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A Decade of Bioscience Development in Eastern Africa:

The BIO-EARN Programme 1999–2010



Piet van Asten, IITA

Traditional agricultural landscape typical of the East African highlands.

It is no secret that Africa's history has been marked by a development narrative in which the benefits from science, technology and innovation have been enjoyed by few, instead of being seen as tools for the development of all citizens. Today this is changing and Africa's leaders view science, technology and innovation as critical to human development, global competitiveness and ecological management.

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BIO-EARN: a decade of bioscience development in Eastern Africa

Developing, adopting and utilising the new biosciences to promote African development will require active support from African governments and a dynamic public research and development (R&D) sector. Regional integration and collaboration, international research initiatives and multidisciplinary national innovation platforms will also be key factors in ensuring that the new biosciences benefit Africa.

BIO-EARN has been the leading research programme that has brought together scientists from the region, with a team spirit to solve regional problems collectively for resource maximisation.

Dr Joel Mutisya, Kenya Agricultural Research Institute, Kenya

The Eastern Africa Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) was an international collaborative effort to empower four countries – Ethiopia, Kenya, Tanzania and Uganda – to realise the potential of the bioscience revolution under local conditions. BIO-EARN supported the four countries in making informed decisions about how modern biotechnology should be used to promote sustainable development in the region. A particular focus of the BIO-EARN programme was to help eastern Africa to use agricultural, environmental and industrial biotechnologies to address local problems and to take advantage of and benefit from the opportunities offered by these technologies.

BIO-EARN: CREATING THE CONDITIONS FOR SUCCESSFUL BIOSCIENCE DEVELOPMENT AND TAKE-UP

From the beginning, BIO-EARN worked to address a number of critical factors in bioscience development, including:

Human capacity: It is essential that competent local researchers have the capacity to use and adapt modern biosciences to local needs, and the ability to manage regional and international collaborations.

Institutional infrastructure: Effective public R&D institutions are equally important, equipped with high-quality laboratory facilities as well as institutional policies on matters such as handling intellectual property. Well-developed institutional policies and mechanisms for accountability will help to facilitate international collaboration and are important when entering into functional partnerships with the private sector and other market actors.

An enabling environment: Appropriate and workable national policies and regulatory systems are needed to provide a safe and efficient framework for the adoption and use of bioscience technologies. This includes regulatory systems on biosafety, clear R&D priority setting, incentives for public-private partnerships and the ability to balance socio-economic and environmental risks and benefits.

Networking platforms: Africa needs programmes, networks and structures that enable researchers to collaborate regionally, that is, structures that promote the sharing of scarce R&D infrastructure and key competences. This includes collaboration platforms that facilitate effective partnerships with leading international institutions and scientists. Equally important for the region is the ability to develop multidisciplinary innovation consortia involving all the essential actors in the product development value chain. The links in this chain include public sector R&D partners with a primary focus on technology adaptation and transfer, and private sector actors responsible for commercialising and disseminating technologies.



John Komen

Food market in Kampala, Uganda.

BIO-EARN was based primarily around a set of strategic regional, interdisciplinary biotechnology R&D projects involving African and Swedish research institutions. These projects focused on improving the yield and quality of African crops such as sorghum, cassava and sweet potato, and on the efficient treatment and use of industrial and agricultural waste for the generation of bio-energy and high-value products. The programme also included a policy component to strengthen the ability of the network of institutions to manage complex collaborative projects and initiate product development partnerships with private sector partners.

BIO-EARN completed its third and final phase in 2010, but the programme's accomplishments continue to benefit new and existing bioscience initiatives in eastern Africa. For example, a new regional competitive grant-making programme, Bio-Innovate Africa, was launched in 2010 with financial support from the Swedish International Development Cooperation Agency (Sida). It already involves many of the scientists who played key roles in BIO-EARN projects.

This is a very important platform from which a multitude of partnerships have emerged and will continue to emerge – thanks to BIO-EARN.

Dr Suhaila Hashim,
University of Nairobi, Kenya

Bioscience innovations for Africa

More than ever, Africa faces opportunities that can transform its rich base of biological resources into a force for economic growth. Bioscience innovations in particular can be a strategic tool to assist countries in eastern Africa in making the transition to a knowledge-based and sustainable bio-resource economy.

New bioscience platforms are emerging but BIO-EARN deserves a pioneer-status in its multidisciplinary and comprehensive approach supporting countries in eastern Africa to adopt modern biosciences according to their own needs.

Dr Linus Masumbuko, Mikocheni
Agricultural Research Institute,
Tanzania

The rapidly moving bioscience revolution, with its spectrum of applications to improve agricultural productivity, environmental protection and human health, provides new opportunities for economic and social development worldwide. This is particularly relevant to Africa, where most economies are based on agriculture and the export of agricultural commodities. Biosciences can be applied to increase agricultural productivity, to create new agro-processing opportunities and to improve environmental management. In order to benefit from the rapid and wide-ranging advances in biosciences and biotechnology, African governments need to actively increase their ability to develop and adopt technologies and knowledge based on their own priorities and needs. BIO-EARN has risen to this challenge over the past decade.

BIOSCIENCE INNOVATIONS SUPPORT SUSTAINABLE DEVELOPMENT

The growing global demand for food, feed and renewable materials, such as bio-fuels, is changing the conditions for the production and utilisation of natural resources. At the same time, modern biosciences provide an increasingly powerful engine for innovation on a global scale in sustainable agricultural production, waste treatment, energy production and the development of a diverse range of novel bio-products. The BIO-EARN programme focused particularly on assisting countries in eastern Africa to adopt and use agricultural, environmental and industrial biotechnology applications.

Agricultural biotechnology can assist research systems in sub-Saharan Africa to be more efficient at producing improved crops more precisely tailored to African farming systems. Novel crop varieties are being developed that are higher yielding, more nutritious and more tolerant to various types of stress, such as disease and drought.

Environmental biotechnology is used to convert agro-waste into valuable products such as feed, bio-energy and other valuable by-products, helping the agro-industry to become more productive while at the same time reducing environmental impacts. Biotechnology is also used to develop cost-effective waste treatment processes, helping municipalities and cities to reduce the negative impact of waste and to improve water quality.

Industrial biotechnology has resulted in the creation or identification of micro-organisms that help to generate novel products for industrial use, such as ethanol as a bio-fuel or in biodegradable plastics, or biological alternatives to replace synthetic chemicals.

Using a combination of agricultural, environmental and industrial biotechnology, countries in the region can promote the development of more productive agriculture and a more environmentally friendly agro-processing sector. Modern biosciences can create new value chains that enhance and diversify smallholder production, leading to increased demand for local crops and to improved rural livelihoods.

A Sweden – Eastern Africa partnership

The BIO-EARN programme was developed and implemented through close collaboration and partnerships between institutions in Sweden and eastern Africa.

The BIO-EARN programme was developed by the Stockholm Environment Institute (SEI) in close collaboration with eastern African institutions and Sida, which funded the programme.

The first two phases of the BIO-EARN programme (1999–2005) focused on building human and infrastructure capacity in the use of advanced agricultural, environmental and industrial biotechnology, and on developing biopolicy and biosafety regulatory skills. Six Swedish research institutions collaborated closely with eastern African partners to develop new capacities and knowledge, and provided venues for advanced biotechnology and biosafety training at MSc and PhD levels. In these first two phases, activities centred around 20 biotechnology and biosafety PhD projects as well as a series of technical training workshops and policy seminars. During the initial seven years, BIO-EARN was coordinated by SEI in collaboration with the Uganda National Council for Science and Technology (UNCST).

In the programme's final phase, coordinated by IUCEA, nine regional research consortia were created, involving science and business actors engaged in research for development (R4D) with a focus on crop productivity, agro-processing, and environmental and industrial development.

BIO-EARN's overall priorities and projects were jointly formulated by programme partners at national and regional planning meetings, and guided by a Programme Steering Committee and a Governing Board. Individual projects were developed by researchers from the region and all responded to national priorities in the individual BIO-EARN countries. The close dialogue between researchers and policymakers in BIO-EARN enabled the programme to be successfully anchored at the national policymaking level.

TOWARDS REGIONAL OWNERSHIP

A positive evaluation of the programme in 2004 encouraged the development of a programme proposal for a third phase to run between 2006 and 2009. At this juncture, and to recognise regional ownership, the management and coordination of BIO-EARN was transferred to the Inter-University Council for East Africa (IUCEA), Kampala, Uganda.

The programme has inspired me to get more involved in work directed towards developing countries – where my professional experience in plant science can do some good.

Dr Anders Carlsson, Swedish University of Agricultural Sciences, Sweden

An integrated approach to capacity building: supporting people and policies

One of the main objectives with the BIO-EARN programme was to develop a comprehensive regional network of scientists and policymakers that would form a solid base for R&D collaboration. A key feature of BIO-EARN was its integration of technology and policy issues into each activity and project.

In terms of human capacity building, infrastructure improvement, research management capacities and addressing bioscience policy issues, the contribution of BIO-EARN has been immense and is a basis for the establishment of a national biotechnology programme for graduate students here at Addis Ababa University.

Dr Teklehaimanot Haileselassie,
Addis Ababa University, Ethiopia

In the BIO-EARN programme, research capacity building has been accompanied by training in biotechnology policy, biosafety assessments, the handling of intellectual property issues and assessments of the socio-economic impacts of ongoing research. This approach has been highly successful at facilitating dialogue between scientists and policymakers in the region, leading to a comprehensive and integrated capacity-building process with the following key elements:

Human capacity building: An important feature of the BIO-EARN programme was to train a new core of African scientists and policymakers to be able to evaluate, adopt and use modern biosciences. More than 30 PhD students were trained using a “sandwich model”, by which students shared their time between African and Swedish research institutions. Through BIO-EARN supported projects, these PhD graduates have in turn trained a large number of the next generation of PhD and MSc students. BIO-EARN also built competences in biosciences and related policy issues through internships, short courses, workshops and seminars.

Building functional R&D institutions: Another key feature of the programme was the support provided to a significant number of institutions in developing their research facilities, laboratories and greenhouses, and their capacity to maintain such facilities. BIO-EARN assisted institutions to develop their research management capacities and to formulate institutional policies in the areas of biosafety assessments, intellectual property management and private sector collaboration.

Developing collaboration structures: All BIO-EARN projects and programme efforts were geared to enabling institutions to collaborate nationally, regionally and internationally, with the aim of pooling regional and international expertise to resolve



Above: Setumba Mukasa working on micro-propagation of sweet potato at Makerere University's Tissue Culture Laboratory.

Fred Tairo

Above right: Tissue culture plant in test tube.



Danny Coyne, ILTA

THE BIOSCIENCE REVOLUTION

The biosciences and biotechnology are expanding extremely fast. They range from established and widely used techniques, such as food fermentation, to more novel, continually evolving and converging technologies such as molecular breeding, genetic modification, and functional and structural genomics. The BIO-EARN Programme has assisted institutions in eastern Africa in the use of the latest advances in bioscience, such as:

Molecular diagnostics to provide, for example, more accurate and quicker identification of pathogens to protect sweet potato, cassava and coffee crops.

Tissue culture to enable mass propagation of improved and disease-free planting material for economically important crops such as banana, sweet potato and enset.

Molecular breeding and marker assisted selection to identify and evaluate desirable traits in breeding programmes and establish a basis for improved sorghum cultivation in the region

Bioprocessing where complex biological processes are characterised, optimised and used to improve the conversion of agricultural and urban waste into useful products such as biogas, and valuable feed and food additives.

local problems. BIO-EARN also helped institutions to form multidisciplinary innovation consortia, in which public R&D institutions collaborated with the private sector to ensure that technologies and knowledge were disseminated to various sectors of society.

Supporting biotechnology policy development: Another important feature of the programme was the assistance provided to eastern African countries to develop an enabling environment for adopting modern biosciences in a safe and efficient manner. BIO-EARN developed a critical mass of human capacity through seminars, training workshops, background studies and policy briefs, creating awareness of the large number of key biotechnology policy issues of importance to the region. Topics included biosafety assessments and biosafety regulation, intellectual property management, product development partnerships, innovation policies, and socio-economic assessments related to adapting biosciences in eastern Africa.

BIO-EARN programme impact

BIO-EARN's outputs and impact were regularly monitored and assessed through its reporting structures, internally commissioned reviews and independent external reviews. The main finding of these exercises is that BIO-EARN strongly contributed to its mission and programme objectives. Six impact areas can be distinguished, and these are described below.

The BIO-EARN Programme is everything to me: starting my professional career development as a PhD student, and developing the skills and expertise in biotechnology, biopolicy and biosafety that are critical for using biosciences for sustainable development in Ethiopia and eastern Africa.

Dr Seyoum Leta, Addis Ababa University,
currently the Manager of the Bio-Innovate
Africa programme

As regards important programme achievements, across the board, my impression would be in the human capacity building: exposing people to international situations, academic training, practical training, personal development, project management, team management, etc., it all matters and makes a difference.

Dr Danny Coyne, International Institute of
Tropical Agriculture, Uganda

A trained core of bioscience leaders

One of the most important achievements of the BIO-EARN programme is the training of a new cadre of young scientists, enabling them to act as research champions by adopting the latest knowledge and technology. Projects supported by BIO-EARN provided for the education of 30 PhD students and more than 30 MSc students.

The high proportion of trained researchers retained by their home institutions was a major success for the BIO-EARN programme. The follow-up support provided by BIO-EARN for researchers after the completion of their PhD training contributed significantly to the strengthening of local and national bioscience innovation capacities. The vast majority of the graduates are now acting as senior researchers – training the next generation PhD and MSc students and building new research groups. Through their broad training, and due to the programme's excellent reputation, the BIO-EARN graduates have also been successful at generating new funding opportunities for regionally-driven R&D initiatives. They were actively involved in developing and implementing BIO-EARN's third phase (2006–2010). Many of the graduates have expanded their regional and international networks and are now, through various projects and programmes, acting as pioneers in exploring opportunities for adapting useful bioscience applications for the region. Their exposure to biotechnology policy issues means that a substantial number of the PhD graduates are now engaged in national policy development and bioscience decision-making systems.

Expanded knowledge and skills

The BIO-EARN programme has provided opportunities for senior scientists from the region to upgrade their skills and knowledge. In addition, well over 1000 policymakers were exposed to and trained on technology, policy and regulatory issues through internships, training workshops and seminars arranged by the programme. The programme also supported hands-on training for laboratory technicians at partner institutions, which further enhanced R&D capacities. Swedish counterparts played an important role in technician training. During phase two, for example, three technicians from Mikocheni Agricultural Research Institute (MARI), Tanzania, attended a three-week intensive biotechnology laboratory training course at the Swedish University of Agricultural Sciences.

The skills gained in the BIO-EARN Programme have been the basis for my promotion to the Head of Department of Biochemistry at Makerere University in Uganda.

Dr Joseph Kyambadde,
Makerere University, Uganda



Sweet potato seedlings under development.

Benita Forsman

By setting up and equipping laboratories in eastern Africa, BIO-EARN has made it possible to carry out high quality research.

Dr Betty Mbatia,
University of Nairobi, Kenya

Building R&D infrastructure

As well as human capacity, efficient institutional infrastructure is a necessity for countries that wish to take part in the bioscience revolution. This includes the availability of functioning laboratories, and the management capacities for their maintenance. BIO-EARN contributed significantly to the build-up of well-equipped laboratories in 17 key eastern

It is difficult to imagine where our institute would have been without the BIO-EARN programme. Through BIO-EARN we were able to significantly enhance our human resource base and our laboratory infrastructure. This in turn has attracted more funding from various sources, including the Tanzanian government, and more collaboration with partners in the region and internationally.

Dr Alois Kullaya, Mikocheni Agricultural Research Institute, Tanzania

The broad training I received as a PhD student in the BIO-EARN Programme has helped me to manage projects effectively and establish linkages with scientists in the region and all over the world.

Dr Beatrice Were, Moi University, Kenya

African institutions. Since 1999, over SEK 25 million has been invested in infrastructure support for:

- Improved research facilities, such as greenhouses and laboratory facilities;
- Modern research equipment, such as bioanalytical instruments;
- Laboratory consumables as well as procedures and robust channels for the procurement and importation of the required chemicals and reagents;
- Equipment for improving Internet connectivity and computer capacity.

In Uganda, as a case in point illustrative of all the programme countries, BIO-EARN contributed substantially to the improvement of research infrastructure and equipment, and the stocking of consumables in the network institutions.

Through BIO-EARN, funds were secured at the Faculty of Agriculture at Makerere University to develop a state-of-the-art tissue culture facility. Other laboratories, such as those at the Faculty of Biochemistry, the Institute of the Environment and Natural Resources, and MedBiotech Laboratories, were also able to procure essential equipment. These investments had significant spillover effects, enabling new teaching programmes at Makerere University and others, and enhancing the ability of network partners to compete for international grants.

COLLABORATION AND NETWORKING ARE INCREASINGLY IMPORTANT IN SCIENCE, TECHNOLOGY AND INNOVATION

Judging from the steadily increasing proportion of scientific papers that list the authors as living and working in different countries or different continents, international collaboration in scientific research has been steadily increasing in recent years. Africa is no exception to this trend, which is prominent in areas such as natural resource management, bioscience innovation and environmental protection. African governments and research institutions have in recent years taken the lead in initiating extensive regional collaboration. This has proved to have many advantages, such as:

- Sharing of scarce R&D infrastructure and key competences to avoid duplication and harness available resources;
- Producing regional public goods while reducing transaction costs and enhancing economies of scale;
- Bringing new knowledge and technologies to a broad set of institutions and creating a critical mass of skilled scientists and policy researchers;
- Establishing partnerships with not only actors in the region but also international collaborators interested in working with eastern African partners on bioscience innovation issues.

Strengthening research management capabilities

In order to benefit from regional and international collaboration, African institutions need to further develop their R&D management capacities to handle collaborative projects. This includes institutional policies, administrative routines and the capacity to facilitate the exchange of staff, material and resources between institutions in different countries. Being part of a collaborative project can be demanding in terms of management, communication, reporting and networking.

BIO-EARN has greatly strengthened the abilities of network institutions to become equal partners in international R&D projects, and enhanced regional collaboration to a great extent. BIO-EARN network members have gone through extensive training in research and project management. The programme has arranged several courses on scientific writing and writing proposals.

A regional platform and a network of excellence

The adoption of modern biosciences requires highly skilled scientists and policy analysts. To this end, BIO-EARN's regional approach has enabled the pooling of expertise and key competencies, and created synergies between eastern African research and policymaking institutions. This has greatly improved the region's competitiveness in R&D.

BIO-EARN as a network of excellence has initiated extremely useful R&D initiatives in the region. The programme has catalysed and developed regional links for a multitude of initiatives. One example is the exchange of graduate students, in which PhD students from Ethiopia and Tanzania were trained in Uganda. African scientists and students are now well-equipped to conduct advanced biosciences research and to receive advanced training in biosciences without having to leave the region. Through this collaboration, network institutions have been able to share experiences on science- and policy-related issues, particularly on biosafety, intellectual property management and product development.

This regional platform has been an efficient mechanism for linking researchers and public R&D institutions to suitable R&D partners, local private sector partners and international centres of expertise. As a result, BIO-EARN has brought new knowledge and technologies to a network of eastern African institutions, and has served as a dynamic and effective tool for developing regional public goods and new bioscience products of interest to the region.



Rajni Hatti-Kaut

Suhaila Hashim wearing a doctoral hat, celebrating her graduation at Lund University.

BIO-EARN has trained us and provided us with a platform to collaborate with scientists in the country, in the region and all over the world. It has also assisted us in forging a much needed linkage to local industries and private sector partners.

Dr Suhaila Hashim,
University of Nairobi, Kenya

BALANCING BENEFITS AND RISKS

The use of biotechnologies and in particular the introduction of genetically modified (GM) crops has caused debate and in some cases controversy. Adoption of GM crops in eastern Africa has been slow so far, although a number of promising technologies are involved in field trials in Kenya and Uganda. One of the issues of contention involves the assessment of the benefits of GM crops in relation to the potentially negative effects on the environment and on human and animal health. The safe development and utilisation of GM crops requires scientific and regulatory skills, to ensure that the risk assessment process is science-based. It also requires the ability to collaborate with other scientific bodies worldwide, as well as regionally, on the validation of known data and deliberations of risks and benefits.

The debate over GM crops does not only deal with the technology. It also touches on the livelihoods of small scale farmers, and the relevance of advanced agricultural biotechnology and genetic modification, especially in relation to trade, ownership and the control of genetic resources. Concerns have been voiced about private sector monopolies on technologies and seed. Agricultural biotechnology, its research tools and output traits are largely proprietary, that is, protected as intellectual property. This could have implications for public sector access and the use of bioscience technologies and improved crops.

Public institutions therefore need to engage in collaborative technology dissemination efforts with various market actors to ensure that their R&D efforts are contributing to societal improvement, such as increased crop productivity and a cleaner environment. This requires a system for technology transfer at the institutional level including:

- Technology transfer capacity and infrastructure;
- Institutional intellectual property policies and corresponding management capacity; and
- The ability to develop contractual agreements to establish rights and obligations between partners

BIO-EARN recognised early on that, in deciding whether to use or approve the use of specific technology applications, such as GM crops, authorities and various stakeholders need to carefully weigh the potential benefits and the potential risks. Through regional conferences and training workshops, BIO-EARN initiated a much-needed dialogue between policymakers, scientists and stakeholders. Furthermore, the programme supported the development of decision support materials such as socio-economic evaluations of specific technologies, a biosafety resource book, and intellectual property management guidelines and templates.

The BIO-EARN programme was the pioneer in biosafety training in the region as well as in initiating the formulation of biotechnology and biosafety policies.

Dr Sam Kiboi, University of Nairobi, Kenya

Towards an enabling policy environment

The challenge for African countries is to integrate advanced biosciences into key economic sectors such as agriculture, the environment and industry. From the start, BIO-EARN has had a strong biotechnology policy component driven by collaboration between the Science and Technology Councils in the four participating countries. BIO-EARN's policy activities have acted as a catalyst in the broad biotechnology policymaking process in eastern Africa. The programme has supported government agencies in the region to develop functional regulatory systems, improved national policies and institutional reforms enabling the safe and efficient adoption of bioscience applications.

The programme has stimulated a much-needed dialogue between policymakers and scientists on key biopolicy issues, both nationally and regionally, contributing to a better enabling environment for bioscience adoption and technology dissemination. BIO-EARN policy support has covered many areas including:

- Pioneering capacity-building efforts on biosafety risk assessment of GM crops in the region through a series of national and regional biosafety workshops and the production of a biosafety resource book.
- Support for product development partnerships between academia and the private sector.
- Assisting network institutions to move technologies from the laboratory to the field.
- Assistance to network institutions to develop appropriate contractual agreements regulating the exchange of genetic material, the ownership of intellectual property and the sharing of the potential benefits arising from R&D projects.
- National and regional workshops and intellectual property background studies assisting network institutions to develop technology transfer structures, including institutional intellectual property policies and hands-on capacity to manage intellectual property.
- Establishment of an Intellectual Property Management Committee (the IPMC) consisting of designated technology transfer officers from each of the BIO-EARN network institutions. The IPMC is an innovative mechanism for sharing experiences of the complex handling of intellectual property matters and contractual issues between network institutions and their collaborating partners.
- Analysis of the bioscience innovation system in the region and recommendations on how these innovation systems could be made to function better and to better contribute to sustainable development.
- Assessments of the potential socio-economic benefits emanating from the various BIO-EARN R&D projects, assisting policymakers in the region to perform cost-benefit analyses on the use of biosciences.

Results from the BIO-EARN policy component have been communicated in reports and policy briefs and through outreach activities for high-level policymakers at the country level. Regional policy seminars and workshops were organised, gathering together more than 1000 participants representing policymaking bodies, scientific institutions and the private sector.



John Komen

Confined field test of virus-resistant GM cassava in Uganda.

BIO-EARN has been instrumental in raising awareness and understanding of key biotechnology policy issues and has positively influenced the development of the National Biotechnology Policy and Biosafety Framework in Tanzania, as well as putting in place an institutional intellectual property management structure at our institute.

Dr Alois Kullaya, Mikocheni Agricultural Research Institute, Tanzania

The programme has catalysed the development of an enabling environment, such as the development of national intellectual property offices for handling intellectual property issues arising from the R4D projects – paving the way for product development partnerships and national biotechnology innovation policy development.

Dr Seyoum Leta, Addis Ababa University, currently the Manager of the Bio-Innovate Africa programme

PROGRAMME ACHIEVEMENTS AND RESULTS		
Major programme components	Outputs	Observable and potential impacts
General capacity development and policy formulation		
- Research capacities and competences in the region mobilised to use biotechnology on key problems	- More than 90 peer-reviewed publications - More than 20 scientific protocols/models - 30 PhD students trained - 30 MSc students trained - Senior staff and technicians trained - 17 laboratories substantially upgraded	- Countries better able to develop and adopt modern bioscience according to their own needs - BIO-EARN network institutions more competitive at obtaining research grants and government funding - R&D capacity significantly improved at network institutions - Regional and international collaboration enhanced - New curriculum development in biosciences at network universities
- Enabling policy environment for bioscience adoption and technology dissemination supported - Product development partnerships between academia and the private sector supported	- A series of regional and national biosafety risk assessment workshops conducted - Biosafety resource book published - Assistance to network institutions to develop appropriate contractual agreements - Policy recommendations and management tools assisting network institutions to develop technology transfer structures, including policies on intellectual property and skills to manage intellectual property - Intellectual Property Management Committee (IPMC) established and trained - Assistance provided to intellectual property and technology transfer officers and with establishing Institutional intellectual property offices - Laboratory notebooks developed and distributed - Studies on how to improve innovation systems in the region conducted - Assessment of the potential socio-economic benefits emanating from the various BIO-EARN R&D projects - A series of policy studies and policy briefs analysing product development and dissemination from BIO-EARN supported projects	- BIO-EARN contributing to science-based biosafety risk assessment and functional regulatory regimes - Management tools, structures, policies and capacities established to transfer technologies to local markets - IPMC serves as an effective mechanism for sharing experiences in the complex handling of intellectual property matters and contractual issues between network institutions and their collaborating partners - BIO-EARN institutions better able to effectively engage in technology and knowledge transfer to various sectors of society - Science, technology and innovation actors in the region better able to design functional innovation systems - Enhanced skills to perform cost-benefit analyses of bioscience applications and projects - BIO-EARN policy publications used to inform policy development for science and technology and innovation in the region

PROGRAMME ACHIEVEMENTS AND RESULTS

Major programme components	Outputs	Observable and potential impacts
Regional R4D and innovation projects		
- Using marker assisted selection technology to improve the potential of sorghum breeding	- More than 40 multiple stress tolerant sorghum lines identified and introgressed in farmer preferred varieties - Robust bioscience technologies established that make sorghum cultivation more effective and precise	- New sorghum cultivars tolerant to multiple stresses (e.g. diseases, drought, aluminium and Striga tolerance) will help sorghum farmers in the region to improve their productivity and profitability
- Using biosciences to improve sweet potato and cassava cultivation - Improving methods for managing sweet potato and cassava virus diseases - Establishing methods to produce disease free seedlings	- 15 promising sweet potato varieties in terms of yield, vitamin A, quality traits and disease resistance selected for variety trials - Improved understanding and management of sweet potato virus disease and cassava brown streak virus - Robust methods for producing disease-free sweet potato, enset, banana and cassava seedlings	- New varieties contributing to significant improvements in sweet potato productivity in the region - Distribution of disease-free plants will improve sweet potato, cassava and enset productivity in the region
- Adding value to local crop plants (sesame, cassava, millet and enset)	- Integration of value chain actors into producing fermented millet and sorghum products - Developing value-addition opportunities for enset - Advanced biotechnologies to produce cassava with starch qualities for industrial purposes	- New value addition pathways identified to improve future profitability for cassava farmers and agroprocessing industries in the region and local agroprocessing actors - Improved prospects for a wider utilisation of the drought- and stress resistant starch crops, enset and cassava
- Technologies to treat waste water to mitigate water pollution - Establishing methodologies to evaluate waste water treatment systems - Developing bioreactor systems for biogas production utilising fish, brewing, slaughterhouse and sisal waste	- Water quality indices for slaughterhouse and tannery waste water developed - Six microbial isolates identified for treating tannery waste water and twelve isolates identified for abattoir waste water - Integrated bioreactor systems developed for slaughterhouse and tannery waste water - Two biogas production processes available from sisal and fish waste - Construction of two pilot waste water treatment facilities - Cost-benefit analyses carried out on developed bio-processes - Scaled-up integrated processes installed for demonstrating biogas production	- Technologies for the biological treatment of slaughterhouse and tannery waste water ready to use - Waste water treatment technologies successfully demonstrated on a pilot scale. - Interest demonstrated by two public sector partners and one private sector partner - Secured involvement of private sector partner in sisal biogas production and fish wastewater treatment
- Using agricultural waste to produce valuable products	- Two microbe-producing carotenoids fully characterised, sequenced and deposited in genebank - Five extremophile yeasts isolated - Fatty acid composition and yield in Nile perch processing waste determined - Treatment of fish processing waste tested for up-scaling - Proof of concept established for recovery of commercially interesting fatty acids	- Micro-organisms of relevance to industrial use identified and ready for use - Value addition technology in fish processing waste tested and established - Industrial partner identified as a potential commercial partner

BIO-EARN has made a difference: narratives from the field

The programme was based on the development of regional consortia addressing local problems. A presentation of selected BIO-EARN projects follows below, involving science and business actors engaged in research for development (R4D) with a focus on crop productivity, agro-processing, and environmental and industrial development.

Biosciences unlock the potential of sorghum

Sorghum is ranked the second most important crop for food security after maize in sub-Saharan Africa. Sorghum is also an important animal feed and has increasingly become a basis for industrial products including biofuels.

Sorghum is a crop with superior drought tolerance and adaptability to poor soils and, in contrast to maize, is well adapted to diverse climatic conditions. Despite its great potential, the yield from sorghum is low and has been declining due to stress factors such as frequent, prolonged droughts, plant diseases, low soil fertility, particularly in acid soils often associated with aluminium toxicity, and low levels of available phosphorus.

The objective of the project was to use advanced biosciences, in particular marker assisted selection (MAS), to improve ongoing sorghum cultivation programmes in the region. The project focused on identifying sorghum plant material with increased tolerance to drought, aluminium toxicity, low levels of phosphorus and the plant diseases anthracnose and Turcicum leaf blight.

Using advanced molecular breeding tools, the project screened several hundred sorghum accessions and was able to develop a large number of new sorghum lines with increased tolerance in the areas outlined above. The most promising cultivars, those tolerant to multiple stresses, have been crossed with the varieties preferred by farmers and made available for the major sorghum cultivation improving programmes in the region. In some cases, the new and improved sorghum cultivars are undergoing varietal testing and will soon be made available to farmers in the region.

According to Dr Samuel Gudu, the principal project investigator at Moi University: “Overall, the project has greatly enhanced the capacity in the region to use MAS to

The programme has raised the profile of Moi University in training and research. Through the collaborative research efforts between Moi University and the various partners on the programme, the institution has attained international recognition for the specific research competencies it houses.

Dr Beatrice Were, Moi University, Kenya



Field testing of improved sorghum cultivars. Selfing bags are fixed to control pollination.

Joyce Agalo

improve eastern Africa's sorghum cultivation. The project has also led to a large number of new sorghum cultivars tolerant to multiple stresses which will help sorghum farmers in the region to improve their productivity and profitability”.

COLLABORATING PARTNERS

- Ethiopia: Addis Ababa University, Department of Biology
- Kenya: Moi University Department of Botany, University of Nairobi, Crop Science Department, Kenya Agricultural Research Institute (KARI)
- Tanzania: Mikochei Agricultural Research Institute (MARI)
- Uganda: Makerere University, Department of Crop Science, Namulonge Agricultural and Animal Research Institute (NAARI)
- Sweden: Swedish University of Agricultural Sciences, Department of Plant Biology and Forest Genetics and Department of Plant Breeding and Biotechnology



Richard Gibson

Super tuber! Developing high yield and disease resistant sweet potato in Uganda.

The BIO-EARN programme has made us more visible in the country and internationally through our research findings and publications.

Dr Settumba Mukasa,
Makerere University, Uganda

Higher returns from roots: cassava and sweet potato productivity

Sweet potato and cassava are important food security crops in Africa. Both crops are used as a source for food, processed products and animal feed, generating income for millions of African resource-poor farmers. Despite their great potential to alleviate malnutrition and poverty, and despite being priority crops in eastern African agricultural research programmes, these crops are still underdeveloped. The productivity of cassava and sweet potato is still severely limited by various diseases, particularly those of viral origin. Devastating virus diseases such as the emerging cassava brown streak virus disease (CBSVD) and sweet potato virus disease (SPVD) can cause yield losses of more than 90 per cent.

This project has used modern biosciences to improve the potential for sweet potato and cassava cultivation in the region. The key objectives were to produce sweet potato and

cassava varieties with improved yields, of better quality and nutritional value and with a resistance to viral diseases. Other specific objectives were to develop more efficient methods for understanding, diagnosing and managing SPVD and CBSVD and to establish methods for producing disease free seedlings.

Dr Settumba Mukasa, the project's co-principal investigator at Makerere University explains: "We collected and evaluated more than 1300 sweet potato cultivars from all over Uganda. Based on disease resistance, yield and quality traits, 20 sweet potato cultivars were selected for further breeding studies. From these crossings, over 550 new plant lines were produced and evaluated through a farmer participatory process for yield, quality, SPVD resistance and vitamin A content. From these, 15 promising sweet potato varieties were selected for trial before their final release through the Ugandan variety release committee. We are confident that these new varieties will contribute to significant improvements in sweet potato productivity in the region."

In the case of cassava, the project resulted in a deeper scientific understanding of CBSVD, and the development of disease management strategies and new bioscience-driven methods for developing virus-resistant cassava. Advanced biotechnologies were also developed to produce cassava with starch qualities suitable for industrial purposes, providing a basis for new value addition pathways and improved profitability for cassava farmers and agro-processing industries in the region.

According to Dr Mukasa "The project has succeeded in establishing a robust and bioscience-driven model for the production and delivery of disease free cassava and sweet potato seedlings, involving close collaboration between public and private sector actors".



Deudedith Mbanzibwa

Virus-resistant varieties are key to building more resilient and productive cassava farming systems.

COLLABORATING PARTNERS

- Ethiopia: Addis Ababa University, Department of Biology
- Tanzania: Mikocheni Agricultural Research Institute (MARI)
- Uganda: Makerere University, Department of Crop Science, Namulonge Agricultural and Animal Research Institute (NAARI), MedBiotech Laboratories (MBL)
- Sweden: Swedish University of Agricultural Sciences (SLU), Department of Plant Biology and Forest Genetics
- Finland: University of Helsinki, Department of Applied Biology

Robinson Odong



Untreated waste-water discharge from Kampala abattoir.

Through this project we have been able to build advanced capacity in the region to develop waste water treatment technologies for different purposes. BIO-EARN partner universities are now offering advanced training in environmental biotechnology and attract research grants from the public and the private sector to develop waste water treatment processes for wider application.

Dr Joseph Kyambadde,
Makerere University, Uganda

From waste water to drinking water

The discharge of untreated industrial and municipal effluents into rivers and lakes is a serious problem in Africa. It threatens local livelihoods, negatively affects ecosystems and limits access to clean drinking water. Waste water treatment facilities are either inefficient or non-existent, and untreated waste water is a growing problem driven by high population growth, urbanisation and a steady rate of industrial growth.

The development of efficient and sustainable waste water treatment technologies adapted to conditions in the region was a major focus of this project. A specific objective was to develop more efficient and environmentally friendly treatment methods for waste water from the agro-processing industries, using slaughterhouse and tannery effluents as models.

The project characterised slaughterhouse and tannery waste water in detail, determining the pollution load on the receiving environment. Pollutant degrading microbes with the ability to increase the efficiency of the treatment of slaughterhouse and tannery discharges have been isolated and evaluated. Pilot models have been developed using integrated anaerobic-aerobic reactors. A wetland treatment system was constructed for slaughterhouse waste water at the City Abattoir, Kampala, and one for tannery waste water at Modjo, Ethiopia. These have been evaluated and optimised. The successful pilot treatment systems have generated great interest from industries such as the City Abattoir and Top Cuts in Uganda and the Modjo Tannery in Ethiopia.

The project has greatly enhanced the human capacity needed to understand and manage these complex technologies and processes. The technologies and bioprocesses generated will contribute considerably to improved waste water management practices in the region.



Frans Lemmens/Corbis

Young boy enjoying the luxury of clean drinking water.

COLLABORATING PARTNERS

- Ethiopia: Addis Ababa University, Department of Biology
- Kenya: Kenyatta University, Department of Biochemistry and Biotechnology
- Tanzania: University of Dar es Salaam, College of Engineering and Technology
- Uganda: Makerere University, Institute of Environment and Natural Resources and Department of Biochemistry
- Sweden: Royal Institute of Technology (KTH), School of Biotechnology

Waste not want not: market value from fish and sisal by-products

The agro-processing industry in Africa produces large amounts of waste, which contributes to environmental pollution in the region. In many cases, this waste is a resource that could be used to generate bioenergy and value-added chemical products. Waste from sisal and fish processing can offer a great deal in this regard.

The commercial fish catch in eastern Africa is dominated by Nile perch, which generates considerable amount of fish solid wastes. These wastes are not currently fully utilised. They are either disposed of or sold at a low price to be converted into low value products. According to Dr Betty Mbatia, University of Nairobi, “The waste has the potential to generate considerable revenue and can be turned into a commercially viable business. It can be used in the production of fish oils, fish protein hydrolysates, enzymes and bio-energy”.

Fish oils are a good source of valuable omega-3 polyunsaturated fatty acids (PUFA). Omega-3 has been associated with several health benefits, including the prevention of cardiovascular and inflammatory diseases. They are also vital for infant brain development and vision. They therefore find use in the pharmaceuticals, nutraceuticals and food industries. Nile perch oil is reported to contain considerable amounts of PUFA. The challenge is to maximise oil extraction and PUFA recovery from the surplus biomass.

Using biotechnology, the project has developed processes for the recovery of valuable PUFA from Nile perch waste. The project has undertaken a techno-economic analysis of utilising fish waste for biogas production and PUFA production. This has attracted industrial partners in the region to collaborate on commercialising fish waste processing technologies.

The project has demonstrated that valuable products can be obtained from fish surplus biomass using an eco-friendly approach. Through this BIO-EARN project we have developed a new capacity to create market value from waste and a regional platform where industrial and academic actors can collaborate in making agroprocessing more efficient and more sustainable.

Dr Betty Mbatia,
University of Nairobi, Kenya

The project has also successfully improved and scaled-up integrated processes for biogas production from sisal waste. The commercial viability of these more efficient biogas bioreactor systems has been demonstrated. As a consequence, collaboration with the sisal industry has been established with the aim of producing biogas more effectively from sisal processing waste.



Betty Mbatia

Fish by-products were used e.g. for extraction and recovery of omega-3 polyunsaturated fatty acids (PUFA).

COLLABORATING PARTNERS

- Kenya: University of Nairobi, Department of Biochemistry
- Tanzania: University of Dar es Salaam, Applied Microbiology Unit
- Uganda: Makerere University, Institute of Environment and Natural Resources
- Sweden: Lund University, Department of Biotechnology

The BIO-EARN call arrived at the perfect time for our colleagues and us, when we had reached a juncture of having a potential product based on years of research. We responded to the call for taking the results of our research into a development phase, which we were successful in doing. The development of a useful tool for crop protection is rewarding for us in that the toil of our combined research efforts over the years can come to fruition and result in a useable, useful tool to improve pest management.

Dr Thomas Dubois and Dr Danny Coyne,
International Institute of Tropical Agriculture,
Uganda

Fungal friends fight the good fight: bio-protection of bananas

Endophytic fungi exist in the plant tissue of all plants. They cause no damage to their hosts and often provide benefits, such as enhanced protection against diseases. The use of tissue culture to produce healthy, uniform plants in a rapid manner is becoming an attractive means of mass plant propagation in eastern Africa. However, tissue culture-derived plantlets are free not only of pests and disease but also of endophytes – their natural protection. Following years of research driven by the International Institute of Tropical Agriculture (IITA), a particular non-pathogenic, that is, safe, strain of *Fusarium oxysporum*, a common root and soil dwelling fungus, was identified as the most effective endophyte for bananas. When infected with this endophyte, tissue culture banana plants were better protected against root parasitic nematodes and corm burrowing weevils than plants without this strain of endophyte. They were also more robust, stronger and faster growing, leading eventually to better harvests.

This project aimed to take advantage of bioscience to develop mechanisms for supplying these bio-protecting endophytes to eastern African tissue culture banana producers and banana farmers. A BIO-EARN product development consortium was formed consisting of Jomo Kenyatta University of Agriculture and Technology, IITA, VEDCO (a Ugandan non-governmental organisation), AGT (a private sector tissue



Thomas Dubois, IITA

Young tissue culture banana plantation in Kenya.



Danny Coyne, IITA

Planting of tissue culture plants in a rural nursery for disease-free and improved cultivars.

culture company in Uganda) and Real IPM (another private company in Kenya). The consortium collaborated to establish a suitable method of mass production and followed through to complete the product registration procedures for biological control agents. The project has been a success and a product, based on the IITA *Fusarium oxysporum* strain, will be registered in Kenya and Uganda and available for sale in the near future. Tissue culture banana plants that are bio-enhanced using this product will be more durable and better protected from pests and diseases, and will perform better for the ultimate benefit of farmers in the region.

BIO-EARN contributed to critical thinking regarding intellectual property issues and implementing them; our project has partly been responsible for IITA starting to think about intellectual property issues in a proactive way in its other activities.

Dr Thomas Dubois, International Institute of Tropical Agriculture, Uganda

COLLABORATING PARTNERS

- Kenya: Jomo Kenyatta University of Agriculture and Technology (JKUAT), International Service for the Acquisition of Agri-biotech Applications (ISAAA), Real IPM (Kenya) Co.;
- Uganda: International Institute of Tropical Agriculture (IITA), Volunteer Efforts for Development Concerns (VEDCO), Agro-Genetic Technologies (AGT)



Millet is used to produce indigenous beverages.

The project has so far been a success as the product has such a high potential demand that it could probably be compared with the way yoghurt was introduced on the Ugandan market, with the industry growing from a few hundreds of thousands of Uganda shillings to billions of shillings. The most important message here, however, is that the project has demonstrated that academia can come in to support local industry to develop new or improved products through R&D. I expect this project to be a stimulus or impetus for more collaboration, which will eventually have bigger impacts on the economies in the region.

Mr Robert Mawanda, Uganda Manufacturers Association, Uganda

University-industry partnership commercialises beverages produced from sorghum and millet

Drought tolerant and locally adapted crops such as millet and sorghum are essential to the livelihoods of small-scale farmers in eastern Africa. These crops are underdeveloped in terms of processing and value addition, which means low levels of profitability for the farmers that grow them.

The aim of this project was to use established biosciences and technologies to optimise and commercialise the production of bushera and togwa – indigenous malted and fermented non-alcoholic cereal-based beverages. The rationale was that optimising the process for producing these indigenous beverages would support the local agro-processing industry and create employment, as well as improving the livelihoods of the farmers producing sorghum and millet – the major raw materials. The production of fermented cereal-based products in Uganda and Tanzania is a thriving cottage industry, which mainly employs women.

The project used a university-industry partnership mode of operation, in which linkages between the project partners were used to enrich the product development process and to ensure that the processes and technologies developed were suitable for industrial application. A business incubation approach was used as the main pathway for the transfer of technology to industry.

By the end of the project the production time for the beverages had been reduced by up to 35 per cent, and the product had a longer, more economic but safe shelf life. Three sorghum and three millet varieties were identified that were suitable for processing. It is anticipated that the demand for these varieties will increase with increased adoption of the industrial processes for the production of bushera and togwa. This in turn will contribute to increasing the incomes of the farmers. Lisha Products Ltd, in Uganda, is in the process of initiating the production and marketing of bushera. Lisha Products will link with farmers to ensure supply of the sorghum and millet with specific processing qualities.

COLLABORATING PARTNERS

- Tanzania: Sokoine University of Agriculture, Department of Food Science and Technology, Morogoro Ben's Winery
- Uganda: Makerere University, Department of Food Science and Technology and Department of Agribusiness and Agricultural Economics, Jakana Foods Limited, Uganda Manufacturers Association.

Constructed wetlands ensure cost-effective and robust waste water treatment

There is an increasing need to dispose of untreated waste water from households, institutions and industries in eastern Africa due to rapid urbanisation and growing populations, and this is becoming a serious environmental problem. Most cities in the region do not have adequate systems for waste water treatment and the development of cost-effective and robust waste water treatment technologies is therefore a high priority.

Constructed wetlands are a biological waste water treatment technology designed to mimic processes found in natural wetland ecosystems. Constructed wetlands are receiving increased attention worldwide for waste water treatment due to their cost-effectiveness, easy construction and operation, low maintenance requirements and process stability. The possibility of recycling key nutrients is also a major advantage with the constructed wetlands technology.

The goal of this project was to increase knowledge of constructed wetlands technology and its use for waste water treatment in Tanzania and Uganda, targeting local government authorities. Some of the main project outputs were:

- Raised awareness in the region of the potential of constructed wetlands technology through the use of training workshops, brochures, posters and documentaries.
- Improved performance of constructed wetlands through studies of a pilot constructed wetland established at SEETA High School in Uganda. The reuse of treated waste water for aquaculture, paddy irrigation and the irrigation of elephant grass, used for feeding cows, has also been studied.
- Manuals developed in Swahili and English on the design, operation and maintenance of constructed wetlands, specifically targeted at the conditions in the region.



BIO-EARN archives

Establishment of constructed wetland system in progress.

The BIO-EARN project's support has led to a major increase in enquiries from African companies and local authorities interested in using constructed wetlands technology. The operations and maintenance manuals have also been well received and will contribute to the sustainability of constructed wetland systems in the region. There has also been international and regional interest, and there are plans to transfer the constructed wetland technology to countries such as Burundi, Haiti, Mozambique, Rwanda and the Seychelles.

Dr Karoli Njau, University of Dar es Salaam, Tanzania

COLLABORATING PARTNERS

- Kenya: Nairobi Convention, United Nations Environment Programme-Global Environment Facility (UNEP-GEF) WIO-LaB Project
- Tanzania: University of Dar es Salaam, Waste Stabilisation Ponds and Constructed Wetlands Research Group, University of Dar es Salaam Entrepreneurship Centre; National Environmental Management Council; AGENDA for Environment and Responsible Development; ENVICON
- Uganda: Makerere University, Institute of Environment and Natural Resources.



Harvesting and processing of enset plants in Ethiopia.

This project aimed to develop a process for the isolation of enset starch and methods for the utilisation of a range of potential enset by-products for different applications. The project has successfully developed a range of enset products and processes that can be scaled-up and used to improve livelihoods in the region.

Dr Amare Gessesse,
Addis Ababa University, Ethiopia

Employing enset in the quest for rural development

Enset (*Ensete ventricosum*) is closely related to the banana plant and used as a major food source in south-west Ethiopia, where more than 12 million people use it as a staple food. Enset tolerates drought better than bananas and provides a higher amount of food per unit area than most cereals. The enset plant has a multitude of different applications. The edible parts of the plant accumulate large quantities of starch, and therefore have enormous potential as a source of industrial starch. Enset can be used as a shade plant, for example, for coffee, and also produces good quality fibre. Many parts of the plant can be used as animal feed.

The high starch yield combined with a high fibre yield makes enset an attractive plant as a food crop, and also as an industrial crop substituting for imported starches. Despite this, to date, enset cultivation remains confined to south-west Ethiopia. This is mainly due to the amount of time and people required for, and technical difficulties associated with, enset processing. In order to utilise the full potential of enset there is an urgent need to develop a more efficient processing technology.

In its quest to more fully employ enset in agricultural production and rural development, the scientists involved in this project developed a range of technologies and protocols for demonstrating the crop's potential. The project:

- Produced a pilot-scale process for the large-scale processing of enset to produce starch and fibres;
- Established protocols for the use of enset starch as sizing in the textile and paper industries, the production of syrups and the production of alcohol through fermentation;
- Successfully tested the use of enset in starch-wheat composite flour for making bread and injera (flatbread), and in the production of local soft drinks;
- Improved enset's potential for use as a source of fibre in pulp and paper production, and in rope and textile manufacturing;
- Confirmed the potential of enset by-products as high carbohydrate animal feed.

COLLABORATING PARTNERS

- Ethiopia: Addis Ababa University; Department of Biology, Department of Chemical Engineering, Department of Economics
- Kenya: Kenya Forestry Research Institute, Kitui Regional Centre
- Tanzania: University of Dar es Salaam, Department of Botany
- Uganda: National Agricultural Research Organization (NARO), National Crops Resources Research Institute (NaCRRI), Namulonge.

Lessons learned and future prospects

A multi-country, multi-faceted programme such as BIO-EARN, which involves a range of research and policymaking institutions, yields a rich set of lessons that are relevant to current and future bioscience capacity-building programmes.

A number of key lessons were learned.

Following the initial phase in which the emphasis was placed on human resource development through MSc and PhD projects and on infrastructure development, in the past five years BIO-EARN has supported nine regional R4D projects – including one policy project – and focused on product development and diffusion. It is noteworthy that all the research projects, with scientific and management leadership from within the region, are now delivering new technologies and products, including new policy and management tools. A number of BIO-EARN technologies have moved beyond the proof-of-concept stage to enter the testing stage or the pilot-phase production stage. BIO-EARN's integrated approach has ensured that important policy aspects, such as biosafety regulations, intellectual property management, and public-private sector collaboration, were addressed both early on and throughout the life of the projects.

The BIO-EARN model built an inclusive regional network around competitively funded R4D projects with strong regional ownership and leadership, as well as technical backstopping primarily from Swedish counterparts. This model clearly increased the programme's impact. The programme's emphasis on monitoring and evaluation was another important feature, as was the aim to shape BIO-EARN as a "learning organisation". This meant that the priorities identified and the recommendations made by the network's advisory and governing bodies were incorporated into project development and implementation. In addition, the issues identified and the recommendations made in a mid-term external review conducted in 2004 were fully taken into account in the design and implementation of BIO-EARN's third and final phase.

The BIO-EARN programme has helped in enabling my institution compete for international research grants, thereby enabling the institution to move towards fulfilling two of its main objectives – capacity building and world-class research standards.

Dr Sam Kiboi, University of Nairobi, Kenya

BIO-EARN has created an enabling environment for researchers to attract more funding from other donor agencies, such as those in the agricultural sectors.

Dr Joseph Kyambadde,
Makerere University, Uganda

The programme has assisted in elevating the University of Dar es Salaam as a regional authority in constructed wetland technology and I have been able to take constructed wetland knowledge beyond the borders of my country.

Dr Karoli Njau, University of Dar es Salaam, Tanzania

The BIO-EARN programme has definitely been an eye opener for me – especially to see firsthand that a local food raw material can be turned into a business opportunity through scientific research. I now have better insight into what biotechnology can do for industry.

Mr Robert Mwanda, Uganda Manufacturers Association, Uganda

As the regional R4D projects progressed, in 2009 BIO-EARN commissioned an analysis of their likely socio-economic impacts. The analysis highlighted a number of important areas of impact:

- Increased crop productivity: Improved sorghum lines, selected for tolerance to drought and other abiotic stresses, increased yields by around 25 per cent compared to the local base variety in Kenya. In Kenya and Uganda, local breweries showed strong interest in locally produced sorghum to substitute for imported barley.
- Environmental gains: Biogas technologies to enhance production from fish processing waste and sisal waste contribute to agro-industrial waste management and reduce the need for firewood – a major cause of deforestation – and imported fuel.
- Human health benefits: Constructed wetlands technology for the treatment of slaughterhouse and tannery effluents has been tested at the pilot scale in several BIO-EARN countries. Treatment of waste water results in a much reduced exposure to chemicals, heavy metals and pathogens. In Tanzania, it was demonstrated that the technology leads to significant cost reductions in treating common diseases such as diarrhoea.

BIO-EARN's impacts, as described above, will continue to be felt in eastern Africa. The programme's alumni have succeeded in attracting additional funding for their R4D efforts, and a number of them have successfully competed for funding from the new Sida-supported Bio-Innovate Africa programme. These graduates are well connected to a range of international bioscience initiatives, and act as champions for further development and diffusion of the new technologies they helped to generate.

Nonetheless, it must be acknowledged that the road to successful technological innovation is neither short nor straight. It remains important within current and future bioscience programmes to identify the demand for a specific technology, and to plot the essential links as early as possible in the research, development and dissemination process.

This has important implications for the design and implementation of future bioscience initiatives:

- The need to think beyond science in project design and early on to take into account the question of demand in both the economic and the social sense. This is essential in order to be able to make realistic assumptions about the prospects for translating research into an innovation in the farming field or in the hands of end-users, and to plot realistic innovation pathways.
- The need for disciplines other than the biosciences in project teams. Technology markets in most African countries are still relatively undeveloped. This makes it all the more important for projects to be able to add economic, marketing and/or social perspectives to their research efforts if they are intended to result in a technological innovation. Techno-economic and market assessments were conducted as part of many BIO-EARN-supported technologies and these proved valuable in building the case for further product development.
- Funds will be required for product development, testing and demonstration projects. Provision should therefore be made for adequate funds to carry out product development and facilitate the innovation process. For example, funding for the construction of pilot-scale facilities encouraged the adoption of waste water treatment technologies.
- The BIO-EARN programme was special in that it had a policy component. Lessons from the BIO-EARN experience suggest that policy and regulatory issues should be included as an integral part of individual projects rather than as a separate, stand-alone programme component.
- Strong regional coordination and communication with programme partners and relevant stakeholders are essential to the implementation and management of multi-country, regional R4D programmes. In addition, agreed and robust plans for monitoring and evaluation, with associated performance indicators, and results-based management should be established early in the life of the programme and of individual projects.

BIO-EARN played a significant role in moving my institute to new horizons as a regional service provider in topical training courses, such as tissue culture and plant genetic resources conservation, virus indexing, and so on.

Dr Yona Baguma, National Crops Resources Research Institute, Uganda

BIO-EARN collaborating partners

Kenya

African Centre for Technology Studies (ACTS)
Biosciences eastern and central Africa Hub (BecA)
International Service for the Acquisition of Agri-biotech Applications (ISAAA)
Jomo Kenyatta University of Agriculture and Technology
Kenya Agricultural Research Institute (KARI),
Biotechnology Centre
Kenya Forestry Research Institute (KEFRI)
Kenya Intellectual Property Institute (KIPI)
Kenya National Council for Science and Technology (NCST)
Kenyatta University, Department of Biochemistry and Biotechnology
Moi University, Department of Botany
Real IPM Company
UNEP-GEF WIO-Lab Project
University of Nairobi
Department of Biochemistry; Department of Botany;
School of Biological Sciences; Department of Plant Science and Crop Protection

Uganda

AgroGenetic Technologies Ltd
International Institute of Tropical Agriculture (IITA)
Inter-University Council for East Africa (IUCEA)
Jakana Foods Ltd
Makerere University
Department of Crop Science; Department of Biochemistry;
Institute of Environment and Natural Resources;
Department of Agribusiness and Agricultural Economics;
Department of Food Sciences and Technology
MedBiotech Laboratories (MBL)
National Agricultural Research Organisation (NARO),
National Crops Resources Research Institute (NaCRRI)
Uganda Manufacturers Association (UMA)
Uganda National Council for Science and Technology (UNCST)
Volunteer Efforts for Development Concerns (VEDCO)

Ethiopia

Addis Ababa University
Department of Biology; Department of Economics;
Department of Chemical Engineering; Institute of Development Research
Awassa Research Institute
Ethiopian Agricultural Research Organisation (EARO)
Ethiopian Intellectual Property Office (EIPO)
Ethiopian Science and Technology Agency (ESTA)
Mekelle University

Tanzania

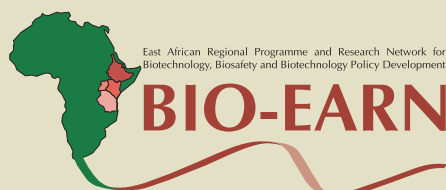
AGENDA for Environmental and Responsible Development
ENVICON
Mikocheni Agricultural Research Institute (MARI)
Morogoro Ben's Winery
National Environment Management Council (NEMC)
Sokoine University of Agriculture (SUA)
Department of Crop Science and Production;
Department of Food Science and Technology
Tanzania Commission for Science and Technology (COSTECH)
University of Dar es Salaam (UDSM)
Department of Botany, Applied Microbiology Unit;
Chemical Engineering Department; Department of Molecular Biology and Biotechnology; WSP and Constructed Wetland Research Project;
Entrepreneurship Centre

International partner organisations

Lund University, Sweden
Department of Biotechnology; Department of Theoretical Ecology
Royal Institute of Technology (KTH), Sweden,
School of Biotechnology
Stockholm Environment Institute, Sweden
Swedish University of Agricultural Sciences, Sweden
Department of Plant Breeding and Biotechnology;
Department of Plant Biology and Forest Genetics
University of Helsinki, Finland
Department of Applied Biology
International Center for Tropical Agriculture (CIAT), Colombia
International Service for National Agricultural Research (ISNAR), the Netherlands
Plant Research International (PRI), the Netherlands

BIO-EARN was the best-organised and most goal-minded and modern development-oriented programme that I have ever been involved in. To me it is the model for how development can be enhanced through research training. BIO-EARN has created a network of well-educated scientists in eastern Africa. Their modern problem-solving skills and deep knowledge on local problems are now widely recognised by organisations from all parts of the world.

Professor Jari Valkonen, University of Helsinki, Finland



East African Regional Programme and Research Network for
Biotechnology, Biosafety and Biotechnology Policy Development

Sida works according to directives of the Swedish Parliament and Government to reduce poverty in the world, a task that requires cooperation and persistence. Through development cooperation, Sweden assists countries in Africa, Asia, Europe and Latin America. Each country is responsible for its own development. Sida provides resources and develops knowledge, skills and expertise. This increases the world's prosperity.

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The BIO-EARN Programme 1999–2010

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