

External Evaluation of Sweden's Support to Bioscience Research and Innovation in Eastern Africa through BIOEARN and BioInnovate Africa Regional Initiatives



SIDA'S 20 YEARS OF SUPPORT FOR BIOSCIENCE RESEARCH
AND INNOVATION ADOPTION IN EAST AFRICA;
EVOLUTION AND ACHIEVEMENTS, A REVIEW OF PROJECTS
FUNDED UNDER BIOINNOVATE AFRICA PHASE II AND
RECOMMENDATIONS FOR A FURTHER PHASE.

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Acronyms and Abbreviations

AU	African Union (AU)
BA-FWS	BioInnovate Africa Fellowship for Women Scientists
BecA-ILRI Hub	Biosciences eastern and central Africa – International Livestock Research Institute Hub, Nairobi, Kenya
BIOCon	BioConversion Technology Africa Company Limited
BSF	Black Soldier Fly
CAADP	Comprehensive Africa Agriculture Development Programme
CGIAR	Consultative Group on International Agricultural Research
COVID-19	Coronavirus disease 2019
EA	East Africa(n)
EAC	East African Community
EASTECO	East African Science and Technology Commission
ICT	Information and communication technology
ILRI	International Livestock Research Institute, Nairobi, Kenya
IP	Intellectual Property
ITEC	Innovative Technology and Energy Center
IUCEA	Inter University Council of East Africa
JKUAT	Jomo Kenyatta University of Agriculture & Technology
KIRDI	Kenya Industrial Research Institute
M&E	Monitoring and Evaluation
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries, Uganda
MoU	Memorandum of Understanding
NassARi	
NEMA	National Environment Management Authority, Kenya
NEPAD	New Partnership for Africa's Development
OAU	Organisation of Africa Unity, the predecessor of the African Union
OFSP	Orange-fleshed sweet potato
PAC	Program Advisory Committee
PASET	Partnership for Skills in Applied Sciences, Engineering and Technology
PMO	Program Management Office
PS	Private Sector
R4D	Research for Development
RSIF	Regional Scholarship and Innovation Fund
RWDT	Refractance window drying technology
SEI	Stockholm Environment Institute, Sweden
SEK	Swedish Krona
SFTNB	Makerere University School of Food Technology, Nutrition and Bioengineering, Uganda
Sida	Swedish International Development Cooperation Agency
SME	Small and Mid-sized Enterprise
STI	Science, Technology and Innovation
TARI	Tanzania Agricultural Research Institute
TFRA	Ministry of Agriculture's Tanzania Fertilizer Regulatory Authority
TVET	Technical Vocational Education Training
UNBS	Uganda National Bureau of Standards
UNCST	Uganda National Council for Science and Technology

Executive Summary

BioInnovate Africa Phase II supported 20 projects under three themes (policy, value added products and value added agro/biowaste) between 2018 and 2021. This was the most recent Phase of Sida's support for bioscience in East Africa with each phase building on previous ones, and each with a design modified in response to the lessons from previous phases.

This review found that most Phase II projects had met their milestones despite the impact of the COVID-19 pandemic throughout much of 2020 and continuing to constrain the program up to the time of the review (January – March 2021), with four projects progressing to the stage where they were launching products into the market.

Notwithstanding the achievements of most projects, each was confronted with constraints ranging from regulatory approvals, procurement, institutional policy, IP management, market analysis, and scaling up. However, the review found that the project teams, supported by the Program Management Office (PMO) were able to respond and advance towards their goal in the program, which is increased food and nutritional food security, environmental health and reduced poverty.

Continuing the commitment to support the development and implementation that began in the very first Phase of BioEARN in 1999, a project to develop a Bioeconomy strategy for East Africa was supported under this current Phase. That strategy is now published and is potentially one of the most important outputs from Phase II.

In addition to project delivery, the review found that the tradition of capacity development continued in Phase II. Capacity building included supporting 10 PhD and 22 MSc graduates, and 36 Fellows under the BioInnovate Africa Fellowships for Women Scientists program. Capacity building in this phase outside the more formal training covered a range of issues including business development, regulation, IP management, project implementation and financial reporting with the training being delivered to all projects by the Business Development manager within the PMO, a new position under this phase. That training is one of the major factors in enabling BioInnovate Phase II to achieve such the degree of success it has, and which is beyond what can usually be expected from endeavors of taking biosciences, and other technologies, to market.

BioInnovate is widely considered across the East African innovation system to be a mature and key participant in helping bioscience play the role it should in the subregion. It has achieved that reputation by being attuned to the innovation system's strengths and weaknesses and understanding how it can best support bioscience's contribution to the subregion. Nevertheless, even greater efficiency and effectiveness can be achieved with further refinement. This review recommends a further 5-year phase of the program so that the recommendations from this review can be implemented whilst benefitting from the continued support of Sida. That next phase however should prioritise sustainability of BioInnovate Africa as a legal entity or as a more independent program.

The review has made 10 recommendations for consideration in the design and implementation of a future BioInnovate Phase. These are:

1. **New Phase:** That Sida continue its support towards bioscience and bioeconomy in East Africa through another 5 years BioInnovate Phase.

2. **Adaptive Management:** That a new BioInnovate Program introduce a stronger adaptive management approach with:
 - a. A stepwise approach to project development be introduced whereby selected projects will be supported for 6-9 months to fully develop key plans for critical aspects of project development such as procurement, management of IP, business development, team membership and market analysis before seeking to gain final approvals to advance to full project status.
 - b. The number of projects/partners supported in full by BioInnovate be reduced by about 33%.
 - c. The current mechanism for open calls be continued but that the PMO and the PAC reserve the option of commissioning projects in response to emerging priority issues.
3. **Policy:** That the design of a next Phase includes the addition of a policy specialist whose role would include steering the Phase II-developed Bioeconomy strategy plan to implementation and provide advice and support to individual projects on issues related to policy and regulation.
4. **Research Themes:** That the next phase should continue to support the same themes as in Phase II, especially projects in the public good agro/biowaste theme. The review considered that investment in health-theme projects such as those projects aiming to reduce disease vectors worthwhile. However, it is recommended that when approving projects for support, the PMO and the PAC be cognisant of the potential challenges where project delivery might be reliant on complex and expensive clinical trials.
5. **Program sustainability:** That the next phase commences transition from the status of a program supported by a single donor, to one that is a legal entity in its own right, has multiple donors and a degree of self-funding that is sourced through an expanded role in providing key services and support to subregional universities and other agencies taking their research from the laboratory to impact.
6. **Consolidation in East Africa and expansion into West Africa:** That the next phase of BioInnovate includes partnerships with suitable institutions within the new (South Sudan) and aspiring members (Somalia and Democratic Republic of Congo) of the East African Community (EAC). It is also recommended that the next phase begin to expand beyond East Africa and commence operations in West Africa, and that it does so by taking advantage of the expansion of its host institute, *icipe* into West Africa.
7. **Communication:** That the next phase design includes a greater focus on communication, especially in communication targeted towards the East African business community.
8. **PAC membership:** That the PAC membership be adjusted to move away from the current membership, which is dominated by senior researchers and senior research managers, to a membership that has representation from the business community, and an additional representative from the donor community.
9. **Expansion of PMO personnel and skills:** That the PMO be strengthened to meet the stronger focus on communication, policy and business development by the appointment of three new positions.
10. **Impact assessment and lessons from 20 years of investment and partnerships:** That priority be given in the next phase for an impact assessment of the 20 years of BioEARN and BioInnovate programs and that that assessment and the lessons from the 20 years of Sida support be the subject of at least one major peer-reviewed research paper so that the evolution of the BioEARN and BioInnovate programs in response to reflection and frequent external reviews is made available for future research for development programs.

Introduction

The BioInnovate Africa Phase II Program has been the latest phase of five, almost continuous Sida-funded programs. The first phase, BioEARN Phase I, commenced in 1999 and progressed to BioEARN Phases II and III (2006-2010), (2006-2010). The three phases of BioEARN were followed by BioInnovate Phase I (2011-2015) and BioInnovate Phase II (2015-2021) (Figure 1).

BioEARN was initiated at a time of rapid advancement in plant-based biotechnologies and their use in agricultural and natural resource research for development (R4D), and a parallel recognition by governments across Africa of the importance of Science, Technology and Innovation (STI) to national and regional economies. BioEARN Phase I and II were targeted towards supporting policy development in the participating countries, and more widely in the sub-region, and towards capacity building through both PhD sandwich scholarships and through funding upgrades of research facilities to East African bioscience laboratories. While Phase III of BioEARN ceased its support of PhD scholarships under the sandwich model, it continued to support PhD training locally through academic supervision under sub-regional senior scientists. BioEARN Phase III saw the commencement of support of research projects that each aimed at advancing proven new technologies and innovations that were considered ready for commercialisation, or in the case of public-good-targeted technologies, ready for uptake by central or local government and in some cases parastatal agencies.

The timing of the commencement and the subsequent evolution of the BioEARN/BioInnovate programs paralleled significant changes in how Africa, through its regional consortia, and its member countries, considered the potential that biotechnology could play in enhancing the livelihoods of their communities and growth of their economies. The changes in policy priorities included the establishment of the African Union (AU) in 2001 along with the New Partnership for Africa's Development (NEPAD) and, by 2003 the Comprehensive Africa Agriculture Development Programme (CAADP) was adopted with its four pillars (Box 1) that encompassed the goals of the BioEARN/BioInnovate programs.

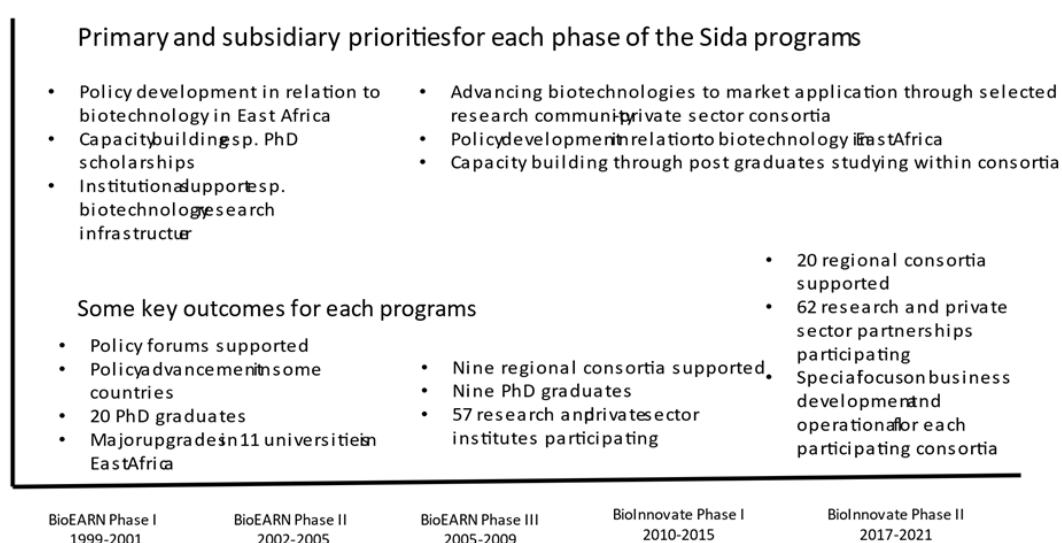


Figure 1. Overview of the five phases of BioEARN and BioInnovate programs, their priorities and some key outputs for each program.

Since its establishment in 2001, the AU goal of having Science and Technology deliver benefits for Africa has strengthened, and in 2014 it adopted a 10-year Science Technology and Innovation Strategy for Africa (STISA 2024), with its mission to “Accelerate Africa’s transition to an innovation-led, knowledge-based economy”. The BioEARN/BioInnovate programs have been well aligned with this regional goal.

Box 1. The four CAADP Pillars

- Sustainable Land and Water Management
- Market Access
- Food Supply and Hunger
- Agricultural Research

BioEARN, and later, BioInnovate Phase I and Phase II have played a significant role in building biotechnology capacity, and assisting in the development of policies at institutional, national and sub-regional levels. A large part of the program has been dedicated to supporting selected research teams to take their particular biotechnology from its origins in a research institution’s science portfolio, to either being marketed or, in the case of public-good technologies, have technologies employed to overcome significant environmental challenges. However, some of the most valuable long-term benefits of the program have been through the lessons that have been learned over those 20 years by the BioEARN/BioInnovate teams and the institutes and private sector partners that have been engaged in so many ways. These are the hard-won lessons that can be accommodated in a future BioInnovate phase and in other programs that strive to take technologies to market in developing economies in Africa and elsewhere. This review and evaluation seeks to take stock of Sweden’s support to Bioscience research and innovation in East Africa in the last 20 years (1999-2021) by highlighting the achievements, challenges, lessons learned and providing possible scenarios for future support.

This review addresses three questions (see ToR, Appendix 1).

1. Report on the performance of BioInnovate Phase II Program.
2. Report on the evolution of ideas and environment for Biosafety and the Bioeconomy in East Africa and the impact of 20 years of Swedish support since BioEARN Phase I.
3. Discuss and make recommendations towards possible continued support beyond 2022.

Methodology

The review was undertaken during the global COVID-19 pandemic, and the methodology reflected that significant constraint. One reviewer (BP) was unable to travel to the sub region and while the two Africa based reviewers (PSO and TE) were able to undertake significant travel over a 3-week period, although they were not able to visit projects in Burundi and Rwanda because of COVID-19 quarantine constraints. The East Africa based reviewers visited key stakeholders (Appendix 2a) of some Phase II projects while additional information for all Phase II projects was gathered by specially assigned, locally based review support staff who were appointed by *icipe* in each of the six countries.

Other information for the review was gathered from reports of previous program reviews, project reports and by virtual meetings with many stakeholders (Appendix 2b).

The selection of Phase II projects’ sites to visit was based on a two-stage qualitative sampling strategy, which took into consideration the duration limit of the field mission and how many

project partner interviews could be undertaken during that period, and key criteria of each project agreed in consultation with the Program Management Office (PMO). The criteria were: the program themes (value addition to agro produce, agro/biowaste conversion or policy analysis), project cohorts (cohort 1 or 2), program coverage (countries), project history (transitioned from phase I or not), project category (category 1/large investment or 2/small investment), and perceived overall performance (weak or strong).

Notwithstanding the inability to have face-to-face meetings with the Program Leader, other members of the PMO and members of the Program Advisory Committee (PAC), a critical part of the review was the frequent virtual meetings between all reviewers and the staff of the PMO who not only provided valuable insights and reflections on the current Phase and in some cases, previous phases of the Sida support period, but also provided clarification where it was required. The PMO also coordinated all travel and meetings, both face to face and virtual.

Evaluation of the projects supported in BioInnovate Phase II

The purpose of BioInnovate Phase II program was to enhance the capacity of Eastern African universities, research organizations and firms to translate modern biosciences research outputs into innovations targeting smallholder farmers and agro-process enterprises in the region. The program sought to overcome two key barriers to the translation of research results to meet the needs of users, viz., lack of private sector investment in R4D and innovation and lack of or, at least, ineffective collaboration between academia, smallholder farmers and private sector. The objectives of the program, as outlined in the BioInnovate Phase II (2017-2021) program proposal included 1) generation of biosciences innovations, 2) evaluation of relevant policy options to support scientists, and 3) establishment of BioInnovate as an independent, legally registered and not-for-profit network.

The program's outputs include generation and development of bio-innovations (knowledge, products and services), bio-based business models, new small enterprises spin-off companies, networks and partnerships and policy analysis. Delivery of outputs is expected to lead to enhanced research capacity, increased linkage and improved prioritisation and coordination of policy responses to promoting biosciences innovations. These outputs are expected to improve the benefits flowing from bioscience innovations to farmers, agribusinesses and agro-processors. Adoption of technologies is anticipated to eventually lead to increased farmers' and agro-processors' productivity, increase farmer market participation in key target markets, profitability of agribusinesses, and reduced agro/biowaste. These changes are expected to contribute to increased household food and nutrition security, improved environmental health and reduced poverty.

THEORY OF CHANGE

The reconstructed theory of change logic model represented in Figure 2 illustrates the program's pathway to increased food and nutritional security, environmental health and reduced poverty outcomes. While it shows how the planned BioInnovate actions were linked to the desired outcomes, it also highlighted the roles of BioInnovate, consortium partners (universities, research institutes and private sector) and policy makers in the delivery of the program's results. The consortium partners had a key role in the realisation of the intermediate outcomes through translation of modern biosciences into innovations and commercialising the technology to reach

the farmers and agro-processors. The policy makers had a role in the delivery of concrete results and realisation of the program impact through ownership and role in generation of useful policy interventions recommendations,

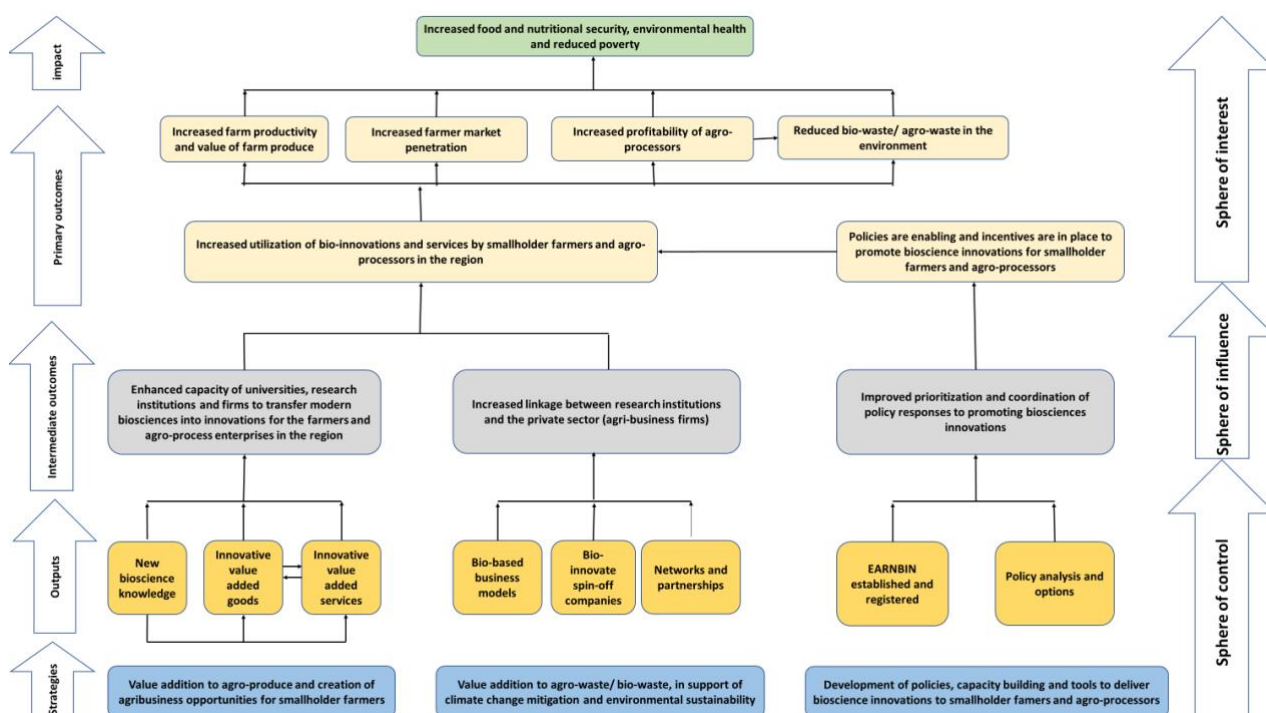


Figure 2. Reconstructed Theory of Change.

STRUCTURE AND ROLES

The BioInnovate Phase II Program is located within *icipe* at its Duduville Headquarters in Nairobi, Kenya and as such the program uses and benefits from the management and governance systems of that well-established international research-for-development institute. This hosting arrangement was negotiated between Sida and *icipe* at the commencement of Phase II.

The BioInnovate Phase II program is led by a program manager and a Program Management Office (PMO), which has Business Development and Monitoring and Evaluation specialists, and other support staff.

The PMO is supported by an advisory group, the Program Advisory Committee (PAC), whose membership is predominantly senior scientists from regional, national and Africa-based international research organisations. Although *icipe's* input into the Program strategy and management has been organic via its integration within the host agency, a more formal input into the Program is through the role of the Director of Research and Partnerships as a member of the PAC.

BioInnovate Phase II is implemented through three thematic areas:

- value addition to agro-produce

- b. value addition to agro/biowaste
- c. policy development for delivering bioscience innovations

The thematic areas build on and strengthen some of the thematic areas of BioInnovate Phase I and have an overarching objective to support innovation consortia who have demonstrated a realistic goal of delivering value to smallholder farmers and agribusinesses within the program duration of five years.

Twelve projects were supported under the value addition theme, seven under the agro/biowaste conversion theme, and one under the policy theme. The projects were selected, in part, for their potential to scale up research results to regional uptake through clear pathways to impact. A special focus was on supporting consortia who were working on technologies that had potential benefit for smallholder farming communities. The criteria for project selection included:

- alignment with the Program's overall objective
- demonstrated demand for the product or technology
- strategic value of the project to the region; scientific, technical and knowledge excellence
- incorporation of capacity building in the plan for delivery
- market knowledge
- private sector linkages
- gender responsiveness
- composition and quality of the project team
- project management (including track record of Principal Investigator) and
- a regional approach to implementation (*icipe BioInnovate Manual 2017*)

Phase II had an overall budget of SEK120.7 million (US\$13.6 million) over a five-year period. It was envisaged that 80% of the total budget would be allocated to research and innovation activities as well as policy projects. The other 20% of the total budget was to be utilized for program management and administration.

REVIEW OF PHASE II PROJECTS

BioInnovate Phase II projects were selected for support by the program through two separate main calls-for-proposals. Two calls were considered preferable to a single call as it should provide greater opportunity for projects to be put forward by East Africa consortia, and the sequencing of the two calls provided the PMO and PAC the opportunity to spread the workload but more importantly, enabled the program to make decisions of the budget allocation to projects in a more considered efficient and effective way. The decisions on funding cohort 2 projects were taken after the first round considerations were complete and contracted or well advanced towards contracting

Eleven projects (Table 1) were selected from the first call (Cohort 1) and were expected to run from the period 2018 to 2020. Eight of these projects were aligned to the value-addition to agro produce theme and three to the value-addition to agro/biowaste conversion theme.

The second cohort (2019-2021) contained nine projects. Four were aligned to value-adding to the agro produce theme, four to value adding through agro/biowaste conversion, and one to policy analysis.

A third restricted and targeted call was made in 2020 (Cohort 3 Jan-Oct 2021), from which five projects targeting improved human health in relation to COVID-19 were selected. The projects from this third cohort were not included in the review of individual projects as they had only recently been approved. However, the strategy to commence this expanded “health” theme is discussed in later sections of this report.

Projects differed considerably in size and project team composition. The PMO classified Category 1 projects, which had a maximum 3-year budget of USD 750,000 (a total of twelve), as being those undertaken by consortia, which had a background in working and partnering with the Private Sector (PS) and had progressed their technology beyond a proof-of-concept stage (Table 1).

Category 2 projects, which each had a total 3-year budget of USD \$250,000, had a project design that included new business startups rather than direct partnerships with the PS (Table 1).

Category 3 was a single project, which aimed to develop a regional innovation-driven bioeconomy strategy that would underpin an enabling environment and strengthen the innovation system.

Three of the BioInnovate Phase II projects had transitioned from BioInnovate Phase I. These were C1-3 ICT Sweet potato, C1-2 Fungal Biopesticides PROSAFE and C2-11 Agro-waste conversion and BIOCon. All other projects were new to the BioInnovate program.

While all projects were assessed from their periodical reports through discussions with the PMO, nine projects were selected for deeper examination. That selection was based on their history (transitioned from Phase I or not), the project theme, their reporting of success and constraints. All 20 projects are listed below with the nine projects selected for deeper analysis and personal visits noted.

Table 1. Projects funded by BioInnovate Phase II, their official projects number and full title. Also shown are shorthand titles for each project used in this review whether the project was subject to a full evaluation or evaluated only by reference to project reports and discussions with the PMOS.

Number	Full name	Short name	Evaluation mode
C1-1 \$748K	Adaptation and promotion of refractance window drying technology (RWDT) for production of high quality bioproducts	Refractance drying of fruits	Reports only
C1-2 \$750K	Promoting Smallholder Access to Fungal Biopesticides Through Public Private Partnerships in East Africa – PROSAFE	Fungal Biopesticides – PROSAFE	Reports only
C1-3 \$741K	Integrating ICT in Commercial Production of Quality Sweet potato Planting Material.	ICT Sweet potato	Full
C1-4 \$750K	Piloting and commercialization of economically viable leather processing technology	Leather processing	Full

Number	Full name	Short name	Evaluation mode
C1-5 \$560K	Nitrogen bio-fortified and pelletized commercial-grade organic fertilizer made from urban biowaste to improve soil productivity and livelihoods of small holder farmers	Bio-fortified N fertiliser from urban waste	Reports only
C1-6 \$750K	Promotion of post-harvest disinfestation treatment in Kenya and Uganda: Facilitation of market access for mango, avocado, French bean and bell pepper	Post-harvest fruit and vegetable treatment	Reports only
C1-7 \$750K	Insect-Based Agri Business for Sustainable Grasshopper and Cricket Production and Processing for Food in Kenya and Uganda – INSBIZ (doing well)	Insect production and processing for human food	Reports only
C2-8 \$193K	Partnership to deliver to market Striga weed resistant maize and finger millet varieties in Kenya and Uganda	Striga weed resistance	Full
C2-9 \$250K	Commercialization of Novel Sorghum and Millet Products for Improved Socio-Economic Gains in Eastern Africa	Sorghum and millet products	Full
C2-10 \$250K	Innovation and commercialization of nutrient rich mushroom substrate blocks in East Africa (OKOA Mushroom Substrate)	Mushroom substrates	Full
C2-11 \$249K	Establishment of a Regional Enterprise to Commercialize the Integrated Technologies for Agro/Biowaste Conversion in Eastern Africa – BIOCon	Agro waste conversion and BIOCon	Full
C1-12 \$746K	Using Black Soldier Fly (BSF) larvae as an environmentally sustainable source of affordable protein for chicken and fish feed	Black soldier fly for poultry and fish feeds	Reports only
C1-13 \$746K	Production, processing and marketing of catnip (<i>Nepeta cataria</i> L., Lamiaceae) products to prevent malaria in Eastern Africa	Catnip malaria products	Full
C1-14 \$750K	Development of improved semiochemical prototypes and their integrated push–pull deployment in areawide control of tsetse flies in Eastern Africa	Semiochemicals for control of tsetse flies	Reports only
C1-15 \$750K	Small-scale community biorefining of sorghum for food, sugar, and biomaterials in rain fed areas of Eastern Africa	Biorefining sorghum for food sugar and biomaterials	Reports only
C1-16 \$743K	Orange-Fleshed Sweet Potato Puree for Bakery Applications in East Africa for Nutrition, Post-harvest Loss Management, and Youth & Women Economic Empowerment	Orange sweet potato puree in bakeries	Full
C1-17 \$250K	Pro Integrating Aroma Honey Toffee and Bamboo Hives into Apiculture Value Chains in Uganda, Kenya and Rwanda	Aroma Honey Toffee and Apiculture	Reports only

Number	Full name	Short name	Evaluation mode
C2-18 \$243K	Delivering bio-alkanol gel fuel as a renewable energy source to rural households of communities living in the Lake Victoria basins	Bio-alcohol gel for fuel in L Victoria basin	Reports only
C2-19 \$250K	Bio management of coffee waste from coffee processing industries through vermicomposting and its integration with aquaculture, horticulture, and poultry	Coffee waste vermicomposting for aquaculture, horticulture and poultry	Reports only
C3-20 \$500K	Developing a Framework for Biobased Economic Growth in Africa: Vision, strategies and Policy Agendas (For-BETA)	Bioscience Policy framework	Full

Short summaries of the progress of all projects are provided in Appendix 3. Projects were given an overall rating on performance (unsatisfactory, moderately satisfactory (moderate) or fully satisfactory (satisfactory) based on the achievement of the projects against expected outcomes. They were also given a ranking on how far they had progressed towards impact using a 5-step scale that had been implemented by the PMO to define progress in projects (Box 2). The scale reflects the maturity of projects as they advance from the concept through market testing, development of an appropriate business model with partners, or as a new project specific startup company, to market launch.

It should be noted that not all Phase II projects began at the same point on this scale. Some such as those entering from BioInnovate Phase I had progressed beyond stage 2 before their activities under Phase II. The combination of the two measures ensured that assessment of progress was undertaken in all projects regardless of the starting point (proof of concept or a more advanced position), with the assessment based on achievements against expected outcomes within the agreed timelines, stakeholder's satisfaction, performance of the business model and cost.

Box 2. Stages of project advancement used in the project assessment. The scale has been developed and used by the PMO.

1. Proof of concept investigations
2. Product or prototype development & testing
3. Production of minimal viable products for market testing
4. Market testing and business model validation
5. Product/market launch

KEY FINDINGS FROM PROJECT REVIEWS AND EVALUATION

The Phase II projects were diverse in the technologies they sought to employ, and the markets they were attempting to enter. They also differed in institutional leadership, partnerships and structure. Some of the diversity across the Phase II projects can be summarized as:

- All but three projects were evaluated to have performed satisfactorily (moderately to fully) despite the damaging impacts of COVID-19 during a large proportion of the program period (Table 2).

- The majority of projects had progressed at least to the stage that they had produced minimal product for a market (Stage 3) and three had reached the stage of market launch (Stage 5) (Table 2).
- 14 East African universities participated in Phase II (Makerere in 7 projects, Hawassa 3, JKUAT 3, University of Nairobi 2, Sokoine University 2, Maseno University 2, the rest 1 project each).
- 12 non-university national research institutes participated (TARI and NassARI both in 2 projects, the rest 1 each), 3 Regional research institutes and 5 Ministries and commissions.
- 37 individual private sector partners participated across the portfolio.
- Most (16) projects were led by University partners.
- C1-14 Semiochemicals for control of tsetse flies and C2-10 Mushroom substrates were by either national or regional institutes (non-universities).
- One project has been led by a public commission (Innovation-led bioeconomy strategy).
- Three projects were led by private sector partners (C1-16 Orange Sweet Potato Puree in bakeries, C1-17 Aroma Honey Toffee and Apiculture and C1-12 Black soldier fly for poultry and fish feeds).
- Nine projects operated in two countries, nine in three countries, and two projects in four countries.

Table 2. Each project ranking for project performance (**Unsatisfactory**, **Moderately Satisfactory** or **Fully Satisfactory**) and for stage of development 1-5 as outlined in Box 2 above.

Project	Performance	Stage of progress
C1-1 Refractance drying of fruits	Moderate	3
C1-2 Fungal Biopesticides - PROSAFE	Moderate	3
C1-3 ICT Sweet potato	Satisfactory	5
C1-4 Leather processing	Unsatisfactory	3
C1-5 Bio-fortified N fertiliser from urban waste	Satisfactory	5
C1-6 Post-harvest fruit and vegetable treatment	Unsatisfactory	3
C1-7 Insect production and processing for human food	Moderate	4
C2-8 Striga weed resistance	Moderate	4
C2-9 Sorghum and millet products	Unsatisfactory	4
C2-10 Mushroom substrates	Moderate	4
C2-11 Agro waste conversion and BIOCon	Moderate	4
C1-12 Black soldier fly for poultry and fish feeds	Moderate	3
C1-13 Catnip malaria products	Unsatisfactory	2
C1-14 Semiochemicals for control of tsetse flies	Moderate	3
C1-15 Biorefining sorghum for food sugar and biomaterials	Moderate	3
C1-16 Orange sweet potato puree in bakeries	Moderate	3
C1-17 Aroma Honey Toffee and Apiculture	Moderate	5
C2-18 Bio-alcohol gel for fuel in Lake Victoria basin	Moderate	4
C2-19 Coffee waste vermicomposting for aquaculture, horticulture and poultry	Moderate	3
C3-20 Bioscience Policy framework	Satisfactory	5

There was a consistent message from project teams that the PMO was both effective and efficient. The Program calls (the competitive grants mechanism) were transparent and efficiently handled through the PMO and the PAC. The criteria for selection, the grant agreements, financial management and reporting requirements were all clearly laid out in the comprehensive Program Implementation Manual (*icipe* 2017).

Some stakeholders emphasised that the experience in working with BioInnovate Phase II and the PMO was far better than other previous experiences when working with donors and partnering institutes. All project teams recognised the value addition from the PMO through their focus on enhancing capacity of partners especially in the areas of innovation management, business development and financial management. There was some feedback that the reporting, and especially the financial reporting that was required by the PMO and *icipe* was overly demanding, but the overwhelming view was that the reporting was in line with the governance necessary for such a program.

The diversity of projects and the number and range of institutes represented are indicative of the ability of the program to attract proposals from across the innovation ecosystem and of the effectiveness of the competitive-grant's mechanism. The short reports in Appendix 3 show not only the diversity of the portfolio, but also the range and complexity of the issues, and combinations of those issues, that had to be addressed by project teams and the PMO as they attempted to support projects through their challenges. That so many projects have been judged to be performing satisfactorily or moderately satisfactorily can only be seen as an outstanding result for the whole BioInnovate Phase II network.

The program has been particularly effective in initiating and supporting new capacity building. Each consortium project included research and capacity building activities related to value addition, policy analysis and product or business incubation. Some of that capacity building was the more traditional research capacity and as a result, 10 PhD and 22 MSc students were supported under BioInnovate Phase II.

In addition to formal degree opportunities, there were 36 female research fellows (12 in Cohort 1, 12 in Cohort 2, 12 in Cohort 3) supported under the BioInnovate Africa Fellowship for Women Scientists (BA-FWS). The BA-FWS gives individuals the opportunity to work with and learn from diverse BioInnovate Africa bio-economy projects and networks in the region. At the same time, the BA Fellows gain experience and establish networks to advance their skills, innovation capacity and overall career progression. This significant initiative within BioInnovate supports early and mid-career women scientists and innovators to play their own key roles in taking innovative bioscience research ideas and technologies to market.

However, the most innovative capacity building component of BioInnovate Phase II was the provision of business development and innovation management training to consortia by the PMO. The inclusion of such training in the Phase II design was in response to recommendations from reviews of Phases I. The value of this training is acknowledged by project consortia, but more importantly, the business development and market launch achievements under Phase II demonstrate that this training has improved the effectiveness of the program.

Monitoring and Evaluation (M&E) capacity in the PMO was increased in Phase II, and the reporting templates were also upgraded although one or two projects provided poor reports, which were of minimal value for the PMO or for the review team. This is not a substantial issue, but it is important that such reports should not be deemed acceptable by the PMO.

While most program outcomes had their performance indicators for tracking progress appropriately specified in the M&E plan, some outcomes including “Improved environmental health”; and “Reduced bio/agro-waste in the environment” were not specified. Specification of relevant “improved environmental health” related indicators could have assisted the program to track important changes such as those witnessed in the banana winery through the support of BIOCon startup in Tanzania. In that case the winery was facing almost certain closure due to environmental pollution and complaints from the community as well as increases in environmental management cost. The installation of the wastewater management plant under this project enabled it to continue operation through its new capacity to discharge treated water from the plant back into the stream under a sound monitoring system overseen by an assigned staff, BIOCon and the environmental regulator. Specification of appropriate indicators would have also assisted the program to track changes related to reduction in agro/biowaste in the environment occasioned by supported projects like that on management of coffee waste in Ethiopia.

In addition, while one primary outcome (enhanced capacity) was given prominence in the M&E plan, the other two on “increased linkage between research institutions and the private sector”, and “improved prioritization and coordination of policy responses” were missing. Specification of indicators could have assisted in appreciating the link between social, economic and environment changes connected to program interventions. Hence alongside “% change in estimated amount raised through external and internal funded innovative bioscience projects (US Dollars)” indicator, other effectiveness indicators, should be considered in future programs so as to track effectiveness of linkages created between the research and private sector. For instance, the number of partnerships/agreements in operation after three years, volumes of production under agreements after three years might be included (e.g. in the case of C5 Bio-fortified N fertiliser from urban waste, such indicators would have better highlighted the progress made by this project).

Additional indicators to assess effectiveness of a program’s prioritization and coordination of policy responses in future phases should include the number and type of initiatives adopted to address projects’ policy-related issues, number of policies generated and enforced (e.g., the application of project supported root and tuber crops policy/guidelines in Tanzania, Kenya and Uganda to improve access to quality planting materials), and general satisfaction of the project’s stakeholders with policy framework). Such indicators would link to the existing specified output indicators (e.g. number of MoUs signed and number of policy seminars organized) to primary outcomes.

Overall though, the review found that the M&E being undertaken was comprehensive and the PMO was precisely aware of progress of projects, their achievements, their emerging constraints and were proactive in endeavoring to assist projects overcome those constraints.

As expected, the global COVID-19 pandemic has had a continuing impact on the implementation of most projects. Only four projects have been able to avoid most COVID-19 constraints. These are C1-3 ICT Sweet potato, C2-8 Striga weed resistance, and releasing Striga weed resistant maize and

finger millet varieties, C1-5 Bio-fortified N fertiliser from urban waste and C3-20 - Bioscience Policy framework.

Most projects, as at May 2021, were slightly underspent (Appendix 4), but in discussions with the PMO in May 2021, there was confidence that once outstanding expenditure was acquitted and the final payments made to projects later in 2021, most projects would be within budget despite the effects of COVID-19 on all projects. However, some projects were significantly underspent by May 2021 and are likely to remain so. The most outstanding underspends were in: C4 Leather Processing, C8 Striga Weed Resistance, C8 Catnip malaria products, C17 Aroma Honey Toffee and Apiculture, and C18 Bio-alcohol gel for fuel in L. Victoria Basin. Procurement was a major factor in many of these projects (e.g. C4 Leather processing and C18 Bio-alcohol for fuel in the L. Victoria Basin) but in others, project administration and other aspects of project delivery appear to have been more important factors in delaying project progress (e.g., C13 Catnip malaria products). Procurement delays was a major reason for the tardiness of projects in BioInnovate Phase I. Solving the issue of procurement has to be amongst the priorities for the remaining period of these projects and for any future BioInnovate Phase. There is also a case for considering what options the PMO can put in place if other project delivery constraints are not able to be addressed satisfactorily, even with capacity building.

Arriving at a particular project assessment was confounded in some instances by the program design that mandated all projects operate in at least two or three participating countries. Six projects had mixed country assessments, where the project was performing well in at least one country and performing poorly in at least one other (Appendix 5). The reasons for performance differences between countries are varied, but they included procurement, institutional and national policies, and undoubtedly team dynamics. The location of the PI was also a factor, local leadership being more likely to facilitate quick decision making and implementation especially where leadership roles were based in established networks such as those encompassing policy makers. Examples of the importance of the location of the PI of projects are the sound performance of C3 ICT Sweet potato and C17 Aroma Honey Toffee and Apiculture projects in Uganda compared to their progress in other participating countries. In most of the six cases the documentation and discussions with the PMO suggested that poor national performance might be overcome. However, the issue of different performance in different countries highlights the need for the Program and the PMO to have contracting options that enable poorly performing national teams to be culled from projects where appropriate. While the aim of having multiple countries participating in each project is supported, as is the notion that BioInnovate puts a priority on building capacity, poorly performing national components of projects should not become an impediment to project success elsewhere. It would be far preferable to cut the underperforming components and to reallocate budgets accordingly.

The presence of private sector partners in teams, the size of those partners, their enthusiasm, and the roles they are expected, and expecting, to play were highly variable. The review found that there was no one or two models of engagement with the private sector that worked well or failed. Nevertheless, the evaluation of individual projects provides some observations that should be considered in a future Phase or in similar programs. Prior engagement with PS partners, bonding of teams including the private sector partners at the beginning of the project and awareness of and

managing personality differences and the modes of effective communication were all mentioned in discussions as important in determining the success or otherwise of projects.

Some projects (those in category 2) had a business model that incorporated a “start-up” SME. Some of these performed well e.g. C2-11 Agro waste conversion and BIOCon and managed to register orders for the provision of services. C1-12 Black soldier fly for poultry and fish feeds project, initiated and led by a newly established SME, produced and sold small tonnages of fertilizer, secure the support of a private financier for \$50,000 to acquire a collection truck and motorcycle, and attract the attention of other potential investors who are considering USD \$5 million input into this project that aims to produce animal feeds in Kenya and Tanzania. Others from this category performed less well (e.g. C2-9 Sorghum and millet products).

In the case of **C2-11 Agro waste conversion and BIOCon** it did both. BIOCon was registered in Tanzania without significant delays and that entity is performing well in that country, in part because of the partnership and business skills brought in by iTEC (Innovative Technology and Energy Center) a project partner, but also through the entrepreneurial prowess of the Principal Investigator. After some delays, BIOCon has also recently commenced operations in Uganda. However, in Ethiopia, the project is failing because the registration of BIOCon in that country is being delayed by university bureaucracy and policies. The delays seem to be so concerning that there are serious doubts about the project ever succeeding there.

The startup associated with **C2-9 Sorghum and millet products** has produced products but by February 2021, had not progressed these products to market. The overriding constraint in this project appeared to be insufficient business and marketing skills in all the participating countries.

Some projects have partnered with established medium to large companies, which are playing major roles in projects in terms of defining how products are best introduced to markets. The Agri Seed Company **Project C2-8 Striga weed resistance** has a presence in most project countries with decentralized structures and networks with other key industry players. They have used their experience and networks to predict and overcome potential shortages in seed production of the newly developed crop varieties. The business model adopted by the university for this project linked the startup with Maseno Business Centre to support IP and management with a provision for royalties to go to the university for facilitating the researchers to market their innovations. This model provided a sound environment for the project and enabled Agri Seed company to successfully lead the process of commercialisation of the improved striga resistant varieties commercialization. This was unlike less pro-private sector business models pursued by projects in other universities. The Novel sorghum products project in Tanzania was established to be independent of the existing university innovation centre and, as a consequence, the project lacked access to key skills and the strong business connection with the private sector. The evidence from the Phase II projects indicates that models of commercialization of innovation still requires careful monitoring and nurturing. Certainly there are challenges that arise when a business is established within the university that is largely managed as a government institution with finance and procurement policies that can be a barrier to the needs of running a business in a competitive environment.

However, not all private sector partners were able to fulfil their roles and there were instances where private sector partner failed to honor commitments of co-investment or were removed from

projects because they were unwilling or unable to meet the required level of financial accounting and reporting.

Projects underestimated the complexity involved in taking a product to market. Three projects; OKOA mushrooms, novel sorghum and millet projects, and the project on hot water treatment of fruit and vegetables all failed to find an appropriate private sector partners, business model, and capital. Therefore, all three have faced difficulties in achieving market presence in the timeframe agreed under the projects' plans.

Transition from pilot scale operations to large enough production to undertake market launch was challenging for several projects. This was the case with projects in sustainable leather processing technology; post-harvest disinfestation treatment; production, and processing and marketing of catnip. All these projects suffered serious setbacks arising from poor planning with respect to scale transitioning. Planning for and implementing changes in scale will always be a crucial in projects. However, more critical thinking about the issue, the engagement of what might be termed process engineering, and certainly, clarity in procurement should be at the forefront of future project deliberations and should be a key criterion for selecting which projects to support. In the case of the leather processing project, the failure to procure the necessary bioreactor (> 50% of the total project budget) has virtually stopped this project from progressing much further than it had at the end of Phase I.

Summary

BioInnovate Africa has supported a wide range of projects with extensive representation from the institutes of East Africa and all six countries represented in the portfolio. As might be expected because of the history of BioInnovate and its predecessors, the more recent inclusion of Rwanda and Burundi in the program, and the smaller research communities in those countries, their representation is far less than the others. The diverse representation of countries, institutes and private sector partners is particularly important because this diversity catalyzes linkages across the subregion and because it means that the capacity building that is forthcoming from the PMO and through postgraduate opportunities and through fellowships reaches across those networks.

The projects have progressed despite the many challenges that they have had to confront and the project teams and the PMO have had to be nimble to attempt to address them as they have arisen. Not all challenges have been overcome. Some have been overcome in one country but not in another. Yet despite the problems, significant progress has been made.

Three of the 20 Phase II projects were considered to be performing well despite the impacts of COVID-19. Fourteen (14) projects were performing satisfactorily or moderately satisfactorily, and only three were deemed to be performing unsatisfactorily. Some projects have already reached market launch. This is an outstanding result given the difficulties in achieving commercialisation and adoption of any new technology. None of these projects could be considered well placed in a market but many of them show signs that they will be sustainable and have the potential to make a difference in East African communities. It is noteworthy that there does not appear to be a particular combination of partners, countries, bioscience technologies or team membership that

influences success. The BioInnovate Program has demonstrated that successful adoption of bioscience technology can have many origins.

Equally important has been the capacity building that the program has achieved. The program's achievements in building partnerships and a network involving so many universities, other public institutions and more than 30 private sector players coupled with its gender capacity building that the program has delivered to all participating projects demonstrates the potential impacts that this program has created. The program's capacity building, and especially the focus on capacity building for women, is perfectly aligned with and supports the Partnership for Skills in Applied Sciences, Engineering and Technology (PASET) and its Regional Scholarship and Innovation Fund (RSIF) for which BioInnovate, at the PMO level, provides technical support and are involved in implementing the research and innovation component of the RSIF. This current capacity building adds to the commitment that was prominent in BioEARN Phase I (see below) and has continued for 20 years.

The breadth of projects that have been undertaken have contributed significantly to the priorities of the participating countries. The environmental projects address major issues confronting East Africa with respect to clean water, environmentally safe and healthy natural waterways, waste management associated with rapidly growing agricultural industries such as coffee production and in providing alternatives to deforestation near Lake Victoria. The projects in the value-adding to agricultural production are similarly well aligned with regional priorities with the projects on Orange-Fleshed Sweet potato puree being a prime example.

In addition to the benefits through the projects and capacity building, one of the most outstanding outcomes from BioInnovate Phase II has been the cohesion within the program, the strength of the East African network including the CGIAR, which the program has developed and nurtured. The program has undoubtedly strengthened the links within the research community and especially between researcher's home institutes and the private sector. The progress that has been made in those researcher-private sector links has laid the foundation for even stronger relationships in the future and well beyond the BioInnovate program. Of note has been the relationship between the BecA-ILRI Hub. That Hub, located at the ILRI campus in Nairobi, has first class facilities and has provided training, guidance and research opportunities for scientists from across East and Central Africa for > 10 years. The Hub and BioInnovate have a history of collaboration on training, conferences and seminars and the sharing of knowledge and expertise. Individual Phase II projects have also been able to utilise the Hub facilities and take advantage of the mentoring that goes with working at the Hub. C7 Insect production and processing for human food used the BecA-ILRI Hub for nutritional analysis of insect-enriched food products; C15 Biorefining sorghum for food sugar and biomaterials worked at the Hub to analyse micronutrients in the syrup extracted from new sorghum varieties, and ILRI, as a partner in C19 Coffee waste vermicomposting for aquaculture, horticulture and poultry project is hosting one of the Phase II BioInnovate Africa Fellows.

The relationship with the Hub however is not considered to be limited to the use of its facilities. Rather, the BioInnovate Africa PMO considers the Hub to have the potential to provide a growing pipeline for innovation in a future phase. That pipeline was the catalyst for C15 Biorefining sorghum for food sugar and biomaterials as that project is founded on the research of a BecA alumnus who used genotyping capability at the Hub to establish the breeding lines for the hybrid maize/sorghum variety.

Based on its project-based progress, its capacity building and the partnerships and networks it has nurtured, BioInnovate Phase II's design and implementation can undoubtedly be judged as successful. Improvements can and should be made in any future Phase, but East Africa BioInnovate partners have already benefitted from the program and the EA community seems certain to benefit from its outcomes in the near future.

20 years of support: Evolution, learnings and benefits from BioEARN to BioInnovate Phase II

Sida's 20 years of support towards enabling biotechnologies to contribute to the East African economies commenced through BioEARN Phase I and II programs. These were specifically designed to support the emerging bioscience innovation system that was being recognised as crucial for emerging regional bio-economies. The design for these phases recognised that achieving impacts from biotechnology would be dependent on not only the relevance and value of the particular technology, but that policies, infrastructure and partnerships with the private sector would play an important role. As a result, the first years of Sida's "Bio" program included support for policy development and capacity building. BioEARN Phase I and II (1999-2005) (Figure 1) was coordinated by SEI (Sweden) and Uganda National Council for Science and Technology (UNCST), while BioEARN Phase III (2005-2009) was hosted and coordinated by the Inter University Council of East Africa (IUCEA) and had 9 regional research consortia (projects).

The capacity building in BioEARN Phase I and II included both biotechnology-focused PhD scholarships and investments to improve infrastructure in selected national universities. Twenty students, five each from the four participating countries (Ethiopia, Kenya, Tanzania and Uganda) were selected through a competitive process to undertake their studies through sandwich courses involving a Swedish university and one from East Africa. Other PhD scholarships were subsequently added so that by the completion of BioEARN Phase II, there had been thirty PhDs completed across all three BioEARN phases. There were also significant investments (totaling approximately SEK25 million (~ USD \$ 3million) for equipment and consumables into 17 sub-regional institutions across all four countries.

Possibly the most complex and challenging component of the BIOEARN program was in its support for development of biotechnology enabling policies across the sub-region. This was even more challenging because policy development had evolved to different levels across the participating countries, and because Science and Technology policies were, at that time, being recognised by the African Union (AU) and its predecessor, the Organisation of Africa Unity (OAU) as a priority with significant levels of debate on Science and Technology policies at national, sub regional and regional levels.

BioEARN's policy focus was always aligned with national and regional priorities and existing policies and its program was undertaken in collaboration with the Science and Technology Councils in the four participating countries. As such its overall aim was to be a catalyst for policy discussion and

development of “functional regulatory systems, improved national policies and institutional reforms enabling the safe and efficient adoption of bioscience applications.”¹

The design and implementation of BioEARN Phase III saw perhaps the most significant changes over the 20-year history. Rather than focus exclusively on enabling policy and capacity building directly, BioEARN Phase III took a far more direct approach to enhance the role of bioscience contributing to the East African economy by supporting nine consortia that had developed proven biotechnologies that were judged to be ready for commercialization, or, in the case of public-good projects, through other adoption pathways. The BioEARN III themes under which those nine consortia/projects were selected and supported were crop productivity, agro-processing and environmental and industrial development.

BioInnovate Phases I and II have been natural progressions from BioEARN Phase III. Modifications have been made along the way in response to lessons learnt and recommendations from excellent external reviews and analyses. The most striking changes from BioEARN III to BioInnovate II have been a narrowing of the themes supported, a reduction in policy development support, greater recognition of the role of the entrepreneur in teams and a growing increase in business support provided by the PMO. There have also been changes in the “hosting” arrangements and indeed, the perceived roles of the hosting agency.

The evolution from BioEARN III to BioInnovate II has accommodated the continuation of projects that demonstrated that they had made real progress towards their aim of delivering innovations to the market. Both BioInnovate I and Bio Innovate II have projects that originated in the previous phases of the Sida investment.

BioInnovate I supported four themes:

1. Climate change adaptation, productivity, and improvement for food and nutrition security.
2. Waste treatment, production of bioenergy from renewable bio-resources, and securing freshwater resources.
3. Innovation incubation and promotion of targeted value chains.
4. Bio-resource innovation policy and sustainability analysis.

Despite there being two open calls for proposals, seven of the nine projects supported under BioInnovate Phase I “emerged” from BioEARN Phase III projects, and although the BioInnovate Phase I projects were redefined from their BioEARN origins, the similarities were sufficient to consider that those continuing consortia and projects had, by the end of BioInnovate Phase I in 2015, received about 10 years of support under the Sida programs.

Bioinnovate Phase II commenced in late 2016 and had two open calls for projects in 2017 and 2018. The first call was for projects that had larger budgets (~ \$750,000 USD), where partners had

¹ A Decade of Bioscience Development in Eastern Africa: The Bio-Earn Programme 1999-2010. By B. Forsman J. Komen and I. Virgin; May 2011. URL: <https://mediamanager.sei.org/documents/Publications/SEI-Report-Forsman-Sida-ADecadeOfBioscienceDevelopmentInEasternAfrica.pdf>

experience working together and with partnering with existing entities in the private sector (Category 1). The second call (Category 2) was for projects with smaller budgets (~ \$250,000 USD) and which planned to go to market via startups.

There were two critical changes between BioInnovate Phase I and Phase II; the introduction of Business Development support through the PMO, and the redefinition of the themes that were supported to the following three:

1. Value addition to agro-produce and creation of agribusiness opportunities for smallholder farmers.
2. Value addition to agro/biowaste, in support of climate change mitigation and environmental sustainability.
3. Development of policies, capacity and tools to deliver developed bioscience innovations to resource-poor farming and agro processing systems.

In total, Sida has invested a total of 382 million SEK (USD 43 million) into the BioEARN and BioInnovate programs since 1999 (Table 3).

Table 3. Total budget for each of the 5 phases of the Sida investment into East Africa under BioEARN and BioInnovate programs.

Phase and years for each phase	SEK (Million)	USD (million)
BioEARN Phase I (3 years)	39	4.3
BioEARN Phase II (3 years)	56	6.3
BioEARN Phase III (4 years)	77	8.7
BioInnovate Phase I (5 years)	90	10.1
BioInnovate Phase II (4 years)	120	13.6
Total	382	43

ACHIEVEMENTS AND IMPACTS

Alignment with the Swedish (Sida) strategy: The 20 years of support are completely aligned with the key elements of the Sida strategy for research and development cooperation as outlined in 2015 (Anon 2015). Those elements are a focus on each of capacity building, ensuring that the research is relevant to the participating countries and regions, and promotion of that research, which can contribute to poverty reduction and sustainable development. The program has been able to achieve that alignment by incorporating all three elements into program and project bioscience development that is interwoven with diverse capacity building (e.g., fellowships, postgraduates and business development) and policy initiatives. This systemic approach to the entire 20 years of support is one of the most striking aspects of the programs.

Subregional and national Policy development: Although BioEARN I and II resulted in considerable numbers of reports and workshops (Komen and Virgin 2006), the impacts from policy investments during those phases are difficult to assess. Policy development by various actors and agencies associated with an emerging bioeconomy is influenced by many stakeholders, and the influence

and impacts attributable to one stakeholder is impossible to assess in isolation. Nevertheless, many of those associated with policy development in the BioEARN Phase I and II period, and interviewed as part of this review, recognised that the policy focus in that period strongly influenced key stakeholders and the views they took to regional policy debates. That influence was mostly via financially supporting and participating in numerous national and sub-regional policy fora. Two areas of policy development were recognised by multiple interviewees and by the synthesis of BioEARN Phases I and II (Komen and Virgin 2006) as being most valuable and most influenced by the BioEARN policy investment:

1. Biosafety where the impacts were different in each country. Kenya and Uganda had enacted biosafety policies by the end of BioEARN Phase III and Tanzania and Ethiopia have had partial progress in policy development.
2. Universities developing policies on how to work with the private sector and while doing so, developing institutional policies on how to manage IP (e.g. Makerere University).

Notwithstanding the impacts that BioEARN-BioInnovate had on policy development, interviews with the Phase II project teams and other stakeholders with specialist policy understanding point to a continuation of policy challenges across East Africa in 2021. At a macro scale, policy development and adoption vary significantly across the six participating countries. At a finer scale, regulatory approvals for use of technologies almost invariably varies between countries and harmonisation between countries is uncommon. An example of the difficulties arising from lack of harmonisation comes from BioInnovate Phase II where Project C1-5, : “Nitrogen bio-fortified and pelletized commercial-grade organic fertilizer made from urban biowaste to improve soil productivity and livelihoods of small holder farmers” has been able to register its “HAKIKA” fertilizer in Tanzania but the required independent efficacy testing process required by the Ugandan Ministry of Agriculture, Animal Industry and Fisheries to allow for its use in that country will take more than one additional year.

There has been a view expressed by past reviewers of BioEARN and BioInnovate that further investment in more general policy development support is problematic in part because of the differences in stages at which policy development has progressed between countries, universities, and the private sector. Brenner et al (2011) and Liavoga and Leta (2016) were of the view that policy work had to be tightly integrated with the other parts of that program. BioInnovate Phase II has taken this advice onboard and the PMO has played key roles in addressing specific policy issues that have challenged product development e.g. national registration of biopesticides and approvals for use of insects as human food. The support of the PMO in developing the right policies to support specific policy issues has been invaluable. However, BioInnovate Phase II has maintained a commitment to higher level policy development through its support of a project, which aimed to deliver an East African Bioeconomy strategy. That project has been outstanding in its delivery and the comprehensive strategy developed by that project is available online². This valuable resource for the future has been developed with the East African Science and Technology Commission

² <https://bioeconomy.easteco.org/wp-content/uploads/2020/10/Executive-Summary-of-the-EAC-Regional-Bioeconomy-Strategy-1.pdf>

(EASTECO) and seven participating countries (Burundi, Ethiopia, Kenya, Rwanda, South Sudan, Tanzania and Uganda). The collaborative approach that the project has taken gives the strategy the best chance of being adopted and discussions with EA Ministers during this review highlighted that the strategy and BioInnovate's input is much valued. However, policy development is seldom rapid and so the BioInnovate team, the project participants and other key stakeholders should be incorporating the next steps to achieve policy change as a priority in the next phase.

Intellectual property support: IP developed by researchers should certainly be protected but it's not a simple task and it is one with which research institutes can often struggle. How do you protect IP; in what parts of the world should it be protected; and how can IP share be agreed appropriately amongst collaborators who often have different IP policy structures? These are just some of the key elements of IP management. As is the case elsewhere in the world, institutional management (including sharing IP) is often an issue burdened by administration, risk avoidance and unrealistic perceptions of the value of a particular "invention". Overzealous IP management could be more likely kill a project and an innovation than enhance it by slowing the path to commercialization and impact especially by reducing the interest and enthusiasm of any private sector partners.

Advances made under BioEARN I and II in assisting the subregions university sector to develop policies for management of IP (Komen and Virgin 2006) made significant contributions to how the university sector dealt with this growing issue. Nevertheless, IP sharing was again a significant issue in a few projects in BioInnovate Phase II. Any future BioInnovate Phase should continue capacity building to achieve projects implementation where participating institutes, including universities, can have both productive partnerships with the Private Sector and appropriate IP management and sharing.³

IP management within BioInnovate Phase II was based on binding agreements at the commencement of projects. That initiative demonstrates the maturity of this phase and is an excellent example of how lessons from previous phases have been incrementally incorporated into designs of following phases. Nevertheless, at least three projects were identified in the review where IP management and sharing lacked clarity (C1-3 ICT sweet potato, C2-11 Agro/biowaste conversion and BIOCon, C1-5 Bio-fortified fertiliser from urban waste). Further refinement in response to these issues may be warranted in a future phase as IP discussions mid project appear to impact on the project performance and especially project teamwork.

Capacity Building: The impact of the capacity building investment from BioEARN and BioInnovate I and II has been substantial through > 50 PhD and MSc graduates across all phases -30 PhDs from BioEARN, 7 PhDs and 38 MSc from BioInnovate phase I and 10 PhDs and 22 MScs from BioInnovate Phase II. A measure of the ongoing influence from the capacity building programs can be gauged through the successful careers of the 20 sandwich course PhD students from BioEARN Phase I and II where sixteen (16) are currently in senior positions (e.g. Deputy Vice Chancellor, Professor, Associate Professor, Deputy Director General) in Subregional Universities or national research agencies, and a further ex-student has recently retired from a senior position. The senior positions

³ https://cgspace.cgiar.org/bitstream/handle/10568/77300/chapter_5.pdf?sequence=1&isAllowed=y

held by these products of the Sida investment in biotechnology not only demonstrates the value the individual students gained from their studies, but also shows the ongoing value of that investment as these research leaders across the sub region shape the careers of the current and future emerging researchers and teachers and the future strategic direction of their institutes. While this cohort of postgraduates has made a difference in East Africa, they have been just the first from the BioEARN and BioInnovate programs, and so impact from this capacity building can confidently be expected to reach far beyond those mentioned above.

PROJECT DEVELOPMENT AND DELIVERY FROM BIOEARN AND BIOINNOVATE PHASE II

About 75% of the investment period (2006 to current) has been dominated by support of research consortia and projects. Taking new and even existing technologies to adoption, commercialization and impact is difficult. Adoption of new technologies is mostly slow even when the benefits are, in the eyes of the research team at least, clear and unequivocal. Slow adoption of new technologies applies equally to agricultural systems in both developed and the developing world (Llewellyn and D'Emden 2010; Mottaleb 2018). It's through this lens that comment on the success of BioEARN and BioInnovate in taking biotechnologies to market and use must be seen. Farmers and other users of new technology are slow to adopt for a range of reasons, including perceptions of risk and investment cost and extra labour, which have to be balanced against potential increases in either production and/or profit, or reduced risk.

While taking a product from proof of concept to a traditional market is challenging, BioEARN and BioInnovate, have, in each of the phases, included projects which are targeted towards environmental impacts, and which can be considered “public-good” projects. The pathways these projects might take to widespread use don't fit a typical commercialization model. Often the benefit of the technology is both environmental and commercial, but it can be that the commercial benefits are associated with an enterprise such as a tannery or slaughterhouse being able to continue operation.

BioEARN Phase III project delivery: The reports by Forsman et al. (2011) and Brenner et al. (2011) detail the achievements of each of the projects undertaken under BioEARN Phase III. In almost all cases, projects had progressed in their science and had delivered most of their planned outcomes. Few, however had made substantial progress towards commercialization. For example, the key achievements in some plant improvement projects were listed as varieties being identified to go into further breeding trials (sorghum), new varieties that were entering final testing (sweet potato) and a better understanding of key viral diseases of sweet potato. Other projects such as the brewing project and tissue culturing of sweet potato sisal made technical progress but were overcome by partnership issues or logistics. Some projects, such as the water management project, did progress at least to pilot scale.

The critical lessons from BioEARN outlined in those reports can be summarised as:

- The need to focus on demand for specific technology and the engagement with the private sector early.
- The need to avoid selecting projects that still required significant research to develop the technology or would require too much proof-of-concept research.

- Having the right mix of skills in project teams and not have teams dominated by researchers.
- To not underestimate the time necessary to take an innovation to commercialization.

BioInnovate Phase I project delivery: A similar pattern of projects success in the technical sense emerged from BioInnovate Phase I. Many projects were able to progress to pilot-scale scale out with the midterm review of Phase I (Crouch and Bloch 2013) being largely supportive of the projects and the program. Some of the technical and pilot scale-out achievements from BioInnovate Phase I included⁴:

- New varieties of sorghum, finger millet, sweet potato and cassava adapted to climate or disease challenges being developed and available for further large scale evaluation.
- A plant improvement project on beans yielded new varieties better adapted to canning, which were released and taken up by industry.
- Disease free plantlets produced of crops which are vegetatively propagated (sweet potato, cassava, banana).
- Pilot projects successful in treating polluted water from agro-industries or treating large volumes of agricultural waste from some rapidly expanding agricultural industries and enterprises (sisal, coffee and banana).
- Successful production at small scale of value-added products (malt drink, beer, flour and snack products) from sorghum and finger millet.

However, as was the case in BioEARN Phase III, few projects from BioInnovate Phase I progressed beyond pilot to commercialization by 2017, two years after Phase I was completed. There were many explanations for projects not proceeding to full commercialization. In some cases, the projects needed extra time to advance, some suffered from challenges of increasing scale of production or processing, while still others faced significant competition, especially projects that were seeking to produce new varieties of the major crop species. Commercialisation success was also constrained by non-technical issues with project team leadership, membership and roles, governance, processes (including procurement) and IP being prominent.

BioInnovate Phase II delivery: Crouch and Bloch (2013) highlighted several issues that warranted change in their mid-term review of BioInnovate Phase I. They included:

- Strengthening the PMO
- Strengthening the PAC with entrepreneurial membership
- Essential demand for the product
- Better structured reporting for greater clarity of achievements and challenges
- Highlighting the success stories to attract new investors (communication)
- Ensuring projects have close partnerships with the private sector (PS), including negotiating real (cash) co-investment by the PS
- Flexibility to put money and resources into projects to get them over the line or close off poorly performing

⁴ <https://bioinnovate-africa.org/program-summary/>

- Enthusiasm in leadership

Most of these issues were addressed in the design of Phase II. The PMO has been strengthened by the addition of a professional business development advisor and manager, improved reporting formats, which gave clarity to achievements against planned outputs have been adopted, and *icipe*, as host organisation, has adopted an approach, which has BioInnovate well incorporated into the organisation and provided both leadership and administrative mentoring to the PMO.

As stated previously, this review found that most BioInnovate Phase II projects are delivering towards their contracted outcomes and commercialization. All Phase II projects have pathways to commercialization mapped, but annual reports and discussions with project team members point again to projects being confronted with some of those same constraints, and others, as they progress towards commercialisation. Some of these recurring issues included procurement, absence of a market or lack of knowledge of that market, quality and role of the private sector partners (Appendix 3).

However, some Phase II projects have achieved small but significant commercial success.

- C1-3 ICT Sweet potato. Sweet potato seeds adoption is increasing and there are signs that VIAZI VITAMU App is triggering demand for the certified seeds through linking of the labs, multipliers and certification bodies, and is also attracting buyers of large volumes of certified seeds
- C1-5: Bio-fortified N fertilizer from urban waste. Biofertiliser is increasingly being adopted for use, especially by avocado farmers, and SMEs which have been developed by youth groups are being linked with financing mechanism and are producing and selling vermicompost in Ethiopia.
- C2-11 Agro/waste Conversion and BIOCon. BIOCon has been awarded wastewater treatment contracts and is building a strong public profile.
- C1-16: Orange Sweet Potato Puree in Bakeries. Orange sweet potato puree is systematically growing in Kenya, and there are signs of adoption in the Ugandan, Rwandan and Ethiopian markets.

However, product launch and gaining a foothold in the market is just one measure of success. Some projects, especially some that started late and have been heavily compromised by COVID-19 could not be expected to get to that point. What is important to note is that the incremental changes since 1999 have led to both a high proportion of projects being judged to have achieved satisfactory progress and that some have commenced commercialisation. These outcomes are directly attributable to the Phase II design and implementation improvements.

Communication: BioInnovate maintains an excellent webpage, which provides details of the program overall, details of each project, its implementation partners, and its resources. The documentation for each of the calls for proposals are excellent and provide the clarity necessary for those considering submissions. The program manual (Anon 2017) is similarly comprehensive and covers process, grants agreements, funding and funding management, monitoring and evaluation, and reporting. The clarity and detail in these documents is exceptional. However, communication of achievements has been less comprehensive. Despite some projects progressing to markets and the successful development and publication of an East African bioeconomy strategy, there has been

minimal exposure of these and other successes to the general public via traditional or digital media. Nor has there been specific communication events aimed at heightening the business community's interest in the program as a source of new ideas and products.

The minimalist approach to external communication of achievements, especially communication targeted at the business community is likely to be acting as a brake on the success of the program by restricting potential new partnerships, new opportunities for venture capital and the value of achievements as tools for influencing policy.

Impact assessment: Making the most of past successes also requires an ongoing commitment to track past projects. BioInnovate Phase I listed several programs that delivered outcomes that were market ready, and in some cases, had reached product launch. However, except for the BioInnovate I projects that were funded into the current phase, there is little information on the progress of proclaimed BioInnovate Phase I successes. For example, the bean varieties developed especially for the canning industry under Phase I were reported to be used commercially by the end of that project in 2015. If those varieties, or varieties of other crops developed under Phase I are still being used, six years later then that achievement has real value in encouraging investment in current and future BioInnovate Programs.

The failure to track impact from the program has been a conspicuous omission from the design of Phase II and BioEARN and BioInnovate Phase I. Documenting the impact from all aspects from personal capacity building through to economic and policy impacts should be a priority in any future phase. Such an assessment is necessary to not only weigh the true value of the past 20 years of investments and partnerships, but it will also be invaluable in designing the future of BioInnovate Africa and other similar programs across the developing world.

Program Management Office (PMO): The structure, skills and roles of the PMO and the advisory committee of the various phases (PAC) have also evolved over the course of the investment period. Under BioEARN Phase I and II, the PMO (at that stage made up of a single coordinator) was focused on selection of scholarships awardees, oversight of the institutional capacity building programs and implementation of the “policy agenda”. The roles of the PMO changed significantly under BioEARN III and BioInnovate I with the refocus to delivering impact through selected bioscience projects. However, even in BioInnovate Phase I the PMO was limited in capacity and capability with no in-house business skills to support project links to the private sector, and no professional monitoring and evaluation component in the program. In response to the reviews of BioInnovate Phase I, the PMO for BioInnovate Phase II has added both of those skills and has also improved its reporting. Overall, the PMO under BioInnovate Phase II has adopted a model of being much more integrally involved in assisting each project in all aspects.

Program Advisory Committee (PAC): One of the recommendations from the review of BioInnovate I was to add more business skills to the PAC whose membership under that Phase was overwhelmingly dominated by senior researchers or research managers. As such, the PAC was unable to add real value in connecting the program to the business sector. Despite some effort to accommodate that recommendation, the difficulty in attracting additional members with those competences has resulted in the PAC for BioInnovate Phase II being not dissimilar to that of the previous Phase. This remains a major issue for the program generally and for the value and relevance of the PAC in particular. The PAC membership should include influential representatives

from participating countries who are a mix of senior researchers/research managers, members who can provide direct links to the business councils or equivalent in East Africa. Process engineering skills would also be highly valuable.

Towards a New Phase of BioInnovate: Recommendations

Recommendation 1 - New Phase: The successful evolution of the Sida investment to the successful BioInnovate Phase II program warrants a further investment for a third phase of BioInnovate for 5 years. That further investment will provide opportunity for the program to advance its East Africa bioeconomy policy agenda and to adjust its operating policies and practices so that it can have a clear strategy to become an independent body that supports African universities and other research institutes to develop and commercialize bioscience. The changes BioInnovate should adopt into the next Phase include structure, mode of operation and personnel.

Recommendation 2- Adaptive Management: The experience from BioInnovate Phase II is that, at the time of initial submission for funding support, project teams often have not finalised key start-up processes such as membership of the project team, clear practices for procurement, management of IP, a preferred business plan or undertaken preliminary market analysis. Commencing a project with uncertainty around some or all these issues introduces an unnecessary level of risk to the program. There is also evidence that some projects perform well in some counties and not in others, and that some would benefit from a modest top-up budget to enable them to overcome some crucial final hurdles to achieving market success. In addition, the workload for the PMO under the current project load is probably not sustainable.

It is recommended that the next phase include a greater degree of adaptive management so that the PMO and the PAC have the tools and options to further improve the efficiency and effectiveness of the programs:

- a. Projects selected from the calls in the next phase should undergo a step-wise progression of support so that, in the initial step, projects have a period of preliminary support (about 6-9 months) when ALL of the start-up processes are finalised and agreed in sufficient detail as to satisfy the PMO and the PAC. Only at that point would the program advance to the comprehensive support similar to that provided in Phase II. It is further recommended that projects that progress to a second stage are allocated ~75% of the funds with the remainder being held by the PMO in a pool to invest in those projects that warrant a final push to achieve market launch.
- b. The number of projects receiving preliminary support in the next phase be about the same as Phase II but that the stepwise approach be used to reduce the number of projects receiving full support to be about 2/3 of that number.
- c. It is recommended that one or at most, two open calls be conducted in the next phase to bring forward the best ideas and innovations. While it would be preferable for all the next projects to be new, it is recognised that some projects from Phase II might warrant continued support in the next phase. However, continued support across phases should be the exception.

- d. In line with an approach that enables greater adaptive management of the program and the expected failure of projects to proceed to full support or, that components of projects will be culled due to poor performance, it is recommended that the PMO and the PAC reserve the option of commissioning particular projects outside the open call procedure. This facility would enable strategic projects and project teams be assembled to address emerging priority issues. It is recognised that such an arrangement could bring into question issues of transparency and accountability and so it is suggested that commissioned projects be limited to < 15% of the total number of projects and total budget.

Recommendation 3- Policy: The BioEARN and BioInnovate programs have maintained a commitment to support the development of policies in East Africa that enable the adoption of biosciences and establishment of a subregional bioeconomy. This commitment has culminated in the Phase II program and its partners developing and publishing a bioeconomy strategy for East Africa. However, the strategy should not be considered the end point. Rather, a next phase of BioInnovate should incorporate in its design the objective and the capability to advance that strategy towards practice. It is recommended that a new phase would include the addition of an appropriate policy specialist within the PMO whose role would be to work closely with EASTECO and national partners to achieve strategy implementation. It is also recommended that the same position have the additional specific task of enhancing the PMO's role in assisting projects meet project specific policy and regulatory requirements. This additional role is in line with recommendations from previous reviews that sought to align policy support with project requirements.

Recommendation 4-Research Themes: A new phase of BioInnovate should continue with the theme priorities of value addition to agro-produce; value addition to agro-biowaste as well as advance the policy strategy developed in Phase II towards implementation. The next phase should especially ensure that a public-good portfolio of projects, which are addressing water quality, waste and environmental issues continues as they have the potential to deliver major benefits when government policies and their implementation demand that industries such as slaughterhouses and leather processing meet more stringent environmental parameters. These projects and the issues they address are becoming more important in a subregion, which has both rapidly growing populations and economies.

The focus on water, waste and value adding was broadened in the Program's response to COVID-19 when a few small health-related projects were chosen for support. The decision to add these projects to the Phase II portfolio was taken by PAC in April 2020 shortly after the pandemic was established. The reason for this new investment focus was that COVID-19 was an emerging novel public issue, and BioInnovate Africa, as a science and innovation program considered finding of solutions peculiar to the continent and built upon traditional knowledge should be a program priority. The potential benefits from investing in traditional medicines has been outlined through a recent Mali example by Willcox et al 2011. Further investment in such a theme as an addition to other themes warrants consideration in a new phase. However, while maintaining flexibility to address emerging novel scientific challenges of public importance more generally and investment in

traditional medicines in particular could be a stronger theme in a new Phase, the PAC and the PMO should ensure that project selection recognise the challenges of supporting health product development if complex and expensive clinical trials are potentially required to meet regulatory requirements and that the advances partnerships and relationships made under Phase II themes are not lost or marginalised by large changes in investment direction.

Recommendation 5-Program Sustainability: The BioInnovate program operates in an environment of a growing number of universities for teaching and research. However, the universities and the other public research agencies, such as the national agencies, mostly don't have the capacity or the experience to run programs of Research for Development that can safely capture IP, link to market and successfully engage with the private sector. 20 years of BioEARN and BioInnovate has enabled development of preferred practices that can assist innovators take their biosciences to impact. Much has been learnt in that period and the success in multiple projects in Phase II demonstrates that the model is working, that the university network in East Africa is willing to partner with BioInnovate and that the program fills a need in the region. An expanded BioInnovate PMO has the potential to provide a service to those institutes beyond the scale that is now operating under the BioInnovate program, to either advise them, or preferably, take an active role in mentoring and managing efforts to take innovations to impact. Funding for the program has relied solely on funding from a single donor. Continued reliance on such a funding model is not sustainable past the next 5 years. The most obvious change would be to seek an alternative or an additional donor. However, that too is only marginal change. Rather, the program needs to at least begin the task of developing a business model that will enable it to support itself and reduce the dependency on donors. It is recommended that a priority task of a next phase of BioInnovate should be the development of a business model, which transitions from a single donor dependence to one, which has additional donors and has a degree of self-funding through a recalibrated engagement with research community and the private sector that enables it to build on the critical roles it now plays into the future. Such a more independent business model should include consideration of BioInnovate Africa becoming a legal entity.

Recommendation 6- Consolidation in East Africa and expansion into West Africa: It is recommended that a new phase of BioInnovate both consolidates its operations in East Africa and simultaneously commences operations in West Africa by taking advantage of *icipe's* newly established office in that subregion. To date, BioEARN and BioInnovate programs have operated in just six countries in East Africa. Restricting its operation to East Africa till now has been an appropriate decision as the restricted geography has enabled a better process of reflection and continuous improvement. A new Phase should continue to consolidate progress in the subregion by building on the program's success to date, by promoting a stronger and more inclusive subregional "ownership" of the program and by being the foundation of a new business model (Recommendation 5). That consolidation should include further expansion to recent and proposed new members of the EAC (South Sudan, Somalia and the Democratic Republic of the Congo), particularly where universities and other institutions in those countries have sufficient capacity to fully participate.

Because BioEARN/BioInnovate can now claim to have reached its overarching objective of taking biosciences to market, it can also claim that it has both experience and the expertise to widen its geographical horizons. The benefits to economies and communities from new biosciences should be realizable across the whole of sub-Saharan Africa and it is now appropriate to consider expanding its influence beyond East Africa. With more than 50 countries in Africa, the options for next regional focus are many. While consolidation in East Africa should be paramount, there are potential benefits in following *icipe* into West Africa through the host agency's new office in Benin. The diverse economies of West Africa would undoubtedly provide opportunities for bioscience to contribute, but an equally important aspect is that the BioInnovate PMO can be hosted by *icipe* with the operational and governance benefits that flow from that arrangement. If the program does initiate a West African office, it will be essential for the PMO to place a coordinator in Benin, plan to commence interactions slowly and to restrict the number of projects, countries and partnerships in the first few years.

Recommendation 7 - Communication: There is a significant diversity in the roles and level of engagement by the private sector in each project, but in most projects, private sector engagement is or has been a constraining issue. Despite the growing and emerging success of the program, it has been evident that limited resources have been directed towards communication. In particular, communication that is directed towards the business community is a must-do step in creating awareness and attracting members of the business community, new entrepreneurs, venture capital and additional donors to the BioInnovate program. Similarly, the BioInnovate program has not taken advantage of the potential value of past successes in attracting business partners. Innovations which were taken up by industry in BioInnovate I have not been tracked since, so there is no value being placed on those successes. Successes since inception (see "BioInnovate Phase I project delivery" above) need to be tracked, independently verified, documented and communicated in order to demonstrate the value of the program and the potential benefits to the business sector and the wider community. It is recommended that a new phase of BioInnovate places a higher priority on communication and that the program M&E include tracking the ongoing achievements or otherwise of past projects.

Recommendation 8- PAC membership and skills: PAC plays a highly influential and important role in supporting the program generally, the PMO, and, where appropriate, individual projects. That strong role and the presence of expertise on the PAC that enables it to play those roles should continue. However, the PAC membership does lack diversity with respect to skills and experience. Most current members of the PAC are senior scientists or senior research managers from regional universities, or from international institutes. There is little private sector or regional policy presence on the current PAC. The PAC should be recalibrated to include a balance of senior university scientists, subregional and/or Africa-wide policy expertise and at least two high profile members of the business community (at least one who has participated in the program).

Recommendation 9- Expansion of PMO personnel and skills: To implement the changes necessary for the next Phase, there should be three significant additions to the PMO office. The rationale for a new communications and policy specialists are outlined under recommendations 3 and 7. The

additional position is to enhance the business development capacity within the PMO. The role of the current business development manager has been crucial to enabling projects to achieve what they have. However, a program model with so many projects working in at least 2 or 3 countries requires more capacity to undertake the mentoring and the management. The three positions are:

- a. Strengthening of the business development and market analysis capacity in the PMO by the appointment of another experienced entrepreneur who will support the current Business Development manager and to have their roles rationalised, and also provide more capability for linking projects to entrepreneurs
- b. A specialist position that will focus on following the market impacts of new technologies from BioInnovate and to communicate the program's current and historical achievements
- c. A policy specialist who will be charged with working with key stakeholders to advance the East Africa Bioeconomy strategy to implementation and provide advice and support to projects facing issues associated with regulation

Recommendation 10- Impact assessment and lessons from 20 years of investment and partnerships: The lessons learnt over the 20 years of BioEarn and BioInnovate programs are immensely valuable for the research and development communities in Africa and in other developing regions of the world. Such a long period of continuous program operation and evolution in response to regular external reviews is undoubtedly rare, if not unique. While the reviews have been published separately, the 20-year period provides an opportunity to reflect on the progress and the challenges and how the experience might be applied in the future in east Africa and elsewhere in the developing world. The Program leadership, with support of research for development specialists should undertake a detailed impact assessment of BioEARN and BioInnovate programs and publish that assessment and the lessons from the 20 years of Sida in peer reviewed journals. Both the assessment and the publications should be amongst the highest priorities of a new program over the next 2-3 years.

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Appendices

APPENDIX 1. TERMS OF REFERENCE



An External Evaluation of Sweden's Support to Bio-Sciences Research and Innovation in Eastern Africa through BIO-EARN AND BIO-INNOVATE AFRICA Regional Programmes

Terms of Reference Final Version 8, August 28, 2020

1. Background

The Swedish International Development Cooperation Agency (Sida) has been supporting bioscience research, innovation and capacity building in Eastern Africa for almost two decades now. This support started through BIO-EARN (1999-2010), and evolved into BIO-INNOVATE phase I (2010-2016), and BIO-INNOVATE phase II (2017-2021). The latter is being implemented by International Centre of Insect Physiology and Ecology (*icipe*) through an agreement with Sida. The current agreement between Sida and *icipe* on support to BIO-INNOVATE phase II (2017-2021), stipulates an external independent evaluation to be carried out during the year 2020 (now amended to not later than 30 June 2021). In the agreement, partners-Sida (the funding agency) and *icipe* (the implementing agency of /BIO-INNOVATE), have agreed to undertake an external evaluation, which will not only review the performance of BIO-INNOVATE phase II, but also the overall impact of Sida support to bio-sciences research and innovation in the region particularly through BIO-EARN and BIO-INNOVATE (1999-2020). The outcome of the review should inform discussion of a possible continued Sida support to BIO-INNOVATE as from 2022 and beyond.

BIO-EARN (1999-2010) was a regional multi-institute collaboration initiative aimed to support East African countries of Ethiopia, Kenya, Tanzania and Uganda to benefit from advances in biosciences within their contexts for sustainable development. The programme consisted of a set of strategic regional interdisciplinary biotechnology R&D projects involving East African and Swedish universities and research institutes. The focus of the programme was to increase use of agricultural, environmental, and industrial biotechnologies to address local problems and capture opportunities created by these technologies. Projects were designed to respond to three main areas, namely: (1) improving the yield of sorghum, cassava and sweet potatoes, (2) improving the treatment and use of industrial and agricultural waste for the generation of bioenergy and value added products, and (3) strengthen the capacity of institutions to manage complex collaborative projects and initiate product development with the private sector. BIO-EARN also supported biotechnology policy development as well as enhancing regulatory capacity for biosafety. BIO-EARN completed its second and final phase in 2010 with its prior projects leading to BIO-INNOVATE Africa, also supported by Sida.

BIO-INNOVATE (2010-2020) is a regional initiative that supports scientists and innovators in the region to link biological based research ideas, inventions, and technologies to business and the market. The programme has been implemented in two phases: Phase I (2010-2016) and Phase II (2017-2020).

Phase I (2010-2016) supported consortia-based research and innovation and policy projects involving 57 regional and international partners. Consortia projects focused on developing new drought tolerant, disease resistant crop varieties for sorghum, finger millet, cassava, and sweet potatoes adaptable to various agroecological zones of eastern Africa. In addition, a regional consortium to exchange/share sorghum and millet-based products amongst the three countries of Uganda, Ethiopia, and Tanzania, was supported. The consortia projects were hinged on building strong academia-industry partnerships. Besides, during this phase, BIO-INNOVATE Africa developed innovative and adaptable approaches for wastewater treatment to respond to the deteriorating status of the environment. The phase was concluded in 2015.

An agreement between Sida and *icipe*, for a five-year phase II of the programme (2016-2021), was signed in October 2016. Phase II built on the successes of Phase I, but with a greater focus on moving innovative bioscience ideas, technologies, and inventions closer to market and deployment for beneficial societal use. The Programme aims at transforming the agro- and bio-processing sectors so that it is competitive and environmentally and socially sustainable, thereby expanding and diversifying growth opportunities for smallholder farmers and communities in eastern Africa. The primary beneficiaries are scientists, researchers, and innovators working in universities, research institutes, private sector companies and smallholder farmers and communities in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. The Programme also supports policy initiatives that foster bioeconomy development in the region. Smallholder farmers and agro-processors benefit through the technologies developed or promoted by the Program. The Program competitively selected 11 innovation projects (Cohort 1) in 2017; and additional nine projects in the second round of the call in 2018 (Cohort 2), making a total of 20 projects currently in the Program, with over 90 universities, research institutes and firms (Click [here](#) to see a description of the projects). Each phase II project is comprised of at least three team members from different organizations in at least three countries in eastern Africa. The projects run for at least three years. The projects are implemented under three categories including (1) category 1-consisting of 12 projects focusing on developing and piloting innovative and economically viable biobased technologies and products, (2) category 2- consisting of 7 projects incubating biobased technology businesses, mostly start-ups, and (3) category 3- consisting of one project aiming to develop a regional innovation-driven bioeconomy strategy for eastern Africa.

The desired impact of the Programme is improved productivity (and hence better living standards) of small holder farmers and communities in eastern Africa through value addition and agro/bioprocessing that is competitive and environmentally sustainable. The main desired outcome of the Program is increased capacity of scientists, researchers and innovators in eastern Africa to link innovative biobased research ideas, technologies and inventions to business and the market as well as to inform policy decisions.

It is expected that Sida's funding, since the inception of BIO-EARN in 1999, has consistently contributed to innovative bioscience ideas, innovative technologies and services that solve real African problems, influenced bioscience related policies in the region and created academia-industry-public partnerships to move technologies into the market and for beneficial use. An evaluation of Sweden's support/funding would be beneficial at this point to assess the progress so far made towards the projected impact and capture lessons to inform further Sida support to biosciences research and innovation in eastern Africa.

icipe, therefore, intends to hire the services of a team of consultants to carry out an external evaluation of this sustained Sida support. The results of the evaluation will assist *icipe* and Sida to improve program implementation and inform the development of the next phase of BIO-INNOVATE.

2. Objectives

- 2.1 The objective of the evaluation is to report on the performance of BIO-INNOVATE Phase II in meeting set objectives and milestones, and to undertake an analysis of challenges and deviations. The evaluation shall not comment on auditing in the BIO-INNOVATE program.
- 2.2 The objective of the *review* is to, with the discussion on bio-sciences/bio-safety in Africa in mid-/end-90's and the motives for the start of BIO-EARN as a point of departure, present how these original ideas have developed and changed throughout the years. Discuss impact of 20 years of Sweden's support.
- 2.3 Based on the evaluation and the review, *discuss* ideas and different scenarios for possible continued support to BIO-INNOVATE as from 2022 and onwards.

3. Scope of Work

3.1 Evaluation of BIO-INNOVATE Phase II, 2017-2021

3.1.1 Focus of the evaluation

The evaluation will focus on the performance of BIO-INNOVATE Phase II against its set objectives and milestones. It will also include an analysis of challenges encountered (including the effect of COVID-19 pandemic situation) and how they were addressed, any new ideas and best practices introduced to ensure smooth implementation. Recommendations from the evaluation will be used to:

- a. ensure that BIO-INNOVATE Phase II, hereinafter “the programme” continues to align with Sida's Strategy for Research Cooperation (2015-2021), and
- b. improve programme implementation and if necessary reorient or change the present management and/or implementation approach. The evaluation shall focus on the BIO-INNOVATE Phase II and should include, but not necessarily be limited to:
 - i. an evaluation of the overall progress and results from the inception of the current phase until the now,
 - ii. interrogate the progress, achievements and challenges with reference to the Results Based Framework (RBM) as well as Annual Work Plans and the extent to which the programme is fulfilling its mandate and delivery of expected results,
 - iii. the context in which the programme has been and is acting, as well as conclusions, recommendations and outlook for the future.

3.1.2. Framework for the evaluation

Keeping in line with the programme's theory of change, results frameworks and implementation plans, the evaluation shall assess the following issues:

- a. *Relevance*

Evaluate the extent to which the programme design and intervention support the Sida strategy as well as ongoing national, regional and continental African strategies in bio-sciences research and innovation.

The keys of interest will include:

- i. Is the program consistent and in line with these strategies?
- ii. Is the program in line with the national and regional environmental programs and priorities, and will it contribute to be a part of them?
- iii. Is there clarity and adequacy of program design with respect to logical consistency of inputs, activities, outputs and progress towards achievement?
- iv. How appropriate are the indicators for monitoring performance and to what extent are they being used by the program management to track progress?
- v. Has the program taken into consideration recommendations given in the BIO-INNOVATE Phase I Final Evaluation of July 2015?

b. Effectiveness

Assess the extent to which the program has achieved its goals and objectives of this phase. The following questions will be important:

- i. To what extent has the program contributed to research, innovations, policy and decision-making in the region?
- ii. To what extent are the identified and anticipated outcomes results of program activities rather than external factors?
- iii. What are the reasons for the achievement or non-achievement of outputs or anticipated outcomes?
- iv. Were the Results Based Management (RBM) framework and the Annual Work Plans effective in directing implementation of the program, or what could be done to make implementation more effective?

c. Efficiency

Assessment of the extent of output delivery in relation to inputs, including assessments of expenditures vis-à-vis activities. The following questions will be important:

- i. Has the program been managed and set up with reasonable regard for efficiency? Has BIO-INNOVATE Standard Operational Procedures (SOPs) helped in program implementation, including internal management and control assessments of universities and research institutions as well as anti-corruption practices?
- ii. What measures have been taken during planning and implementation to ensure that resources have been efficiently used?
- iii. Were the outputs delivered as agreed? Could the same outputs be achieved by other means at a lower cost in the same or shorter time?
- iv. Is the original design of the program still valid in relation to the approved financial resources, or is there a need to reassess the scope?
- v. Have support, monitoring and evaluation to sub-projects at universities and research institutions been adequate?

d. Sustainability

Assessment of the long-term continuation of program activities and benefits. The following questions will be investigated:

- i. To what extent is the sustainability of the program being addressed?
- ii. What is the extent of ownership of the program among stakeholders and beneficiaries?
- iii. Is the program sharing experiences with other similar initiatives – at national, regional, African and/or international level?
- iv. Are the partnerships sustainable beyond the program’s lifespan?

3.2 Review of Sweden’s support to Bioscience research and innovation in East Africa from 1999-2020 (BIO-EARN Phase I and II to BIO-INNOVATE Phase I and II) - the journey

3.2.1 Focus of the review

The review will highlight how the original ideas of BIO-EARN have developed and changed throughout the years and evolved into BIO-INNOVATE and present the impact of 20 years of Sweden’s support to bioscience research and innovation in eastern Africa.

The review will focus on the following aspects of Sweden’s support:

- a. Discussion of the ideas on support to bio-sciences research and policy development as well as bio-safety regulatory capacity building in Africa in the mid-/end-90’s,
- b. The set-up of BIO-EARN, the regional cooperation, the position of African and non-African stakeholders, and Sida,
- c. Objectives and the theory of change, as expressed in the program documents and applications to Sida for support to BIO-EARN/BIO-INNOVATE,
- d. Progress and challenges, as expressed in reporting from BIO-EARN/BIO-INNOVATE,
- e. Assessments from Sida, as expressed in memos for continued support to BIO-EARN/BIO-INNOVATE,
- f. Review of program evaluations documents, especially the mid-term reviews, the external evaluations, and a review of “A Decade of Bio-science Development in Eastern Africa” – assessments, conclusions, and recommendations.

3.2.2 Assessment of the impact of 20 years of Sweden’s support

This component will discuss the impact and lessons learnt of 20 years of Sweden’s support to bio-sciences research and innovation in Africa through the BIO-EARN and BIO-INNOVATE programs.

The following questions will be sought:

- a. What is the impact in research training, research capacity, policy/decision-making and management, communication and partnerships, etc.?
- b. What is the perception among the beneficiaries and other stakeholders of the progress in regional development made by BIO-EARN and now being made through BIO-INNOVATE program, and do they anticipate benefitting from the outcomes?
- c. To what extent have the BIO-EARN and BIO-INNOVATE programs contributed to the strengthening of institutional capacities in sub-projects at universities and research institutions?

3.2.3 Future scenarios for BIO-INNOVATE Phase III

This component of the evaluation will focus on discussing the possible continued support, different options/scenarios, to a BIO-INNOVATE phase III after 2022 and onwards in the context of the current landscape of bio-sciences research and innovation and bio-economy development in Africa. Key issues to assess may include:

- a. The set up/model, moving further towards the market/start-up funds with a selected number of promising innovations, and/or take a step backwards and start all over again with new promising ideas/innovations,
- b. The balance between support to research, innovation and/or policy development and advocacy,
- c. Whether support should be to fewer, larger and a limited number of sub-projects,
- d. Should support be focused geographically within the continent, have an international/global outlook or a regional co-operation outlook?
- e. Implications of African strategies and priorities e.g. African Union Development Agency (AUDA-NEPAD) for continued funding?
- f. What would support to female researchers entail; would the focus be on scholarships, fellowships, secondments, or networks?
- g. What would be the thematic direction of the support? And how would health related issues be captured?
- h. What would be the priorities for program monitoring and evaluation, communication and dissemination of results and learning?
- i. What would be the synergies with national programs, e.g. National Agricultural Research Systems, Sida supported bilateral research co-operations, etc, regional economic blocks, and international organisations, e.g. *icipe*, BecA/ILRI Hub, the CGIAR system, etc, and synergies with PASET Regional Scholarship and Innovation Fund for applied sciences, engineering and technology?
- j. How would long-term financial sustainability be guaranteed? What would be needed to bring new donors on board?

APPENDIX 2A. STAKEHOLDERS' CONSULTATION MEETINGS

Project level stakeholders and partners interviewed face-to-face.

External Evaluation of Sweden's Support to Biosciences research and Innovation in Eastern Africa through Bio-Earn and BioInnovate Africa Regional Programmes

Revised Program for Stakeholders' Consultation meetings

January 2021

Date	Type of meeting	Stakeholder	Location of stakeholder	Name and Designation
Monday, 1 February	Field visits	C1-3 Jomo Kenyatta University of Agriculture & Technology (JKUAT),	Nairobi, Kenya	Prof. Elijah Ateka, (BioEARN Alumni), JKUAT Laboratory Postgraduate and MSc students.
		C1-3 MIMEA International Limited	Nairobi, Kenya	Ms. Ann Kitisya and MIMEA team, MIMEA laboratory, Sweetpotato vine multipliers, farmers
Tuesday, 2 February	Field visits	C2-8 AgriSeed Company Limited	Nairobi, Kenya	Mr. Peter Mbogo and team, Fields
		C1-16 Euro Ingredients Ltd	Nairobi, Kenya	Mr. Antonio Magnaghi and team, puree innovations
		C3-20 National Commission for Science, Tech, and Innovation (NaCOSTI)	Nairobi, Kenya	Dr. Benson Mburu (Chief Research Officer); Jane Omari (Chief Research Officer)
Wednesday, 3 February	Field visits	C1-4 University of Nairobi Lasting Solutions	Nairobi, Kenya	Prof. Francis Mulaa Dr. Wycliffe Wanyonyi Mr. Joab Ouma Postgraduate students
Thursday, 4 February	Field visits	C2-8 Maseno University	Kisumu, Kenya	Prof. Mathews Dida, Co-PL & Phase 1 project Mr. Nelson Obange, Coordinator, Business Incubator, Visit to farmers
Monday, 8 February	Field visits	C2-9 Hawassa University	Awasa, Ethiopia	Prof Kebede Abegaz, Start-up enterprise team (Sorghum Complimentary foods)
		C1-16 Hawassa University	Awasa, Ethiopia	Mr. Tesfu Bekele & team, processors, local bakeries, and informal vendors
Wednesday, 10 February	Field visits	C3-20 Ethiopian Biotechnology Institute + Ministry of Innovation and Technology	Addis Ababa, Ethiopia	Dr. Kassahun Tesfaye (Dir. General) Mr. Ahmadian Mohammed (Hon.State Minister)
		C2-11 Addis Ababa University	Addis Ababa, Ethiopia	Prof Seyoum Leta (BioEARN Program Coordinator), incubators, commercial customers; Bio-Earn Student alumni (Prof. Seyoum Leta, Prof. Tekle Haileselassie)

Date	Type of meeting	Stakeholder	Location of stakeholder	Name and Designation
Friday, 12 February	Field visits	C2-9 Makerere University	Kampala, Uganda	Prof. Yusuf Byaruhanga, PL
	Field visits	C1-4 Makerere University	Kampala, Uganda	Prof. Frank Kansiime, Co-PL
	Field visits	C3-20 BioInnovations Company Ltd	Kampala, Uganda	Mr. Alex Tumukunde, MD
	Field visits	C2-11 Makerere University (BIOCon Uganda Limited)	Kampala, Uganda	Dr. Joseph Kyambadde, Co-PL & MD
Monday, 15 February	Field visits	C1-3 Senai Farm Supplies Limited	Kampala & Mityana, Uganda	Prof. Samuel Kyamanywa, PL Prof. Settumba Mukasa, MD A Sweetpotato farmer
	Field visits	C1-13 Gudie Leisure Farm	Kampala Uganda	Dr. Gudula Naiga Basaza, MD
	Field visits	BioFresh Uganda Ltd)	Kampala Uganda	Dr. Richard Miiro Ms. Sonia Mwadime
Wednesday, 17 February	Field visits	C1-3 Tanzania Agricultural Research Institute – Mikocheni (TARI-)	Dar es Salaam, Tanzania	Dr. Fred Tairo (BioEARN Alumni), MARI laboratory, multipliers & farmers
		C3-20 Tanzania Commission for Science and Technology (COSTECH)	Dar es Salaam, Tanzania	Dr. Beatrice Lymo (Principal Scientist)
Thursday, 18 February	Field visits	C2-9 Sokoine University of Agriculture	Morogoro, Tanzania	Prof Jovin Mugula & team, start-up enterprise – Sorghum Clear malt drink and instant sorghum porridge flour
		Courtesy visit to C2-10 (OKOA Mushroom Enterprise Ltd)	Morogoro, Tanzania	Ms Bertha Mamiro & team
Friday, 19 February	Field visit	C2-11 Nelson Mandela African Institution of Science and Technology & iTEC (Including a courtesy call to Prof. Anthony Mshandete – BioEARN alumni)	Arusha, Tanzania	Prof. Karoli N. Njau (BioEARN alumni) Dr. Herb Rhee (iTEC) Prof. Anthony Mshandete

APPENDIX 2B. KEY STAKEHOLDERS

List of key stakeholders interviewed by reviewers virtually during the review period.

Name	Country	Organization	Position
BioEARN Student Alumni			
Yona Baguma	Uganda	National Agricultural Research Organization	Deputy Director General
Patrick Okori	Malawi	ICRISAT	Country Director
Suhaila Omar	Kenya	Pwani University	Professor
Antony Mshandete	Tanzania	Nelson Mandela African Institution of Science and Technology	Deputy Vice Chancellor
BioEARN Student Alumni (Supervisors)			
Samuel Gudu	Kenya	Rongo University	Vice Chancellor
Alois Kullaya	Tanzania	Ministry of Agriculture	Principal Agricultural Officer
BioEARN Program Coordinator			
Charles Mugoya	Uganda	Uganda National Council for Science and Technology	Chair of National Biosafety Committee
Previous evaluators			
Jane Morris	England		
BioEARN/BioInnovate Sida Managers			
Gity Behreva	Uganda	Embassy of Sweden, Uganda	First Officer
Claes Kjellstrom	Sweden	Sida	
Ivar Virgin	Sweden	Stockholm Environment Institute	Lead Scientist
Swedish stakeholders/beneficiaries			
Bo Mathiasson	Sweden	Lund University/Dept of biotechnology	Professor Emeritus
Torbjörn Fagerström	Sweden	Lund University/Dept of Ecology	Professor Emeritus
Policy experts in Eastern Africa			
Aggrey Ambali	South Africa	AUDA-NEPAD	Head of Planning and Resource Mobilization
Elioda Tumwesigye	Uganda	Ministry of Science, Technology and Innovation	Minister
Name	Country	Organization	Position
Maxwell Otim	Uganda	Ministry of Science, Technology and Innovation	Director of Research and Innovation
Gaspard Banyankimbona	Burundi	Ministry of Higher Education and Scientific Research	Minister

Kassahun Tesfaye	Ethiopia	Ethiopian Biotechnology Research Institute	Director General
Ahmedin Mohammed	Ethiopia	Ministry of Innovation and Technology	State Minister
icipe Management and Staff			
Gatigwa Kimana	Kenya	International Centre of Insect Physiology and Ecology	Director of Finance and Administration
Sunday Ekesi	Kenya	International Centre of Insect Physiology and Ecology	Director of Research and Partnerships
Biobusiness incubation partners			
Ian Lorenzen	Kenya	Growth Africa	Founder and Co-Director
PAC Members			
Yifru Tafesse	Ethiopia	Agricultural Transformation Agency	Ag. CEO
Mans Nilson	Sweden	Stockholm Environment Institute	Executive Director
Peggy Oti Boateng	France	UNESCO	Director
Ignace Gatare	Rwanda	University of Rwanda, College of Science and Technology	Principal and former Minister of Information
Ruth Oniang'o	Kenya	Rural Outreach Africa	Founder and CEO & Editor in Chief, AFJAND

APPENDIX 3. REPORTS OF ALL 20 PHASE II PROJECTS

Reports of all 20 Phase II projects that progressed from the first two open calls for projects. The projects include those that were visited by reviewers (indicated by an asterisk after the title), and those that were assessed by reviewing project reports and through discussions with the PMO.

Project C1-1: Adaptation and promotion of refractance window drying technology (RWDT) for production of high quality bioproducts. Reviewed by reports and discussions only.

The purpose of this project is to develop capacity for local production of refractance window drying technology (RWDT); produce high quality dryers (based on RWDT) in Kenya and Uganda; develop capacity for production of high-quality value added RWDT products; penetration of the national and regional market with products produced by RWDT; and enhance collaboration among farmers, agro-processors, researchers and support agencies. The project fabricated, tested and installed four RWDT equipments in Uganda. It also documented improved RWD designs in Kenya and fabrication of the prototype at Kenya Industrial Research Institute (KIRDI) is estimated at 40%. Key partnerships have been forged with industry actors in Kenya and Uganda to promote use of RWDT driers for small scale drying of fruits, vegetables and herbs; commercialize both the commercial and hybrid RWD, and to manage and oversee the certification and commercial usage of the large-scale dryer installed. The project has undertaken training of selected potential customers (agro-processors, farmers) in Kenya and Uganda, and has received expressions of interest as a result of training on RWD including from outside the region including from Burundi and Nigeria. It is supporting PhD and MSc students training.

Key issues facing the project

- The delayed procurement of raw materials and the importation clearance from NEMA that has affected fabrication of the RWD prototype at KIRDI must be overcome quickly.
- There remains a lack of clarity on how IP will be protected beyond the project countries.
- The agreement to guarantee access to a large-scale dryer at Makerere University and certification of a large-scale dryer installed in Uganda to facilitate commercial scale processing have to be finalised.
- The project has to work through the issue of farmers shifting from papaya to banana production because of papaya diseases. This has stimulated a discussion on whether the project should continue a focus on papaya.
- There is need to fast-track pilot testing and market validation of the RWDT at commercial level and refine the draft business model.

*The project is rated **moderate**, however, COVID-19 containment measures and procurement delays reduced effective implementation timeline and disrupted some key planned activities. The burn rate at May 2021 was 72%. The project has managed to produce and test RWDT but the SME startups have not commenced operating commercially hence project is rated to be in "**Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-2: Promoting Smallholder Access to Fungal Biopesticides Through Public Private Partnerships in East Africa – PROSAFE. Reviewed by reports and discussions only.

The project's expected outcomes included enhancement of market size for biopesticides in East Africa; development of innovative formulation and application technologies, establishment of pilot mass-production facilities at commercial and small-scale level; registration of new biopesticide products for use in integrated pest management, and enhanced awareness and capacity of various stakeholders on biopesticides. The project engaged with various stakeholders including regulators and R&D cycle actors to improve application strategy for enhancing the presence of biopesticides. The project has developed two new products for commercialization – one is being developed and the other is an extension label. It has identified fungus for vegetables pests and tested efficacy of the endophytes. The project has initiated patent registration in Kenya and Tanzania for two biopesticide products against Fall Army Worm namely biopesticide products ICIPE7 (Detain®) and ICIPE 78. The project partners brought onboard a new partner with greater capacity to engage with more farmers to overcome experienced challenge of regulating smallholder farmers and has trained lead farmer groups and facilitated use of safe products in the project countries. Through partnerships with the research institutions the project is building the capacity of seven students (4 MSc, 1 PhD, 3 Post-doctoral under Bioinnovate women fellows). The project is addressing IP issues through partnership agreements and benefits sharing and engaged at institutional level to attain commercialization of products.

Key issues facing the project

- A key challenge is the issue of scale (how to get more product into the market) and how to package products for smallholders.
- Options for building employment opportunities in the smallholder systems.
- Options for strengthen the financing system to facilitate smallholder use of the product(s).
- Quality control issues for smallholder/farmer group.
- The licence agreements with the private sector have not been concluded, and nor have essential Materials Transfer Agreements. There is a need to pilot the already developed products at a commercial level and refine the business model; strengthen partnerships that enhances farmers' awareness on the new products; and capacity building of the farmers groups on quality control.

*The project is rated **moderate**, however, COVID-19 restrictions and procurement delays reduced effective implementation timeline and disrupted some key planned activities. The burn rate at May 2021 was 90%. The project has managed to produce and test two products, but the startups have not commenced operating commercially, hence project is rated to be in "**Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-3 Integrating ICT in Commercial Production of Quality Sweet potato Planting Material. Comprehensive review which included face-to-face meetings with the project team.

The aim of the project was to realize a system for commercial production and delivery of certified seed; adoption of field based sweet potato disease diagnostic kit and use of a web-based mobile application for information access and seed production monitoring, inspection, and marketing. Project research partners have a long working relationship/partnership since BioEarn phase I, which built their capacity. The project's support to specific root crops policy change allowed stakeholders to develop standards and guidelines, which made it possible to register over 40 multipliers and link them with private partner labs in Kenya, Uganda and Tanzania. For instance, in Tanzania, the project supported change in law for the root crops (including sweet potato, cassava), which has allowed for registration and linkage of private multipliers with project partner labs. In Kenya, JKUAT and stakeholders have developed university level guidelines, which have formed the basis for national stakeholders' engagement workshops in the national policy-making process on setting standards for vegetative planting material. In Uganda, Senai and Makerere University produced guidelines for seed system in sweet potato vines, which has been adopted by the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). Five MSc and 1 PhD students are being trained under the project. The system developed triggered demand for the certified seeds leading to the university, the labs and the multipliers to achieve above targets on pre-basic (116%), basic (12%) and C1 seeds (1%) respectively. The "VIAZI VITAMU" App has enabled linking of the labs, multipliers and certification bodies. It is also facilitating a centralized application and scheduling for garden inspection and certification of vine multipliers in Uganda where over 30 App-registered farmers are accessing market-related information and plant inspection services. The App is also attracting buyers of large volumes of certified seed, with evidence that large-scale fresh-produce entrepreneurs, e.g. Lishe Limited, were signing contracts with labs for the supply of large volumes of seed, which are then passed on to contracted smallholder farmers who are then able to produce quality produce for high-end export markets. The project has a focused partnership bringing together scientists who have worked together and build their capacity from previous program and private partners who are grounded and already pushing other innovations to the market.

Key issues facing the project

- Some activities affected by COVID-19 especially the launch of the project App and the commercial testing of the portable diagnostic kit. These accounted for most of the expenditure shortfall of the committed budget.
- There has been a delay in clearance of JKUAT by the regulatory authority to formally certify production of clean planting materials.
- Limited farmers' awareness of the availability of quality clean vines.
- Farmers are used to getting vine material for free so reluctant to pay.
- Seasonal variability affects demand for vines.
- Non-return buyers indicates that farmers are unconvinced of the value of clean material.
- Partnership agreements that includes IP rights and revenue sharing needs finalising. High cost of the App (for a small private firm).
- Sustainability aspects of the App need clarity.

*Project performance is rated **satisfactory** because despite the COVID-19 containment measures, it managed to finalize the development of the App, pilot tested and market validated it at commercial level, and is currently being applied in Uganda before the launch. Burn rate in May 2021 was 78%. The project is rated in **"Level 5 (Full production and market launch)** of growth.*

Project C1-4: Piloting and Commercialization of Economically Viable Leather Processing Technology for Environmental Protection and Zero Waste Discharge. Comprehensive review which included face-to-face meetings with the project team.

The project purpose was to upscale production of processing enzymes; develop a “green” leather processing technology that can give high quality leather products and implement new technology in collaboration with regional companies. The project generated high expectations at policy level due to its direct link to the environmental priorities of the governments of Kenya and Uganda. It completed laboratory level piloting and has so far developed a management plan for bioprospecting (of enzyme from local bacteria). The project signed a framework agreement with major tanneries to pilot the green enzyme technology in Kenya and Uganda and to use the tanneries facilities for research and training purposes. Specifically, the project team signed a framework agreement with Alpharama Tannery (the largest tannery in East Africa) to pilot the enzyme technology in Kenya, and earmarked Skyfat Tannery Co Limited in Uganda as a pilot for the use of the enzyme technology. Students from both Makerere University and University of Nairobi are currently collecting baseline data to develop flowcharts due to the university-tannery partnership. Land for the construction of the bioreactor was allocated within the University of Nairobi and is awaiting the procurement of the large bioreactor under the guidance of *icipe*.

Key issues facing the project

- The project is on hold and cannot advance a whole raft of activities due to delays in the procurement and installation of the bioreactor.
- Industrial scale piloting of the enzymatic production and further development and implementation of a viable business model cannot be undertaken.
- In the absence of the bioreactor, the project is unable to build partnerships with relevant stakeholders like tanneries, slaughterhouses, and farmers.
- The universities’ plan to use the project to introduce and strengthen curricula focusing more on demand driven research in leather industry is uncertain.

*The project performance is rated **unsatisfactory** because most of its activities have not been implemented due to the delay in the procurement of bioreactor, which is a key component for its success. This has resulted in one of the lowest burn rates in May 2021 of 31%. Since the project has only developed and tested products at laboratory level, it is at **"Level 3 (Minimal products produced)** of growth.*

Project C1-5: Nitrogen bio-fortified and pelletized commercial-grade organic fertilizer made from urban biowaste to improve soil productivity and livelihoods of small holder farmers. Reviewed by reports and discussions only.

The project's expected outcomes included: adoption of pelletized bionitrogen fortified fertilizer; creation of awareness in smallholder farmers on optimum fertilizer application rates; publication in peer review journals; product certification and quality mark; increased preference of target farmers for new organic fertilizer over synthetic fertilizer; uptake of the technology by stakeholders; and potential for securing investment partners for scale-up. The project has produced more than 4,500 bags of Hakika Organic Fertilizer and recorded total sales of \$64,087 due to orders and demand from farmers. In addition, it has produced 146 tons of 'Hakika' granulated organic fertilizer of which, 100 tons was sold to farmers. Product registration for Hakika Organic fertilizer has been obtained from the Ministry of Agriculture's Tanzania Fertilizer Regulatory Authority (TFRA). Trademark certificate has been acquired for a fertilizer brand "HAKIKA" in Tanzania. One agro-dealer entered into an agreement with Guavay Co. Ltd to order and sell Hakika organic fertilizer to interested farmers at Ruaha-Mbuyuni Tanzania.

Key issues facing the project

- The project is faced with policy and legal framework issues in East Africa, which lack standards for the organic fertilizer.
- Municipal market waste in East Africa is mostly disposed-of unsorted and so the project is faced with separating biodegradable and non-biodegradable fractions.
- The development of a business plan is being delayed due to insufficient funds.
- The transfer of funds to the project is slow.
- The approval of foreign organic fertilizers in Uganda requires independent efficacy trials by the Ministry of Agriculture, Animal Industry and Fisheries.
- The project has not yet finalised agreements on IP and benefit sharing.

*The project is rated **satisfactory**, despite COVID-19 challenges. Despite its challenges, it has produced and sold products and also obtained registration. The progress is reflected in the May 2021 burn rate of 83%. The project is rated in **Level: 5 (product launch)**.*

Project C1-6: Promotion of post-harvest disinfestation treatment in Kenya and Uganda: Facilitation of market access for mango, avocado, French bean and bell pepper. Reviewed by reports and discussions only.

The project's expected outcomes included: enhanced knowledge on post-harvest dis-infestation treatments among the partner entrepreneurs; implementation of post-harvest dis-infestation treatment against key pests by the partner entrepreneurs; rules and regulations governing the use of the post-harvest dis-infestation treatment shared and harmonized among the partner entrepreneurs; quality and quantity of target vegetables' production improved; and access to regional and international lucrative export markets for the target commodities was facilitated. The project has fabricated and delivered a 1,670 litre hot water treatment tank to *icip*e Duduville for experimentation work. A functionally similar 1,000 litre hot water treatment machine was procured

and delivered to Uganda and a PhD student recruited. A post-harvest protocol for treating French beans from infestation by thrips was finalised and awaits submission to peer reviewed journals for publication. The project recognized advances to be made in direct support to farmers; e.g., to treat their own fruits by low-cost equipment like charcoal cooling so farmers can hold their fruit for longer, reduce losses and sell at better times for prices.

Key issues facing the project

- The project has endured significant procurement delays.
- The initial private sector partners lacked commitment and had expectations that their roles would be fully funded.
- Identifying new private sector partners remains a major issue for this project as funding for a commercial scale operation is significant.
- This project has not been able to source appropriate (process) engineering skills in a timely manner.
- The project is yet to assess economic viability of using the post-harvest disinfestation equipment.
- The PAC has recommended that there be a more active involvement of the private sector partners to develop business models for commercializing the technology.
- There is need to enhance capacity for partnerships to support identification of right interested private sector actors with capacity to pitch their business models before establishing the plant at industrial scale. Need to address sustainability aspects of the project.

*The project is rated **unsatisfactory**, has been affected by governance issues, poor choice of commercialization partners, and may be forced to look for new commercialization partners at the tail end of the program. It has also been restricted in carrying out experiments due to the COVID-19 pandemic. The burn rate in May 2021 was 87%. It is rated in **Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-7: Insect-Based Agri Business for Sustainable Grasshopper and Cricket Production and Processing for Food in Kenya and Uganda – INSBIZ. Reviewed by reports and discussions only.

The project's expected outcomes included: adoption of processing and marketing of cricket and grasshopper products by SMEs; approval of insect-based food standards and policies in Kenya and Uganda; and consumer acceptability for insect-based foods in Kenya and Uganda. The project developed cricket-enriched products, cookies and instant porridge flour in Uganda, which were market tested with high acceptability results. It has also characterised lower cost extruded products and is optimizing drying protocols for crickets for incorporating into the products. Also, optimization of processing protocols for ready-to-eat grasshoppers is proceeding. The development of the edible insects' standards in Uganda is complete and awaiting approval while in Kenya it is in advanced stages with standards under-going public review. The development of standards on the Code of practice of edible insect, edible insect processing and edible products have been completed and gazetted in Kenya and Uganda.

Key issues facing the project

- This is a relatively new economic activity and there are no current guidelines for rearing and processing of insects for food and feed.
- Market feasibility studies were also not possible due to lack of standards besides the immobility due to the COVID-19 crisis.
- Need for more awareness creation on the importance and potential benefits of edible insects' value chains.
- Large scale production of the insects has been significantly impacted by cannibalism. This has required this project to revisit their options for scaling up production to the levels that would be required for a commercial operation.

*Despite the recent production issues, the project is rated **moderate** as it has developed products and undertaken pilot testing and market validation for some products despite being affected by the COVID-19 pandemic but has run into the serious issue of cannibalism when production is lifted to larger scale. The burn rate in May 2021 was 87%. It is rated in **Level 4 (Market tested and revenues generated) level of growth for cricket while rated in Level 2 (product development and testing) level of growth for grasshopper.***

Project C2-8 Partnership to deliver to market Striga weed resistant maize and finger millet varieties in Kenya and Uganda. Comprehensive review which included face-to-face meetings with the project team.

The expectations from the project included incubation in the Maseno University Seed Unit, testing and release of New Striga weed resistant varieties, and creation of new markets through commercialization in Kenya and Uganda. Based on the previous close working relationship between the researchers and the private sector researchers, a partnership was developed with experienced Agri Seed Limited to support commercialization. When it was realized that the university would not raise enough seeds promptly, Qualibasic seed limited was brought on board to support seed multiplication through novelty approaches. The project entered two Striga weed resistant maize varieties for performance variety evaluation, initiated certified parental seed bulking for seven varieties and undertook joint demonstrations with farmers. These have been made possible through a non-exclusive commercialization licensing arrangement with Agri Seed Company Kenya Limited, which specifies a royalty payment rate of 2.5% on gross annual sales to Maseno. Five hundred kilograms of Maseno EH14 breeder seed was sold to Agri Seed and Qualibasic Seed Companies and the project has acquired a Plant Breeder's Rights Certificate for Maseno EH14 maize variety in Kenya. The Agri Seed company is aggressive in the engagement and has a regional decentralized operational presence in project countries. It also has sound partnerships with large scale seed multipliers and regulators built on previous engagements in the region and top company leadership has aligned the project to its objective of making new varieties contribute about 50% of the profit (innovation driven company). The project partner Maseno has a more progressive business model, which supports commercialization of the products. The university business model focuses on entrenching the roles and functions of the University on Teaching, Research, and Outreach; and how the university can harness the potential i.e. policies in place; patent policy in

the university, Incubation policy; cascading from the university to the community; all these are proving to be private partner and researcher friendly in terms of incentivization.

Key issues facing the project

- Smallholder farmers have been accustomed to free seeds and are not easily attracted to hybrid varieties.
- Regulatory difficulties in moving new varieties across national borders.
- Patenting and protection of plant breeders' rights are not clear.
- Plant breeding for Striga resistance is made especially difficult because taste and colour of new varieties is so important to their uptake. There is need to have significant seed increase of the promising products so that potential impact can be realised.
- The business model used by this project probably needs further consideration and fine tuning.
- New varieties require evaluation against other pests and diseases, especially Fall Army Worm. The results of that testing might influence promoting the Striga-resistant maize varieties.

*The project is rated **moderate**, due to sound partnerships with “aggressive” lead seed industry private sector commercialization and bulking firms and the use of the existing KEPHIS rights equivalent to operationalize partnership and avoid ‘running away’. The burn rate is lower than might be expected at just 52% in May 2021. It is rated in “**Level 4 (Pilot testing and market validation)** of growth.*

Project C2-9: Commercialization of Novel Sorghum and Millet Products for Improved Socio-Economic Gains in Eastern Africa. Comprehensive review which included face-to-face meetings with the project team.

The project aimed to increase utilization streams for sorghum (industrial production of snacks and instant flour), increase business and employment opportunities in the sorghum and millet value chain, enhance adoption of technologies for sorghum products and widen the range of value-added products in the market. The project established a working partnership between the university, local authority and trade and industry office in Ethiopia resulting in the allocation of a shade to the start-up at the industrial park. Approximately one metric ton of sorghum enriched instant porridge flours and snacks were produced and sold in Ethiopia, Tanzania and Uganda at the pilot testing and market validation stage. Some SMEs linked to the project in Uganda are reporting increased demand and employment in malt beverage businesses. Some sorghum farmers linked to the SMEs are also reporting improved sales and revenue due to increasing demand for quality sorghum. In Ethiopia, the startup has employed women as casuals to clean sorghum for processing.

Key issues facing the project

- Ethiopia:
 - The products considered “not smooth” or sufficiently rich in nutrients for children.
 - Delays in delivery of fabricated components of the processing machine.
 - Inadequate supply of quality sorghum.
 - Slow and labour-intensive sorghum cleaning process.
 - The dehulling process was found to cause nutrient loss by up to 40%.

- Community perceptions that associate sorghum consumption with low livelihood status.
- Uganda:
 - Regulatory issues with registration of the products.
 - Limited business skills and commercialisation capability in the project team.
 - Lack of capital.
- Tanzania:
 - Initial partnerships with larger companies on whole sorghum flour production and processing failed.
 - Not able to add nutrients to the products.
 - Business model unclear.
 - Poor relationship with the university technology transfer office.
- Project wide challenges include:
 - Perception that researchers have insufficient incentives (how can IP be used to commercialize and reward the researchers?).
 - Slow market testing and piloting due to lack of capacity. This leads to limited learning among partners.
 - All initial partnerships failed due to lack of adequate quantities of bulk products like malt and flour to be used as raw materials by large companies.
 - Poor Startups' struggling due to poor commercial skills and absence of a sustainability plan.

*The project is rated **unsatisfactory**. Despite the fact that the products are quite innovative and coming from Phase I, the consortium partners are all researchers and they lack adequate business skills and support from strong private sector partnerships leading to poor pilot testing and market validation. The burn rate in May 2021 was only 66%. The project is rated in "**Level 4 (Pilot testing and market validation)** of growth.*

Project C2-10 Commercialising nutrient-rich substrate blocks for mushroom cultivation in East Africa (OKOA Mushroom substrate). Comprehensive review which included face-to-face meetings with the project team.

The project aimed to establish a mushroom supplies enterprise, enhance adaptation and use of OKOA mushroom substrate blocks by farmers; publish new scientific research findings; increased mushroom production and marketing, and adaptation of the innovation by target SMEs in Tanzania and in Rwanda. The project registered OKOA Substrate Company and later rebranded it to OKOA Mushroom Company to establish a one stop station for production and sale of OKOA mushroom substrate blocks, growing of mushrooms, bulking and marketing. It has put in place a substrate blocks production system, trained farmers and other institutions on mushroom production, and has constructed a new production facility. It has acquired trademark certificate for a mushroom brand "OKOA mushroom" in Tanzania, and generated sales revenue from nutrient-rich substrate blocks for mushroom production in Tanzania.

Key issues facing the project

- The project has achieved good substrate block production.
- Mushrooms are not considered a priority in community diets.
- Sales of the blocks have been poor due to absence of demand for mushrooms.
- Weak distribution channels.
- Lack of commercial partnerships.
- SME lacks entrepreneurial skills.
- Need to undertake details market analysis of mushrooms and substrate blocks.
- Business model needs redesign that can incorporate stronger business skills, especially in marketing.

*The project is rated **moderate** due to lack of strong commercial partnerships to push through the marketing aspects hence is threatened with sustainability challenges beyond the program. The burn rate in May 2021 was 72% . The project is rated in "**Level 4 (Pilot testing and market validation)** of growth.*

Project C2-11 Establishment of a Regional Enterprise to Commercialize the Integrated Technologies for Agro/Biowaste Conversion in Eastern Africa – BIOCon. Comprehensive review which included face-to-face meetings with the project team.

The project expected to increase demand for the integrated wastewater treatment technology and its by-products by agro-processors in the region. The project research partners benefited from the BioEarn capacity building investments. In Tanzania the project piloted the use of biowaste management technology in, amongst others, a private banana wine distillery in Tanzania, a tannery in Ethiopia, and in a waste treatment plant in Uganda. The project has registered start-up companies - BioConversion Technology Africa Company Limited (BIOCon) in Tanzania and Uganda, with established, staffed and branded offices. While the registration of start-up companies in Tanzania and Uganda progressed relatively smoothly, registration in Ethiopia has been delayed because of conflicts between operation of the private enterprise and the university policy that requires that such registrations be undertaken under the faculty to getting support. The start-ups in Tanzania and Uganda have commenced competing for and being awarded tenders. BIOCon Tanzania has also played a key role in the sanitation component of the Government of Tanzania's review of the manual for Municipal wastewater management and has expanded through a strategic partnership with a private sector firm. The project initiated the establishment and registration of BIOCon in Ethiopia under the existing university policy provisions.

Key issues facing the project

- Overcoming policy constraints that were unforeseen by the consortia (e.g., a conflict between BIOCon Tanzania and the university governing council over compliance with university guidelines on innovations, and, in Ethiopia, conflict at the university with regard to interconnectedness of the university with the private sector, lack of adequate business capacity among researchers in some countries and IP recognition and sharing).

- Different priorities of stakeholders and partners where researchers are focused on environmental impacts and the private sector partners and potential partners have a stronger focus on financial returns.
- Capacity of the consortium to attract impact investor is required. This is likely to be achieved through further capacity building of researchers in business skills and, having real business expertise playing stronger roles.

*The project is rated **moderate**. Despite initial conflict of the startups with policy frameworks of some universities, which delayed activities implementation progress, the project managed to test the innovation in the market and is generating revenue in Uganda and Tanzania. The burn rate in May 2021 was 69%. The project is rated in "**Level 4 (Market tested and revenue generated)** of growth.*

Project C1-12: Using Black Soldier Fly (BSF) larvae as an environmentally sustainable source of affordable protein for chicken and fish feed. Reviewed by reports and discussions only.

The project aimed to enhance the acceptance of BSF by small-scale farmers as an alternative source of protein; adoption of BSF as an alternative feed ingredient, and adoption of BSF standards in partner countries. The project was led by the private sector, has registered a startup in Kenya (BiBuu), which has produced ten tons of fertilizer out of which 2 tons were sold. The startup secured a loan with a private financier for \$50,000 to acquire a raw material collection truck and motorcycle. The project acquired new BSF standard body and is considering a proposal by a corporate investor to invest USD \$5 million USD. This could enable the project to deliver their target of producing animal feeds in Kenya and Tanzania.

Key issues facing the project

- This project argues that the slow pace of project implementation is due in many parts to an absence of a policy friendly environment. This includes the inability to obtain the necessary export permits to send samples of insect protein to Ethiopia for lab trials, and the difficulty in obtaining manufacturing certification but possibly most importantly, the need for relevant feed policing in Tanzania and Kenya.
- The contracted market survey in Tanzania resulted in a poor-quality report that was not useful in guiding project planning and monitoring of activities in the aquaculture industry.
- Commercial level piloting for insect protein, farmer level trial on fish feed, poultry on-station trials on feed are yet to be done (due to slow drying process of cake/feed, need for a hydrator).

*The project is rated **moderate**, it has developed a product which awaits pilot testing and market validated. Most outputs were not accomplished due to COVID-19 travel restrictions in the region. The burn rate in May 2021 was 82%. The project has managed to develop a product and is rated to be in "**Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-13 Production, processing and marketing of catnip (*Nepeta cataria* L., Lamiaceae) products to prevent malaria in Eastern Africa. Comprehensive review which included face-to-face meetings with the project team.

The project's expected outcomes included acceptance, certification and/or registration of the products by the authorities; and commercial consumption of products. The project obtained a sanitary and phytosanitary certificate to produce seed in Burundi and is currently raising catnip seedlings in the nursery. It is pursuing a certificate for the production of catnip seed from the Ministry of Agriculture, which will be analysed and certified for exportation to partners for the production of catnip. The project signed a contract with a Chinese Company to supply 300 and 500 litre distillation equipment for essential oil extraction, and the procurement process for civil works for a catnip repellent product facility in Burundi was completed. The Uganda partner who was to major in the supply of raw materials such as catnip and essential oil has already planted essential oils and installed a processing facility to sustain the farmers while awaiting clearance to supply processed essential oils to Burundi.

Key issues facing the project

- Most crucial challenge is provision of evidence of the composition of the lab-level repellent samples already produced.
- Have not received Government certification to permit products being marketed in the region.
- Procurement is a major issue for this project.
- Have yet to obtain the release of protocols for developing samples from *icipe*. This has delayed processing and subsequent release of the nature-based mosquito repellent products in the market.
- There is a lack of clarity on how to achieve certification in partner countries so that catnip seeds can be sent to Uganda and Tanzania.
- Capacity building at the University of Burundi to enable more efficient and effective certification of products, and for stronger commercial and policy level partnerships to support the initiative.

*The project is rated **unsatisfactory** due to the above. The burn rate in May 2021 was just 54%. The project developed a product and is rated to be in **"Level 2 (Product development and testing) of growth**.*

Project C1-14: Development of improved semiochemical prototypes and their integrated push-pull deployment in areawide control of tsetse flies in Eastern Africa. Reviewed by reports and discussions only.

The project's expected outcomes included: publication of new knowledge on effective tsetse repellence and attraction; optimization of push-pull technology and devices for market availability; mapping and documentation of target markets and distribution networks (supply chains) for the push-pull devices and technologies; and development of networks and partnerships for commercialization for the push-pull devices and technologies. The project aimed to remove tsetse fly from the tourist camps and has successfully masked odour blends (attractant and repellent) to

enhance odour appeal through an industrial partner, in collaboration with third party technology/service providers. It successfully prepared one repellent specific and two attractant specific modifiers. It also developed three modifiers that are applicable to both repellent and attractant and assessed the efficacy of two against three species of tsetse fly in Tanzania and Uganda. The project has generated interest from other private sector actors and development agencies like USAID who have assessed its potential and are looking to see if there is opportunity to fund the projects. The project has applied for patents for new attractants and repellents. Project partners have successfully managed to maintain a schedule of meeting every first Tuesday of the month.

Key issues facing the project

- The project lacks a clear investment plan, and this should be a priority.
- Fiduciary management structure (funds go to different partners and different institutes some of which can be well removed from the team members within that institute).
- The rigid agreements under BioInnovate dictate that funds have to go to particular institutes so virtually impossible to reallocate funds to meet a changing set of circumstances.
- There is a lack of data on market trials of the attractant and repellent blends for common application.
- The project has yet to obtain regulatory approvals for repellent and attractant blends.

*The project is rated **moderate**. The burn rate was just 60% in May 2021. It is rated in **Level 3 (Minimum viable products produced) of growth**.*

Project C1-15: Small-scale community biorefining of sorghum for food, sugar, and biomaterials in rain fed areas of Eastern Africa. Reviewed by reports and discussions only.

The expected outcomes included: increased uptake of sormaize by smallholder farmers; increased use of sorghum-based value-added products by target industries; and products registration of feedstock and bio-based products. The project contracted farmers for variety verification trials for candidate sweet sorghum in Ethiopia. An application for sweet sorghum variety verification, trial evaluation and release was submitted to the National variety release committee in Ethiopia. In Uganda, the project produced 200 litres of sorghum syrup from 1.5 acres of harvested sormaize. The project registered and received a trademark registration certificate. The project produced sorghum syrup minimum viable products, which were submitted to the BecA-ILRI Hub for biochemical and nutritional profiling. In Kenya, seed bulking at university experimental research farm proceeded and currently the team has at least 500 kgs of sweet sorghum seeds. In addition, a total yield of 495 kgs of sorghum stalks yielded 115 litres of juice were extracted producing 14kgs of sorghum syrup and ethanol for sanitizers. It has also characterized crops and is now able to know how much syrup is produced. The project is working on broadening the linkages including with large scale farms. Prototypes of sweet sorghum syrup were minimally produced and tested as ingredients in food consumption in Ethiopia, Kenya and Uganda.

Key issues facing the project

- This project is dealing with a new product and so it is hampered by the issue of perceptions.
- Locust invasion of most farms meant that “project farmers” had alternative employment in managing locust numbers.
- Flooding in Uganda and Kenya destroyed production on some farms.
- There is a lack of commercialization and innovation skills among most research institutes (most do research and support work up to piloting then stops) and this accentuates the need to have more strategic private sector companies’ participation to lead commercialization. Delays in procurement of biorefinery equipment in Ethiopia are delaying progress.
- Political instability in Ethiopia worsened during project implementation and there were difficulties in accessing farmland for planting the varieties.

*The project is rated **moderate**, however COVID-19 and procurement delays reduced effective implementation timeline and disrupted some key planned activities. The burn rate in May 2021 was 67% The project has managed to produce and test products, but the startups have not started operating commercially so the project is rated as "**Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-16: Orange-fleshed Sweet potato (OFSP) Puree for Bakery Applications in East Africa for Nutrition, Post-harvest Loss Management, and Youth & Women Economic Empowerment. Comprehensive review which included face-to-face meetings with the project team.

The main aim of the project was to enhance the use of Orange-Fleshed Sweet Potato (OFSP) puree (steamed mashed root tubers) as a key ingredient in the production of baked and fried products for human consumption. It planned on doing this by reducing the cost of production and by increasing awareness of OFSP puree-based products and their nutritional benefits in Kenya, Uganda, Ethiopia and Tanzania. The project has installed OFSP puree processing equipment in Uganda, Rwanda and Ethiopia. A total of 55kg of sweet potato rolls and sliders were produced for testing purposes in Rwanda. In Uganda, the processing SME formally partnered with Makerere University to commercialise OFSP puree. The project signed a memorandum of understanding to supply clean planting materials to host farmers producing OFSP roots for the processing SME. In Ethiopia, the partner bakery conducted a trial of cookies and Injera bread containing OFSP for testing purposes with positive results. In Kenya, the partner SME has partnered with another SME and is processing purchase orders of 650 pieces of OFSP chapati dough per day from two individual women vendors. The project has also acquired sweet potato puree and bread standards to facilitate trade of safe and quality OFSP puree products in Kenya. Some trained vendors in Kenya are reporting increased sales of OFSP chapati compared to white chapati by up to 130%.

Key issues facing the project

- Project still to overcome late supply of processing equipment to the processors in Ethiopia and Uganda.

- Installation of processor in Ethiopia being delayed because of the need to install a three-phase power connection.
- Farmers scaling down production of OFSP to avoid post-harvest losses due to the lack of market.
- Limited capacity by some bakers to comply with food safety requirement and product promotion.
- Procurement constraints are a priority for the project team.
- The priorities are to address the procurement constraints to ensure that scheduled project equipment is delivered on time.
- Need to bring on board entrepreneurs who can absorb some of the costs of promoting food safety and nutritional security among the users.
- The project requires multiple partnerships with small enterprises, and this necessitates continuing work on market validation and refining of the business model or models.
- The crucial dependence on the specialised equipment to manufacture the puree necessitates the development of a package that includes delivery, installation (including 3-phase power if necessary), and a clear maintenance plan and capability.

*The project is rated **moderate**. It has been able to function satisfactorily during COVID-19 due to its early focus on training which generated interest and adoption. However, most major activities were slowed down by procurement and COVID-19 restrictions. The burn rate in May 2021 was 69% It is rated "**Level 3 (Minimum Viable Products Produced)** of growth.*

Project C1-17: Integrating Aroma Honey Toffee and Bamboo Hives into Apiculture Value Chains in Uganda, Kenya and Rwanda. Reviewed by reports and discussions only.

The expected outcomes included: increased access to improved hives by beekeepers; improved quality of honey sold by beekeepers; increased sales of honey; and increased margins for beekeepers. The project proposal to bring together consortium partners from Kenya, Rwanda and Tanzania was approved to support commercialisation of production of aroma honey toffee based on the natural nature of the products. The project was initiated at Makerere University School of Food Technology, Nutrition and Bioengineering (SFTNB). SFTNB came in later under a short-term agreement of one year to provide technical support. Uganda National Bureau of Standards (UNBS) has tested and approved the sweets. The project has acquired a trade mark for aroma honey toffee and sent the equipment for calibration by UNBS (Q mark) and intends to support partners to achieve national standards. It has done two brief market studies in Uganda and intend to do a bigger distribution model for other countries after an elaborate study. Currently it is achieving some profits but re-investing to put structures in place. It currently has an informal distribution structure for the product, and it uses WhatsApp, emails and shop outlets. (The project has an agreement with a café that stocks the products, but sales are low due to COVID-19). Marketing had not been aggressive due to lack of quality so far but it aims to use digital marketing and candy vending machines.

Key issues facing the project

- The project is endeavoring to develop a better framework for acquiring honey that will be sourced from “bulklers” and from individual beekeepers and in doing so ensure that adulterated honey is avoided.
- The project has to confront issues of government regulation where candies (the toffee) is not considered a food, but is a luxury item. This has implications in various regulations.
- The project recognises that it needs to redefine the business model including payments of royalties (if any!)

*The project is rated **moderate**, however COVID-19 has a reduced effective implementation timeline and disrupted some key planned activities. The burn rate in May 2021 was 46%. The project is rated to be in "**Level 5 (Product Launch) of growth***

Project C2-18: Delivering bio-alkanol gel fuel as a renewable energy source to rural households of communities living in the Lake Victoria basins. Reviewed by reports and discussions only.

The expected project outcomes included availability of Bio-Alkanol gel in enough quantities to demonstrate its beneficial features; consumers adoption and use of Bio-alkanol gel fuel in pilot areas; and registration of the product; acquisition of requisite licenses and certificates; commercialization of the product; finalization of business model; informal sector artisans and agro dealers benefitting from sales of fabricated stoves and Bio-alkanol gel fuel respectively; special interest groups improving their incomes; reduced reliance on Biomass fuels and imported petroleum-based fuels; reduced in-door air pollution,; and a placement facility for capacity development for university and Technical Vocational Education Training (TVET) students. The startup has been registered with partners coming in as individual shareholders and agreements to give royalties to the university for supporting researchers to use its facilities as private enterprises to scale up and commercialize innovation. The project carried out a lab level pilot study and produced minimum viable products (100 to 200 litres), which has been used to pilot the use of the technology by young women with small families using special stoves in Kenya. One patent has been acquired for a bioalkanol gel fuel in Kenya. The startup host institution endorsed the project site through a formal letter.

Key issues facing the project

- COVID-19 and procurement have disrupted the establishment of a facility to pilot commercial scale operations. The operation of that facility was to inform the development of an appropriate business model.
- There is a need to enhance the business skills of the project team, especially skills that will enable the team to progress this project, which has strong environmental value.
- Because ethanol is a “controlled” product, government regulation has resulted in significant delays.

*The project is rated **moderate**, despite COVID-19 challenges, it has acquired patent bio-alkanol gel, undertaken pilot testing and market validation. The burn rate in May 2021 was 47%. The project is rated in **Level: 4 (Market tested and revenue generated)**.*

Project C2-19: Biomangement of coffee waste from coffee processing industries through vermicomposting and its integration with aquaculture, horticulture, and poultry. Reviewed by reports and discussions only.

The project's expected outcomes included: improved livelihood of at least fifteen families at each projects sites in Ethiopia and Kenya through selling the products (vermicompost (biofertilizer), eggs, fishes, chickens and vegetables); Enterprises able to rear fish and chickens with cheap feed; enterprises able to grow vegetables using biofertilizer produced from coffee waste through vermicomposting and effluent water from fish pond; and other coffee processing industries in Ethiopia, Kenya and Tanzania included in the project gets lesson from this project and start processing their coffee waste through vermicomposting. The project built the capacity of coffee-processing company to develop partnerships with the government and private sector to explore how to turn agro-waste they generate to make additional income and address social costs. For instance, the owner of a coffee processing company in Western Ethiopia that had been producing a pile of strongly smelling husks set aside some space for composting and is working with the government to make vermicompost for fertilizing the crop land. The project established youth groups some of which have developed into SMEs linked to financing mechanism and product market and are producing, selling and making money from vermicompost in Ethiopia. The project has also established a vermicomposting system in Kenya, which commenced operations by introducing earthworms and has been introduced to a private sector firm to scale-out the technology. More farmers are purchasing and using vermicompost in Ethiopia at pilot level with improved perception on the product. The project has realized integration of horticulture farming through use of the Vermicompost in Kenya and registered interests including from ILRI management to set up a vermicomposting structure at its main campus in Nairobi to manage agro-waste.

Key issues facing the project

There is a delay in the development of the business case because Kenya's project partner needs further information to confirm the proposed significant reduction of the waste and the effectiveness of conversion of waste to vermiliquid and vermicompost. There is an urgent need to finalize the business model based on the market level pilot data.

*The project is rated **moderate**. The burn rate in May 2021 was 61% due to significant delays in this project as a result of COVID-19. It is rated in **Level 3 (Minimum viable products produced) of growth**.*

Project C3-20 Developing an innovation-led Bioeconomy Strategy for Eastern Africa (BiSEA). Comprehensive review which included face-to-face meetings with the project team.

The project aimed to increase knowledge and awareness of bio-economy issues in East Africa; and to gain approval of an innovation-driven bioeconomy strategy for Eastern Africa by East African Community (EAC) Governance Bodies. It has supported scientists and national institutions in the development of a EAC biotechnology and biosafety policy that has identified the key foci of biofuels, bio-pharmacy and biowaste. That policy is currently under review. An implementation mechanism for involving all stakeholders in the bioeconomy is in place and a bioeconomy repository portal has been developed. A MoU was developed between *icipe* and the East African Science and Technology Commission (EASTECO) to ensure that implementation of the strategy is technically and financially supported. The project also supported the development of a mechanism to be approved by the Intergovernmental Authority on Development (IGAD) to enable countries like Ethiopia, which are not members of the EAC to benefit from its activities. The EASTECO has committed 1 million USD for policy advancement linked to the BioInnovate Africa project.

Key issues facing the project

Despite the advances made in this project, a number of critical challenges remain.

- Increasing the level of understanding of bioeconomy among the national institutions.
- Lack of harmonisation between national and regional policies and the potential that harmonisation might deliver.
- Low number of bioeconomy related activities at subregional universities.
- Lack of entrepreneurship skills and private sector relationships amongst innovators and
- Absence of clear policies on how to manage IP.
- Given the nature of the BioInnovate themes, there is need to determine the potential impacts of investment into policy issues, including policy harmonisation in the areas of poverty reduction, environmental health, and nutritional security (currently this is being done in a piecemeal fashion).
- The issues of policy are large and complex and addressing them demands close relationships with national and subregional agencies such as the Ministries of Agriculture, Environment, and Health.
- Despite the success of the project in undertaking its scheduled activities, the relatively small amount of money available to address multiple policy issues means that progress across the range of issues will be slow.
- With the development of the Bioeconomy strategy, it will be essential to consider how that strategy can be implemented.

*The project is rated **satisfactory**, most of the outputs have been achieved and the burn rate in May 2021 was 89%. The project has delivered its strategy and so is rated to be in "**Level 5 (Product Launch) of growth**."*

APPENDIX 4. BUDGET AND EXPENDITURES

Budget, disbursed funds to projects, acquitted expenditure and burn rate calculated in May 2021.

Project No.	Project short name	Budget Total	Disbursed funds May 2021 (USD)	Expenditure Acquitted May 2021 (USD)	Burn rate (Expenditure disbursed; %)
C1-1	Refractance drying of fruits	748,486	485,135	351,102	72%
C1-2	Fungal Biopesticides – PROSAFE	750,000	485,264	434,508	90%
C1-3	ICT Sweet potato	741,015	578,257	450,374	78%
C1-4	Leather processing	750,000	324,880	101,313	31%
C1-5	Bio-fortified N fertiliser from urban waste	560,573	543,999	452,326	83%
C1-6	Post-harvest fruit and vegetable treatment	750,000	557,119	482,526	87%
C1-7	Insect production and processing for human food	750,000	705,060	615,777	87%
C2-8	Striga weed resistance	193,725	133,329	69,687	52%
C2-9	Sorghum and millet products	250,000	154,506	101,863	66%
C2-10	Mushroom substrates	249,940	221,965	159,873	72%
C2-11	Agro waste conversion and BIOCon	249,920	229,388	157,371	69%
C1-12	Black soldier fly for poultry and fish feeds	746,458	701,397	578,534	82%
C1-13	Catnip malaria products	745,834	688,907	371,355	54%
C1-14	Semiochemicals for control of tsetse flies	750,000	528,349	315,590	60%
C1-15	Biorefining sorghum for food sugar and biomaterials	750,000	530,567	352,924	67%
C1-16	Orange sweet potato puree in bakeries	743,753	417,552	288,684	69%
C1-17	Aroma Honey Toffee and Apiculture	250,000	220,122	101,067	46%
C2-18	Bio-alcohol gel for fuel in Lake Victoria basin	242,918	166,961	78,452	47%
C2-19	Coffee waste vermicomposting for aquaculture, horticulture and poultry	249,975	207,225	126,186	61%
C3-20	Bioscience Policy framework	500,000	500,316	443,023	89%
	TOTALS	10,972,598	8,380,296	6,032,537	72%

APPENDIX 5. PERFORMANCE RANKING OF PROJECTS

Performance ranking of projects in each of the countries in which they were operating. Projects in which ranking differed between countries are highlighted. Because of the nature of the project, Project 20 was not ranked for each country.

No.	Project	Kenya	Uganda	Burundi	Ethiopia	Rwanda	Tanzania
C1-1	Adaptation and promotion of RWDT	unsatisfactory	moderate				
C1-2	Access to fungal biopesticides	moderate					moderate
C1-3	ICT in sweet potato planting materials production	moderate	satisfactory			moderate	satisfactory
C1-4	Leather processing technology	unsatisfactory	unsatisfactory				
C1-5	Nitrogen bio-fortified and pelletized organic fertilizer		moderate				satisfactory
C1-6	Promotion of post-harvest disinfestation treatment	unsatisfactory	unsatisfactory				
C1-7	Insect-based agribusiness	moderate	moderate				
C2-8	Striga weed resistant maize and finger millet varieties	moderate	moderate				
C2-9	Novel sorghum and millet products		unsatisfactory		unsatisfactory		unsatisfactory
C2-10	Nutrient rich mushroom substrate blocks					moderate	moderate
C2-11	Integrated Technologies for Agro/Biowaste Conversion		moderate		unsatisfactory		satisfactory
C1-12	Black Soldier Fly Larvae as Chicken and Fish Feed	moderate			unsatisfactory		
C1-13	Production, processing and marketing of catnip		unsatisfactory			unsatisfactory	unsatisfactory
C1-14	Semiochemical prototypes and control of Tsetse flies	moderate	moderate				moderate
C1-15	Biorefining of sorghum for food, sugar and biomaterials	moderate	moderate				moderate
C1-16	OFSP Puree for Bakery Applications	moderate	moderate		moderate	moderate	
C1-17	Aroma Honey Toffee	unsatisfactory	moderate				unsatisfactory
C2-18	Delivering bio-alkanol gel fuel	moderate	moderate				moderate
C2-19	Biomangement of coffee waste from processing industries	moderate			moderate		moderate
C3-20	Developing an innovation-led Bioeconomy strategy						

External Evaluation of Sweden's Support
to Bioscience Research and Innovation in
Eastern Africa through BIOEARN and
BioInnovate Africa Regional Initiatives

