Fostering a bio-economy in eastern Africa: Insights from Bio-Innovate

Fostering a bio-economy in eastern Africa: Insights from Bio-Innovate

Editors
Allan Liavoga[1], Ivar Virgin[2], Julius Ecuru[3], E Jane Morris[4], John Komen[5]

1. Bio-Innovate program, International Livestock Research Institute
2. Stockholm Environment Institute
3. Uganda National Council for Science and Technology
4. School of Biology, University of Leeds, UK
5. Komen Bioscience Consultancy, The Netherlands

June 2016

Acronyms

AATF	African Agricultural Technology Foundation
ABI	African Bioscience Initiative
ASEAN	Association of Southeast Asian Nations
AU	African Union
BecA	Bioscience eastern and central Africa
BGA	Blue-green algae
BIC	Biotechnology innovation centre
BIL	Banana Investments Ltd
BIO-EARN	The Eastern Africa Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development
Bio-Innovate	Bio-resources Innovations Network for Eastern Africa Development
Biotechnology YES	Biotechnology Young Entrepreneurs Scheme
BIPCEA	Bioscience Innovation Policy Consortium for Eastern Africa
BIRAC	Biotechnology Industry Research Assistance Council
CAADP	Comprehensive Africa Agriculture Development Program
CEO	Chief executive officer

CSIR	Council for Scientific and Industrial Research
Danida	Danish International Development Agency
DST	Department of Science and Technology
DTI	Departments of Trade and Industry
ETP	Effluent treatment plant
EU	European Union
ILRI	International Livestock Research Institute
IP	Intellectual property
ISAAA	International Service for the Acquisition of Agribiotech Applications
KALRO	Kenya Agricultural and Livestock Research Organization
KBBE	Knowledge-based bio-economy
KEPHIS	Kenya Plant Health and Inspection Service
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organization
NSI	National system of innovation
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
S&T	Science and technology
SDG	Sustainable Development Goal
SEARCH	Southern and Eastern African Regulatory Committee on Harmonization
Sida	Swedish International Development and Cooperation Agency
SME	Small and medium enterprise

SSA	Sub-Saharan Africa
STI	Science, technology and innovation
STISA	Science Technology and Innovation Strategy for Africa
TCBN	Tissue Culture Business Network
TIA	Technology Innovation Agency
UK	United Kingdom
US	United States (of America)
WEMA	Water Efficient Maize for Africa

ILRI thanks all donors and organizations which globally supported its work through their contributions to the CGIAR system

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Cover picture: Bio-Innovate, Ecomedia

ISBN: 92–9146–474–0

Citation: Morris, E.J., Kunert, K. and Comins, N. 2016. Bio-incubators in South Africa: Lessons for policy and implementation. IN: Liavoga, A., Virgin, I., Ecuru, J., Morris, J. and Komen, J. (eds.) 2016. *Fostering a bio-economy in eastern Africa: Insights from Bio-Innovate.* Nairobi, Kenya: International Livestock Research Institute. pp. 71–82.

Patron: Professor Peter C Doherty AC, FAA, FRS

Animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

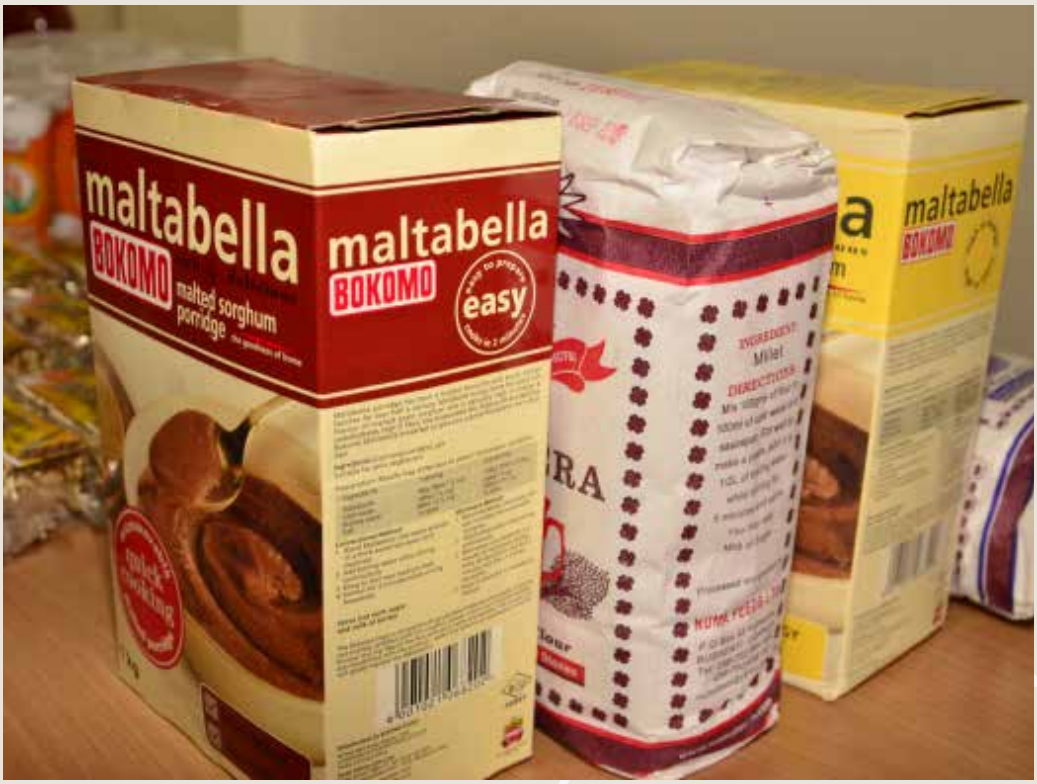
ilri.org
better lives through livestock

ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa

Contents



Bio-Innovate Africa

Bio-Resources Innovations Network
for Eastern Africa Development

Chapter 6
Bio-incubators in South Africa: Lessons for policy and implementation

E Jane Morris, School of Biology, University of Leeds, UK
Karl Kunert, Department of Plant Science, University of Pretoria, South Africa
Neville Comins, Independent Innovation Consultant, South Africa

Introduction

The purpose of this chapter is to chart the history of bio-incubator development around the world, but with particular emphasis on South Africa, and to highlight lessons learned that could be useful in eastern Africa.

What is incubation and what is bio-incubation?

The US has probably the longest and most successful track record in business incubation. It is generally accepted that the first business incubator was created by Joseph Mancuso in Batavia, New York, in 1957 (Leblebici and Shah 2004). To quote from the information provided on the website of the US National Business Incubation Association (NBIA 2009):

> Business incubation is a business support process that accelerates the successful development of start-up and fledgling companies by providing entrepreneurs with an array of targeted resources and services. These services are usually developed or orchestrated by incubator management and offered both in the business incubator and through its network of contacts. A business incubator's main goal is to produce successful firms that will leave the program financially viable and freestanding. These incubator graduates have the potential

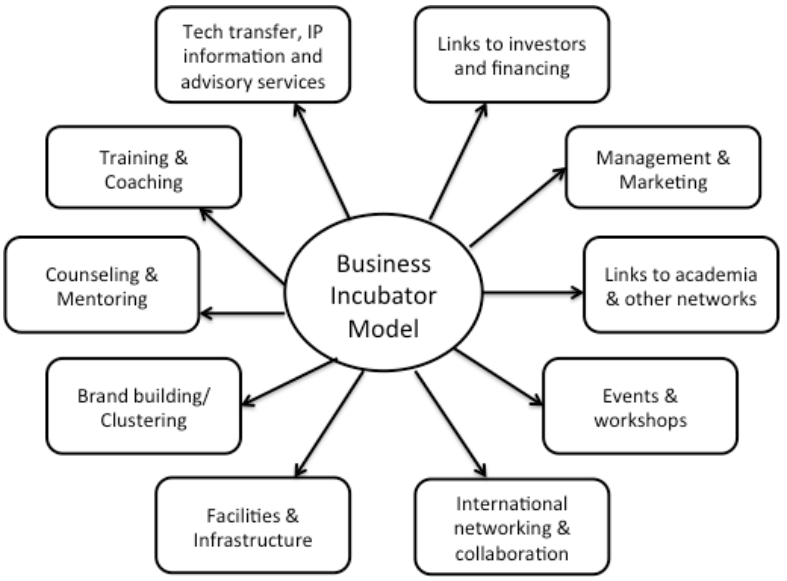
> to create jobs, revitalize neighbourhoods, commercialize new technologies, and strengthen local and national economies.
>
> Critical to the definition of an incubator is the provision of management guidance, technical assistance and consulting tailored to young growing companies. Incubators usually also provide clients access to appropriate rental space and flexible leases, shared basic business services and equipment, technology support services and assistance in obtaining the financing necessary for company growth.

Most incubators use a non-profit business model. Sponsors generally include universities, economic development organizations and other community-based groups, often with help from government. Particularly in developing countries, most incubators are government-funded (Akçomak 2009).

While some incubators are multipurpose, there has been an increasing tendency for them to focus on specific market sectors and/or specific technologies. This is certainly the case in the biotechnology sector, where technology development generally has a long lead time and requires focused attention. Having said this, biotechnology also encompasses a range of lower technology opportunities, particularly in the agriculture and food sectors. Entrepreneurs within the biotechnology sector are normally scientists with limited business managerial experience, often setting up university spin-out companies. The R&D process can take up to 15 years (McAdam and McAdam 2008), and is expensive and high-risk compared with some other sectors.

Bio-incubators thus provide dedicated support to the biotechnology and broader life sciences sectors. Conventionally, bio-incubators also offer flexible office and laboratory spaces, as well as specialized support services and networking, to provide an enabling environment for new biotech companies. Some programs linked to bio-incubators or to other business support also run so called 'accelerator' programs that aim to provide dedicated business coaching to selected projects. Examples include the seed accelerator at Chalmers Innovation in Sweden, and the Biotechnology Young Entrepreneurs Scheme (Biotechnology YES) in the UK. Figure 3 shows some of the general services and functions commonly offered by incubators (Mutambi 2013).

Figure 3. Services offered by incubators



Bio-incubators in the developed world

There are more than 100 bio-incubators in the US. The majority have been established with a mix of university and government funding and can be associated with a single university or a network of universities. Europe has been slower to jump on to the bio-incubator bandwagon, but is led by the UK where 20 bio-incubators were established during the decade of the 2000s (Ehret et al. 2012). Well over a quarter of new life science start-ups in the UK are located in a bio-incubator (Crocker and Pope 2012). Switzerland ranks second in Europe in the development of biotechnology, with the world's highest per capita biotechnology density (Ukropcova and Sturdik 2009).

A key success factor for new biotech start-ups within a bio-incubator is access to capital. In the US, despite the recession, bioscience venture capital investments have consistently exceeded USD 4 billion per year, even reaching 7.6 billion in 2014 (Ernst and Young 2014), with the average investment for a start-up company being USD 5.74 million (Battelle/BIO 2010). Even before reaching the stage of accessing venture capital, there is a need for funding to establish proof of concept (assess the potential of the technology, identify the market, protect the IP, develop a prototype, test and validate) and then for pre-seed funding to establish the business function and work towards securing initial financing. Again, the US scores well in this respect, largely due to state support, with more than USD 200 million available annually for proof of concept, and even more for pre-seed and seed funding (Battelle/

BIO 2008). Funding for start-ups in Europe is more limited, leading to a greater focus on bio-incubators hosting service-based rather than product-based companies (Ehret et al. 2012). European venture capital funding in 2014 amounted to USD 2 billion (Ernst and Young 2015). In that year the UK attracted the most venture capital investment followed by Switzerland and Germany (Ernst and Young 2015).

Evidence regarding the value added provided by bio-incubators in the developed world is somewhat sparse, and tends to form part of the general literature regarding the value of business incubators as a whole. Nevertheless, it is claimed that incubated biotechnology companies internationally have a 70–80% success rate, as opposed to the 20% overall success rate of biotechnology start-ups (DST 2001). It is apparent that there is considerable variation in the performance of individual incubators (Al-Mubaraki and Wong 2011), but the complex high-risk nature of biotechnology and the long development times involved would tend to provide justification for the need for specialized bio-incubation services.

Bio-incubators in the developing world

In many developing countries, bio-incubators are either non-existent or only just starting to be put in place. Somewhat more advanced countries with emerging economies, such as Brazil and India, are increasingly focused on the development of biotechnology through the establishment of bio-incubators and biotech business parks.

In Brazil, where there is a supportive environment and well organized public funding, more than half the biotech enterprises are linked to an incubator, demonstrating the importance of incubators and technology parks for the development of the sector. There are more than 10 incubators hosting biotech start-ups, though most are multi-sectorial and not focused exclusively on the life sciences and biotechnology (BRBIOTEC/CEBRAP 2011).

Likewise in India, there is a supportive government environment, with a burgeoning number of government-funded bio-incubators and biotech business parks. The Biotechnology Industry Research Assistance Council (BIRAC) has initiated a scheme for strengthening existing bio-incubators and establishing new ones, and there are at least a dozen BIRAC-funded incubators. Government grants provide initial seed funding for incubated biotech start-ups. However, companies still face a number of challenges, primarily related to the long gestation period for new companies in the biotechnology sector and the difficulty of accessing follow-on funding (Acharya 2013). Venture capitalists are few and far between in developing countries, resulting in an ongoing need for government-backed financial support during the incubation process.

Bio-incubators in South Africa

Biotechnology has been identified as a priority area for development in South Africa since the publication by the Department of Science and Technology (DST) of the National Biotechnology Strategy (DST 2001), and the National Research and Development Strategy (DST 2002). These were followed by the 10-year Innovation Plan (DST 2008), which states that 'over the next decade South Africa must work to become a world leader in biotechnology' and, more recently, by the Bio-economy Strategy (DST 2013a). All these documents recognize the gap between research and commercialization.

The National Biotechnology Strategy proposed the creation of biotechnology innovation centres (BICs), each of which should be associated with an incubator. Following its publication, a number of BICs were established, including BioPAD (covering the Pretoria/Johannesburg region) and Cape Biotech (covering the Western Cape region). In 2010, the BICs were incorporated into a new entity funded by DST, the Technology Innovation Agency (TIA), with the objective of stimulating and intensifying technological innovation in all sectors. Unfortunately, TIA encountered severe problems from its inception. The merging of pre-existing entities proved to be a challenge. Each entity had its own mandate and its own legal, structural and organizational background, resulting in conflict and infighting in the new organization. There was also a breakdown of relations between DST and the chief executive officer (CEO) of TIA. Disciplinary action was taken against both the CEO and chief financial officer, resulting in an extended period with interim leadership. A new chief executive was appointed in 2015. Stakeholders encountered poor response times for enquiries and applications, unwieldy application processes and poor communication (DST 2013b). All of these problems led to severe disruption in funding for biotechnology, and have taken time to resolve.

The first two biotechnology incubators were established in 2002–03 through the Godisa initiative, with financial support from the Department of Trade and Industry (DTI) and the DST, augmented with some European Union funds. Godisa is a Tswana word meaning 'nurturing and growing', which was the main aim for technology-intensive start-up businesses. Acorn Technologies was established as a biomedical, bioengineering and biotechnology business incubator in Cape Town, while eGoliBio (now based in Pretoria) focuses on all aspects of bioscience and biotechnology. Both eGoliBio and Acorn Technologies have had a troubled history; Acorn is now defunct but eGoliBio continues to exist.

eGoliBio was originally based at Modderfontein (outside Johannesburg), with offices in close proximity to the laboratories of the Council for Scientific and Industrial Research (CSIR) site, where there were both laboratory and pilot-scale facilities. Incubator tenants were housed in the same building as incubator staff. This allowed for excellent interaction in a campus-type environment. Funding constraints, coupled with CSIR's closure of the Modderfontein site, resulted in the relocation of eGoliBio to Pretoria, where there was no longer dedicated

space for incubator clients but where there was access to the laboratories at the main CSIR campus. eGoliBio currently has around 60 clients in its database at various stages of incubation, but all on a virtual basis, and the level of support that can be provided by a small team of staff is suboptimal. The past years have seen a high turnover in incubator staff due to the uncertain environment, with the result that the current small staff complement is relatively inexperienced and, therefore, not well positioned to provide the necessary business advice. In the past, good use was made of external mentors and coaches with private sector and business experience to support the staff of eGoliBio, but this has been terminated due to limited resources.

The client portfolio of eGoliBio largely reflects the low-tech end of biotechnology and the life sciences sector in part due to short-term strategic goals. Only five clients have graduated from eGoliBio since its inception, all of them at the margins of what would be considered biotechnology (Table 5). The lack of more high-tech projects may also reflect the fact that universities in South Africa remain largely focused on education and academic research, and there is little incentive or support for entrepreneurship. Adequate 'proof of concept' work is lacking, as is a thorough understanding of market potential. Joint funding from the university and government that includes specific funding for 'proof of concept' as is available in the USA and Europe would be beneficial to South Africa. Given the relatively small size of the academic community and the limited funding available, it may be difficult for South Africa to compete internationally at the high-tech end.

Table 5. Firms graduated from eGoliBio

iSlices	iSlices produces dermal eye treatment pads based on cryogel polymer technology for the cosmetics and beauty market. The company has nine employees and runs a full export business with a turnover of more than ZAR 1 million. See http://www.eyeslices.co.za
Biodx	Biodx produces an environmentally-friendly biocide based on a natural citrus extract that kills or inactivates 99.9% of microorganisms in minutes whether fungus, bacterium, mould or virus. INDUSDX™ is used as a preservative by formulators in industries such as timber, plastics, adhesives and cleaning products as well as in paints. See http://www.biodx.co.za
Herbal Horse	Herbal Horse formulates and supplies herbal food supplements for horses and other domestic animals. Each of the products contains herbs, vitamins, amino acids and minerals known to be safe and effective for horses and other animals. Herbal Horse products are not only available in South Africa, but the company is also expanding into a number of export markets. The company has two employees and contract manufactures some of its products. See http://www.theherbalhorse.com
JEN-TIL Touch	JEN-TIL Touch manufactures and sells natural (no animal products) healing creams made from pure essential oils. The products were developed by a professional-nurse-turned entrepreneur. See http://www.jentiltouch.com
Cosmeceutical Products (Pty) Ltd	The formulation of products is based on well-known safe herbal extracts, fruit acids and emollient oils for individuals who have a skin disorder or a need for personal skin care.

Akçomak (2009) itemizes a number of points necessary for incubator success. Two of these points relating to incubator management stand out:

- *Incubator managers should be qualified, preferably with business experience*
  There is a shortage of such managers and staff with sufficient business knowledge and experience in South Africa as in most developing countries. As a result, the services provided are not ideal, and there are difficulties in properly evaluating and developing business plans. The threatened sustainability of the incubators also destabilizes managers in their ability to accept the longer-term challenges of a biotechnology incubator.
- *Monitoring of incubator clients is essential for success*
  Regular monitoring of incubator clients is necessary to determine if they are on the right track. It is the manager's job to be proactive in monitoring. Firms should be evaluated carefully on the basis of their management skills, market knowledge and financial strength before being admitted to an incubator. In the drive to recruit incubator clients into eGoliBio, it is likely that insufficient attention has been paid to this aspect, as reflected in the small number of companies which have graduated from the incubator.

It is thus apparent that considerable emphasis needs to be placed on recruiting, training and supporting highly-skilled incubator staff if the incubator is to achieve the desired results. Attention must also be given to ensuring sufficient funding to allow the full focus of incubator staff to be on the client companies and not on survival.

The recently launched Bioeconomy Strategy mentions the need for 'increased state involvement in life science incubators', yet the modalities for any new interventions are not described. In the US and Europe, many incubators are established in association with universities, and with a combination of national and sub-national government, and university, funding. eGoliBio and any future bio-incubators might fare better if they were more closely linked to a university or a research cluster, although for eGoliBio some promising interactions are starting to take place. New initiatives in the region include the Biomanufacturing Industry Development Centre at the CSIR, which is financed by the Development Bank of South Africa, and the new BioPark development at The Innovation Hub in Pretoria, an initiative of the provincial government and the DTI. Unfortunately, the anticipated benefits of growing collaboration and critical mass between these initiatives and eGoliBio have not been achieved and the behaviour appears to reflect more 'empire building'. Such a trend will not support the growth of a vibrant support system for emerging biotechnology innovations which is sorely needed if the sector is to grow.

Lessons learned from the South African experience

Manimala and Vijay (2012) point out that in developed countries it was the existence of promising technologies without institutional or entrepreneurial expertise that drove the

creation of technology incubators. In emerging economies, on the other hand, the process has been reversed, and the hope is that incubators will bring about the much-needed technology development. The authors stress that this is unlikely to be successful unless the research culture and initiatives in the universities and R&D institutions are supportive. To a certain extent this is the case in South Africa. However, continuing changes in government policy, all the different institutions, the lack of linkages and cooperation between government departments and other factors make the life of an incubator, especially a high-tech-focused one, much more complex and threaten sustainability.

The academic world in South Africa is not yet sufficiently engaged with the incubation process, since graduates and faculty members generally lack entrepreneurial feel and hunger. The younger generation of academics are discouraged from setting up a spin-off company by complex institutional rules and policies. Thus, the pipeline of projects is based on early-stage research without much attention given to the commercial opportunities created. Jordaan and Jordaan (2010) highlight the fact that despite the efforts of DST to stimulate biotechnology and associated business development in South Africa, the country is lagging behind other emerging economies in terms of biotechnology patents filed. Nevertheless, there may be considerable opportunities for service-based rather than product-based start-ups, as has been the case in Europe. Amongst other issues, Jordaan and Jordaan blame 'vested interests by academia that are in competition with private enterprise'. This situation may change following the implementation of the Intellectual Property Rights from Publicly Financed Research and Development Act (2008) in 2010, but only time will tell as the ability to exploit the generated IP needs to be developed.

For biotech incubators, such as eGoliBio, to be able to support the development of high-tech projects, a number of factors need to be in place that relate to the funding agencies supporting both the incubator itself and projects with commercial potential (in South Africa's case the instruments of both DST and the Department of Small Business Development (formerly DTI). First, funders must be willing to embrace higher-risk, longer-term, opportunities. Secondly, educated funding decisions must be made quickly to avoid long delays that result in loss of competitiveness. Thirdly, there must be clear and simple funding policies that ensure there are no gaps in the innovation chain to avoid accusations of a 'policy-on-the-go' approach (Jordaan and Jordaan 2010). Fourthly, there needs to be more engagement with the Department of Higher Education, the primary funder of universities. Decisions on salaries and promotions for university faculty members are based on academic merit with little consideration being given to patenting or commercialization activities. Without these aspects being improved, the incubator is currently limited to a pipeline of relatively low-tech opportunities with limited growth potential.

Nevertheless, there is some light on the horizon as a new generation of bio-entrepreneurs emerges. A number of South African universities now offer courses in bio-entrepreneurship to trigger the entrepreneurial mind-set among their postgraduate students in biotechnology.

For example, the University of Pretoria has successfully introduced an honours-level course on biotechnology in the workplace based on the UK Biotechnology YES scheme (Kunert et al. 2012) to teach students to identify innovative ideas and establish a fictional company. It also offers more advanced short courses in bio-entrepreneurship under its continuing education program. The University of the Witwatersrand also offers a Master of Science course in biotechnology that incorporates business aspects. DST supports internships where new graduates have an opportunity to be placed in industry for periods of 6–12 months. With an appropriate supportive environment, these young scientists will be well positioned to be the next bio-incubator tenants and also better equipped to join existing smaller companies.

Bio-incubation in eastern Africa

There are already initiatives under way in eastern Africa to foster bio-incubation, supported both by local organizations and by donor agencies.

In Uganda, an incubator (Bio-Biz incubator) has been established at the National Agricultural Research Laboratories with support from the National Agricultural Research Organization, and following a competitive process, five projects were selected to receive initial funding and acceptance into the incubator. Projects include mushroom spore growing and cassava value added products, but financial sustainability and availability of sufficient technical competence are problematic (A Kiggundu, personal communication to J Ecuru). US governmental organizations have expressed interest in supporting this initiative. A linked initiative involves Bahir Dar University in Ethiopia, where the aim is to set up rural agro-/bio-business incubators and provide support to the development of entrepreneurship.

At Makerere University in Uganda there is the Food Technology Business Incubation Center; its focus is on technology transfer rather than purely on business incubation, and it provides support services for improvement of processing technologies and product development. The Uganda Industrial Research Institute is not sector-specific, but includes some bioscience projects in its incubation portfolio.

In Kenya, the oldest technology and business incubation centre is the government-funded Kenya Industrial Research and Development Institute established in 1979 to enhance technology transfer, dissemination and commercialization primarily in the industrial sector. Kenyatta University established the Chandaria Business Incubation and Innovation Centre in 2011. This incubator covers all sectors. More recently, Jomo Kenyatta University of Agriculture and Technology has announced that it is setting up a business mentoring and incubation centre to translate student innovations into viable business outputs.

InfoDev, a program of the World Bank group, is providing virtual incubation services to rural communities in eastern Africa with funding from UKAid. The Universities, Business and Research in Agricultural Innovation initiative (UNIBRAIN)—funded by the Danish International Development Agency (Danida)—supports agribusiness incubators, including two in Uganda on banana and coffee value chains and one in Kenya on sorghum (FARA 2012). However, Danida has committed funding for only four years, with the expectation that the incubators should be financially self-sustaining within this time; this may be overly optimistic.

As eastern African countries progress on the journey to develop bio-incubators, they will face many of the same challenges and potential pitfalls that have been encountered in South Africa. The following suggestions may help to smooth the way forward:

1. Consider adopting a regional approach to the development of a bio-incubator, as advocated by the Bio-Innovate program. This would help to ensure that there are sufficient promising technologies in the pipeline to justify the creation of a bio-incubator.

2. Work from the start with governments in the region to put in place supportive and sustainable policies to serve the long-term role of a bio-incubator and bio-entrepreneurship.

3. Form strategic alliances with successful incubators in the developed world that can assist with mentoring and support.

4. Place more emphasis on providing virtual types of support rather than on the provision of physical facilities. An alliance with an organization such as the BecA-ILRI Hub could provide access to some of the necessary facilities.

5. Where possible, recruit incubator staff with the necessary skills in business development, potentially from the African diaspora. If this is not possible, then staff training and development should be a top priority.

6. Establish strong relationships with key universities and research institutions in the region and promote the training of staff and students in biotechnology entrepreneurship so that there is a cadre of young people with entrepreneurial skills and an entrepreneurial mind-set.

7. Consider innovative mechanisms to access funding and support, including crowdsourcing and crowdfunding.

By learning from the South African experiences, and building on current initiatives, a positive future for the growth of bio-incubators and bio-entrepreneurship in eastern Africa can be envisaged.

References

Acharya, M. 2013. Challenges in managing incubation of innovation in biotechnology sector in India. *Asia Pacific Journal of Innovation and Entrepreneurship* 7(3):53-69.

Akçomak, i. S. 2009. *Incubators as tools for entrepreneurship promotion in developing countries*. Research paper / UNU-WIDER, No. 2009.52, ISBN 978-92-9230-231-3.

Al-Mubaraki, H.M. and Wong, S.F. 2011. *How valuable are business incubators? A case study of their performance indicators.* European, Mediterranean and Middle Eastern Conference on Information Systems, May 30-31 2011, Athens, Greece, pp. 756-765. (Available from http://www.iseing.org/emcis/EMCISWebsite/EMCIS2011%20Proceedings/SIS2.pdf) (Accessed March 2016).

Battelle Technology Partnership Practice; Biotechnology Industry Organization. 2008. *Technology, talent and capital: State bioscience initiatives 2008*. (Available from http://www.iowabiotech.com/econ_dev_reports/Battelle_State_Bioscience_Initiatives_2008.pdf) (Accessed March 2016).

Battelle/BIO (Biotechnology Industry Organization). 2010. *State bioscience initiatives 2010*. (Available from http://www3.bio.org/local/battelle2010/Battelle_Report_2010.pdf) (Accessed March 2016).

BRBIOTEC (The Brazilian Association of Biotechnology)/CEBRAP (Brazilian Centre for Analysis and Planning). 2011. *Brazil biotech map 2011*. (Available from http://www.clustercollaboration.eu/documents/270120/0/Brazil_Biotec_Map_2011.pdf/40a5c1c5-53b0-47d5-bb44-22f909eadc11?version=1.0 (Accessed March 2016).

Chakma, J., Massum, H. and Singer, P.A. 2010. Can incubators work in Africa? Acorn Technologies and the entrepreneur-centric model. *BMC International Health and Human Rights* 10 (Suppl 1):S7

Crocker, G. and Pope, N. 2012. *Realignment. UK life science start-up report 2012*. (Available from http://www.mobiuslifesciences.com/report) (Accessed March 2016).

DST (Department of Science and Technology). 2001. *A national biotechnology strategy for South Africa.* (Available from http://www.biotechnologie.de/BIO/Redaktion/PDF/de/laenderfokus/suedafrika-biotech-2001,property=pdf,bereich=bio,sprache=de,rwb=true.pdf (Accessed March 2016).

DST. 2002. *South Africa's national research and development strategy*. (Available from http://www.esastap.org.za/download/sa_natrdstrat_aug2002.pdf (Accessed March 2016).

DST. 2008. *Ten year innovation plan*. (Available from http://www.dst.gov.za/images/pdfs/The%20Ten-Year%20Plan%20for%20Science%20and%20Technology.pdf (Accessed March 2016).

DST. 2013a. *The bio-economy strategy*. ISBN 978-1-919966-06-09. (Available from http://www.dst.gov.za/images/ska/Bioeconomy%20Strategy.pdf (Accessed March 2016).

DST. 2013b. *Summary report on the review of the Technology Innovation Agency prepared for the Minister of Science and Technology*. (Available from http://mg.co.za/article/2013-07-11-troubled-technology-innovation-agency-left-spinning) (Accessed March 2016).

Ehret, M., McDonald-Junor, D. and Smith, D. 2012. High technology and economic development: the BioCity Nottingham technology incubator. *Entrepreneurship and Innovation* 13 (4):301-309.

Ernst and Young. 2015. Beyond borders: reaching new heights. Biotechnology industry report 2015. (Available from http://www.ey.com/Publication/vwLUAssets/EY-beyond-borders-2015/$FILE/EY-beyond-borders-2015.pdf). (Accessed July 2016).

FARA (Forum for Agricultural Research in Africa). 2012. *About UniBRAIN.* (Available from http://www.fara-africa.org/our-projects/unibrain/abou/) (Accessed March 2016).

Jordaan, A.S. and Jordaan, D. 2010. Reality bites: biotech innovation in South Africa. *Innovate* 4:72-74.

Kunert, K.J., Okole, B., Vorster, B.J., Brewin, N.J. and Cullis, C.A. 2012. A general model for training the next generation of biotechnology entrepreneurs based on recent experience of USA-UK-South Africa collaborations. *Journal of Commercial Biotechnology* 18(2):61-65.

Leblebici, H. and Shah, N. 2004. The birth, transformation and regeneration of business incubators as new organisational forms: Understanding the interplay between organisational history and organisational theory. *Business History* 46(3): 353–80.

Manimala, M.J. and Vijay, D. 2012. *Technology Business Incubators (TBIs): A Perspective for the emerging economies.* Indian Institute of Management, Bangalore. Working paper number 358. (Available from http://ssrn.com/abstract=2117720) (Accessed March 2016).

McAdam, M. and McAdam, R. 2008. High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation* 28: 277-290.

Mutambi, J. 2013. *Stimulating industrial development in Uganda through open innovation incubators.* Blenkinge Institute of Technology Doctoral Dissertation Series No. 2013:11.

NBIA (National Business Incubation Association). 2009. *What is business incubation?* (Available from https://www.nbia.org/resource_library/what_is/) (Accessed March 2016).

SEDA (Small Enterprise Development Agency). 2009. *Seda Technology Programme: A year in review–2008/9.* (Available from http://www.seda.org.za/Publications/Publications/Stp%20Annual%20Review%202008-09.pdf) (Accessed March 2016).

SEDA. 2011. *Seda Technology Programme annual review 2010/11.* (Available from http://www.seda.org.za/Publications/Publications/Stp%20Annual%20Review%202010-11.pdf (Accessed March 2016).

Bio-resource Innovations Network for Eastern Africa Development Program (Bio-Innovate) is an initiative that supports and promotes bioscience research and innovation activities in eastern Africa through the creation of effective partnerships along the bio-innovation value chain. The goal of Bio-Innovate is to catalyse the translation of bioscience research outputs into scalable and impactful bioinnovations. Bio-Innovate works in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. bioinnovate-africa.org

The International Livestock Research Institute (ILRI) works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock. ILRI is a CGIAR research centre. It works through a network of regional and country offices and projects in East, South and Southeast Asia, Central, East, Southern and West Africa, and in Central America. ilri.org

CGIAR is a global agricultural research partnership for a food-secure future. Its research is carried out by 15 research centres in collaboration with hundreds of partner organizations. cgiar.org

The Swedish International Development and Cooperation Agency (sida) is a government agency working on behalf of the Swedish parliament and government, with the mission to reduce poverty in the world. sida.se

Bio-Innovate Program Management Office
P.O. Box 30709-00100
International Livestock Research Institute
Nairobi, Kenya