The Bio-Innovate Story

MOVING BIO-INNOVATIONS TO THE MARKET PLACE

2010-2015

Bio-Innovate Africa
Bio-Resources Innovations Network for Eastern Africa Development

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

SWEDEN

INTRODUCTION

Bio-resources Innovations Network for Eastern Africa Development (Bio-Innovate) Program is a regional initiative established in 2010 to support bioscience research and innovation activities in eastern Africa. It addresses regional priorities in science, technology and innovation aligned with the AU-NEPAD's Science Technology and Innovation Strategy for Africa (STISA, 2024), the science agenda for Agriculture in Africa (S3A) and the Comprehensive Africa Agriculture Development Program (CAADP). The Program envisions a region with an ecosystem that supports bio-innovation as the driver for sustainable economic growth.

The Program is among very few that support a uniquely designed multi-disciplinary bioscience innovation funding mechanism anchored on the establishment of technology innovation platforms that assemble critical players along the innovation value chain to apply and promote bioscience innovations.

Bio-Innovate supported projects in the six eastern Africa countries of Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. In the current phase, the Program supported 9 multidisciplinary innovation and policy projects involving 57 implementing partners drawn from research organizations/academia, private sector and other delivery agents.

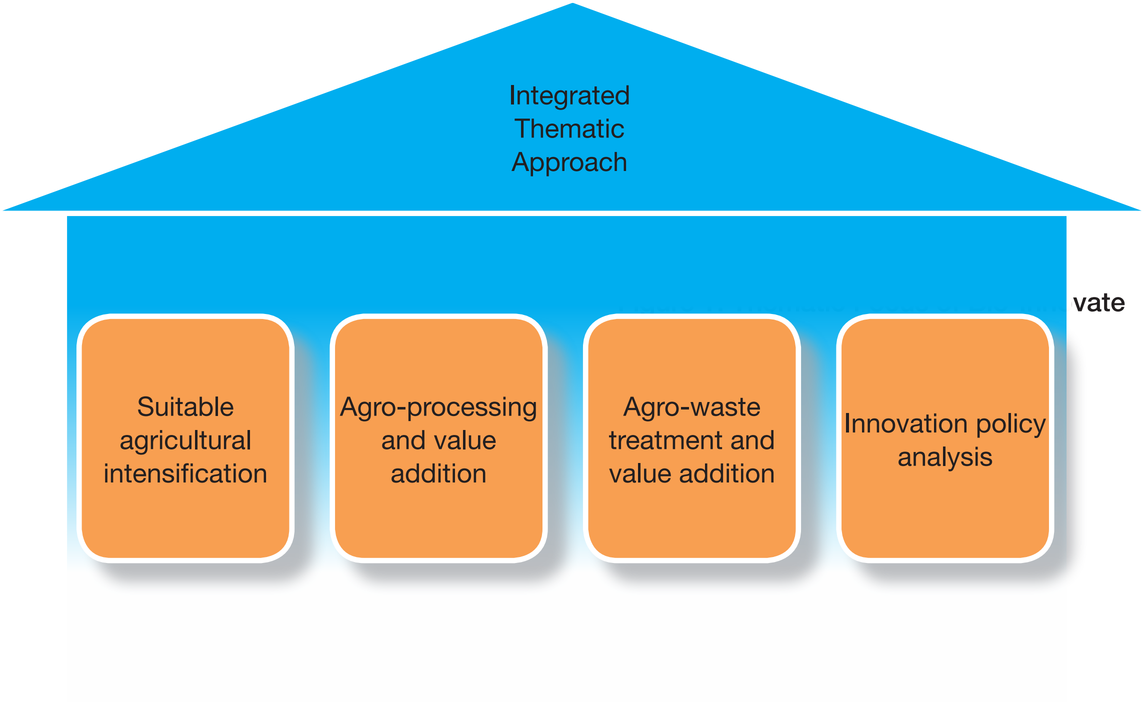
Premise for Establishing a Bioscience Innovation Initiative

The absence of proper technology and business incubation mechanisms as well as enabling policy that would move bioscience innovations along the innovation chain and to the market place has been a big hindrance in integrating bio-resources technology into key sectors like agriculture, environment and industry in the eastern Africa. Conscious of the limited capability of the research organizations and academia in the region to move research outputs to the market there is need to support the innovation process.

The Program has in the past five years demonstrated the deployment of a regional competitive multi-country, multi-disciplinary and multi-stakeholder biosciences innovation funding mechanism aimed at catalyzing the translation of bioscience research outputs into scalable and impactful innovations through the creation and strengthening of various technology innovation platforms. Lessons on what has worked and can be considered good practice and also what did not work have been revealed to guide future initiatives.

Thematic Focus

Bio-Innovate is the only initiative in the region that applies an integrated approach linking sustainable agriculture with agro-processing and value addition and agro-industrial waste management, as well as innovation policy analysis (Fig 1). The Program targeted two main challenges while cognizant of innovation policy limitations necessary to support uptake of technologies. These included poor productivity of important traditional staple crops compounded by effects of climate change and a lack of sustainable mechanisms of adding value to agro-produce and efficiently managing resultant waste as well as use of scarce land and water resources.



TECHNOLOGY INNOVATION PLATFORM

Bio-Innovate applied an innovation systems approach to catalyze the translation of research outputs to innovations in a manner that is sustainable and has impact. The platform is a mechanism for creating effective partnerships to help in moving research outputs and technologies developed by the public sector institutions in partnerships with the private sector further along the innovation chain and to the market place.

The technology innovation platform provided mechanisms in which technologies could transit from more controlled laboratory and experimental environment in the research and academic settings and be tested and applied in the "real world" thus taking the innovations closer to the end users. Through this platform specific services were provided to support product development including project management support, technology incubation and pilot-testing, intellectual property audit and freedom to operate assessment, feasibility and techno-economic analysis, capacity building at both technical and business level as well as innovation policy analysis (Fig. 2).

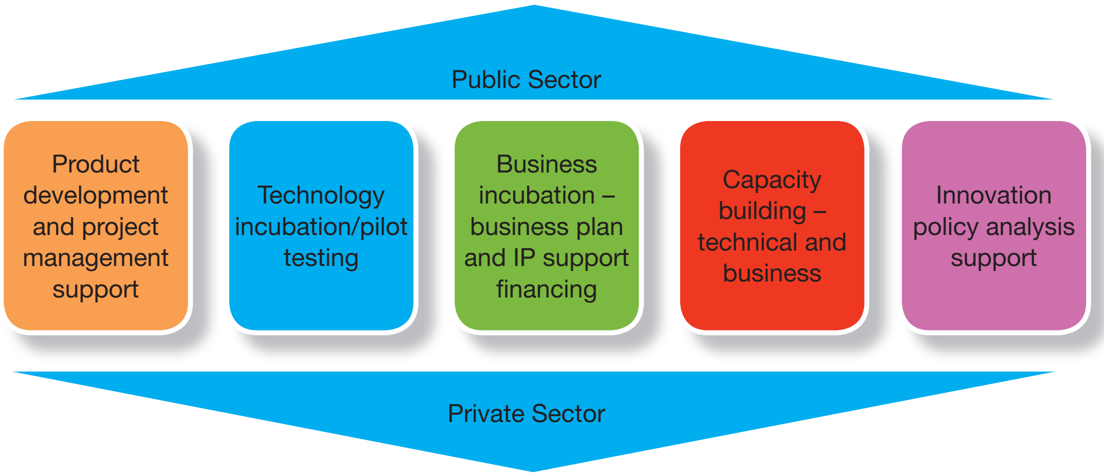


Figure 2: Technology Innovation Support Services

MOVING TECHNOLOGIES ALONG THE INNOVATION CHAIN

The primary goal of Bio-Innovate is to create effective partnerships along the innovation chain necessary to move technologies closer to the end users. The technologies developed in Phase I were funded at pre-proof of concept stage but have moved along the innovation chain and are at varied stages from proven concept, pilot-testing and technology demonstration to full-scale application. The illustration below (Fig. 3) depicts the different stages of the innovation chain employed by Bio-Innovate and the current status and placement of the eight technologies developed in phase I.

1. Proof of Concept: At this stage technologies have been proven to work at controlled experimental environment i.e. laboratory or experimental field.
2. Technology Incubation: At this stage technology has been proven to work after pilot-testing in expected conditions and environment with the participation of end users.
3. Commercialization: At this stage technology has been proven to work either at pilot or full-scale in the final form and adopted by end users at a pilot-scale.

The main achievement of Bio-Innovate Phase I is the demonstration that it is possible to create bioscience innovation platforms around specific technologies that brings together the public and private sector to generate and move bio-innovations along the innovation chain. However sustainability of these platforms will depend so much on the market forces driving the demand for these solutions.

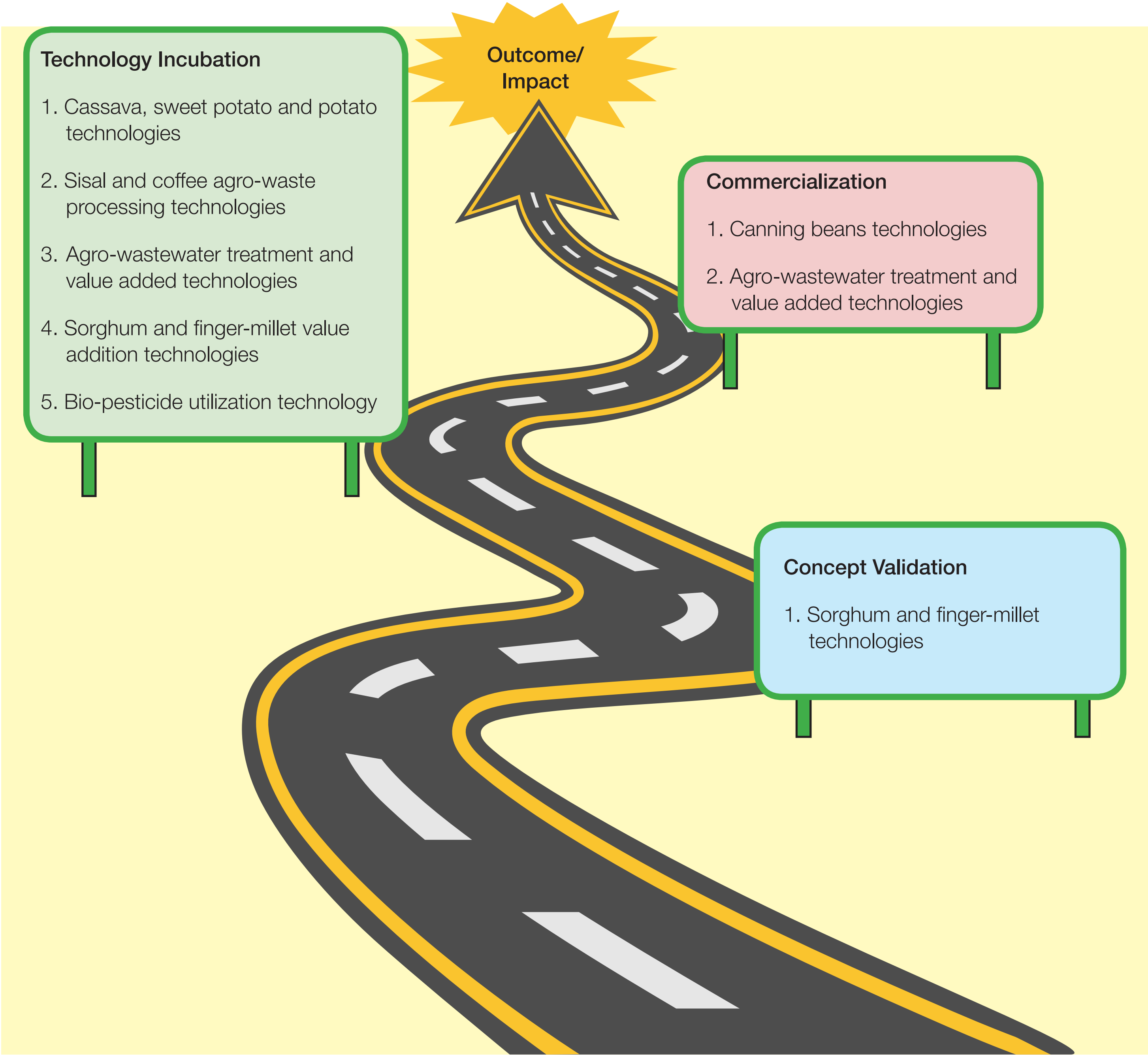


Figure 3: Pathway to impact: Technology development status of projects at end of Phase I

njoro Canning Factory (K) Ltd
Golden Valley
Delici

ADDRESSING FOOD AND NUTRITIONAL SECURITY CHALLENGES

The focus was on generating and promoting technologies for strategically important crops for smallholder farmers and rural communities in the region i.e. sorghum, finger millet, beans, cassava, sweet potato and potato. The aim was to unlock the genetic potential of these crops to not only improve agricultural productivity and mitigate challenges posed by climate change but also meet market needs. To leverage the genetic resources available, conventional breeding techniques were employed. Tthe new advanced molecular breeding tools developed will considerably improve the efficiency of developing robust and superior varieties in the region. Also modelled for the first time was a private sector-led micro-propagation seed system for the vegetatively propagated crops such as cassava and sweet potato, which makes virus-free planting material affordably accessible to farmers.

Tailoring breeding programs to meet industrial and consumer demand: The case of canning beans

The bean innovation team focused on simultaneously addressing both agronomic challenges affecting beans in the region and also industrial and final consumer quality needs. After several years of careful selection and evaluation of existing germplasm in the region, the bean consortium that included research organizations from National Agricultural Systems, Universities and International research centers as well industrial players, is on its way to solving a 60 year problem that has afflicted the canning bean industry in the region and export market due to lack of high quality seeds that are drought and disease tolerant but that also meet industrial quality.

"Our company has been operating below capacity due to lack of good quality bean grain for canning. We have the capacity to produce over 200 tons of canning beans annually but currently only handle a fraction of this due to supply limitations. The quality of beans we buy from farmers and middlemen for has over the years deteriorated such that 10% of the grain obtained is discarded during sorting for not meeting the canning processing standards. This project is therefore offering a timely solution to this challenge by developing superior bean varieties that also meet canning requirements while also creating a dependable supply chain from farmers for our company to use."

Patrick Njiru, Director, Trufoods Kenya Limited

60%

Increase in yield that has been realized from the new bean varieties

Seven new varieties have been validated by regulators and registered in Kenya (six) and Ethiopia (one) and ten are expected to be released within the next one year in Ethiopia (two), Tanzania (three), Rwanda (three) and Burundi (two). Some of the new bean varieties show up to 60% increase in yield and could be a steady source of income for the farmers. In the example of Kenya, that has a strong canning industry, the two industrial partners involved in the project, Trufoods and Njoro Canners Ltd., require a total of 600 tons to meet immediate market demands and to export 200 metric tons of the new canning bean grain annually with an estimated value of USD 2.2 million. In 2015 about 40 farmers were contracted by the bean processing companies using the newly developed lines on a pilot-scale and are expected to earn handsome returns from their produce.

The consortium has also disseminated 167 tons of improved drought tolerant bean seed along with agronomic packages in the five countries directly reaching 213,000 farmers and indirectly 640,000 farmers. In the farming communities that have benefited from these new technologies, the current farmer estimated production of these beans is 28,800 metric tons annually, an increase of about 50% compared to previous production levels. Since some of these lines are richer in micronutrients, the consumption of these beans is expected to improve nutrition both in the rural and urban communities.

Public-private seed system partnership is expected to address productivity challenges for cassava and sweet potato

Sweet potato, cassava and potatoes are staple crops in the eastern African region and play a key role in providing food security to many resource poor rural homesteads, and in particular regions that traditionally have poor soils, degraded environment (pests and diseases) and the uncertainties resulting from climate change. Climate change and lack of adequate quantities of quality planting material are major constraints to cassava, potato and sweet potato production in the eastern African region. Because these crops are vegetatively propagated, they frequently accumulate pathogens in successive crop cycles resulting in reduction in yield and quality. Application of tissue culture and disease diagnostics techniques offers the possibility of rapidly multiplying quality declared planting material (QDPM) for these crops. The lack of a system for clean planting material particularly for sweet potato and cassava and guidelines for quality control leads to up to 80% loss of produce due to low quality vines and diseases.

> *"Since I started using clean and improved sweet potato vines from a local vine multiplier, my production has inceased from 3 tonnes per acre to 8 tonnes. I started sweet potato farming in 2009 and with money from it, I have built myself a house, married and am now able to support my wife and child"*
>
> **Mawesse Ronald, Mpigi, Uganda**

The consortium composed of research organizations and private micro-propagation companies set out to address these challenges including evaluating elite lines suitable for different agro-ecological zones, testing a model seed system for delivering clean planting materials to the farmers and developing and optimizing protocols for rapid multiplication of plantlets.

Over 20 varieties of sweet potato exhibiting disease resistance and drought tolerance adaptable to diverse agro-ecological zones in Kenya, Uganda, Ethiopia and Tanzania were identified. Nine varieties of cassava with similar characteristics were also identified in Uganda and Tanzania. In addition to farmers accessing these resilient varieties, they will also be conserved as useful parentage for future breeding activities.

Identifying these varieties without a sustainable clean seed delivery system that ensures farmers have access to disease-free planting material in a timely manner will negate any gains made. A model seed system involving research institutions, micro-propagating private sector players and NGOs that rapidly multiplies quality sweet potato plantlets was tested in Uganda and Kenya. This was a three tier system: Stage I and II involved the research and private sector facilities equipped with accredited tissue culture laboratories and screenhouses producing and multiplying virus free plantlets; in stage III multiplication was done in the open field by certified vine multipliers, typically entrepreneurial famers, who subsequently supplied generation 1 "seed" to neighboring farming communities. The model showed promise because famers were willing to pay for the clean vines having seen a 30-80% yield advantage. The sustainability of the system is particularly very promising in Kenya due to high demand for planting material for cassava and sweet potato as a result of government efforts to have famers diversify from growing maize after the outbreak of the maize lethal necrosis disease that has devastated the crop. This model system will therefore need to be scaled up for impact.

30-80%

Yield advantage realized by the farmers from using clean sweet potato vines

Underpinning all these activities was the optimization of protocols and procedures for rapid multiplication of tissue culture plants in the laboratory, screenhouse and in the field including protocols for diagnosis of major viruses and rapid multiplication for sweet potato vines. Some of these protocols have already been adopted by the micro-propagation companies in Uganda and Kenya for rapid in vitro sweet potato multiplication.

Applying advanced molecular tools to improve crop productivity and mitigate climate change for sorghum and finger millet

Sorghum and finger millet are two of the so-called orphan crops that have been perpetually underfunded but have potential to improve the livelihoods of rural communities and food security. To fully exploit available genetic resources, advanced molecular breeding tools will need to be developed and integrated into national

breeding programs in the face of complex emerging biotic and abiotic stresses compounded by climate change.

To address climate change effects that have led to erratic rainfall and relatively drier conditions, 7 candidate drought-tolerant sorghum varieties from Kenya and Tanzania and 3 stay-green sorghum varieties from Ethiopia have been developed and recommended for commercial release in those countries. A total of 15 promising drought-tolerant finger millet lines were identified in Ethiopia, Kenya and Tanzania while one line from Kenya that is very early maturing recommended for release. A total of 634 finger millet landraces and 121 cross-compatible wild accessions were collected, conserved and characterized and will be invaluable sources of desirable genetic material for future crop improvement. In addition, novel stay-green sorghum lines identified in Ethiopia will be used to improve promising farmer-preferred varieties as the next step in breeding for drought tolerance.

Advanced breeding tools were developed that will enable transition of finger millet breeding from the slow traditional methods to a more efficient breeding process that generates higher yielding varieties with resistance to biotic and abiotic stresses within a relatively short period of

time. The next step is to fully integrate these tools to modernize mainstream breeding programs. The first steps towards this objective have been taken with training and exposure of breeders from Ethiopia, Kenya and Tanzania to genomics and bio-informatics tools as well as acquisition of molecular breeding tools.

Microbial bio-control technology for smallholder farmers in eastern Africa

Diseases and insect pests are of particular concern in vegetable production, and synthetic chemical inputs are regularly being used by farmers. The synthetic pesticides have toxic effects to producers, consumers, non-target organisms and the environment. Regulators around the world are advocating for stringent standards to protect consumers. Microbial biological control offers an alternative to chemical pesticides used in crops. Unfortunately, biological control is not yet used to its fullest potential in eastern Africa despite its potential for vegetable and cereal crops grown especially by smallholder farmers.

A team of researchers from Kenya partnered with Real IPM Ltd, a bio-pesticide company, to develop bio-enhanced seeds/ seedlings capable of withstanding high damping off diseases – diseases that kill or weaken seeds or seedling before and after they germinate. This has resulted in higher yields in the field among the farmers who were involved in the project. Yield increase was attributed to a stronger seedling in the nursery. The technology allowed for seed dressing using the bio-pesticides formulated from *Bacillus subtilis, Trichoderma asparellum* and *Metarhizium anisophilae*.

50%

Reduction in root rot severity after seed treatment with bio-pesticides

This is a wet method that requires smallholder farmers and small seed dressing companies to obtain the bio-pesticide in powdery form and coat the seeds before planting. The project further determined that bio-enhanced seeds/ seedlings synergistically interacted with synthetic fertilizers in promoting plant growth. Two of these products have been registered in Kenya, Tanzania and Ghana while the registration process has been initiated in Ethiopia and Uganda. In addition, a team from Ethiopia has developed two other microbial (fungal) control agents and one auto-dissemination trap for control of sorghum chaffer, validated and are recommended for commercialization.

As an immediate outcome, the farmers involved in the project have realized a reduction in damping off disease incidences and delayed onset of late blight. In the seed industry, the project has stimulated the demand for the bio-enhanced seeds technology. Seed companies in Kenya, Tanzania and Ethiopia have expressed interest in trying the seed coating technologies using bio-pesticides. As a result of various stakeholder meetings held by the consortium, relevant policy makers in the region now understand the usefulness of the technology and its potential for horticultural production.

Although the seed coating technology was only tested on maize and tomatoes, there is considerable opportunity to scale out the technology to a larger range of seed crops including beans, rice, sorghum, wheat, barley, and other vegetables (onion, cabbages, kales). Further, market positioning and explorative studies to identify competitive products in the market and possibilities of combination with other synergistic products are needed. Dry dressing methods that prolong the shelf life and allow for seeds to be bought by famers already dressed will also be very useful in the future.

Adding Value to Agro-produce will expand Agribusiness Opportunities

Adding value to agro-produce has been touted as one of the best way of creating agribusiness opportunities and wealth for African countries given their heavy reliance on agriculture. Sorghum and finger millet are important traditional crops native to Africa. However, commercialization of sorghum and millet based products has been limited by low added value, as well as poor quality and short shelf life of traditional products made from the two cereals. Currently, these two cereals are used at household and cottage levels to make stiff, and soft porridges and alcoholic beverages with perceived low quality. This may be improved through judicious application of biosciences

18%

Increased plant height after seed treatment with bio-pesticides

> *"This project provides a platform for small scale millet farmers across eastern Africa to increase their potential in farming millet and also providing a reliable millet supply for private sector industries."*
>
> **Nirav Patel, Director Simple Foods Limited**

alongside business and entrepreneurial approaches transforming what is considered as low value crops to competitive value added products on the market that would deliver food security and improve the livelihood of famers.

Creating partnerships with local food processors and addressing their key technology challenges/needs would increase the diversity and competitiveness of value added sorghum and millet products on the market and improve product quality and consistence thus creating new market opportunities. This in turn provides the demand for sorghum and millet produce which creates a steady market for the two cereals with benefits accruing to the farmers and other players in the value chain.

A regional consortium was established to exchange and share sorghum and millet-based product technologies among the three partner countries – Uganda, Ethiopia and Tanzania through academia-industry partnerships. Technologies for commercial production of clear malt drink, instant flours, complimentary composite flours and snack products from

sorghum were developed in partnership with industrial processors.

As a result of this project, clear malt drink and instant sorghum flour are already on the market shelves in Tanzania and Uganda, respectively. An Ethiopian food processor (GUTS Agro-industry) has branded sorghum snack and flour as bio-enriched products and launched them on the market. Currently about 850 metric tons of sorghum and millet are required in the first year for the production and marketing of clear malt drink and instant sorghum flour in the participating countries. This will initially benefit 1,100 farmers but this number is likely to increase as the performance and popularity of the products among healthy conscious urbanites increases. These technologies should be out-scaled widely in the region to increase the number of enterprises and volume of products with concomitant benefits to more sorghum and millet farmers.

Converting Agro-Industrial Waste into Business Opportunities: From noxious wastewater to energy, bio-nutrients and reusable water

Environmental pollution from industrial activities is a serious problem in eastern Africa with less than 10% of industries treating their waste to any degree before discharge to environment. The current treatment processes in the region do not integrate pollution reduction, energy and nutrient recovery from agro-process waste and are designed to primarily meet regulatory emission standards. Therefore, processes that add value along the waste treatment chain are necessary strategies to complement environmental and global climate change mitigation efforts.

99%

Efficiency of the wastewater treatment technologies developed by the project in Tanzania, Uganda and Ethiopia

A project was conceptualized to develop innovative approaches adaptable to local environment for wastewater treatment that not only focuses on meeting environmental standards but also resource recovery. The innovation developed involves treating the wastewater through a two-step process involving bio-digestion followed by a polishing step using a constructed wetland that purifies the water further to meet national discharge standards.

As an immediate outcome, the treatment plants installed at the three sites in Tanzania, Uganda and Ethiopia resulted into 99% removal of pollutants thus meeting effluent discharge standards and a total of 7280 m^3 of methane is captured as biogas which is combusted to recover energy and release carbon dioxide (a less harmful gas). The process also generates nutrient-rich sludge that can be used for crop cultivation and as nutrients for hydroponic systems.

In Tanzania, focus was on optimizing biogas production, water reuse and nutrient recovery from banana wine processing at Banana Investments Ltd (BIL). The company, located at the heart of a rural community in Arusha, processes 25 metric tons of peeled ripe bananas per week to produce wine. The process results

in about 400 m^3 of high-strength wastewater per day that is dumped into the environment. The enterprise unsustainably uses 3600 m^3 of wood fuel and diesel oil costing the company in excess of USD 50,000 per annum. A full-scale integrated wastewater treatment system has been installed that purifies the wastewater and generates 100 m^3 of biogas gas per day that is used to supplement industrial diesel oil used in the boiler. A certificate has been issued to BIL by regulators certifying that the treated effluent meets Tanzanian standards in all parameters and can be used for irrigation of crops. The treated water has been redirected for reuse in a fish pond and for agricultural activities in neighboring farms. This particular partnership is a perfect example of how to leverage the knowledge base at the university and dynamism of the private sector to address a societal problem. Banana Investment Ltd provided significant matching funds for the team to realize the full-scale installation.

"In addition to treating the wastewater, this innovation would generate biogas that could be used in meeting the factory's energy needs, help it adhere to set emission rules, and save energy costs by using generated biogas. BIL is expected to save about 300 litres of furnace oil per day, which costs 8 million Tanzanian shillings (equivalent to $5,000) every month."

Adolf R. Olomi Banana Investments Limited, Tanzania

In Uganda, the focus was on biogas production, water reuse and nutrient recovery from slaughter waste at an abattoir located at the heart of the capital city Kampala. Kampala City abattoir has a slaughter capacity of 900 livestock per day, generating on average 400 m^3 of high strength wastewater per day. This highly polluted effluent contributes to nutrient enrichment and oxygen depletion of Lake Victoria. Following the installation of the pilot-plant, close to 40% of wastewater generated is treated, generating about 20 m^3 of biogas per day that supplements up to 80% of energy costs. The biogas is used to run a generator that powers security lights, deep freezers and refrigerators helping the abattoir save about USD 2,400 per month. The system not only meets regulatory effluent discharge standards but also generates nutrient-rich sludge for cultivation of vegetables, flowers and nutrients for hydroponic systems. Discussions are ongoing with the owners of the abattoir to scale-up the plant to handle 100% of the waste.

80%

Reduction in charcoal usage after installation of treatment plant at Kampala city abattoir

In Ethiopia the technology developed is treating tannery wastewater from Modjo Tannery Ltd. The tannery generates 4500 m^3 per day of noxious wastewater which is discharged to Modjo river, that feeds into Lake Koka. Downstream communities use this lake for irrigation and other domestic activities and this poses a health risk to these communities. Through this pilot facility the tannery is able to treat about 10% of the waste to produce 20 m^3 per day of biogas (with potential for much more) that is used to offset the energy costs and removal of 99% of the residue heavy metals and organic matter. The biogas is used to run a generator that powers the security lights and cooking activities. The treated water can be reused in floor cleaning processes within the factory. The annual energy expenditure by the tannery is estimated at USD 52,000. If installed full-scale, the pilot plant can result in energy costs savings of up to USD 28,500 per year. Discussions are underway on scaling up.

Translating sisal and coffee processing waste into mushroom and biogas

Kenya and Tanzania are large producers of sisal, *Agave sisalana*, with a number of large plantation estates and processing factories. The

sisal sector is considered one of the highest waste producer primarily because from the sisal plant biomass, only 2% is utilized in the sisal production process while 98% of it is considered waste. As a result, the sector generates 20 million tons of wastewater and 5 million tons of solid decortification annually. Ethiopia and Kenya on the other hand are big exporters of coffee and therefore generate huge waste. Coffee processing discards 99% of the biomass generated by the coffee plants at different stages from harvesting to consumption. Ethiopia alone is estimated to generate more than 2 million m^3 of wastewater, 400,000 tons of husks, 70,000 tons of pulp and 12,000 tons of parchment per year. This waste is mostly burnt or dumped on farms contributing to environmental pollution. There is potential to add value and more efficiently utilize this agro-waste. However this is hampered by lack of appropriate technology.

"Kilifi Plantations Limited fully supports the partnership with project 4 as it offers opportunities for more efficient land use while finding alternative use of sisal waste in an environmentally sustainable way. The waste generated from the sisal decorticating process is used to generate biogas. The biogas generated is converted to electricity to augment the energy needs for the farm. The growing and production of the mushrooms is envisaged to add another revenue stream to our operations and create more employment opportunities."

Betty Bundotich Banana Investments Limited

6000

Liters of biogas produced per day from the pilot plant at Alavi sisal estate in Tanzania

A research team from Tanzania, Ethiopia and Kenya sought to demonstrate in partnership with private sector partners that these wastes can be put to good use. Three pilot plants capable of producing 1 ton of mushroom per month, using sisal waste as substrate, have been installed at Mohammed enterprise and Kilifi plantation in Tanzania and Kenya respectively, and using coffee waste as substrate at Horizon Ltd in Ethiopia. The team has gone further to demonstrate that the residue resulting from mushroom production can be used for biogas production. However, the economics of producing biogas this way needs to be investigated further. Moreover in order to consume a significant amount of the waste, a reliable market for the mushroom produced would need to be found.

Enabling Policy and Regulatory Environment is Essential for Uptake of Bio-innovations

For bioscience innovation to thrive and translate the vast bio-resources in the region into products and services that create wealth, there has to be an enabling ecosystem that supports innovation processes. The role of governments is critical through formulation of the right mix of policy and regulation that provide the link between

government, business and academia. Eastern African countries could benefit from bioscience innovations that address local needs, create job opportunities and increase household incomes. However, this is constrained by inadequate policy support mechanisms to move bioscience technologies and other research products to market.

The bioscience innovation policy consortium for eastern Africa (BIPCEA) was designed to help Bio-Innovate scientists understand policy issues that affect translation of their research outputs into useful goods and services in society, and where possible support the scientists to tease out the policy issues. The working hypothesis for the project was that bringing bioscience technologies to market requires, among other things, policies that facilitate linkages between local private actors, academia and the public sector in bioscience research and innovation processes. The aim of such polices is to create opportunities for bioscience business incubation, improve intellectual property management and technology licensing, facilitate access to genetic resources and supporting evolution of a more sustainable financing and incentive mechanisms that would support bioscience innovation processes in the region.

The Project was a collaborative effort between Councils/Commissions and Ministries for Science and Technology (S&T) in eastern Africa, and regional and international S&T organizations and universities. Participating countries included Ethiopia, Kenya, Tanzania and Uganda and to a less extent Burundi and Rwanda. The key outputs from the project included:

- An assessment of Bio-Innovate Program from an innovation system perspective that revealed the need for more specific policies, incentives and financial mechanism for bio-innovation in eastern Africa. This includes the need to focus on building functional bioscience innovation systems and the promotion of bio-innovation business incubators in the region.
- A review of STI policies in eastern Africa that revealed that all the countries have STI policies but their broad nature makes them ineffective and hinders their implementation.
- Specific policy and regulatory intervention strategies on policy and regulatory incentives for adoption of innovative solutions for agro-industrial wastewater management and utilization bio-pesticides for Kenya, Uganda, Ethiopia and Tanzania.
- Stakeholder analysis for bio-innovate projects that mapped out the roles of the various actors along the value chains, and policy limitations.
- Bio-Innovate scientists trained on basic intellectual property (IP) management and equipped with tools for conducting intellectual asset inventory.
- Initiated and spearheaded the compilation of a flagship publication entitled: "Bio-Innovate: Fostering a Bio-economy in the Eastern Africa Region".

A significant outcome of the project was project partners and other relevant stakeholders including key government S&T agencies in eastern Africa agreeing with the study findings and recommendations for policy actions to support the process of moving specific bioscience technologies to market.

Some key learning opportunities observed in the course of project implementation included:

i) the need to engage and link stakeholders early on from inception and throughout project implementation;

ii) IP and freedom to operate analysis should be done early on at project inception and continued throughout project implementation;

iii) need to have clarity on sharing knowledge assets and products and their dissemination when working in consortium situation; and

iv) business cases to be developed as part of the business incubation process, or where possible, link innovation projects to professional business incubation services.

CAPACITY BUILDING ACTIVITIES IN PHASE I

The clamor to transit into knowledge-based bio-economies by countries in the region will remain elusive unless there is a continued heavy investment in training not only in the traditional technical fields but also on how to create and manage intellectual assets as well as business development and bio-entrepreneurship.

Bio-Innovate applied an integrated approach to capacity building that embedded technical training into product development activities. Phase I did not supporting tuition for graduate students but made exceptions for students from Burundi and Rwanda with 3 students at master's level being supported. However, in the course of projects implementation, the program supported research activities for 45 students – 38 masters and 7 PhD. This was a cost effective way to procure cheap but high quality labor that contributed significantly to product development but at the same time offering advanced training opportunities and resources. The outcome of the capacity building activities is the generation of the aforementioned technologies and publication of over 50 peer reviewed articles in international journals in the past four years.

The program also supported short courses for scientists varying from highly technical fields like bio-informatics and genomics for breeders to intellectual asset management and fundamentals of business development. Thirty scientists benefitted from these courses.

Business Development and Accelerator Training Course was offered to 10 of the scientists drawn from three projects that are considered to be at commercialization stage to instill basic business development knowledge to support anticipated commercialization processes.

In total, training and awareness raising activities involved 400 scientists, market actors and policy makers directly connected to projects activities.

45

Number of students supported (38 masters and 7 PhD)

50

scientific articles published in in international journals

400

Number of scientists, market actors and policy makers directly connected to projects activities that were trained

LESSONS LEARNED

The Bio-Innovate program is occupying a critical but challenging space in the research to impact pathway in the region, linking bioscience research outputs with outcomes and eventual impact. This space represents what is sometimes referred to as innovation processes that are often complex and require contributions from different actors.

On the basis of what has been achieved thus far, it is apparent that the technical performance and viability of the projects has been demonstrated. However their commercial potential requires rigorous assessment followed by the requisite support if these outputs are to translate into products and services that will impact the society in the medium to long term. In trying to address this gap, the program conducted intellectual audits of some of the technologies to assess need for protection and/or infringement if taken to the market, as well as techno-economic analysis to evaluate their social and economic potential.

From our experience there is a general lack of appreciation especially in the scientific community on how to manage knowledge and intellectual assets and genetate value as well as the processes of translating research outputs to impact. This is compounded by a general lack of a functional innovation landscape in the region and minimal incentives for bio-entrepreneurship. In trying to inculcate innovation processes into research activities in the region, the program has learned some valuable lessons as discussed here.

What Worked Well

- *Academia-private sector partnership is essential in moving research outputs closer to end users:* This collaboration has significantly increased the chances of the technologies moving towards a larger scale of deployment due to a number of reasons: firstly, the demonstration that the technologies are viable and ready for scale up was critical for buy-in by the private sector to provide needed scale-up investments. Secondly, the partnership also provided a direct feedback loop that shaped the product development process to meet market needs. Thirdly, the fact that the private sector is more dynamic and knowledgeable on market issues and deployment.

- *Creation of innovation platforms involving south-south-north partnerships provided crucial technology backstopping support:* There has been an exchange of useful know-how and biological resources amongst the regional partners and also from global collaborators from Denmark, Sweden, India, USA and Germany, contributing directly to the generation of technologies. This lays the foundation for a regional innovation platform in biosciences augmented by strong South-South-North collaborations.

- *Strengthening regional capacity to utilize bio-innovation as a tool for development:* To a large extent the program has successfully contributed to the development of an innovation mentality with the hope that the community of innovators will share positive experiences within their own institutions and beyond. The academia and private/market actor partnerships demonstrated various models of how to integrate biosciences R&D with techno-economic and market analysis, and the complex issues around up-scaling and commercialization.

- *Provision of project management support:* Provision of project management backstopping support to implementing institutions in the region helped overcome bureaucratic and time consuming procurement processes that hamper product development processes. Applying results-based management approach was also very useful in changing the way projects were being managed with more focus on results and consequently monitoring and reporting of achievement was captured in terms of those results.

What did not Work Well

- *Developing, pilot-testing and deploying innovations need sufficient time and resources:* It was too ambitious and unrealistic to assume that innovations could be developed and/or pilot-tested and deployed in 3-4 years taking into consideration time, resources, expertise and infrastructure particularly with the public sector institutions taking the leading role in the product development process. The public sector has inherent systemic weaknesses that significantly slow down the product development process.

- *Lack of business input in the initial design of innovation projects:* A major problem in Bio-Innovate projects was that in the initial design there was more emphasis on technical aspects with little rigor put on clear business strategy, exit plan and framework for who potential beneficiaries should be. Though there were belated efforts to address this, there were numerous missed opportunities.

- *Private sector was not adequately incentivized to put in matching funds:* The program and public sector partners that took the lead in project development lacked the knowhow to strongly negotiate for matching funds from the private sector, leading to lopsided investments in the projects. There is need for clear framework right from the beginning that stipulates how resources and intellectual property are to be shared.

- *Disconnect between the policy and practice:* The policy analysis project was not sufficiently integrated within the innovation projects to help in identifying policy intervention that support uptake of various innovations in the region. This limited interaction between the policy team and the project innovation teams led to inadequate connection between policy and practice.
- *Lack of support for business development:* There was inadequate business expertise in the execution of the program necessary to provide project teams with business development and incubation support.

CONCLUSIONS AND RECOMMENDATIONS

Bio-Innovate has successfully demonstrated that the region has good capacity to conduct and deliver bio-innovations and that the private sector is eager to participate if appropriately incentivized. However, a lot more needs to be done particularly by national governments to develop supportive ecosystems for bio-innovation to thrive.

In the current phase, the technologies developed have transited from the experimental environment and pilot-tested and validated in the “real world” and shown to work. For the medium to long term outcomes to be realized, these technologies and products would need to be scaled. This requires resources from multiple sources beyond the traditional donors including social and commercial investors as well as private financiers.

It is therefore critical that the anticipated second phase of the Program comes to fruition to ensure that products generated are fully and widely adopted by end users for impact.

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