lands of eastern and central Africa.
8. Barungi M, Ng'ong'ola DH, Edriss A, Mugisha J, Waithaka M, Tukahirwa J. 2011. Enhancing adoption of soil erosion control technologies through enactment of land care byelaws: evidence from Mt. Elgon highlands in eastern Uganda. Research report.
9. Ngoru B, Kiambi S. Conflicts and community perceptions on wildlife in different zonations of Masai Mara National reserve and adjacent group ranches.
10. Ngoru B, Musyoki C, Kiambi S, Mwangi G, Mugoya C, Masiga CW, Muchai M. Spatial distribution, abundance and diversity of small mammals (rodents and shrews) in relation to land use practices in Maasai Mara ecosystem, Kenya.
11. Ngoru B, Musyoki C, Kiambi S, Mugoya C, Masiga CW, Muchai M. Influence of land use abundance, diversity, and distribution of large mammals in Maasai Mara Ecosystem, Kenya.
12. Warui CM. Two new species of spiders Araneae (family Oonopidae & Papimanidae) from Eastern Africa.
13. Warui C, Nyundo B, Muchai Muchane, Musyoki C, Mugoya C, Masiga CW. Effect of land-use types on the diversity of spiders and other invertebrates in the Mara Ecosystem, Kenya.
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22. Ebiyau J, Hella JP, Okalebo J, Mbwaga AM, Rwomushana I, Oyena D. Opportunities for commercialization and utilization of sorghum in Uganda and Tanzania.
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32. Kayeke J et al. 2011. The effect of herbicide (oxdazion) on the growth and development of rice.
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58. Nakato V, Ramathani I, Beed F. Characterisation of orange bacterium associated with *Xanthomonas campestris* pv. *musacearum, the* causal agent of BXW: banana wilt.
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67. Ouma JO, Asea G, Opio F. 2011. Market access and opportunities for quality protein maize products.
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7.1.4. Booklets

1. Mgonja F, Mmbaga T, Yangole C, Makoko B, Semlow M. Teknologia za kuhifadhi udongo na maji na mbegu za zinazostahimili ukame.
2. Mukantwali C and Mukandahiro IB. June 2010. Booklet on banana production, banana ripening, wine processing and good manufacturing.
3. Onyango M et al. 2011. Success stories on BXW management in Kenya.

7.1.5. Manuals & Field Guide

1. A CBSD resource kit translated into Samia, Acholi, Ateso, Luganda, Lugbara and Runyoro for wider use in Uganda. {Four materials adopted from the kit (leaflet, manual, flyer and factsheet) were translated into French and Malagasy for use in Madagascar}.

2. A field guide on the management of bacterial wilt on banana, Ethiopia.
3. ARIM. Guidelines for irrigated rice production (Manual in Kiswahili).
4. ARIM. Guidelines for the production of rice quality declared seed (QDS).
5. Cherono, P., Kurwijila, L., Omore, A. 2011. Commercialized Supply of Training and Certification in Milk Quality Assurance in Eastern Africa. A Guide for Practitioners. ASARECA manual.
6. Harahagazwe D, Bararyenya A, Hakizimana B, Inamahoro M, Niko N, Niyongabo D. Uburyo Umurimyi Muto Yokoresha Mu Kugwiza Imbuto Z'ibiraya Nziza, Igitabo C'inyigisho, Canditswe Na (Manual in Kirundi).
7. FOFIFA. Guidelines for irrigated rice production (in French).
8. FOFIFA. Guidelines for irrigated rice production (in Malagasy).
9. Habtamu A, Dagne Wegary, Abebe Kirub. 2011. Technologies for maize production in semi-arid areas of Ethiopia.S
10. Karamura EB, Tinzaara W, Sssekiwoko F, Turyagyenda FL, Blomme G, Eden-Green E. 2010. Xanthomonas wilt of Bananas in East and Central Africa (*Xanthomonas campestris pv. musacearum*): Diagnostic and management guide. Bioversity, Uganda, Revised edition (in press).
11. Kayeke J et al. 2011. Integrated diseases management.
12. Kayeke J et al. 2011. Integrated weed management.
13. Kayeke J et al. 2011. Training need assessment and situation analysis for lowland rainfed rice farmers in Southern Tanzania: Lesson learned.
14. Mohammed Yesuf. 2011. Field guide on the management of bacterial wilt of banana and enset (using local language) (Manual).
15. Mohammed Yesuf. 2011. Field guide on the management of bacterial wilt of banana and enset (using local language.
16. Mwalyego FS, Kayeke J, Mghogho RM. 2011. Magonjwa Muhimu Katika Kilimo Cha Mpunga: Dalili, Madhara na Udhibiti.
17. Onyango M et al. 2010. Symptoms used in identification of common banana diseases in Kenya.
18. Solar drying of fruits and vegetables training manual: Principles, GMPs/GHPs and HACCP plan development. Sokoine University of Agriculture.
19. Trainers' Manual and Picture Book for extension officers and farmers groups.
20. Training Manual for management of ticks and tick borne diseases.
21. Kinyua ZM, Kinoti J, Langat BC, Wakahiu MW, Nderitu SK, Kinyae PM, Kipkoech D, Miruci NG, Mwamba E. Enhancing the quality and availability of seed potatoes to small-scale farmers (Field Manual).

7.1.6. Documentaries

Documentary	Theme	Number	Countries
DVD (+ CD)	Consumer characterisation	3	Rwanda, Uganda
	Threatened survival	1	Kenya
	Sorghum value addition	1	Kenya
	Integrated striga management	1	Uganda
	Management of banana bacterial wilt	1	Burundi
	Fodder establishment, management and conservation	1	Tanzania
	Taenia solium cysticercosis	1	Burundi
	Crop–livestock integration technologies and methods	1	Uganda
	Value chain of climbing beans (Burundi, Kirundi; DRC, French)	2	Burundi, DRC
	Dramatised songs on extension of climbing bean technologies (in local language and Kiswahili) {1 DVD + 1 CD}	2	DRC
	Training brochures on intercropping methods between beans and cassava, and beans and bananas in various languages {CD}	1	DRC
	Genetic engineering of maize for drought tolerance	3	Kenya, Tanzania, Ethiopia, Sudan
	Farmer training and forage seed distribution	1	Sudan
Radio Spot Messages & Television	Soils and water management technologies	2	Kenya, Tanzania
	Sorghum value addition technologies and products	29	Uganda
	Farmer sensitisation on climbing beans	3	Burundi, DRC
	Radio programme on climbing beans	1	Rwanda
	Targeting the youth (Mkulima Soko)	3	Uganda
TOTAL		**48**	

7.1.7. Policy Briefs

1. ABCD Policy Brief 1. 2011. Synopsis of policy status on drylands development, pastoralism and conservation in the Horn and East Africa. Draft.
2. ABCD Policy Brief 2. 2011. Pastoralism and biodiversity in Eastern Africa: Valuation of current and potential land use. Draft.
3. ABCD Policy Brief 3. 2011. Policy change, biodiversity conservation and dryland development in Ethiopia. Draft.
4. ABCD Policy Brief 4. 2011. Synopsis of policy status on pastoralism and conservation in Kenya. Draft.
5. ABCD Policy Brief 5. 2011. Tanzania: Wildlife and livestock need each other for prosperity. Draft.
6. Admassu H, Getinet M, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the vulnerability of agriculture to climate change in Ethiopia. Fact sheet presented for use by Ethiopia Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 2011. Johannesburg, South Africa.
7. Baramburiye J, Kyotalimye M, Thomas T, Waithaka M. 2011. Assessing the vulnerability of agriculture to climate change in Burundi. Fact sheet presented for use by Burundi Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 13-14, 2011. Johannesburg, South Africa.
8. Bashaasha B, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the vulnerability of agriculture to climate change in Uganda. Fact sheet presented for use by Uganda Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 13-14, 2011. Johannesburg, South Africa.
9. Bissrat Ghebru B, Araia W, Ogbazghi W, Gebreselassie M, Thomas T. 2011. Assessing the vulnerability of agriculture to climate change in Eritrea. Fact sheet presented for use by Eritrea Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 13-14, 2011. Johannesburg, South Africa
10. Makokha O, Thomas T, Waithaka M, Kyotalimye M. 2011. Assessing the vulnerability of agriculture to climate change in Kenya. Fact sheet presented for use by Kenya Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 2011. Johannesburg, South Africa.
11. Nienke Beintema. April 2011. Benchmark of agricultural research investment and capacity trends across ASARECA countries.
12. Taha A, Thomas T, Waithaka M. 2011. Assessing the vulnerability of agriculture to climate change in Sudan. Fact sheet presented for use by Sudan Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 2011. Johannesburg, South Africa.
13. Tenge N, Mutabazi A, Thomas T. 2011. Assessing the vulnerability of agriculture to climate change in Rwanda. Fact sheet presented for use by Rwanda Government officials as background material for Africa—A Call to Action: An African Ministerial Conference on Climate-Smart Agriculture, 13–14 September 2011, Johannesburg, South Africa.
14. Wafula D. 2011. Policy statements and guidelines for commercial planting of genetically modified organisms (GMOs), trade in GMOs, and emergency food aid with GM content. COMESA Ministerial Brief, forthcoming.
15. Wafula D, Karembu M, Waithaka M, Belay G. 2011. Highlights of key contributions from ASARECA countries on Draft COMESA Biosafety Policies and Guidelines. RABESA Policy Brief. September 2011.
16. Wafula D, Karembu M, Waithaka M, Belay G. 2011. Modern biotechnology in the European

Union: Achievements and challenges. RABESA Policy Brief .September 2011.

17. Yirga C. 2011. Facilitating policy reforms in NRM: Experiences of participatory action research from the central highlands of Ethiopia. G2S Policy Brief. September 2011.

7.1.8. Posters

1. Best-bet land use practices in savannah ecosystems.
2. Ebiyau J. 2010. Progress on value addition of sorghum. (CD-ROM).
3. Ebiyau J. 2010. Value added sorghum products.
4. Fine mapping of QTLs associated with striga resistance in sorghum.
5. FOFIFA. Guidelines for irrigated rice production (in Malagasy).
6. FOFIFA. Irrigation rice production (in French and Malagasy).
7. FOFIFA. 2011. Fantaro ny aretina vaovao mety mahazo ny mangahazo (CBSD) (In Malagasy)
8. Genetic engineering of maize for drought tolerance.
9. Kuria E., Runo MS, Machuka J. Bioengineering maize with c-repeat binding factors: A strategy towards drought tolerance.
10. Mgonja F, Yangole C. Teknologia za kuhifadhi udongo na maji na mbegu za zinazostahimili ukame.
11. Mgonja F, Mmbaga T, Yangole C, Makoko B, M. Semlow M. Teknologia za kuhifadhi udongo na maji na mbegu za zinazostahimili ukame.
12. Mukantwali C, Mukandahiro IB. June 2010. Booklet on banana production, banana ripening, wine processing and good manufacturing.
13. Onyango M et al. 2010. Update of identification and control of important banana pests and diseases.
14. Poster on BXW for farmers and extension workers (4700 copies produced in English, Swahili, French, Kirundi, Luganda and Runyankore).
15. Posters on Taenia.
16. Seth M, Oduor R, Mneney E, Iyer R, Thomson JA, Machuka J. A transgenic approach to develop drought tolerant maize using genes isolated from xerophyta viscose. Presented at the 10th African Crop Science Society Conference, 10–13 October 2011, Maputo, Mozambique.

7.1.9. Leaflets, Flyers & Fact Sheets

1. FOFIFA. Irrigation rice production (in French).
2. FOFIFA. Irrigation rice production (in Malagasy).
3. FOFIFA. 2011. Fantaro ny aretina vaovao mety mahazo ny mangahazo (CBSD) (In Malagasy).

7.1.10. Pamphlets

1. Ebiyau J. 2010. Value added sorghum products.

7.1.11. CD-Rom

1. Ebiyau J. 2010. Progress on value addition of sorghum.

7.1.12. Website Designed

1. Kenya: http://www.erails.net/KE/; and http://www.erails.net/KE/donata-ofsp/donata-project/Home/.

2. Uganda: http://www.erails.net/UG/iptagulu/donata-ofsp-project/Home/.
3. Ethiopia: http://www.erails.net/ET/eiar/ias-management/project-goal/the-ethiopian-case-/.
4. Burundi: http://www.erails.net/BI/esperancehabindavyi/isabu/projects-at-isabu/.
5. Rwanda: http://www.erails.net/RW/isaradmin/banana-program/about-us/.
6. Sudan: http://www.erails.net/SD/ ; and http://www.erails.net/SD/khliel/gis/about-gis-unit/.
7. DRC: http://www.erails.net/CD/jocelin-makoko/rails-en-rdc/ ; and http://www.erails.net/CD/donata-rdc/qpm-en-rd-congo//.

7.1.13. Brochures

1. Combating hunger: enhancing effectiveness of agricultural input and output markets in ECA.
2. Early warning approaches in arid and semi arid areas.
3. Facilitating collective marketing best practices in Kenya and Uganda: Project profile.
4. Facilitating collective marketing best practices: stakeholders' directory.
5. Onyango, M et al. 2010. Update of identification and control of important banana pests and diseases.
6. Six brochures on drip irrigation (2), lablab (1), Calliandra (1), farmers associations (1), and fixed knife forage chopper (1).
7. Summary of the milk and meat consumer survey results.
8. Two brochures on ticks and management of ticks and tick borne diseases.
9. Two information brochures summarising the results of the milk consumer surveys.

7.1.14. Monographs

1. ASARECA. 2011. Natural resource management and biodiversity conservation in the drylands of Eastern and Central Africa. A report for Association for the Strengthening of Agricultural Research in Eastern and Central Africa (ASARECA).
2. Gelan A, Omore A. 2011. Impacts of changing tariff and non-tariff barriers on dairy trade in east Africa. PAAP Monograph forthcoming.
3. Kasente D. 2011. Gender mainstreaming and research in ASARECA: Paper prepared for the training on gender mainstreaming in agricultural research for ASARECA Secretariat staff at Imperial Botanical Beach Hotel, Entebbe, Uganda, 8–11 February 2011.
4. Kasente D. 2011. Gender mainstreaming and value chains in agriculture: paper prepared for the training on gender mainstreaming in agricultural research for ASARECA Secretariat staff at Imperial Botanical Beach Hotel, Entebbe, Uganda, 8–11 February 2011.
5. Mulwa RM, Waithaka M, Kyotalimye M, Warinda E. 2011. Assessment of potential impacts of adoption of cassava standards. PAAP Discussion Paper.
6. Mulwa RM, Karembu M, Wafula D, Waithaka M. 2011. Assessment of potential impacts of adopting Bt-maize and Bt-cotton in selected COMESA countries. PAAP Discussion Paper.
7. Nelson G, Waithaka M, Kinyangi J, eds. 2011. Vulnerability and adaptation to climate change in eastern and central Africa. IFPRI monograph. Forthcoming.
8. Omore A, Waithaka M. 2011. Synthesis of lessons and impacts of an improved dairy policy environment in eastern Africa: 2004–2010.

7.1.15. General Reports {Workshops, Annual Reports, etc.}

1. Equal opportunity for a just and sustainable agriculture development: proceedings of a training workshop on gender mainstreaming in agricultural research for ASARECA Secretariat staff; Imperial Botanical Beach Hotel, Entebbe, Uganda.

2. Equal opportunity for a just and sustainable agriculture development: proceedings of a training workshop on gender mainstreaming in agricultural research for Ethiopia NARS staff; Intercontinental Hotel, Addis Ababa, Ethiopia.
3. Improving the capacity of agricultural research in the ASARECA sub-region through the SCARDA project, April 2010.
4. Influence of relief on livestock pricing and marketing.
5. January–December quarterly report, July 2011.
6. January–March progress report on SCARDA, April 2010.
7. Kiambi D, Mugoya C, Masiga CW. Proceeding of training in Marker assisted selection for striga resistance in sorghum for sorghum breeders and technicians.
8. Kyotalimye M, Waithaka M. 2011. Proceedings of the Annual General Meeting of the Eastern Africa Seed Committee (EASCOM) held at Imperial Resort Beach Hotel, Entebbe, Uganda, 23–25February 2011.
9. Progress report on EAAPP, April 2011.
10. Report on the second learning workshop in ARC, April 2011.
11. Report on the second learning workshop in ISAR, April 2011.
12. Report on the second SCARDA resource mobilisation workshop, April 2011.
13. Report on the third learning workshop, May 2011.
14. Report on the training of ASARECA Programme Management Team in AIS and VCA, April 2011.
15. Report on Sensitisation Workshop: Evaluation of Drought and Striga Resistance.
16. Report on the Training and Planning Workshop on Genetic Engineering of Maize.
17. Report on the Writeshop to produce project publications and communication materials.
18. Report on the development of the certification of tissue culture plantlets.
19. SCARDA first quarterly report, April 2011.
20. Success stories of application of agricultural biotechnology in ECA.
21. The ASARECA 2009 Annual Report.
22. The May 2011 issue of the ASARECA Newsletter The Agriforum.
23. Toye P, Mugoya C, Masiga C. Proceeding of the training on Taenia cysticercosis diagnostic kit, pig value chains in East Africa, epidemiology.
24. Workshop report on the third EAAPP–ASARECA convened meeting.

7.1.16. Newspaper articles

1. *Daily Monitor,* Friday 8 July 2011. EAC dairy regulators seek channels to grow industry.
2. *The Daily Nation,* Thursday 7 July 2011. EAC officials seek transformation of regional dairy sector. http://www.nation.co.ke/business/news/EAC+official+seeks+transformation+of+regional+dairy+sector/-/1006/1196178/-/hu0jv5/-/index.html.
3. Six articles on Plant Genetic Resources.
4. Three newspaper articles on crop-livestock integration (*Daily Monitor:* – 26 January, 16 February, 9 March 2011).
5. Two newspaper articles on African indigenous vegetable seed production.
6. One newspaper article on nutrient feeding blocks for dairy cattle.
7. Twenty-five articles being drafted for publication in peer reviewed referenced journals for the best bet land use practices for savannah ecosystems.
8. Thirteen news paper articles on evaluation of striga resistant and drought tolerant sorghum varieties.

Annex 3: ASARECA M&E information matrix

Project Development Objective: To enhance access and utilisation of agricultural research technologies and innovations in the regional agricultural systems of Eastern and Central Africa.

Purpose: Enhanced access and utilisation of agricultural research technologies and innovations in the regional agricultural systems of Eastern and Central Africa

Table 1: Cumulative targets and actuals (based on Operational Plan)

Table 1: Cumulative targets and actuals (based on Operational Plan)

Project outcome indicators	Unit of measure	Baseline 2008	Target and (actual) cumulative values Y1 2009	Y2 2010	Y3 2011	Y4 2012	Y5 2013
Indicator 1: Number of stakeholders accessing the technologies and innovations	Number	2,014	9,384 **(9,134)**	33,578 **(32,049)**	121,078 (100,681)	160,078	209,778
Indicator 2. Percentage of stakeholders adopting new technologies and management practices in selected development domains (desegregated by gender)	Per cent	8.3	18 **(20.6)**	27.4 **(25)**	41.8 **(41.5)**	50	63
Indicator 3: Number of reform of policies, laws, regulations and procedures approved	Number	6	6 **(6)**	14 **(12)**	22 (17)	30	34
Indicator 4: Level of satisfaction with technologies and innovations	Per cent	60%	30.3 **(11.5)**	33.3 **(24)**	56.7 **(58)**	67.5	75
Indicator 5: *Number of direct beneficiaries reached through ASARECA support (disaggregated by gender) {New}*	Number						

INTERMEDIATE RESULTS							
Output 1: Strengthened gender responsive governance and management systems in ASARECA							
Indicator 1: Pluralistic decision making processes		10 NARIs in Board	On course	On course	On course		
Indicator 2: Compliance with organisational operational procedures and standards	Per cent	No OM & GM			On course		

Project outcome indicators	Unit of measure	Baseline 2008	Target and (actual) cumulative values				
			Y1 2009	Y2 2010	Y3 2011	Y4 2012	Y5 2013
Indicator 3: Percentage growth in research funding	Per cent	5.70	15 **(14.98)**	30 **(30.56)**	50 **(48.36)**	65	75
Indicator 4: Rate of implementation of the new ASARECA Constitution							
Output 2: Enhanced generation and uptake of demand driven agricultural technologies and innovations							
Indicator 1: Number of demand-driven technologies/ innovations generated	Number	57	97 **(92)**	186 **(161)**	298 **(268)**	343	381
Indicator 2: Number of demand driven technologies available for uptake	Number	15	117 **(101)**	232 **(186)**	326 **(290)**	331	431
Output 3: Enhanced adoption of policy options by decision makers to improve performance of the agricultural sector in ECA							
Indicator 1: Number of policies, laws, regulations and procedures analyzed	Number	6	9 **(21)**	22 **(32)**	43 **(57)**	58	66
***Indicator* 2:** Number of policies, laws, regulations and procedures presented for legislation or decree	Number	6	8 **(17)**	18 **(25)**	32 **(34)**	48	60

Project outcome indicators	Unit of measure	Baseline 2008	Target and (actual) cumulative values Y1 2009	Y2 2010	Y3 2011	Y4 2012	Y5 2013
Output 4: Strengthened capacity for implementing agricultural research for development in ECA sub-region							
***Indicator* 1:** Number of ASARECA projects that have incorporated gender responsive agricultural innovation systems	Number	3	6 **(8)**	33 **(35)**	54 **(55)**	77	89
***Indicator* 2:** Number of stakeholders whose capacity building needs have been addressed	Number	200	711 **(4,072)**	27,352 **(30,977)**	50,982 **(45,264)**	68,436	85,190
***Indicator* 3:** Number of partner institutions with infrastructure capacity strengthened	Number	66	91 **(89)**	206 **(205)**	327 **(316)**	366	388
***Indicator* 4:** Number of partnerships formed	Number	32	75 **(79)**	118 **(123)**	164 **(172)**	199	229
Output 5: Enhanced availability of information on agricultural innovation in ECA							
***Indicator* 1:** Number of information packages produced	Number	82	181 **(130)**	350 **(286)**	568 **(563)**	670	801
***Indicator* 2:** Number of appropriate information delivery pathways used	Number	22	62 **(38)**	114 **(90)**	172 **(149)**	224	279
***Indicator* 3:** Number of people reached with information packages through different pathways {New}	Number	TBD					
***Indicator* 4:** Level of satisfaction of stakeholders accessing disseminated information	Per cent	35%	65% **(69.3%)**	68% **(73.3%)**	70% **(65.2%)**	75%	75%

Annex 4: Acronyms and abbreviations

AIV	African indigenous vegetable
ARC	Agricultural Research Cooperation, Sudan
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BXW	Banana xanthomonas wilt
CAADP	Comprehensive African Agriculture Development Programme
CBSD	Cassava brown streak disease
CGIAR	Consultative Group for International Agricultural Research
COMESA	Common Markets for Eastern and Southern Africa
DRC	Democratic Republic of Congo
EAC	East African Community
ECA	Eastern and Central Africa
FARA	Forum for Agricultural Research in Africa
ISAR	Institut des Sciences Agronomiques du Rwanda
KARI	Kenya Agricultural Research Institute
NARI	National agricultural research institute
NARS	National agricultural research system
NEPAD	New Partnership for Africa's Development
NGOs	Non-governmental organisation
OPV	Open pollinated variety
QDS	Quality declared seed
QTL	Quantitative trait loci
RAB	Rwanda Agricultural Board
RAILS	Regional Agricultural Information and Learning System
ROS	Reactive oxygen species
SCARDA	Strengthening Capacity for Agricultural Research and Development in Africa
SSR	Simple sequence repeat
TIMPs	Innovations and management practices

ASARECA

Transforming Agriculture for Improved Livelihoods

www.asareca.org

DFID Department for International Development

Canadian International Development Agency

Agence canadienne de développement international

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