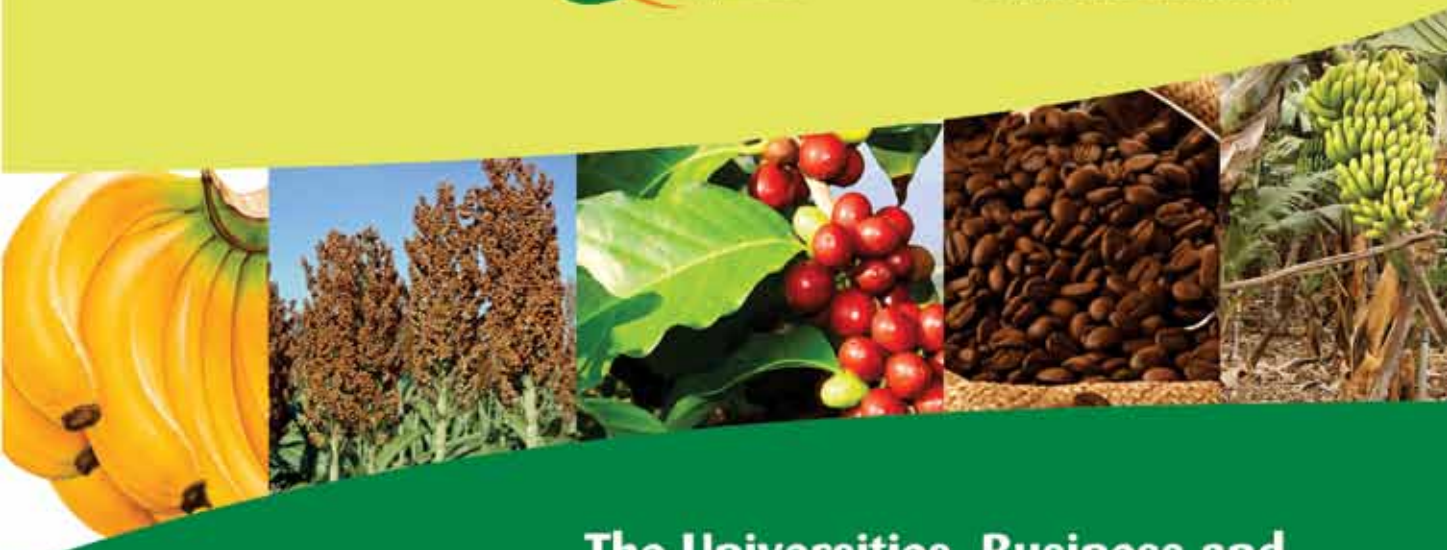
1994-2014
20TH ANNIVERSARY

ASARECA
Transforming Agriculture for Improved Livelihoods



The Universities, Business and Research in Agricultural Innovation (UniBRAIN Initiative)

Opportunities for commercialisation and research under the banana, coffee and sorghum value chains in Kenya and Uganda

Hannington Odame, Joseph Methu, Elosy Kangai, Doris Akishule, Willis Owino and Christine Alokit

UniBRAIN

FARA

The Universities, Business and Research in Agricultural Innovation (UniBRAIN Initiative)

Opportunities for commercialisation and research under the banana, coffee and sorghum value chains in Kenya and Uganda

Hannington Odame, Joseph Methu, Elosy Kangai, Doris Akishule, Willis Owino and Christine Alokit

Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
2014

Correct citation

Odame H, Methu J, Kangai E, Akishule D, Owino W and Alokit C. 2014. *Opportunities for commercialisation and research under the banana, coffee and sorghum value chains in Kenya and Uganda*. ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe.

Association for Strengthening Agricultural Research in Eastern and Central Africa
(ASARECA)
Plot 5, Mpigi Road
PO Box 765
Entebbe, Uganda
tel: +256 414 320212/320556/321885
fax: +256 414 321126/322593
email: asareca@asareca.org
website: www.asareca.org

Editor: Anne Marie Nyamu, Editorial and Publishing Consultant, Nairobi, Kenya
Designer: Timothy Maleche, ImageMate, Nairobi, Kenya

978-9970-484-09-6

The authors

Hannington Odame
Odame is the Founder and current Executive Director of the Centre for African Bio-Entrepreneurship (CABE), Nairobi, Kenya. He is an agricultural policy and institutions analyst with over 25 years of experience, facilitating agricultural knowledge learning and specialising in agricultural innovations systems (AIS). He has consulted widely and his agricultural research has been adopted by Future Agricultures Consortium (FAC), the Comprehensive Africa Agriculture Development Programme (CAADP), the International Food Policy Research Institute (IFPRI), the UK Department for International Development (DFID), the Africa Agricultural Technologies Foundation (AATF), ASARECA, the Alliance for a Green Revolution in Africa (AGRA) and the University of Sussex, UK. Recently he lent his expertise to a book published by the World Bank titled "Agribusiness and Innovation Systems in Africa". Within CABE he started the Kenya Agricultural Innovations Systems Network (KENAIS) to engage the government on agricultural policies. He is also coordinating the East Africa Hub of FAC. His strong interpersonal skills enable him to network with people passionate about uplifting the livelihoods of the rural poor.

Joseph Methu
Joseph Methu is a livestock scientist and agricultural development worker with progressive career growth spanning over two decades in Africa. Currently, he heads the Partnerships and Capacity Development unit of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The unit is responsible for managing ASARECA strategic partnerships, especially in implementation of CAADP Agenda of the African Union. ASARECA capacity building initiatives for national agricultural research systems (NARS) in Eastern and Central Africa are also managed under his leadership in the unit. Before joining ASARECA, Methu was the Senior Regional Animal Production Advisor for Africa, at the International Development Division of Land O'Lakes, a US based cooperative organisation involved in livestock development work in Africa. He had also worked at the International Livestock Research Institute (ILRI) where he was the lead scientist in the ILRI/KARI collaborative research in dairy systems. His career began at the Kenya Agricultural Research Institute (KARI, , now Kenya Agricultural & Livestock Organisation (KARLO)) where he rose from an assistant research officer to a senior scientist by the time he left to join ILRI. He holds a PhD (dairy cattle nutrition) from Reading University in Britain, MSc (animal nutrition) from Aberdeen University also in Britain, and a BSc (agriculture) from the University of Nairobi. He has published widely in the fields of animal production and agricultural innovation.

Elosy Kangai
Elsie Kangai joined CABE in 2008 as a research associate and has risen to the rank of a program manager. She is a final year master's student at Nairobi University studying agricultural and applied economics. She has specialised in rural development and has a keen interest in rural finance. She has coordinated many national and regional research assignments. She has also co-authored different publications covering agricultural policy, youth and agriculture, Agribusiness public–private partnerships, technology uptake pathways, technology inventory, private sector investments in agricultural research and development, high value crops and poultry. Her thesis explores innovations in rural financial systems among Kenyan smallholder horticultural farmers in face of strict international food safety standards.

Doris Akishule
Doris Akishule is currently working as a Programme Assistant in the Partnerships and Capacity Development unit, of ASARECA. The unit is involved in implementing the UniBRAIN initiative. She

graduated with a BSc in agriculture from Sokoine University of Agriculture, Tanzania. She obtained a MSc in agricultural extension/education from the Faculty of Agriculture, Makerere University, Uganda. In her early career, Doris participated in designing and implementing several agribusiness projects supported by CARE International such as: "Income Smoothening through Agricultural Marketing Interventions" (ISAMI) focusing on the Ware House Receipt System for climbing beans in the Kigezi region in Uganda; and Kigezi Business Development Services (KBDS) focusing on strengthening value chains of passion fruits, honey and handicrafts subsectors. She also worked as the monitoring and evaluation/research coordinator and gender focal person for these projects and was charged with designing and managing monitoring and evaluation (M&E) frameworks and gender mainstreaming. She also coordinated several studies such as market studies, baseline and impact evaluation studies, value chain analysis and gender analysis. Akishule also worked as a teaching assistant in the Department of Agricultural Extension/Education Makerere University.

Willis Owino

Willis Owino was the acting Managing Director of Sorghum Value Chain Development consortium (SVCDC), Nairobi in 2013. The SVCDC, trading as Sorghum 4F Agribusiness Incubator, is formed by participating institutions including Jomo Kenyatta University of Agriculture & Technology (JKUAT) (as the lead institution), Kenya Agricultural Research Institute (KARI, now Kenya Agricultural & Livestock Organisation (KARLO)), and private sector partners. Owino graduated with a BSc in Food Science and Technology in 1996 from JKUAT, Nairobi. He later obtained his PhD in post-harvest biology and technology in 2004 from the Faculty of Agriculture, Okayama University, Japan. He was post-doctoral research fellow at the Gene Research Centre, University of Tsukuba, Japan under the Japanese Society for Promotion of Science (JSPS) fellowship from 2004 to 2006. Owino is involved in several research projects including Technology Adoption for Industrial Exploitation of Sweet Sorghum in Kenya. He was one of the key participants that developed the concept on sorghum value chain that was eventually funded as SVCDC. He has also developed several value added products from sweet sorghum. Currently, he is the Manager of Food Technology Centre (FOTEC) and a senior lecturer at the Department of Food Science and Technology, JKUAT.

Christine Alokit

Christine Alokit is an agricultural professional with over 15 years of extensive experience in development, implementation and management of smallholder agricultural projects and programmes in Uganda and other East African Community member states. Her hands-on experiences spans working with institutional capacity development of smallholder farmers for improvement of agricultural productivity and production, commercialisation of proven technologies, linkage to input and output markets, including contractual farming arrangements, addressing nutrition and gender issues affecting agricultural projects. Other aspects included formation of linkages and working with micro-finance institutions to provide credit services to input dealers, and engagement of business service providers to build capacity of farmer institutions and private service providers. Alokit is also experienced in overseeing development of partnerships and implementation of projects with multi-disciplinary organisations and teams ranging from local and international non-governmental organisations and community based organisations, national and international research institutes, universities, ministries of agriculture and national institutions, private sector firms, local governments and farmer institutions across the East African Community. She also has experience in conducting research and working with national and international agricultural research centres. She holds a MSc from the University of Reading, UK, and a BSC in agriculture from Makerere University, Kampala.

Table of Contents

List of tables

List of figures

List of boxes

List of acronyms

AATF	Africa Agricultural Technologies Foundation
ABP	Incubation and Diversification of Banana Products for Agribusiness Consortium
3ADI	African Agribusiness and Agro-industries Development Initiative
AEZ	Uganda Agro-ecological Zones
AGRA	Alliance for a Green Revolution in Africa
AIIC	Agricultural Innovation Incubator Consortia
AIS	Agricultural Innovation Systems
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CAADP	Comprehensive Africa Agriculture Development Programme
CELAC	Collecting & Exchange of Local Agricultural Content
CGS	Competitive Grants System
COREC	Coffee Research Centre
CRF	Coffee Research Foundation
CRG	Collaborative Research Grants
CURAD	Consortium for enhancing University Responsiveness to Agribusiness Development
CWD	Coffee wilt disease
DANIDA	Danish International Development Agency
EABL	East African Breweries Limited
EHC	Excel Horticulture Company
EUCORD	European Co-operative for Rural Development
FAC	Future Agricultures Consortium
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FOM	Farmer ownership model
FREVASEMA	Fresh vacuum sealed *matooke*
GI	Geographical indication
GTL	Genetic Technologies Limited
HLC-3ADI	High Level Conference on African Agribusiness and Agro-Industries
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IPR	Intellectual Property Rights
ISAAA	International Service for the Acquisition of Agri-biotech Applications
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KAPAP	Kenya Agricultural Productivity and Agribusiness Programme
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspection Service
KSC	Kenya Seed Company
NAADS	National Agricultural Advisory Service Programme, Uganda
NARO	National Agricultural Research Organisation, Uganda
NARS	National agricultural research systems
NECOFA	Network for Eco-farming in Africa
NGOs	Non-governmental organisations
NPT	National Performance Trials
NUCAFE	National Union of Coffee Agribusinesses and Farm Enterprises

OPV	Open pollinated varieties
PIBIP	Presidential Initiative for Banana Improvement Programme
PPO	Polyphenol oxydase
PPP	Public–private partnerships
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SVCDC	Sorghum Value Chain Development Consortium
SWOT	Strengths, weaknesses, opportunities and threats
TC	Tissue culture
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority
UGASTOVE	Uganda Stoves Manufacturers Limited
UIRI	Uganda Industrial Research Institute
UniBRAIN	Universities, Business and Research in Agricultural Innovation
URSB	Uganda Registration Service Bureau
USA	United States of America

Foreword

The Universities, Businesses and Research in Agricultural Innovation (UniBRAIN) initiative is a pan-African intervention coordinated by the Forum for Agricultural Research in Africa (FARA) and partners: Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD), the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA), the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) and the Pan African Agribusiness and Agroindustry Consortium.. The initiative is supported by the Royal Danish Ministry of Foreign Affairs (DANIDA). The immediate objective of UniBRAIN is to enable universities, business and agricultural research institutions to commercialise agricultural technologies and produce graduates with entrepreneurial and business skills through agribusiness incubator partnership. The initiative intends to achieve three outputs: (1) commercialisation of agribusiness innovations supported and promoted; (2) agribusiness graduates with the potential to become efficient entrepreneurs, produced by tertiary educational institutions; and (3) the UniBRAIN innovative outputs, experiences and practices shared and up-scaled.

To deliver the UniBRAIN outputs, six agricultural innovation incubator consortia (AIIC) involving universities, businesses, and agricultural research for development institutions were established. Three of these AIIC are in the ASARECA region: Afribanana Products (ABP), based at Kyambogo University in Uganda, and supporting the banana value chain; Consortium for enhancing University Responsiveness to Agribusiness Development (CURAD) which is based at Makerere University and supports the coffee value chain; and the Sorghum Value Chain Development Consortium (SVCDC) which is based at Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya and supports the sorghum value chain.

The role of ASARECA in UniBRAIN is to reinforce the research function of the three UniBRAIN consortia in the sub-region through collaboration with the national agricultural research systems (NARS) in Kenya and Uganda. This role complements the broader mandate of the ASARECA programmes and projects by supporting the incubation of agri-businesses around the key agricultural value chains in the region. This complementarity is especially important for the banana and sorghum value chains in which ASARECA has already invested significant amounts of resources for research and development. Under UniBRAIN, ASARECA strives to seek and provide relevant information that may be useful for NARS to participate in the AIIC agri-business incubation work. ASARECA also facilitates NARS to develop an inventory of existing and pipeline technologies and innovations that have potential for incubation. Such technologies and innovations are then shared with AIIC, which in turn provide additional value added services to make the research products more competitive.

This report, *Opportunities for commercialisation and research under the banana, coffee and sorghum value chains in Kenya and Uganda*, documents technologies and innovations with the highest potential for commercialisation and incubation under the three value chains. I believe this documentation will go a long way in supporting the development of the three value chains.

Dr Fina Opio
Executive Director, ASARECA

Preface

To achieve UN Millennium Development Goal 1 of halving the number of poor and hungry by 2015, Africa must increase production to not only meet the needs of currently food insecure communities but also provide food for populations still growing at about 3% per annum. AU-NEPAD (2002) estimated that this will require a 6% per annum increase in agricultural production as the minimum to make a sustained difference in per capita food availability and affordability. The Comprehensive Africa Agriculture Development Programme (CAADP) was conceived as a framework for achieving this 6% growth by encompassing many different initiatives, including the development and dissemination of new technologies for transformation of agriculture.

The Universities, Businesses and Research in Agricultural Innovation (UniBRAIN) contributes to achieving the CAADP goal by addressing the following strategic questions, which guide the implementation of the initiative:

1. How can we make better use of the existing capacity in African universities, agricultural research organisations and agribusinesses for agricultural innovation?
2. How can African universities produce agricultural innovators and business leaders who could achieve the needed growth?
3. How can innovation cultures and practices be scaled up and sustained at a pan-African level?

The UniBRAIN initiative therefore focuses on innovation in agriculture and agribusiness. This requires a clear understanding of the necessary "ingredients" for innovation which includes technologies and other research products. In 2014 ASARECA commissioned a study to document priority technologies that can be commercialised and incubated around the banana, coffee and sorghum value chains by Afribanana Products (ABP), the Consortium for enhancing University Responsiveness to Agribusiness Development (CURAD), and the Sorghum Value Chain Development Consortium (SVCDC) respectively. This report is a record of the technologies identified. It is designed as reference material for incubators and incubatees not only under UniBRAIN, but also under any other initiatives on technology transfer.

Dr Joseph Methu
Head, Partnerships and Capacity Development, ASARECA

Executive summary

This report provides an inventory of existing and pipeline technologies and innovations which have the potential to be commercialised and are ready for incubation by the agricultural innovation incubator consortia (AIIC) of the Universities, Businesses and Research in Agricultural Innovation (UniBRAIN). The inventory comprises of technologies and innovations in three commodity value chains being banana, coffee and sorghum.

The main role of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in UniBRAIN is to reinforce the research function of the three UniBRAIN AIIC through collaboration with the national agricultural research systems (NARS) in Kenya and Uganda. This inventory offers stakeholders an opportunity to reflect on the readiness of each of the available technologies for commercialisation and also identifies influential stakeholders in realising commercialisation. It also provides a technical base to scale-up technologies and innovations, and seek support for commercialisation. The inventory also details the stages in development of technologies and innovations and offers useful lessons for policy and practice.

The assignment used two complementary approaches to develop the inventory of technologies and innovations for commercialisation: a value chain approach (VCA) and an agricultural innovation systems (AIS) framework. The VCA was applied in carrying out a strengths, weaknesses, opportunities and threats (SWOT) analysis of the value chain and in identifying the constraints that needed existing or new technologies and innovations to solve them. The AIS framework, which borrows from business and industry models, was applied in assessing the commercialisation process of technologies/innovations. In particular, the AIS framework represents a shift from technology-delivery mode to strengthening the capacity of value chain actors to innovate. The six main AIS elements that were useful in the assessment were: technology, aggregation, knowledge and skills, markets, financing, and enabling environment.

Methods of data collection on these elements entailed secondary literature review, consultations with the three AIIC managers, key informant interviews with research scientists in NARS within Kenya and Uganda, and with incubators and incubates. Data was also collected through interviews with a few private sector partners identified as potential collaborators in achieving commercialisation of certain technologies and innovations.

Due to the limited data availability on costs and benefits of some of the technologies and innovations, we used secondary data to fill the gap where possible. However, this was only used as a guideline. Consequently, commercialisation of any of the selected technologies will require a detailed analysis of the costs and benefits, which was not undertaken in this assignment—largely due to resource and time constraints.

For the reviewed value chains (viz. banana, sorghum and coffee), the capacity built over the years has seen many technologies developed. However, the rate of deployment of these technologies is still low largely due to inadequate resource allocation, limited efforts for commercialisation and poor linkages with the stakeholders for improved deployment. The weak intellectual property (IP) systems in NARS have contributed to the above scenario. However, the IP landscape is changing with new forms of IP sharing being adopted.

Financing for private sector engaged in agribusiness research and development (R&D) and agri-based manufacturing was found to be weak in the three value chains. Nevertheless, commercialisation of technologies often stimulates forward innovations and market-oriented R&D, which financiers shy away from. Business incubators therefore need to come up with strategies regarding the form of financial support and services offered to incubatees to sustain their ventures beyond the incubation period.

Overall, this technology inventory will be a valuable tool for stakeholders to engage each other to assess their synergies in optimising the potential of existing and new technological, organisational and institutional innovations to achieve agribusiness development. Aside from conventional capacities, the process of commercialisation will require innovative capacities to document impact: success stories, pitfalls to avoid and best practices. Such stories can provide useful information in shaping policy, research and future related agribusiness development programmes.

Part 1

An inventory of technologies and innovations with potential for commercialisation under the banana, coffee and sorghum value chains in Kenya and Uganda

1 Background information

This report provides an inventory of existing and pipeline technologies and innovations which have the potential to be commercialised and are ready for incubation by the agricultural innovation incubator consortia (AIIC) of the Universities, Businesses and Research in Agricultural Innovation (UniBRAIN). The three AIIC focus on the banana, coffee and sorghum value chains and will provide additional value added services to make the research products and innovations more competitive.

The UniBRAIN initiative is a pan-African intervention coordinated by the Forum for Agricultural Research in Africa (FARA) and supported by Royal Danish Ministry of Foreign Affairs (DANIDA). The immediate objective of the UniBRAIN initiative is to enable universities, business and agricultural research institutions to commercialise agricultural technologies and produce graduates with entrepreneurial and business skills through agribusiness incubator partnership. The initiative intends to achieve the following outputs:

- Commercialisation of agribusiness innovations supported and promoted.
- Agribusiness graduates with the potential to become efficient entrepreneurs produced by tertiary educational institutions.
- The UniBRAIN innovative outputs, experiences and practices shared and upscaled.

The three AIIC being supported in Kenya and Uganda are: Incubation and Diversification of Banana Products for Agribusiness Consortium (UniBRAIN-ABP or Afri Banana); Consortium for Enhancing University Responsiveness to Agribusiness Development (UniBRAIN-CURAD) on coffee; and the Sorghum Value Chain Development Consortium (UniBRAIN-SVCDC).

The main role of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in UniBRAIN is to reinforce the research function of the three UniBRAIN AIIC through collaboration with the national agricultural research systems (NARS) in Kenya and Uganda. This will be achieved by providing relevant information that may be useful for the NARS to participate in AIIC. ASARECA will also facilitate the NARS to develop an inventory of existing and pipeline technologies and innovations that are ready for incubation in the two countries.

This technology inventory exercise offers stakeholders an opportunity to reflect on the readiness of each of the available technologies for commercialisation, identification of the most influential stakeholders in realising commercialisation, and also provides a technical base to scale-up technologies and innovations and seek support for commercialisation. The inventory also details the stage in development of technologies and innovations, and thus offers lessons for policy and practice and has the ability to generate interest among new collaborators and partners from the public and the private sector.

The rest of the report is organised as follows: Section 2 contains a review of the significance of the three value chains in ECA region and also highlights strengths, weaknesses, opportunities and challenges of the three value chains. The methodology and criteria for selection of technologies is presented in Section 3. Sections 4 to 6 represent inventory of technologies which can be commercialised under sorghum, coffee and banana value chain, while Section 7 is a synthesis of the suggested road map for commercialisation.

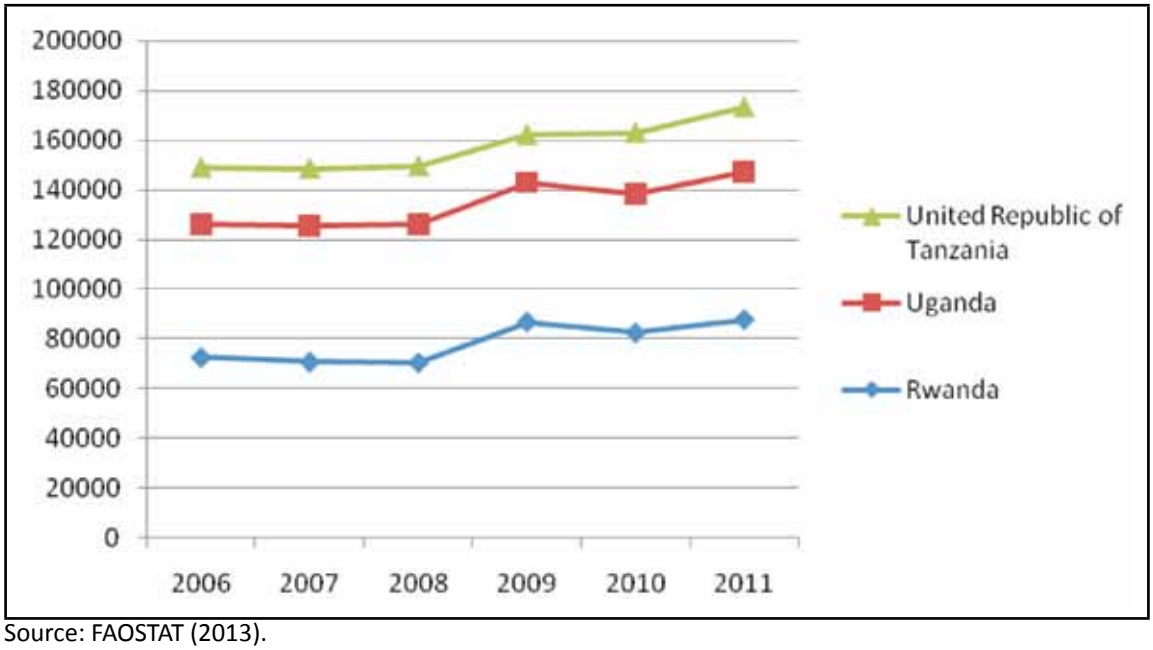
2 Significance of the three value chains in the East Africa region

One of the tasks in this assignment was to conduct a desk review to obtain a thorough understanding of the three value chains, including an analysis of the strengths, weaknesses, challenges and opportunities. It is in this regard that the significance of each of the value chains to the economies of the East Africa region has been highlighted. In addition, the strengths, weaknesses, opportunities and threats (SWOT) analysis helps establish a basis for identifying technologies and innovations which have the potential for undergoing commercialisation.

2.1 Banana value chain

Uganda is the world's leading producer of the cooking type banana (plantain) and ranks second in total banana production after India (Bazirake 2008) valued at US$1.6 billion in 2011 (FAOSTAT 2013). In Eastern and Central Africa, Uganda is followed by Rwanda, Democratic Republic of Congo (DRC) and the United Republic of Tanzania. Of the four countries, Tanzania has recorded the highest yields over the years, as shown in Figure 1. In 2011 banana (plantain) was ranked as the most important food and agricultural commodity (ranked by value) in Uganda, followed by cassava, then by maize (FAOSTAT 2013).

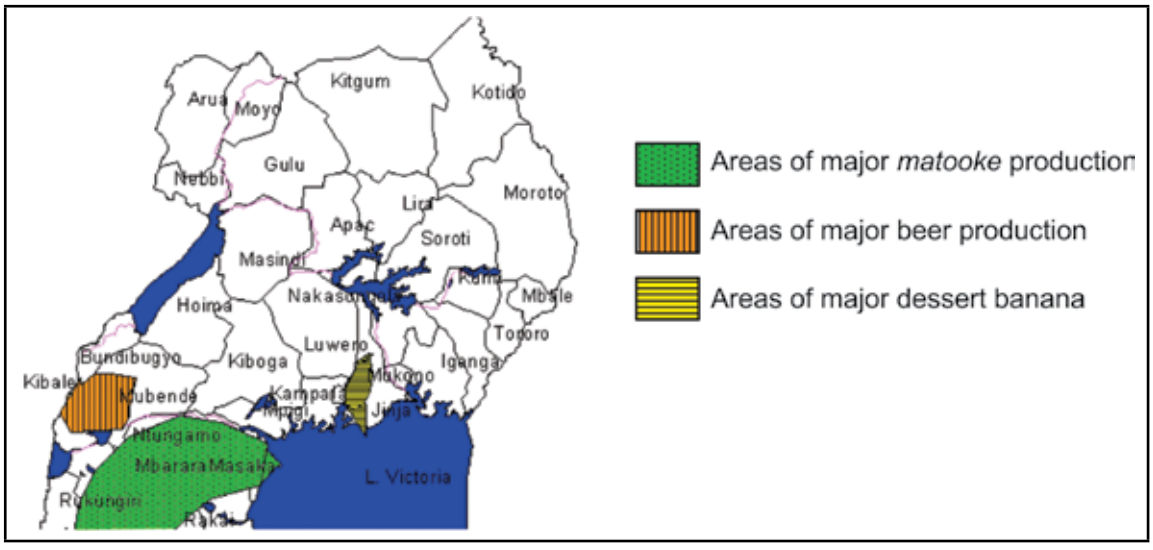
Figure 1: Yields of plantain, kg/ha (2006–2011).



Source: FAOSTAT (2013).

Banana fields occupy over 40% of arable land in Uganda, with over 7 million people consuming bananas daily, as the main staple food. In addition to cooking bananas, dessert bananas, roasting types and juice bananas are also produced here. (Alex Barekye, Plant breeder, NARO-Kawanda, personal communication, 25 April 2013). The main production areas are highlighted in Figure 2.

Figure 2: Main areas of banana production by type in Uganda.



Source: Spilsbury et al (2002).

SWOT analysis

The significance of banana in Uganda has captured the attention of many national, regional and international organisations, who have invested resources in development of certain aspects of the value chain. For example, the Government of Uganda developed a banana sector policy and approved a national biotechnology and biosafety policy which are expected to spur investment in the banana value chain such as through the Presidential Initiative for Banana Improvement Programme (PIBIP).

The major weaknesses of the banana value chain as identified by stakeholders are discussed in the following sections.

Pests and disease infestation

The most significant diseases affecting banana yields in Uganda include Panama disease, black Sigatoka, fusarium wilt and bacterial wilt[1] (Kamau et al. 2011). Fusarium wilt mainly attacks juice bananas and Gros Michel varieties, while bacterial wilt disease is non-discriminative, in that it attacks all varieties, making it a very important disease in banana production (Alex Barekye, Plant breeder, NARO-Kawanda, personal communication, 25 April 2013). The common pests that attack bananas include banana weevils and banana nematodes.

Low labour prioritisation to banana crop

An interview with Alex Balekye of NARO revealed that some banana varieties remain unattended to on the farm due to cultural reasons, leading to poor yields. For instance, many smallholder farmers believe that juice bananas produce the best taste and flavour if they are left to grow in the wild.

Declining soil fertility

This is often as a result of declining macro and micro-nutrients in the soil, poor soil moisture, increasing toxicity and low soil water retention.

[1] Banana bacterial wilt requires cultural methods of control, which have limited aspects for commercialisation.

Post-harvest losses

High post-harvest losses are often reported during the two peak seasons mainly due to poor handling and limited market access for far-flung producing regions. The problem is aggravated by limited value addition at farm level which often leads to low farm-gate prices.

Price fluctuations

Low producer prices have been recorded in the region. For instance, in Rwanda banana fetched an average of US$240 per ton in 2009 (FAOSTAT 2013). In addition, Uganda is ranked 70th in banana trade yet it ranks number two in terms of banana production (UBOS 2010). Because of the irregular market prices and limited sensitisation and support for value addition, the young generation is rapidly losing touch with the national banana based food security livelihood orientation.

Strengths

The ABP consortia acknowledge that various parts of Eastern and Central Africa have ideal agro-ecological conditions for banana production, whose potential has not been adequately exploited (ABP Business Plan 2012). In addition, national agricultural research institutions (NARIs) such as the National Agricultural Research Organisation (NARO) in Uganda and Kenya Agricultural Research Institute (KARI) have released disease resistant varieties suitable for these regions.

Opportunities

The fact that household consumption of bananas and plantain in the East Africa region far exceeds other staples presents an opportunity for commercialisation. A study conducted by Kilimo Trust established that the greatest demand lies in production and marketing of fresh cooking and dessert bananas (Kilimo Trust 2013).

Another opportunity that stakeholders in the banana value chain should consider is the inclusion of banana as one of the enterprises for support under the National Agricultural Advisory Service (NAADS) programme in Uganda for technology transfer and advisory service provision (ABP Business Plan 2012). This implies that NAADS has committed resources to technology transfer which needs to be tapped. Third, the new regional trading block, the East African Community (EAC), is expected to reduce barriers to trade in the region and thus offer more trading opportunities for banana and its products.

The fourth significant opportunity for banana value chain development is Uganda's signing of the Declaration of the High Level Conference on African Agribusiness and Agro-Industries (HLC-3ADI) in March 2010 in Abuja, Nigeria, which called for concerted efforts to accelerate agribusiness development by developing institutional mechanisms in the form of agribusiness public–private partnerships (PPPs) (FAO 2013). The Abuja Declaration also fits into the Comprehensive Africa Agriculture Development Programme (CAADP Pillar II that calls for research and scaling up of innovations and participation of non-state actors in Agricultural development (ABP Business Plan 2012). Therefore, banana being the most important staple food in Uganda and Tanzania (with over 60% household consumption and occupying 40% of arable land in Uganda), it stands a high chance of contributing to the region's economic development. According to Kilimo Trust (2013), processing of banana into bottled juices, wines and gin hold high potential for regional trade.

Threats

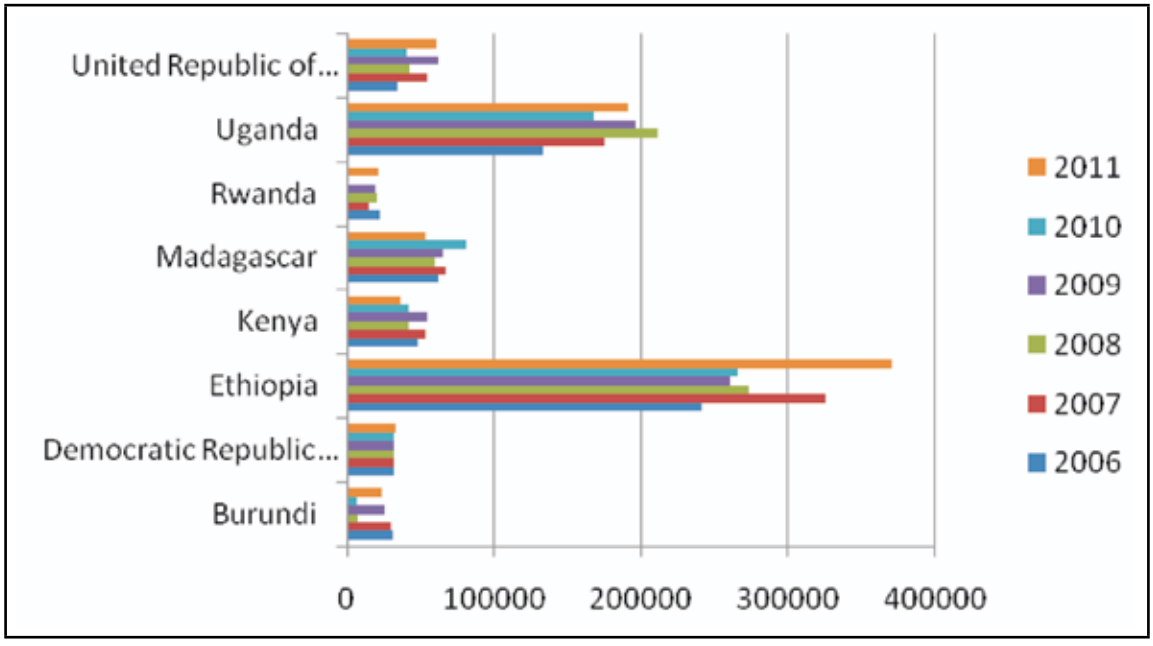
Similar to other forms of subsistence farming, however, the stakeholders have to sensitise farmers to change their attitude from viewing banana as a subsistence crop to which they commit limited

resources, to farming it as a business, which implies a need for more investment in inputs and markets. Other external factors that threaten potential gains, especially in the banana export business, is price fluctuation, under-developed export markets and high air transport costs. Other common threats affecting agricultural enterprises in sub-Saharan Africa are climate change, diverse land tenure system and overlapping land rights (ABP Business Plan 2012).

2.2 Coffee value chain

Coffee production is undertaken in all ASARECA member countries, albeit to differing degrees. Ethiopia leads in terms of yields and quantity of production (Figures 3 and 4). In Uganda, where UniBRAIN CURAD is located, coffee is the most important export cash crop, earning US$450 million in 2010–2011 and directly benefitting 1.32 million households (CURAD Business Plan 2012).

Figure 3: Coffee production (tons) 2006–2011.



Source: FAOSTAT (2013).

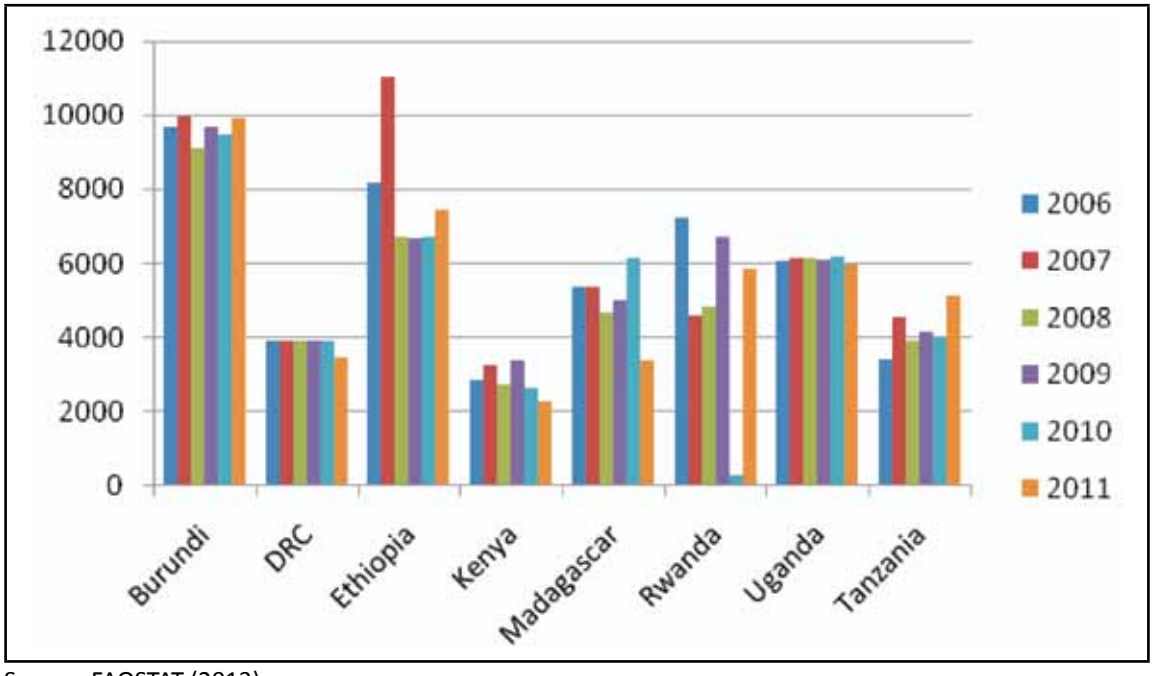
Coffee accounts for 93% of the country's export revenue and employs 83% of all rural workers. Most of the coffee produced in Uganda is robusta, and is used for instant coffee and inexpensive blends.

SWOT analysis

Strengths

The Coffee research institutes, under NARS such as the Coffee Research Centre (COREC) in Mukono, Uganda, and the Coffee Research Foundation (CRF) in Ruiru, Kenya, have developed some elite disease resistant lines which guarantee high yields if widely adopted by farmers. In addition, during the field visit it was also observed that COREC had established a state-of-the-art tissue culture (TC) facility and a hardening/weaning shed with a large capacity for hardening TC coffee clones. However, this facility was largely underutilised for mass multiplication of desired coffee clones.

Figure 4: Coffee yields, kg/ha (2006–2011).



Source: FAOSTAT (2013).

To facilitate technology dissemination, COREC facilitated about 30 nursery operators to undergo training and certification by the Uganda Coffee Development Authority (UCDA) as suppliers of clean vegetative planting materials (Africano Kangire, Coffee Research Centre-Mukono. personal communication 25 April 2013). These nursery operators have the needed capacity for technology dissemination and yet are underutilised in the country.

Thirdly, most of the East African coffee is wet-processed with a big aroma and medium to heavy body which is rich and robust[2]. This is the main strength that producing countries can capitalise on in the world market for production and marketing of niche products.

Weaknesses

Although a few private laboratories in East Africa have shown an interest in commercial production of clean coffee clones, their capacity is limited. Moreover, weak intellectual property rights (IPR) systems in most countries in East Africa hamper private sector investment in TC technology for mass multiplication and commercialisation of improved varieties (AATF 2009).

Another weakness alluded to in Uganda's coffee sector was poor regulation of suppliers of coffee clones. This had led to farmer exploitation by unscrupulous traders who supply diseased clones, which are also sold at high prices (approximately US$0.4). Consequently, the problem of poor yields and diseases remains, increasing the costs of production.

There is limited farm mechanisation and therefore medium-to-large scale farms incur high labour costs, leading to lower profit margins. In addition, there is limited farm-level processing/value addition and consequently farmers fetch low prices. This situation calls for innovations in coffee harvesting, drying and processing technologies and equipment (Joseph Nkandu, Incubator Manager-CURAD, Makerere University Agricultural Research Institute. personal communication, 24 April 2013).

[2] See http://www.aventura-cafe.com/Coffee-Processing:_:60.html?XTCsid=8rng0g5877m1t4vijnbojosu76.

Opportunities

The Government of Uganda through Uganda Coffee Development Authority (UCDA) plans to replace over 200 million plants of robusta coffee with 7 new coffee wilt disease-resistant clones, at an estimated cost of US$10 million. This is an opportunity which private laboratories and companies can target, considering the high demand for coffee seedlings and the existing limited capacity of public and private laboratories to fulfil the existing demand.

Secondly, the UCDA-certified nursery operators presents an opportunity to be contracted by private laboratories, to harden the coffee clones and also establish mother gardens near the farming zones to enhance access to quality and clean planting materials by smallholder farmers.

Threats

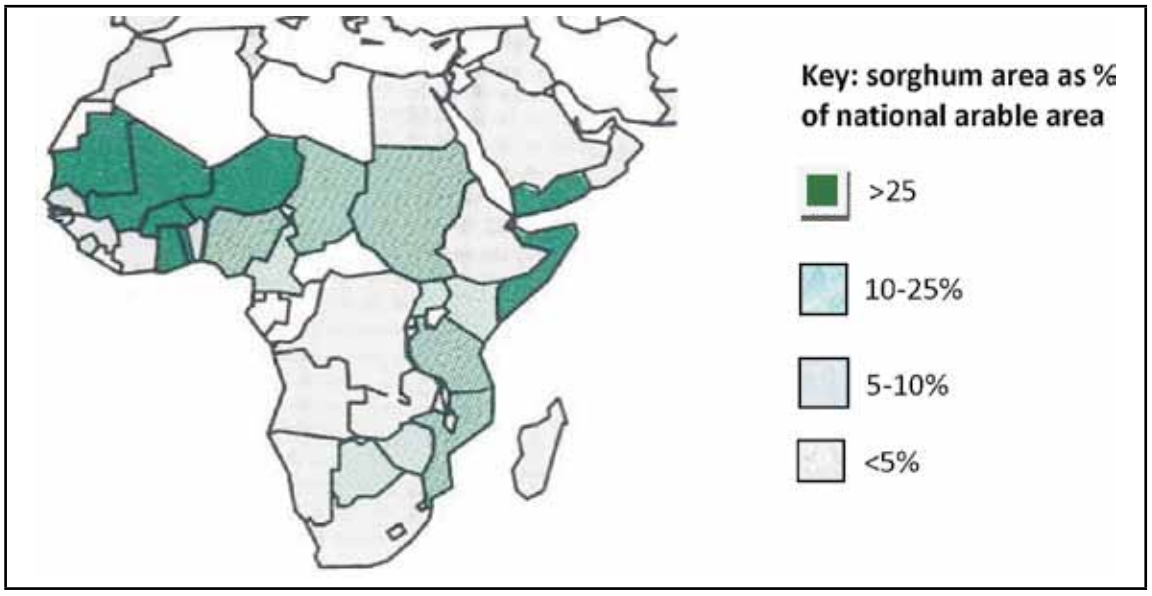
The major threats facing coffee include the fluctuating world prices and technical barriers which limit market access for value-added coffee. However, for the coffee producing families to really benefit, they need to extend their role in the product value chain and play a much more significant role in the processing, trading and marketing of their crop[3].

2.3 Sorghum value chain

Sorghum is a grass (Graminea family) plant that produces grains after three months; it is harvested and the stalks mainly used as feed, thatch, mats, mulch or green manure by smallholder farmers in East Africa (Baiyegunhi and Fraser 2009). Sorghum is mainly grown for smallholder household food security, with limited commercialisation (AATF 2011).

In the East Africa region, Sudan and Tanzania have 10–25% of arable land committed to sorghum production, while Kenya and Uganda have 5–10% of arable land under sorghum (see Figure 5).

Figure 5: Area under sorghum as a percentage of national arable land.



Source: Taylor (undated)[4].

Source: FAOSTAT (2013).

[3] http://www.cordaid.org.

[4] http://www.afripro.org.uk/papers/Paper01Taylor.pdf.

However, Ethiopia leads in sorghum yields followed by Uganda and Tanzania (Table 1). Very little information was available on sorghum trade for East African countries. The available estimates revealed that between 2006 and 2010, the price per ton of sorghum was highest in Kenya compared to Sudan and Ethiopia (Table 2).

Table 1: Comparative sorghum yields (kg/ha)

Country	2006	2007	2008	2009	2010	2011
Uganda	14,286	14,522	14,860	11,009	11,008	12,005
United Republic of Tanzania	9,941	11,874	9,229	8,114	12,914	9,943
Kenya	8,006	9,474	5,221	5,717	7,267	6,291
Ethiopia	15,756	14,844	15,103	17,361	18,356	18,418
Sudan (former)	6,672	7,664	5,845	6,301	4,686	n.d.

n.d. = no data available.

Table 2: Sorghum producer price (US$/ton)

Country	2006	2007	2008	2009	2010
Kenya	365.5	391.7	513.2	633.8	436.3
Ethiopia	173.6	345.3	446.4	323.3	231.3
Sudan (former)	243	178.9	329.7	367.4	447.4

According to AATF (2011), the factors affecting demand and preference for sorghum depend on whether it is for human consumption, commercial use or a combination of the two; other factors include use of the by-products such as biomass. For example, in the case of human consumption, the preference is for big, white grain with low tannin, palatability and digestibility. However, industrial use of sorghum in malting and beer brewing requires high sugar content, greater than 15% brix[5] (Undersander et al. 1990).

SWOT analysis

Strengths

The strengths of the sorghum value chain in Kenya can be associated with the government's renewed support for research and development (R&D) of cereal crops which are suitable for arid and semi-arid conditions. Other than the government, several other institutions fund programmes for improvement of sorghum, namely International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Alliance for a Green Revolution in Africa (AGRA), and the KARI Katumani and Alupe stations. There are 20 released sorghum varieties mostly from KARI, Kenya Seed Company and Leldet seed companies, which have varied attributes for various uses (KEPHIS 2013). The R&D at Egerton University, supported by the Kenya Agricultural Productivity and Agribusiness Programme (KAPAP), has evaluated and identified 5 genotypes for baking, 2 for brewing and one variety for ethanol from stalk juice, capable of producing 600–700 litres per ha.

The strength of the sorghum value chain is its suitability for marginal areas such as the arid and semi-arid regions of East Africa. These regions experience prolonged dry spells leading to drought,

[5] Brix is equivalent to percentage sugar in sorghum syrup. Sugar content of sorghum juice can range from 2% to 20% (www.hort.purdue.edu).

high rates of food insecurity, lack of livestock feed and a general decline in living standards. Thus, reviving the value chain will contribute towards mitigating the adverse effects of climate change and offer a source of animal feed, which can be preserved and utilised in the dry season.

Weaknesses

To maximise the potential of the value chain, the following weaknesses need to be overcome.

Low yields: The yields achieved by the contracted farmers are still very low, at an average of 1.4 tons/hectare. Yet all the released varieties have a yield potential greater than 2 t/ha.

Over-reliance on farmer saved seed: Most farmers disregard the improved sorghum varieties in preference for own seed. This poses a challenge to research on desired traits which can be incorporated into farmer-preferred varieties, to enhance uptake and capture relevant markets.

Labour-intensive systems: Most of the agronomic practices and post-harvest management is done manually. Equipment such as planters, harvesters and threshers, and winnowing tools are not affordable by many smallholder farmers, and thus are rarely utilised. This is therefore a challenge to NARS to innovate or fabricate the equipment and evaluate their effectiveness in smallholder farming systems.

Limited access to appropriate seed: The limiting factor for many private players is the inability to access varieties which possess the desired characteristics for feed, certain foods, syrup and bio-ethanol.

High relative price: Another challenge facing feed manufacturers in particular, is the high relative market price offered by farmers, Ksh25 per kg (US$0.3) compared to a cereal like maize, whose market price is Ksh20 per kg (US$0.24). Many consequently revert to buying maize and using it in feed formulations so as to cut their costs.

Opportunities

Sorghum was mainly produced under subsistence systems until recently (2010 onwards) when East African Breweries Limited (EABL), in partnership with other public and private stakeholders, promoted sorghum production for industrial use (CK Kamau, KARI Katumani, personal communication 26 April 2013). EABL presents an opportunity to transit from subsistence sorghum production to commercial sorghum production. The company has an industrial capacity to utilise 50,000 metric tons per annum in malting and brewing. Apart from EABL, appropriate sorghum varieties are also being sought by other private companies in Kenya and Tanzania for production of syrup, bio-ethanol and animal feeds.

Threats

Externally, speculation in the grain industry affects the marketing of sorghum whereby seed companies stockpile the grain expecting famine relief organisations to purchase it.

In summary, sorghum value chains across East Africa are still very weak considering that the crop is mostly used for domestic consumption. The value chains for sorghum should be developed to link producers with agro-processing, and diversify processed products. This will lead to improvement of the marketing aspects of sorghum resulting in an increased adoption rate for improved variety, which will have a ready market.

3 Methodology

3.1 Approaches used in the study

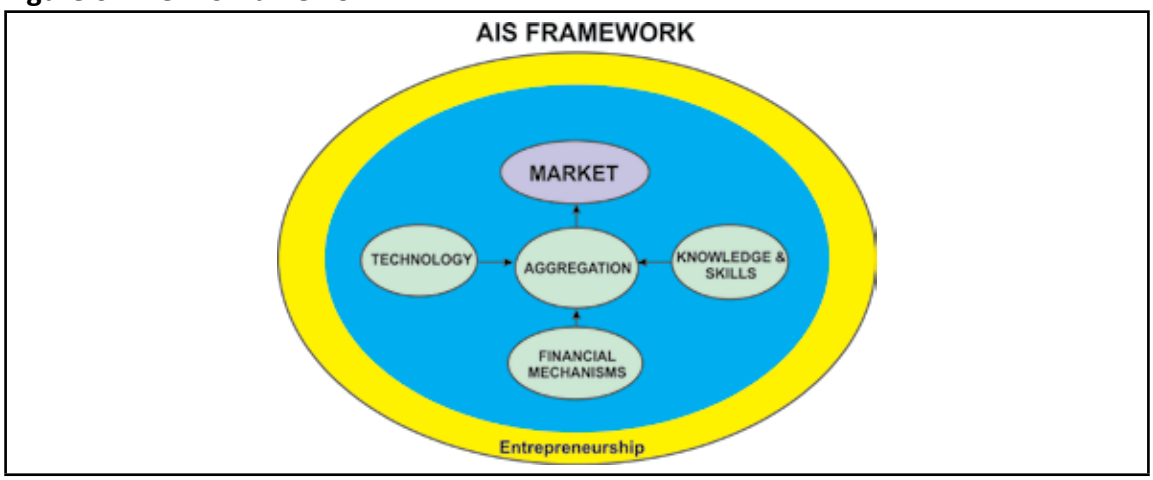
The team used two complementary approaches to develop the inventory of technologies and innovations for commercialisation: a value chain approach and an agricultural innovation systems (AIS) framework. The value chain approach was applied to carry out strengths, weaknesses, opportunities and threats (SWOT) analysis of the value chain as well as in identifying the constraints or problems along the commodity value chain that needed existing or new technologies and innovations to solve them.

However, the AIS framework, which borrows heavily from the business and industry model, was applied to assess the commercial viability of technologies and innovations developed to address the constraints cited along the value chain. AIS framework represents a shift from technology-delivery mode to strengthening the capacity of value chain actors to innovate. The innovation system goes beyond the farmer and researcher to the private sector, technology delivery agencies and other actors in the broader institutional and policy environment. AIS encompasses participatory rural approaches, public–private partnerships (PPP), local innovation and all efforts geared towards entrepreneurship (FAC CAADP Policy Brief 2012).

3.2 Criteria for technology/innovations assessment

The six main AIS elements (Figure 6) that were useful in the assessment were: technology; knowledge and skills; aggregation; markets; and financing and enabling environment.

Figure 6: The AIS framework.



The following over-arching issues informed assessment under each of these elements:

1. Technology: Description of (infra)structure context and the problem the technology is trying to address in the value chain; its uniqueness, potential for job creation, industrial/regional milieu served by the technology.
2. **Knowledge and skills:** Facilities and expertise available in the parent institution, contribution to development of skills and expertise for commercialisation, mechanisms being employed to

develop closer interactions between academic research and industry, educational qualifications of existing incubatees (if any).

3. **Aggregation:** Opportunities for organisational innovations presented by the technological product, specific benefits of aggregation to the entrepreneur.
4. **Markets:** Potential and existing markets, any past commercialisation efforts and associated outcomes, linkages with the private sector.
5. **Financing:** Identification of costs associated with commercialisation, existing financing mechanisms, financial support system for entrepreneurs, potential sources of investment finance for the resulting enterprise(s), tax/trade incentives.
6. **Enabling policy environment:** Review of priority setting, legal and regulations, taxes and subsidies which influence supply and demand of technologies and innovations in a sustainable manner. An important demand-side policy instrument is public technology procurement where public agencies place orders beforehand to stimulate innovation.

3.3 Methods of data collection

At the start of the exercise, consultations were held with the three AIIC managers to obtain relevant literature on the specific value chains and to identify key stakeholders in NARS and private sector companies. The managers also shared the vision of the consortia and the stage they had reached in implementation. After these consultations, key informant interviews were conducted with research scientists in NARS within Kenya and Uganda and also with incubators, incubatees and also with private sector partners identified as potential collaborators in achieving commercialisation of certain technologies and innovations. The interviews were guided by checklists developed around the six elements of the AIS framework (see Annex1).

Due to the limited data available regarding costs and benefits, a detailed cost and benefit analysis was not possible for most of the technologies and innovations. Secondary data came in handy to fill the gaps and, where possible, gross margin analysis has been provided as indicative of the potential of the technology/innovation. However, this was only used as a guideline and consequently, commercialisation of any of the selected technologies will require a detailed analysis of the costs and benefits, which was not undertaken in this assignment due to time and resource constraints.

In addition to the primary data, the inventory was also informed by literature, with particular emphasis on technologies and innovations that are still in the pipeline but may be viable for sustainable commercialisation.

A list of selected institutions and stakeholders interviewed is provided in Annex 2.

3.4 Overview of selected technologies and innovations

Many technologies were proposed by stakeholders in the three value chains (see Annex 3). However, after careful assessment of SWOT and in line with the requirements of the client, ASARECA, at most four technologies were identified for each value chain (see Terms of Reference, Annex 4). The technologies/innovations cut across the commodity value chains, addressing challenges which were deemed significant by the stakeholders and also supported by past studies.

The selected technologies are presented in Table 3.

Young entrepreneurs visit Kenya Industrial Research and Development Institute.

Young entrepreneurs at the SVCDC (photo 2) at JKUAT during the ASARECA workshop with private sector to prioritize technologies for commercialisation.

Table 3: Summary of selected technologies/innovations

Value chain	Challenge(s)	Proposed technology	Unique features	Key partner	Key strategy for commercialisation
Banana	Pests and diseases, limited access to clean planting materials	Tissue culture technology	Mass propagation of clean planting materials	NARO-Kawanda, Private TC Laboratories	Build institutional capacity of private laboratories to supply TC plantlets
	High post-harvest losses due to spoilage while in transit, bulkiness, poor disposal of waste (peels and leaves) in cities and urban centres, low farm gate prices	Vacuum sealed fresh *matooke*	Inactivating the enzyme polyphenol oxydase (PPO) responsible for browning and spoilage of the peeled *matooke*, Vacuum sealing, cold storage and transportation	Kyambogo University, Small and Medium Enterprises, incubated farmer groups	Upscaling by sub-licensing emerging companies, targeting the local and regional urban market
	Environmental degradation and health hazards due to use of wood charcoal, high cost of disposing banana waste in cities and towns	Banana charcoal briquetting	Making charcoal briquettes using banana waste	Green Heat Uganda Ltd, UGASTOVE Ltd Uganda	Lobby for briquettes' standards-setting and enforcement to enhance marketing, targeting institutional markets
	High perishability of bananas, rudimentary banana processing technologies	Improved banana juice processing technology	Semi-automated processing and packaging of natural banana juice	Makerere University, EHC Ltd, incubated farmer groups	Financial support for investment in automated processing, product diversification (blends and flavourings)
Sorghum	Lack of appropriate varieties targeted for specific uses, un-developed seed supply systems	Commercialisation of sorghum varieties for specific uses	Commercialisation of high yielding sorghum varieties with specific attributes for processed foods, feed, fibre and bio-fuels	KARI, Egerton University, Private sector companies such as EABL, incubated farmer groups	Link up with NARS for supply of seed for specific uses, incubated farmer groups, PPPs
	Limited use of sorghum in animal feed processing, limited commercial production of sorghum for fodder production and limited access to technologies for various feed rations, targeting different livestock species and the associated equipment	Animal feed processing	Should be implemented as an innovation bundle comprising promotion of varieties for forage production, R&D for animal feed rations using sorghum, targeting of feed processors	KARI, Egerton University, feed processors, incubated farmer groups	Establish linkages with feed processors for supply contracts and develop capacity for local level feed processing for different animals

Table 3 cont.

Value chain	Challenge(s)	Proposed technology	Unique features	Key partner	Key strategy for commercialisation
	Scattered production by smallholder farmers, Limited access to certified seed, extension services, credit and markets by smallholder farmers	Contract farming innovation	A public private partnership (PPP) for production and marketing of sorghum varieties suitable for brewing through farmer groups	EABL, EUCORD, farmer groups, Smart Logistics, Equity Bank, local NGOs	Investment in mechanised harvesting, threshing and winnowing equipment for better quality produce, introduce new varieties through the organised farmer groups
Coffee	Pests and diseases, use of low yielding coffee varieties, supply of poor quality coffee clones	Tissue culture technology	Mass multiplication of improved varieties of coffee clones	Coffee Research Centre (COREC), Private TC laboratories	Build institutional capacity of private laboratories to supply TC coffee clones
	Limited farm-level value addition, poor governance of coffee VC and limited farmer participation in the VC	Farmer ownership model	Organised and inclusive business model of social entrepreneurship which retains ownership of commodities by farmers and working with other value chain actors as service providers; FOM also provides trading services for its members	National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE)	Identification of new markets, continuous investment in R&D for value added niche products
	Pressure to move away from trading in primary products into processed products, high competition in the global market	Geographical indications	Name or sign used on goods that have a specific geographical origin, possesses qualities, reputation or characteristics that are essentially attributable to that place of origin, GI system may include methods of production, explicit varieties and strict control on quality and volume of production	Uganda Registration Service Bureau (URSB)	Invest in sensitisation, value chain governance and quality control systems
	The common coffee sweetener has been associated with negative health effects (health conscious consumers)	Innovations in natural coffee sweeteners	Making of instant stevia coffee using freeze drying or spray drying technologies	University of Nairobi, College of Veterinary Services; Pure Circle Kenya Ltd	Investment in R&D for product innovations, market research

Source: Authors' compilation.

In the sorghum value chain, technologies identified included commercialisation of sorghum varieties for specific uses including food, beer, bread and animal feeds, feed processing and threshing equipment. In addition, contract farming under a PPP arrangement has also been documented as an organisational innovation which has shown potential for improving sorghum production, productivity and strengthening market linkages.

The banana value chain was the most vibrant in terms of technologies and innovations by small and medium enterprises, mostly in terms of commercial processing and utilisation of by-products. The technologies identified as having the highest potential for commercialisation included commercial production of clean planting materials using the TC technology, extending the shelf-life of cooking bananas through inactivating the browning enzyme and vacuum sealing, making of banana charcoal briquettes, partly to take care of the massive waste but also as an alternative source of fuel, which has been underexploited and lastly, commercial processing of banana juice. Under the coffee value chain, the technologies/innovations identified include: commercialisation of TC coffee clones, the farmer ownership model as an organisational innovation which can enhance chain ownership, governance and higher margins for the farmer, utilisation of geographical indications in branding and marketing of coffee and lastly, innovations in coffee value addition through use of natural sweeteners.

In most cases, there are overlaps in technologies and innovations because often, deployment of technologies often leads to innovations and vice versa.

Young Entrepreneurs with the Executive Director, Forum for Agricultural Research in Africa (FARA) and Head, Partnerships and Capacity Development Unit, ASARECA.

4 Technology inventory for banana value chain

Overview

More than 10 technologies were identified addressing one or more constraints in the banana value chain. Most of these technologies and innovations address value addition challenges in processing and marketing of banana-based products. Numerous informal small and medium enterprises exist, especially in juice and beer processing, but with limited linkages to technology developers, mainly Makerere and Kyambogo universities. NARO-Kawanda has developed hybrids and disease-resistant varieties which have achieved limited uptake. There is a growing interest in multiplication of improved banana varieties, via TC technology by private laboratories.

The uniqueness of players in this value chain is the holistic approach to the development of the value chain, with most actors adopting an innovation bundle combining technology (improved variety), organisational innovation (farmer groups), institutional innovation (contract farming) and organised marketing, among others. The banana value chain enjoys government policy in terms of policy and investment in technologies for banana improvement. However, the linkages between processors/companies and financiers are weak, resulting in the processors' technologies and innovations remaining at the pilot stage.

4.1 Tissue culture banana technology

Box 1: Overview of tissue culture banana technology

TC technology for mass propagation of disease-free banana planting materials is expected to enhance access to improved varieties for enhanced farm productivity. TC technology has a potential market share of 80–85% and leads to early maturity and uniformity, which eases marketing of the final product, green or ripe bananas.

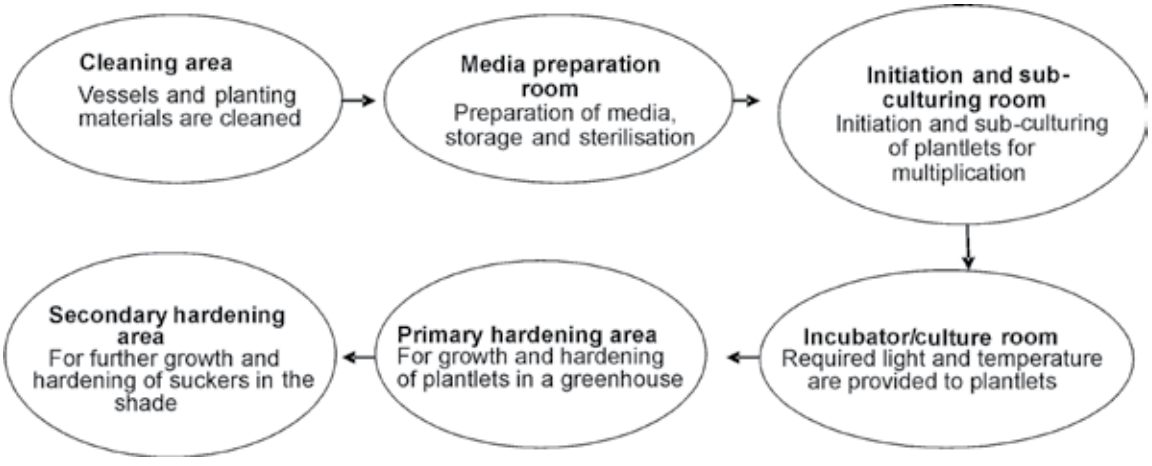
However, the cost of orchard establishment is three times more than with the traditional methods of propagation, which may limit adoption by smallholder farmers. The most prohibitive factor in commercialisation is the limited capacity of existing laboratories to meet the growing demand for clean planting materials. Secondly, the management of intellectual property to enable sharing or exchange of elite lines or clonal materials in the region is weak, which further limits access, especially by private laboratories. Hence, there is a need to develop and harmonise regional standards guidelines for TC banana production and product marketing.

The TC banana technology was developed to prevent spreading of diseases and to enhance access to clean planting materials among banana producers. In recent years, most African countries have been registering a decline in banana production. One of the major causes of this reduction has been crop infestation by pests and diseases, which have reduced yields by up to 90% (Kamau et al. 2011; AATF 2009). Another cause was transferring diseases from one farm to another through suckers obtained from old orchards, resulting in phytosanitary implications since the suckers transferred to new sites often transfer harmful pathogens including pests, if present. This has left many smallholder banana farms infested and recording poor yields over the years. TC technology is especially important in mitigating the spread of banana bacterial wilt, which is non-discriminative in that it attacks all varieties and is therefore a very important disease in banana production (Alex Barekye, NARO-Kawanda, personal communication, April 25, 2013). Moreover, conventional methods of generating banana planting materials through suckers are not only inefficient and unable to meet demand but they also promote the spread of pests and diseases.

Description of the technology

TC is a process of cloning plants in a sterile environment with just a small piece of the main energy portion of the plant, called the apical meristem[6]. It is planted in a special medium and grown in sterile containers where the plantlets can form, grow and be multiplied (Figure 7). The plants are then subjected to hardening conditions where they are carefully watched for stability and possibly a new strain of plant, or discarded as non-useable.

Figure 7: The tissue culture process.



Source: AATF (2009).

Banana fibre processing.

Disease indexing is a key part of the process if supply of quality planting materials is to be guaranteed. This technology allows for mass multiplication of plants from small pieces of the stock plant within a short time (AATF 2009).

[6] The original tissue plant may be from shoot tip, leaf, lateral bud, stem or root tissue, but this depends on the species of interest.

The TC propagation technique was introduced as a deliberate intervention to redress the above problems with the objective of availing clean, disease- and pest-free banana seedlings to farmers. NARO-Kawanda intervened by breeding for resistance to black sigatoka and pest tolerance. As a result, two cooking banana varieties (Kabana 6H and Kabana 7H) were released in 2003 and 2013 respectively. The two varieties have recorded an uptake of 5–8% of the farmer population and yields 25–35% higher than the local varieties (Alex Barekye, NARO-Kawanda, personal communication, 25 April2013).

Tissue culture bananas.

Biodegradable bags.

Breeding for *Fusarium* wilt, which was affecting Gros Michel (juice bananas), culminated in the release of two exotic varieties: Kabana 3H and Kabana 4H in 2002[7]. The two varieties have big bunches and an acceptable taste, though not as good as Gros Michel variety. A study conducted among urban consumers by Mugisha et al. (2009) established that although the exotic varieties were acceptable, they were rated inferior to Gros Michel. In addition, skin appearance for KABANA 3H, taste for Cavendish and texture for Gros Michel were found to affect both market and consumer acceptance. The above study posited that the exotic varieties hold high potential for the regional market, having also been tested in Kagira, Tanzania, and performed well.

All the varieties underwent TC screening and are therefore marketed as clean (disease-free) planting materials. However, NARO-Kawanda does not undertake commercial multiplication of these disease-resistant varieties, although the technologies are available for commercialisation through a partnership arrangement.

The advantage of the TC technology is that large numbers of healthy banana plantlets can be produced in the laboratory in a comparatively short period of time. The technology reduces pests and disease problems for banana growers and offers an ideal opportunity to introduce new and superior germ-plasm quickly on a large scale. Since the plants mature early and uniformly, the technology is especially appealing to smallholders constrained by declined farm sizes since they are able to harvest and sell fairly large quantities of bananas at one time (Kamau et al. 2011).

The technology was developed in NARO-Kawanda, Uganda. It is also available at KARI and Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya. The technology has been licensed to some private laboratories in Kenya and Uganda. In Uganda, TC banana technology is suitable for scaling up in the major production areas, highlighted in Figure 2, while in Kenya the technology is being promoted in parts of Eastern Kenya (Meru region), Central Kenya and Nyanza (Kisii region, where banana production is the predominant economic activity).

Estimated returns (local currency and equivalent US$)

TC banana seedlings have an estimated market share of between 80% and 85%. This is a timely opportunity for private companies and ABP consortia to invest in the ready market for TC banana seedlings in the major producing areas (Alex Barekye, NARO-Kawanda, personal communication, April 25, 2013). The retail price of one TC banana seedling ranges between US$0.75 and US$1.5 compared to the conventional suckers which sell at less than US$0.5. Between March and August 2013, ABP consortia produced 3000 seedlings through TC technology, which fetched US$3600 (ABP 2013).

According to a report by Kamau et al. (2011), crop establishment costs rose threefold (from US$200 to US$600) with TC technology adoption for orchard management. However, the marketing costs reduced significantly due to the uniformity, which can only be afforded through TC technology. There is also ease in production and marketing coordination, especially for farmer groups because of the opportunity for uniform plantation establishment presented by mass multiplication of disease-free seedlings. In addition, the harvest cycle reduces significantly with TC, to 12–16 months compared to 18–24 months for conventionally produced bananas.

Conversely, the price per ton increased by 66% due to improved quality, generating large positive net returns (Kamau et al. 2011), while the TC banana yields have been found to increase from 10–15 kg to an average of 30 kg per bunch (Africa Harvest 2011). This implies higher incomes for banana farmers and improvement in livelihoods.

[7] The varieties were provided by FHIA-Honduras.

Contact details of the generators/promoters of the technology/innovation

National Agricultural Research Organisation (NARO-Kawanda)
PO Box 7065
Kampala, Uganda
Telephone: +256 414567158
Email: a.barekye(@)kari.go.ug

Kenya Agricultural Research Institute
KARI Headquarters
PO Box 57811-00200, City Square, Nairobi, Kenya
Fax: +254 020 4183344
Tel(s): +254 020 4183720, 4183301–20
Email: Resource.center@kari.org

Jomo Kenyatta University of Agriculture and Technology (JKUAT)
PO Box 62000-00200
Nairobi, Kenya
Tel: +254 067 52181/4, 067 52556
Email: info@jkuat.ac.ke

Genetic Technologies Limited (GTL)
Box 47430-00100, Nairobi
Tel: +254 20 4183280

Mak Seeds Ltd
7 Miles Gayaza Road, Luteete
PO Box 7062
Kampala, Uganda
Email: sbmukasa@gmail.com

Agrotech Uganda
Tel. +256 774799277
Email: sebumajames@yahoo.com

Suggested road map for commercialisation

These are views collected from different stakeholders and review of other organisations' commercialisation efforts in TC technology.

- According to NARO-Kawanda, dissemination of the potential benefits of TC technology for banana production should be combined with NARO's awareness campaign and promotion of hybrids and exotic varieties. The organisation also has access to human resources to support establishment of demonstration plots and mother gardens in the high potential areas.
- ABP consortia can also consider partnering with an additional private laboratory based in Uganda for the supply of TC banana seedlings. This would cut down costs of transporting hardened seedlings to Central Uganda and parts of western Uganda, which supply the highest proportion of bananas in Uganda.
- Regional standard guidelines should be developed and harmonised to set up TC banana laboratories and assessing their institutional capacity in terms of infrastructure, human resources, quality control systems and marketing strategy. This will enable interested stakeholders to identify aspects that require capacity building for the laboratories to meet the ever-growing demand for clean planting materials.

- Capacity of nursery operators should be built in hardening of the seedlings, distribution to farmers and in providing advisory services on orchard establishment within the locality. They can take advantage of the opportunity presented by NAADS on building the capacity of advisory services in the banana value chain. These nursery operators will also require certification so that the seedlings they offer are of high quality to build farmers' confidence in the technology. The certified operators can also be contracted by private laboratories to enhance their market share, further increasing the likelihood of adoption and growth of the sub-sector.

4.2 Fresh vacuum sealed *matooke* (FREVASEMA)

Box 2: Overview of FREVASEMA technology

FREVASEMA technology involves inactivating the enzyme polyphenol oxydase (PPO)—which is responsible for browning and spoilage of peeled *matooke*—vacuum sealing, cold storage and transportation. The technology was developed to reduce spoilage of green bananas while in transit to markets, and to reduce bulkiness which translates to high cost of transportation.

With FREVASEMA, bulkiness is reduced up to 40% while the shelf-life of the *matooke* is extended by 6 months under frozen conditions, by thirty days under normal refrigeration and by three days at normal room temperature. In addition, the waste banana peels can be used in production of additional by-products such as animal feeds, vinegar and gin.

The potential market share in Uganda is 100%, even though the company does not currently have the capacity to fulfill this demand. It is recommended that scaling up of this technology be considered by sub-licensing emerging companies, targeting the local and regional urban market. However, the challenge for the innovator is in establishing and managing a royalty payment scheme for the technology, which is already patented.

Although Uganda produces large volumes of bananas, but experiences very low trade volumes due to challenges in the banana sector, including irregular market prices, limited options for value addition, poor infrastructure such as roads, electricity and irregular year-round supply of uniform bananas.. At the same, there is potential for producing a range of banana products including vinegar, enriched animal feeds, dietetic menu and wine.

Problem that the technology/innovation seeks to address

The cooking banana, known in Uganda as *matooke*, has a relatively short shelf-life. This affects exploitation of opportunities to export the banana to markets such as Europe. Secondly, there are poor road networks in the production areas, which often increases the transportation time, even to local urban centres, leading to spoilage en route. This problem is a disincentive to banana traders, who in turn offer very low prices to farmers in order to absorb potential risks and make a profit. In addition, banana trade in most cities and towns of Uganda is a major contributing factor to environmental degradation with the growing waste (peels and leaves) which is often poorly disposed of. The technology developer, Prof Byarugaba Bazirake GW, indicated that "*Matooke* contributes 510 metric tons of waste in Kampala and neighbouring towns per day" (Prof Byarugaba Bazirake GW, Afri Banana Products Ltd, personal communication 27 April 2013).

The fresh vacuum sealed *matooke* (FREVASEMA) technology was developed to mitigate the described marketing and environmental challenges inherent in banana trade. The products are targeted at urban consumers within Kampala and in the export markets.

A description of the technology or innovation

The technology was developed in 2008 at Kyambogo University. FREVASEMA technology involves use of inactivating the enzyme polyphenol oxydase (PPO) that is responsible for browning and spoilage of the peeled *matooke*. This is followed by vacuum-sealing the *matooke* and storage at low temperature, even when in transit. The technology prolongs the shelf-life of the *matooke* by about 30 day) under refrigeration room temperature; the *matooke* can stay fresh for up to three days.

In the process, the weight of the *matooke* is reduced by 40%, implying lower transportation costs and reducing the burden of waste disposal in urban centres and the capital, Kampala. This is because the process takes place at the points of production where the *matooke* are peeled before they are vacuum-sealed and transported to urban centres in small packs.

In addition to developing the technology and proof of concept, the technology developer has also attained a patent which will assure exclusive benefits for a given period, beyond which the technology will be freely available to the public. The patent can also be licensed out to other companies interested in commercialisation of similar products using the technology. This will earn him royalties and thus sustain the brand. The developer has also invested in meeting international quality standards and recently obtained a USA drug certificate which permits exportation of FREVASEMA *matooke* to the US market.

Apart from the FREVASEMA *matooke*, the technology amasses by-products which can be used in the development of other banana-based products. For example, peels can be used to make vinegar, banana charcoal briquettes, blockboard and poultry feeds. They can also be used to produce biogas, which reduces reliance on wood fuel and petrol-based energy.

Fresh vacuum sealed matoke (FREVASEMA).

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling

Although the technology was developed in Kyambogo University, Kampala, it is implemented in Mbarara due to the proximity to the pockets of high production. The logic of reducing bulkiness, increasing shelf-life and enhancing market access makes the technology suitable for promotion in high banana production areas in Kenya and Uganda. However, the target market is the urban

consumer who has a high preference for peeled hygienic *matooke* to reduce meal preparation time and save time since one can buy in bulk and store for a month.

Estimated returns (local currency and equivalent US$)

The ABP business plan estimates a 100% local market share for FREVASEMA *matooke*. The product is currently being sold in the US market with an average weekly export of 0.25 tons (ABP 2013). The revenue stream for FREVASEMA in 2012 was indicated as US$138,685 (ABP Business Plan 2012) while between March and August 2013, a total of 6,107 kg were exported, fetching US$10,496 (ABP 2013).

No data were available to isolate costs associated directly with FREVASEMA technology. However, the technology has created rural employment where women are employed to peel and process *matooke*, youths are engaged in banana handling, and transporters and suppliers of other inputs such as reagents and packaging materials are also involved. In addition, the location of the technology at the point of production has enhanced year-round market access for smallholder farmers, who would otherwise be prone to exploitation by middlemen.

Contact details of the generators/promoters of the technology/innovation

Fresh Vacuum Sealed *Matooke* (FREVASEMA)
Director, Kyambogo University,
PO Box 7181, Kampala, Uganda
Tel: +256 414 222280,
Mobile: +256 776 426578 / +256 712 426578
Email: gwbasirake@gmail.com, gwbb@ymail.com

Suggested road map for commercialisation

- The FREVASEMA technological product, FREVASEMA *matooke*, is on a growth trajectory. Based on the discussions with the technology developer (patent owner)-cum-entrepreneur, the demand in the local market outstrips supply. An opportunity therefore exists for upscaling, targeting the local urban market. The patent owner is also considering licensing the technology to other companies to sustain the local market.
- Regionally, the technology would be the first of its kind in the other East African countries. It is therefore suggested that a market research study be conducted in the region to establish demand and willingness to pay for the fresh peeled, vacuum sealed and hygienically packed *matooke*. This would be followed by an assessment (internal and external) of potential to supply these markets and a cost–benefit analysis of the same to establish commercial viability of the regional markets.
- The company should also establish a system of collecting royalties for use of FREVASEMA patents and fees for licenses issued.

4.3 Banana charcoal briquettes technology

Box 3: Overview of banana briquetting technology

The banana charcoal briquetting technology has been selected due to its potential to mitigate environmental degradation and health hazards associated with poor disposal of banana waste in cities and towns. Banana waste has been estimated to be 500 tons per day in Kampala only and costs US$7 per ton to dispose of.

The technology involves making of charcoal briquettes using banana peels as organic waste. The banana waste can be used alongside sugar cane tops, molasses, potato peels, coffee husks and charcoal dust. The target market for the technology/ technological product would be institutional markets (schools, colleges and hotels) whose average consumption of bananas is 3 tons per month in Uganda.

Although this technology has been in existence for some time, its use in the region has been limited and will therefore require sensitisation campaigns and a commercialisation strategy. Secondly, there is need to lobby for standards-setting and enforcement to enhance marketing, especially in the formal markets.

The problem the technology/innovation seeks to address

The banana charcoal briquette technology addresses two environmental problems that are common in East Africa. First, wood charcoal is fast becoming a scarce product and its production contributes to environmental degradation, causing deforestation and soil erosion. Deforestation results in drought and global warming, while soil erosion leads to loss of soil fertility and poor soil structure, limiting production potential. Secondly, in Uganda, over 7 million people consume bananas daily with waste amounting to over 500 tons on a daily basis in the urban centres alone. The huge waste has high cost implications in terms of appropriate disposal. For instance, Kampala County Council spends approximately US$7 per ton to dispose of urban waste (PAEPARD 2012). This means that the Council allocates at least US$3,500 per day on banana waste disposal.

Furthermore, wood charcoal/fuel poses serious health hazards like respiratory diseases, not to mention the drudgery women are subjected to in sourcing for firewood. Consequently, the banana charcoal briquettes technology provides an alternative source of energy and is versatile enough to incorporate other organic waste for a sustainable environment. The technology also contributes to household costs savings since the briquettes can be made on small scale for household needs.

A description of the technology or innovation

Banana charcoal briquettes can be made using either dried peels or fresh peels. With fresh peels, two other inputs are required: charcoal dust and fine sand[8]. The ingredients are mixed in a ratio of 0.25:0.25:0.25 banana peelings, charcoal dust and sand respectively. The banana sap helps bind the mixture. Next, the mixture is cut into smaller portions which are then dried in the sun and used to cook as required. Drying may take 3–7 days.

The second process, which is more applicable for commercial production of briquettes, involves mixing the sun-dried and semi-burned peels with clay soil and a starch (such as cassava starch) which acts as a binding element. The mixture is then poured into a mould or a briquette press which shapes the briquettes in readiness for drying. Other organic wastes which can be utilised in briquette making alongside banana peels include sugar cane tops, molasses, potato peels, coffee husks and charcoal dust. The moulding equipment or a briquette press can be locally fabricated.

[8] Source of technology: CELAC project, Uganda.

Charcoal briquettes.

Moreover, the technology can be promoted in the form of an innovation bundle encompassing briquette-making, use of energy-saving stoves, baking ovens, incinerators, fireless box cookers and through group formation to aggregate the peels and cut down costs of production and marketing.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

The technology has been tested by several organisations in different parts of Uganda, including an ABP incubatee, Green Heat (U) Ltd. The FREVASEMA incubation centre has also 'proofed' the technology, but produces it in limited quantities. The technology is suitable for promotion in both urban and rural settings in Uganda since banana waste is a common nuisance, though less of a problem in the rural environment. Rural dwellers would most likely take up the technology purely as a source of extra income to the farm family or as a source of employment for rural-based youths. Other target consumers of the briquettes are schools, hotels, roadside food vendors, charcoal vendors and urban households with medium to high income (ABP Business Plan 2012).

The Kampala County Council can also consider investing in the necessary equipment and labour to manage waste in a more environment-friendly manner as well as raise income from the sale of banana charcoal briquettes.

Estimated returns (local currency and equivalent US$)

The main costs associated with this technology would be acquisition and maintenance of a banana press or moulding equipment. A small briquette press costs approximately US$2500. The other inputs are for the most part locally available. A ton of banana charcoal briquettes retails between

US$240 and US$50. Thus, a kilo of banana charcoal briquette would be approximately US$0.35, way below an equivalent amount of conventional wood charcoal retailing at approximately US$0.85. Past studies have also shown that banana charcoal briquettes produce less smoke when used to cook, thereby further protecting the air and minimising cases of respiratory diseases. According to Prof Bazirake, the technology would be more effective if co-joined with energy-saving stoves (Prof Byarugaba Bazirake GW, Afri Banana Products Ltd., personal communication 27 April 2013).

Commercialisation of this technology requires heavy investment in market promotion and awareness creation. ABP estimated a market share of 10%, partly because of limited information available to the public. The technology can also be promoted through farmer groups participating in other banana value chain projects for ease of utilisation, even at household level. In addition, farm households would benefit immensely because of the versatility of the technology, as discussed earlier.

Contact details of the generators/promoters of the technology/innovation

Green Heat Uganda (U) Limited
PO Box 10235
Kampala, Uganda
Tel.: +256 71 2379889
Email: info@greenheatinternational.com

Uganda Stoves Manufacturers Limited (UGASTOVE Uganda)
PO Box 1265, Makindye, Kampala, Uganda
Telephone: +256 752 640073/+256 772 674267/+256 702 674267
Email: ugastove@gmail.com

Suggested road map to commercialisation

- Train farmers, farmer groups, youth groups and women groups on briquette making technology and link them to markets. Institutional markets would be ideal, such as schools, hotels and restaurants, hospitals and industries using wood energy.
- It is still not clear which agency should be in charge of setting and enforcing standards, yet this is a basic requirement when considering markets like supermarkets. There is also a need to invest in product awareness and sensitisation on the positive environmental impact of using banana charcoal briquettes coupled with energy-saving stoves/ovens/incinerators.
- A market survey will be crucial in determining people's perceptions of banana charcoal. This will also inform the marketing and promotional strategies to be formulated.
- Once the technology has been widely adopted, it will be important to document the environmental impact of adoption of the technology, potential carbon trade-offs and savings accrued therefrom.

4.4 Processing of banana into beverages (juice)

Box 4: Overview of commercial banana juice processing technology

This technology is a response to the high perishability of bananas and the existing manual processing technologies, which leads to low quality products. The technology involves organising and training smallholder farmers to produce quality bananas which are aggregated, ripened and processed into banana juice. The innovator is targeting 20% of the current production in western Uganda for juice production, Currently, the company has a production capacity of 500 litres per week which is semi-manually produced. To expand this capacity, the company needs to invest in product development and also in automated processing and packaging technologies, at a cost of between US$40,000 and US$200,000. However, many financiers shy away from investing in product development, yet this is a technology which has surpassed proof of concept and is at the growth stage. There is also need for developing more capacity in incubating farmer groups for consistent supply of quality bananas for juice processing.

The problem that the technology/innovation seeks to address

Uganda has two peak seasons for banana production. During the peak seasons, farm-gate prices fluctuate from as low as US$0.5 per bunch weighing approximately 18–20 kg. The same bunch can, however, be sold for US$10–15 in Kampala. The sale of green and ripe bananas in the city introduces a lot of garbage. Furthermore, there are high post-harvest losses during peak seasons due to the high perishability of the commodity, poor post-harvest handling and poor road networks, which limit timely market access.

In addition, minimal farm/local level banana processing is undertaken save for very limited processing of local banana brews, which is also undertaken by a few small and medium enterprises and sold locally in informal outlets. Since farmers do not add value to bananas, they receive a small margin, despite the investment in crop production.

A description of the technology or innovation

South-western Uganda produces 60% of bananas in Uganda. A juice processing company, Excel Horticulture Company (EHC) Ltd, processes banana juice from cooking and dessert bananas. The bananas are supplied by 270 farmers organised into farmer groups for ease of capacity building. The farmer groups are contracted by the company which offers training in group governance, enterprise management and agronomic advisory services. In turn the groups supply the mature bunches to the company for ripening and eventual juice production. The company processes payments within one week after receipt of the mature bananas. Additionally, the company has invested in training some of the farmer groups' alternative income-generating activities from the banana crop. For instance, some of the groups have been trained in extraction of banana fibre, which they sell to a banana-fibre based incubation centre of ABP.

The juice is processed and packaged into plastic containers under the brand name Excel nectar. The juice is then transported to urban centres, where the company has already developed a network of wholesalers and retailers. EHC Ltd currently has a production capacity of 500 litres per week, which is manually produced. It hopes to expand this capacity with the growing demand for the ready-to-drink natural juice. The company is in the process of acquiring a trademark under facilitation of Uganda Industrial Research Institute (UIRI).

The company has been investing resources in research and development of banana blends and flavourings and banana beer products to gain an edge over competitors and to widen its market share.

Banana juice, nectar and wine.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

EHC Ltd undertakes juice processing in Mbarara and plans to eventually tap 20% of cooking bananas produced in Western Uganda region, once capacity to process at least 20,000 litres per day has been fully developed. Juice production requires constant supply of uniform quality bananas. The technology would therefore be suitable for scaling-up in areas where farmers are organised into groups for constant supply and are also producing a uniform variety of bananas through TC technology.

Estimated returns (local currency and equivalent US$)

The niche markets identified for banana juice include school-going children (families), supermarkets and social gatherings such as weddings. According to a recently concluded market research commissioned by the company, there are very positive and promising reports regarding the demand for the banana juice. This quote is attributed to EHC Ltd Programmes Director Dr Andrew Ainomugisha. The company produced 5000 litres of banana juice between March and August 2013 (ABP 2013).

Complete stainless steel processing equipment comprising a processing unit, ripening room and a blower could cost approximately US$40,000 (Andrew Ainomugisha, Excel Horticulture Co. Ltd., personal communication, 25 April 2013). Prof Khamuhangire, also an innovator of banana juice technology, cautions that viable commercialisation of juice processing technologies would require an investment of between US$50,000 and US$200,000. At US$50,000 the processing of

juice would be labour-intensive and packaging would be in plastic bottles, whereas at US$200,000 the system of production would be automated and packaging would be in tetrapak sachets.

To operate commercially, a juice processor also requires certification from the bureau of standards, whose cost is quite prohibitive for a start-up company. EHC Ltd is in the process of acquiring a trademark under facilitation of Uganda Industrial Research Institute (UIRI).

Contact details of the generators/promoters of the technology/innovation

Excel Horticulture Co. Ltd (EHC Ltd)
Head Office
Plot 67, Buremba Road
PO Box 664, Mbarara, Uganda
Tel: +256 485 66110

Professor W. Khamuhangire
Makerere University
School of Food Technology, Nutrition & Bio engineering
Agricultural & Bio Systems Engineering
PO Box 7062 Kampala, Uganda
Tel: 0772 519 422
Email: wkyama@agric.mak.ac.ug

Suggested road map to commercialisation

- Financing for private sector players engaged in agribusiness R&D or agri-based manufacturing is usually weak in Uganda. There is need to research business portfolios that finance agricultural value-added product development such as manufacturing.
- Makerere University Kampala's incubation centre has nurtured 15 different enterprises of food processing technologies which are due to graduate. However, the exit strategy has been difficult due to weak support systems for growth and investment for graduates. Thus, it will be important to strengthen linkages with the industry and support services so that the growth stage is well set in advance.

5 Technology inventory for coffee value chain

Background information on each incubation centre

TC technology for micro-propagation of coffee clones bred with resistance to coffee wilt disease (CWD) provides an opportunity to replace over 200 million coffee bushes in Uganda. Commercialisation of this technology will be most successful when coupled with satellite nurseries operated by licensed nursery operators to ease access to smallholder farmers throughout the country.

The farmer ownership model (FOM) addresses the challenges of limited farm-level value addition, governance of commodity value chains and farmer-participation in the value chain. The model promotes social entrepreneurship and equitable shared value along agricultural value chains such as the coffee value chain. The principles underlying this model consist of performance pay, coffee is an entry and integral part of other agricultural enterprises, no buying the product by the service provider, only playing a facilitating role, emphasis on value addition and eventually sustainability of efficient services to farmers.

The geographical indication (GI) is an upcoming institutional innovation in Uganda, which will help to access niche markets and also to negotiate premium prices for coffee from certain parts of the country, which has unique characteristics and quality attributes. Since GI is a form of product differentiation, its users will be able to command premium prices and maintenance of a product's market share in the shrinking global market for agro-based products.

Stevia has caught the attention of coffee consumers because its extracts having up to 300 times the sweetness of sugar and with the rise in demand for low-carbohydrate, low-sugar food alternatives. This innovation therefore presents an opportunity to come up with coffee product innovations, with a sweetener that has little or negligible effect on the blood sugar as well as having low caloric value.

Tissue Culture coffee at Agriworks (Uganda Limited).

5.1 Tissue culture coffee clones technology

Box 5: Overview of TC coffee technology

The mass multiplication of improved varieties of coffee clones is meant to improve the supply of good quality and clean coffee clones to fill the existing gap of replacing over 200 million plants of Robusta coffee with seven new CWD resistant clones in Uganda.

Just like the banana TC technology, there is need to build institutional capacity among private laboratories and nursery operators to supply TC coffee clones. In addition, there is need to support private laboratories in creating product distinction to minimise distribution of poor quality clones as is the case currently.

The problem that the technology/innovation seeks to address

One of the major challenges facing coffee production in the East African region is low productivity occasioned by pests and diseases, use of low yielding coffee varieties, poor soil fertility and poor agronomic practices. CWD is considered the most significant disease affecting coffee production in Uganda. This has prompted the Government of Uganda, through UCDA, to develop plans to replace over 200 million plants of robusta coffee with the 7 new CWD resistant clones (Mukasa Ssetumba, Makerere University, Kampala, personal communication, 24 April 2013). Another challenge being encountered in the country is widespread supply of poor quality coffee clones to farmers by unscrupulous traders, yet the current national capacity of producing clonal seedlings and maintaining genetic purity and CWD resistance is way below 1 million per year. This has left a big supply gap, which presents an opportunity for technologies that can achieve mass multiplication of clonal seedlings within a relatively short time.

A coffee plantation.

A description of the technology or innovation

To supply 200 million coffee seedlings, there is need for a technology that ensures mass multiplication of the coffee clones alongside an innovative system of distribution that guarantees quality and fair prices to farmers. The TC technology suggested here is no different from the one described in Section 4.1. Here, the same technology is applied in mass multiplication of improved varieties of coffee clones for yield improvement.

Supply of clean planting materials is embedded in the CURAD business plan through partnership with public and private laboratories, which have accredited TC facilities. CURAD intends to build the capacity of an existing laboratory to supply disease-free TC coffee seedlings to its clients. CURAD will also support partner laboratories in creating product distinction through branding. CURAD AIIC will also facilitate licensing of nursery operators involved in distribution of the coffee seedlings.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

COREC, as the institution charged with R&D in the coffee sector, developed seven Robusta lines with resistance to CWD, which are available for mass multiplication. In addition, COREC established a TC facility with a large capacity to wean TC coffee clones. To enhance distribution of the improved coffee varieties, COREC established approximately 30 nurseries throughout the coffee growing zones. The nurseries have been certified by UCDA as suppliers of clean planting materials.

Estimated returns (local currency and equivalent US$)

To run a successful TC laboratory enterprise, there is need for each laboratory to develop or have access to expertise in biotechnology, plant pathology, plant breeding and agronomy, as well as infrastructure (AATF 2009).

One of the companies gearing up for partnership with CURAD estimated that setting up a laboratory capacity to multiply 300,000 coffee clones would require equipment worth US$150,000 inclusive of operational costs. They also forecast that for every 10,000 plantlets to be produced, 10 workers will be required in the laboratory. This number does not include 3 satellite nurseries (each with an annual capacity of 100,000 plantlets) which it hopes to set up to enhance access of clean planting materials to farmers throughout the country. It is hoped that each satellite nursery will employ at least five people to assist in hardening of the plants and subsequent distribution to farmers. In terms of revenue generation for the company, each TC clone is expected to retail at US$0.4 for the next 3 years. Thus, the company has the potential to generate an annual income of US$120,000 in three years. With funding of US$150,000, the company has projected to break even in the 4th of operation (Mukasa Ssetumba, Mak Seeds Ltd., personal communication, 24 April 2013).

Contact details of the generators/promoters of the technology/innovation

Coffee Research Centre (COREC), Mukono
PO Box 185, Mukono, Uganda
Email: cor@ africaonline.co.ug.
FAX: +256 392 700 726

Mak Seeds Ltd
7 Miles Gayaza Road, Luteete
PO Box 7062
Kampala, Uganda
Email: sbmukasa@gmail.com

Agrotech Uganda
Tel. +256 774 799 277
Email: sebumajames@yahoo.com

Suggested road map to commercialisation

- Beyond start-up stage, the company will rely on the CURAD brand to penetrate more markets and maintain quality of the clones.
- The TC laboratories can increase their market penetration by contracting the UCDA certified nursery operators, who also partner with COREC to disseminate new technologies.
- COREC also has a large capacity of satellite nurseries/mother gardens in various agro-ecological zones (AEZ) which should be better equipped to support weaning of TC plantlets and distribution to farmers. This would enhance farmers' access to clean coffee clones.
- Private laboratories or entrepreneurs are also encouraged to enter into a memorandum of understanding with COREC for leasing of the expansive and under-utilised TC facility at the institution.

5.2 Farmer ownership model—Organisational innovations

Box 6: Overview of farmer ownership model

The farmer ownership model (FOM) is an organised and inclusive business model of social entrepreneurship which retains ownership of commodities by farmers and works with other value chain actors as service providers. The model provides trading services to participating members and ensures that smallholder farmers are active participants in the VC up to the level they find beneficial or up to their capacity. Through the FOM, participating coffee farmers have been able to organise production, processing and marketing of ground coffee in the export market. Farmers are also able to access new markets, which would previously be out of reach for many smallholders. The challenge in implementing FOM is organising the many stakeholders involved to ensure value for money and effectiveness of the chain. In addition, there is need to invest in continuous R&D for value-added niche products to remain competitive in the market.

Background information

To improve the standards of living of smallholder farmers, the all-inclusive, innovative and entrepreneurial FOM was conceived by Mr Joseph Nkandu, the NUCAFE Executive Director, in 1999. Testing of the model began in 2004. The model is copyrighted and patented in Uganda and is applicable in all agricultural value chains. It has won the recognition of national, regional and international organisations as an outstanding smallholder farmer empowerment model.

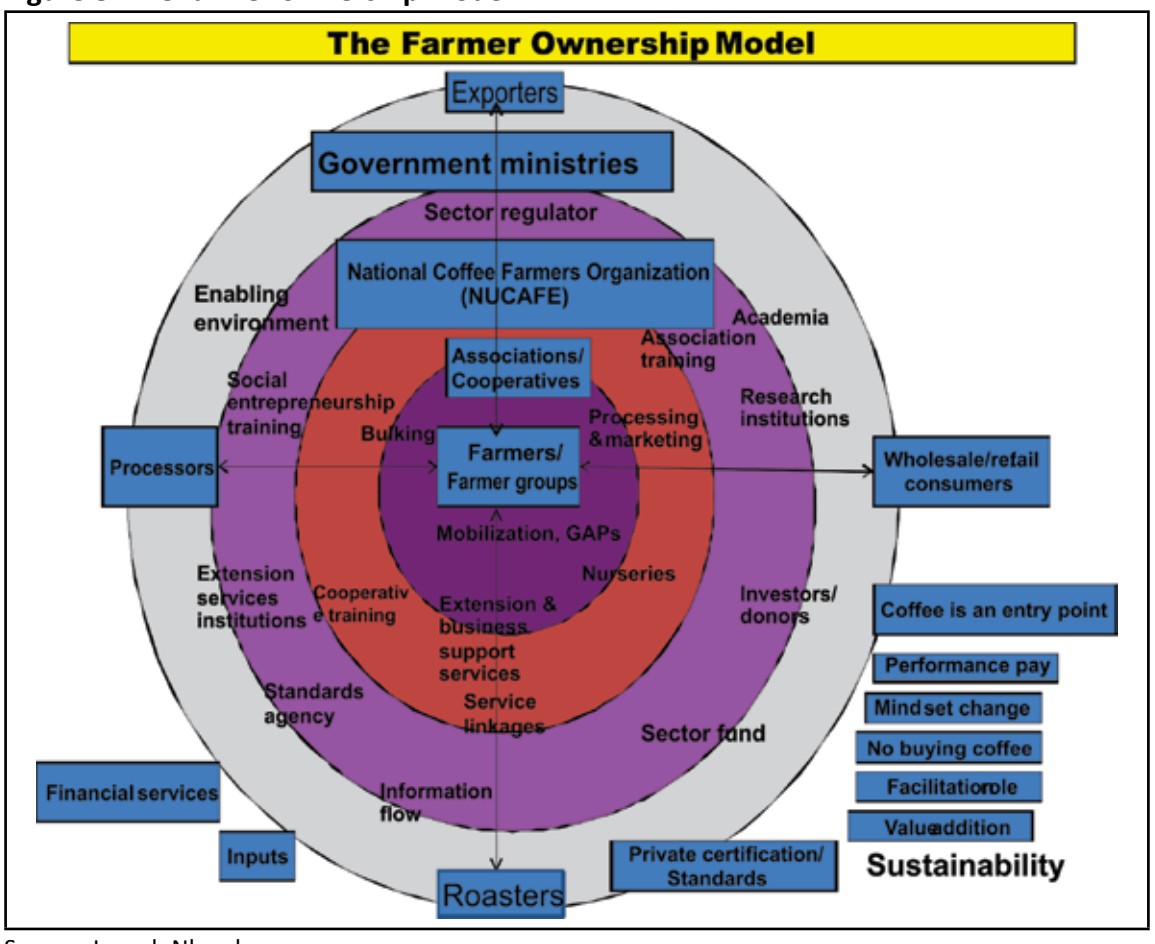
The problem that the technology/innovation seeks to address

The FOM is a response to the many challenges that exist within the coffee value chain seeking to address the paradox where players in the coffee trade are wealthy and yet the farmers who produce coffee live in a vicious cycle of poverty. The model addresses the challenges of limited farm-level value addition, governance of commodity value chains and farmer participation in the value chain. The model promotes social entrepreneurship and equitable shared value along agricultural value chains such as the coffee value chain.

A description of the technology or innovation

The FOM is an inclusive business model that enables thousands of smallholder farmers to retain ownership of an agricultural commodity (such as coffee), where partners facilitate the process flow of coffee so that farmers graduate from trading in raw materials (green coffee) to more valued added forms of coffee as commercially-oriented social entrepreneurs working with other stakeholders: academia, research, public extension institutions and civil society organisations as service providers who do not take ownership from farmers (see Figure 8).

Figure 8: The farmer ownership model.



Source: Joseph Nkandu.

As shown in Figure 8, farmers organise themselves to assume as many roles and responsibilities as possible at different nodes of the coffee value chain to increase their social and economic

power. Individual farmers are organised into groups, which are then organised into associations/cooperatives. Those in the first centric provide some services: bulking, primary processing of coffee and delivery to the central hub at the national farmer organisation level (NUCAFE) in the second concentric. Then NUCAFE facilitates further value addition and other inclusive business services comprising: (1) secondary processing and manufacturing; (2) training; (3) marketing; and (4) information dissemination and advocacy.

The focus of partners and associations has shifted from buying coffee to process facilitation, providing services that empower farmers to upgrade in the profitable segments of the coffee value chain so that they can satisfy the tastes and preferences of different customers. For instance as a facilitator, NUCAFE and its partners do not buy coffee to take away ownership of coffee from farmers; instead they provide affordable services which would otherwise be extremely hard to get from the conventional middlemen (buyers of raw materials). The principles underlying this model consist of performance pay; coffee as an entry and integral part of other agricultural enterprises; no buying of the product by the service provider but rather playing a facilitating role only; emphasis on value addition and eventual sustainability of efficient services to farmers. The model is already patented. The manual that describes the FOM is also copyrighted.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

The model was piloted with the coffee value chain and actual implementation began in 2005. It is suitable for upscaling in all agricultural commodity value chains and other African countries facing similar paradoxical challenges in facilitating smallholder farmer upgrading in the value chains. The technology is also being used by policy makers to offer lessons for policy and practice. Other users of the technology include processors and roasters within the value chain. The FOM is also being considered for adoption by the East Africa Farmers' Federation.

Estimated costs and returns (local currency and equivalent US$)

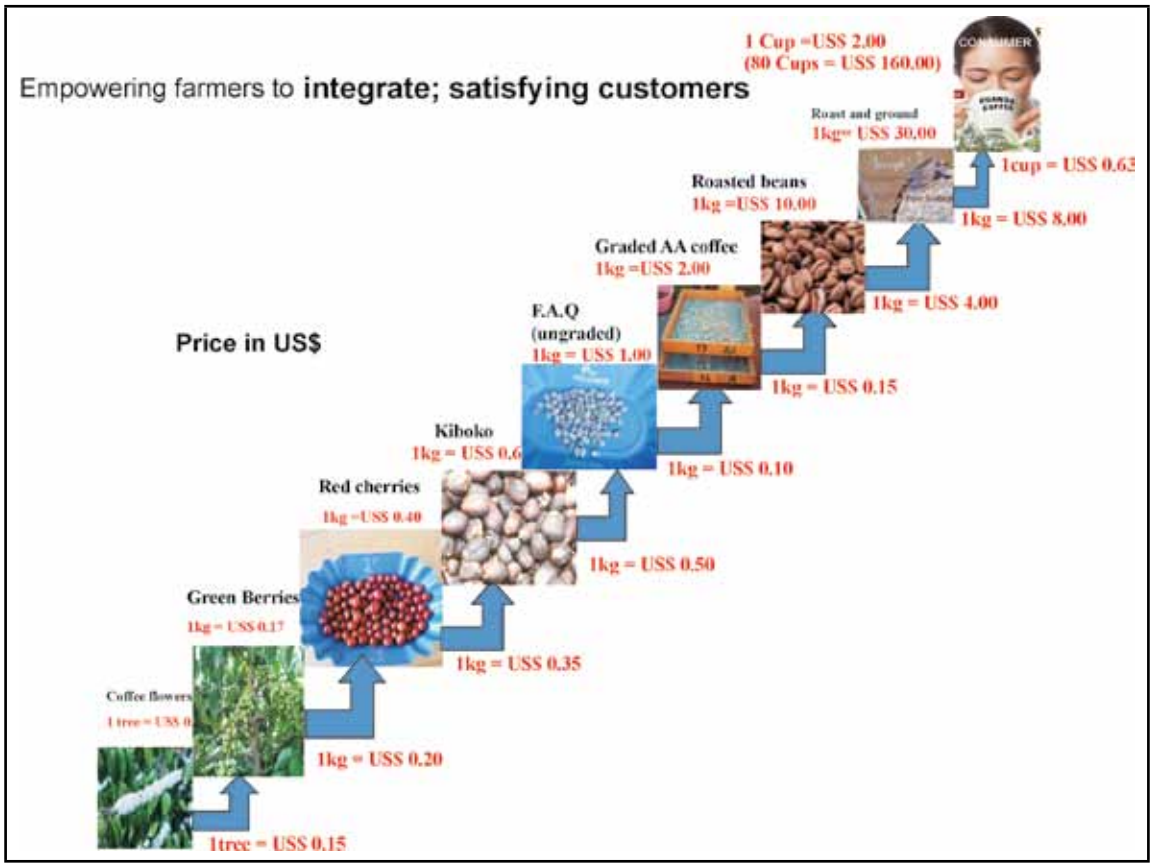
Borrowing from the experience of implementing the model in the coffee value chain by NUCAFE, an investment of US$1.45 results in at least US$10 per kg to the farmer for coffee traded in the form of roasted beans (Figure 10). However, NUCAFE cautions that the cost of the technology will vary depending on the value chain in which it is being applied.

The coffee value chain (Figure 10) helps farmers make informed decisions regarding the desired level of participation in the value chain. NUCAFE plays an oversight role in addition to coordination of all the actors in the value chain. It has been a learning process for NUCAFE and the 600 farmers organised around the model. It took close to eight years to implement the model from production to packaging and marketing of the first product, roasted and ground coffee, sold under the brand name NUCAFE Coffee. Thus, careful selection of the agricultural value chain in which to implement the model will be very crucial, considering that the business incubation period under UniBRAIN consortia lasts three to four years. The main challenge with this model revolves around governance of the value chain and coordination of the diverse actors to ensure quality services and products. The government can cushion farmers who may be excluded from participating in such a model due to the inevitable self-selection bias associated with collectives.

However, the market for the FOM is large with the potential to scale-out to other African countries and agricultural value chains. There has been great demand with a large number of regis-

tered purchases of the FOM manual in many African countries (Joseph Nkandu, CURAD, Makerere University Agricultural Research Institute, personal communication, 24 April 2013).

Figure 9: Costs and returns associated with FOM along the coffee value chain.



Source: Joseph Nkandu.

Other benefits of participating in the FOM, enumerated by NUCAFE team, are as follows:

- Farmers have graduated from selling primary products to selling value added products—more shared equity and value
- Quality improvement of coffee
- Income improvement and livelihood improvement—enhanced access to education and health services
- Expanded farms due to regained confidence in the coffee trade and a 'feel' of ownership
- An organised coffee industry—good for lobbying for appropriate policies and better prices
- The maiden product of FOM, NUCAFE coffee, has penetrated export markets in Italy and Denmark.

According to Dr Mukasa Ssebuliba of Makerere University, Kampala, the FOM is instrumental in empowering value chain players in facilitating entrepreneurial business processes along the value chain.

Contact details of the generators/promoters of the technology/innovation

Joseph Nkandu
National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE)
Plot 35, Jinja Road, Coffee House
PO Box 34967 Kampala, Uganda
Tel: +256 414 236199
Email: joseph.nkandu@nucafe.org
Phone: +256 772595030
Website: www.nucafe.org

Road map to commercialisation

The innovators of the FOM indicated that for full commercialisation in the coffee value chain, adopters will require support in market access and continuous investment in identification of value addition technologies/innovations for production of niche products and sustaining the markets. This view is supported in Future Agricultures Consortium (FAC) policy brief for CAADP processes which observes that smallholder farmers—including women—can enter markets if linked to participatory processes, effective farmer organisations and technical and policy research (FAC 2012).

5.3 Geographical indications—Organisational/ institutional innovations

Box 7: Overview of geographical indications

As African economies seek to access export markets, there is pressure to move away from trading in primary products to processed products in order to remain competitive in the global market. Geographical indications systems involve assessing methods of production, explicit varieties and strict control on quality and volume of production to ensure the products possess qualities, reputation or characteristics that are essentially attributable to that place of origin. The GI is expected to overcome the fierce market competition leading to retention of a product's market share. The East Africa region stands to benefit considering the renowned rich and robust qualities of the region's coffee, which have been under-utilised in coffee marketing.

Although GI system has been in use for many years, its adoption in the EA region has been limited; this will require investment in sensitisation, value chain governance and quality control systems.

Background information

Agricultural products typically have qualities that derive from their place of production and are influenced by specific local factors such as climate and soil. A geographical indication can be used to distinguish these products to capture a niche market and charge premium prices. The indications can be used for a wide variety of products whether natural, agricultural or manufactured. Geographical indications have been used before in developed countries such as France in marketing of agricultural products.

The problem that the technology/innovation seeks to address

Geographical indication (GI) is an upcoming innovation in Uganda, which will help to access niche markets and also to negotiate premium prices for coffee from certain parts of the country which has unique characteristics and quality attributes. The innovation will thus spur interest among fair trade enthusiasts and consumers concerned with the origin or conditions under which a product of their choice has been produced or processed.

There is increasing pressure for African countries to move away from trading in primary products to processed products. However, attempts to export processed products are often met with barriers to trade, such as quality standards and ethical trade practices. The increasing use of GIs for other agricultural products and foodstuff is a reflection of the increasing demand for quality agricultural products amidst proliferation of mass-produced standard products. Thus, GI is expected to overcome the fierce market competition leading to retention of a product's market share (Rangnekar 2003).

A description of the technology or innovation

A geographical indication is a descriptive term indicating the geographical origin of a product and a specific quality or reputation which is due to this particular geographical origin (Hui-Shung Chang et al. 2007). It can be in the form of a sign used on goods that have a specific geographical origin, possesses qualities, reputation or characteristics that are essentially attributable to that place of origin. It may also include the name of the place of origin of the goods (URSB 2013).

There are several different GI systems in the world that provide the opportunity for producers to differentiate their products. Some systems are based solely on location while others take geographical features into account along with methods of production, explicit varieties and strict control on quality and volume of production. An applicant for GI undergoes rigorous assessment to authenticate his/her claims, before the certificate is issued. Examples of products which have used GI as a marketing tool include Champagne wine from France, Ceylon tea from Sri Lanka and Wisconsin cheese from the USA (Hui-Shung Chang et al. 2007).

Uganda Registration Service Bureau (URSB) will be in charge of issuing standards/guidelines for GIs and also in assessing the same. URSB will also provide legal protection and registration of GIs as well as remedies for infringement or prohibited use of GI and related matters.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

As indicated above, a GI can be used on any agricultural good/commodity/ product provided it possesses unique qualities, reputation and characteristics attributable to a certain place of origin.

Expected benefits of the innovation

The Government of Uganda passed the GI law recently and was awaiting Presidential assent in April/May 2013. Since GI is a form of product differentiation, it is expected that its users will command premium prices and maintenance of a product market share in the shrinking global market for agro-based products.

Past studies on hedonic pricing have shown that an indication of source had a statistically significant impact on prices (Schamel 2003). While emphasising the benefits of establishing GI systems and its use as a marketing tool, Hui-Shung Chang et al. (2007) observed that a well-defined and

well-protected GI allows the producers in the region to act as monopoly and hence command a premium price due to their exclusive use of the GI.

NUCAFE has been instrumental in the formulation of the GI law in Uganda, which it hopes will leverage its FOM in coffee marketing.

Contact details of the generators/promoters of the technology/innovation

Uganda Registration Bureau Services (URBS)
Plot 5, George Street, Georgian House
PO Box 6848 Kampala, Uganda
Tel: +256 414 233 219

National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE)
Plot 35, Jinja Road, Coffee House
PO Box, 34967 Kampala, Uganda
Tel: +256 414 236199

Suggested road map to commercialisation

- According to Mr Bemanya Twebaze, the URSB Registrar General, GI is a new law which requires much sensitisation for the relevant public to appreciate. This implies that if stakeholders in the coffee value chain want to reap the benefits of GI, they have to invest in sensitisation, value chain governance and quality control systems that afford them uniqueness in the market.
- Stakeholders also need to commission a study to assess the potential of a proposed GI for the emerging farmer-controlled coffee processing in Uganda.
- There is also a need for assessment of Uganda's preparedness to establish GI systems and identify economic and regulatory conditions which would ensure successful application of GIs as a marketing tool.

4.4 Innovations in natural coffee sweeteners

Box 8: Innovations in natural coffee sweeteners

This technological innovation involves use of stevia as a natural coffee sweetener due to its desirable nutritional benefits such as negligible effect on blood glucose and even in glucose tolerance, making it an attractive natural sweetener for health-conscious consumers. The technology involves making of instant stevia coffee using freeze drying or spray drying technologies. The technological product is still in the product development stage, implying a need for investment in R&D for product innovations, market research to establish product potential and its commercial viability.

Background information

Coffee is a common beverage enjoyed by a large segment of the population all over the world. The CURAD Consortium is in the processes of identifying viable natural coffee sweeteners and develops products based on these sweeteners. One potential sweetener is the stevia plant, commonly known as sweet leaf or sugar leaf.

Coffee beverage; tasting coffee at Volcano Coffee Ltd.

The problem that the technology/innovation seeks to address

Many coffee lovers have been forced to reduce or completely do away with coffee due to the negative health effects of sugar, which is used as the common sweetener. This therefore presents an opportunity to come up with coffee product innovations, with a sweetener that has a negligible effect on the blood sugar as well as having low caloric value.

Stevia, scientifically known as *Stevia rebaudiana* and locally called sweet leaf or sugar leaf, is widely grown for its sweet leaves and medicinal value. With its extracts having up to 300 times the sweetness of sugar, stevia has attracted attention with the rise in demand for low-carbohydrate, low-sugar food alternatives. Medical research has also shown possible benefits of stevia in treating obesity and high blood pressure. Because stevia has a negligible effect on blood glucose, it is attractive as a natural sweetener to people on carbohydrate-controlled diets. Stevia is believed to enhance glucose tolerance and is therefore attractive as a natural sweetener for diabetics and others on carbohydrate-controlled diets. Other than its low glycemic value, stevia has many other desirable nutritional benefits hence making it the most preferred natural sweetener.

A description of the technology or innovation

The most important aspect of stevia is the leaf, which is harvested after three months, dried and ground into a powder that forms the basis of the sweeteners. Stevia also consists of 10–12% stevio side, a component that can be extracted as liquid concentrate to be used directly in soft drinks and beverages. Using coffee and stevia extract in defined concentrations, instant stevia coffee can be made by using freeze drying or spray drying technologies.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for up-scaling/promotion

Stevia grows optimally in upland areas with a sub-tropical climate. It was introduced in Kenya in 2009 by a private company, Pure Circle Kenya Ltd, initially in Kericho region, and produced purely for export. Over time, non-governmental organisations have promoted the crop in other parts of the Rift Valley as a healthy product and also for export. Stevia powder is light and can be transported easily and can therefore be used anywhere in the formulation of various products.

Estimated returns (local currency and equivalent US$)

Stevia production presents a new income stream for the farming community due to its current high market value, ranging from Ksh800–1300 (US$9.7–15.8) per kg of powder. Although market research for naturally sweetened coffee has not yet been established, the product is expected to attract the growing numbers of health-conscious coffee consumers within the East Africa region and even in the export market. The powder can also be used in chocolates and candies, further presenting an opportunity for R&D in additional coffee-flavoured chocolates and candies with natural sweeteners. Stevia also possesses an anti-microbial property, meaning it can be used in all the sweets that children are fond of[9].

Contact details of the generators/promoters of the technology/innovation

Prof Jasper Imungi and Ms Joy Munge
College of Agriculture and Veterinary Services

[9] Pure circle website.

University of Nairobi
PO Box 29053-0065
Nairobi
Email address: jasper.imungi@uonbi.ac.ke

Suggested road map for commercialisation

- R&D to determine acceptable concentrations of stevia in stevia coffee.
- Conduct an exploratory study on market potential.

6 Technology inventory for sorghum value chain

Background information on each incubation centre

Despite the numerous benefits that sorghum possesses and the research efforts made in the past, its adoption, production and utilisation as a staple and commercial crop in Kenya remains low. Sorghum production at farm level is limited by low yielding varieties, lack of appropriate varieties targeted for specific uses, poor agronomic management practices, diseases and pests, and undeveloped seed supply systems (KAPAP 2011). Although Kenya produces 5000 metric tons of sorghum annually, it is the leading industrial consumer of sorghum in the East Africa region.

The recent opportunities presented by East African Breweries Ltd (EABL) through contract farming have triggered many stakeholders to invest in the sorghum value chain development, focusing on the production end of the value chain. Few stakeholders have invested in promotion of value added sorghum products.

This background informs the establishment of Sorghum Value Chain Development Consortium (SVCDC), with specific focus on promotion of agro-enterprises around food, feed, fibre and biofuels.

The inventory on the sorghum value chain has identified the following technologies/innovations: commercialisation of sorghum varieties for specific uses, contract farming as a form of organisation innovation, and animal feed processing. This component should be implemented as an innovation bundle, comprising promotion of varieties for forage production, R&D for animal feed rations using sorghum, targeting of feed processors in sorghum promotion and linking them to farmers and innovations in small-scale feed processing to benefit the smallholder farmers.

6.1 Commercialisation of sorghum varieties for specific uses

The problem that the technology/innovation seeks to address

In Kenya, the problem of continued poor yields season after season has remained a paradoxical challenge, considering the significance of the crop in household food security and the unexploited potential in industrial uses. Similarly, farmer preference for own saved seed astounds many breeders and stakeholders with regard to the low adoption of improved seed varieties. By March 2013, there were 20 registered sorghum varieties in Kenya, of varying special attributes such as wide adoptability, dual purpose, high quality forage, resistance to bird damage, tolerance to stem borer and high yielding varieties (KEPHIS 2013). Discussions held with the SVCDC CEO (Willis Owino) and one of the partners' representatives, Fred Oduke of Agritrace in April 2013, established that the time had come for promotion of appropriate varieties for targeted uses. This meant a need to undertake evaluation of existing genotypes for specific uses and identify those that require possible improvement or, if satisfactory attributes are identified, then contract farmers to produce the specific variety (Willis Otieno, SVDC/JKUAT, personal communication, 18 April 2014; Fred Oduke, Agritrace, personal communication, 30 April 2014).

Box 9: Overview of commercialisation of sorghum varieties for specific uses

Until recently, sorghum value chain development was the domain of the public sector due to the perceived subsistence nature of the commodity. However, there is an emerging demand for sorghum for industrial use mainly in production of beer, ethanol, syrup and animal feeds. The challenge in meeting this demand has been limited access to technologies, undeveloped seed supply systems and poor flow of information between technology holders (mainly NARS) and technology users (farmers and private companies). Consequently, this technology bundle exemplifies available technologies for commercialisation of high yielding sorghum varieties with specific attributes for processed foods, feed, fibre and bio-fuels.

To maximise the potential of these varieties, it will be crucial to forge partnership arrangements, such as contract farming, and build the capacity of farmers to supply high quality produce as well as the seed supply system. In addition, there is need to come up with technologies/innovations that minimise cost of production and primary processing to compete favourably with industrial sorghum substitutes such as maize, whose retail price is lower than that of sorghum.

Beyond these discussions, a desk review of past and ongoing R&D in sorghum revealed that KARI Katumani and Alupe stations had released most of the sorghum varieties. The R&D challenge discussed above was also reiterated by a plant breeder, from KARI-Katumani, who said, "the research challenge for sorghum in Kenya today was development of new seed varieties which had less tannins and a high sugar content" (Dr C.K Kamau, Plant Breeder, KARI-Katumani. Personal communication, April 26, 2013). However, Egerton University began a sorghum R&D project in 2011 to text the appropriateness of over 40 genotypes for targeted uses.

A description of the technology or innovation

The SVCDC forecasts that there is a rising demand for sorghum with specific attributes for processed foods, feed, fibre and bio-fuels. Therefore, the varieties proposed here possess some of these attributes, although some are still in the process of registration.

Two main varieties which have the potential to be commercialised in Kenya for industrial use are KARI Mtama 1 and the Gadam varieties. According to CK Kamau, both varieties are suitable for:

1. Human foods such as porridge, ugali, gruel and bread (roti)
2. Livestock feed
3. Beer
4. Production of a dye for colouring wine and foods
5. Extraction of sorghum oil for the perfume industry
6. Blending with coffee to produce sorghum coffee

KARI Mtama 1 has a higher sugar content than Gadam and also has superior yields (3.4 t/ha) compared to Gadam, with optimal yields of 2.5 t/ha. However, Gadam is specially adapted to coastal and semi-arid lowlands unlike KARI Mtama 1 whose optimal production altitude ranges between 250 and 1800 metres above sea level.

At Egerton University, a project funded by the Kenya Agricultural Productivity and Agribusiness Programme (KAPAP)[10], has undertaken variety evaluation of 31 hybrids, 60 lowland open pollinated

[10] Project title: Enhancing sorghum production, processing and marketing for improved smallholder incomes and livelihoods in Kenya, funded by KAPAP Competitive Grants System (CGS) Collaborative Research Grants (CRG) awarded in July 2011.

varieties (OPV) and 40 highland OPVs. These were evaluated for yield and suitability for baking (*chapati* and bread), ethanol yield, malting and brewing. From the evaluation, 5 genotypes for baking (12–16% sorghum in sorghum–wheat flour), 2 for brewing (1 hybrid and 1 OPV), 1 variety for ethanol from stalk juice capable of producing 600–700 litres/ha were identified as having superior attributes. Some of these varieties are already at the national performance trials (NPT) stage of registration. With regard to the development and testing of diverse products, laboratory analysis at Egerton University on baking attributes of 46 genotypes had been completed and preliminary results indicated that five varieties were best for different products. Nakuru Patisserie Bakery was expected to undertake the baking tests of the five varieties for bread with consumers by May 2013. In addition, a potential incubatee of SVCDC, Ms Roselyn Nyambura, an incubatee of SVCDC (affiliated to AgriTrace) had been testing the baking qualities of various sorghum varieties for bread and confectioneries such as biscuits and cakes. KARI has a fully-fledged seed processing facility (KARI Seed Unit) for seed commercialisation which operates as a registered company (not a public institution).

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

Optimal production altitude for varieties released in Kenya ranges between 0 and 2300 metres above sea level. Thus, the sorghum production potential lies in Eastern, Nyanza, North Eastern and Coast regions of Kenya, where it is possible to achieve high volumes of the crop for industrial use, human consumption and livestock feed.

The value-added products such as bread and confectioneries will be suitable for promotion in urban settings and in retail outlets such as shops, supermarkets, hotels and restaurants.

Estimated returns (local currency and equivalent US$)

Table 4 shows some production estimates from an organisation promoting sorghum production and marketing, mainly for industrial use in Kenya.

From Table 4, production per acre was slightly higher in the 12-acre farm than it was in the 3-acre farm. However, there was a significant difference of Ksh8651 (US$105.5) in cost per acre with the 12-acre farm incurring relatively higher costs. It is important to note that the yields achieved in 2012 were slightly higher than the potential of most released varieties in Kenya, ranging between 1.4 and 1.5 tons per acre whereas the optimal yields are 2.5 tons per ha.

An interview with an aggregation, the company contracted by EABL to aggregate the sorghum, found out that sorghum grain market retail price for the period ending Feb 2013 was KES25 per kg thus translating into KES25,000 (US$304.87) per ton (Rose Mutuku, Smart Logistics, personal communication, 26 April 2014)

EABL has a capacity to utilise 50,000 metric tons annually. However, this capacity remains under-utilised most of the time due to poor yields and logistical challenges in supply of the commodity.

Table 4: Smallholder sorghum production estimates in Kenya

Sorghum production for 3-acre plots in Mukothima-Tharaka County, Eastern Kenya

Sorghum production for 3-acre plot						Sorghum production for 12-acre plot					
Cost centre	Unit	Qty	Rate per acre	Total (Ksh)	Total (USD) 1USD:Ksh84	Cost centre	Unit	Qty	Rate per acre	Total	Total (USD)
Seed	Kilos	9	140.00	1260.00	15	Land hire (annual)	Acre	12	4000.00	48,000.00	571.4286
Land preparation	Acre	3	1500.00	4500.00	53.57143	Seed	Kilos	52	140.00	7,280.00	86.66667
Planting labour	Acre	3	800.00	2400.00	28.57143	Land preparation	Acre	12	1500.00	18,000.00	214.2857
Weeding	Man-days	90	49.00	4410.00	52.5	Planting labour	Acre	12	800.00	9,600.00	114.2857
Insecticide		3	2000.00	6000.00	71.42857	Weeding	Man-days	1080	49.00	52,920.00	630
Foliar feed		9	90.00	810.00	9.642857	Foliar feed	Lts	36	90.00	3,240.00	38.57143
Labour to spray	Knapsacks	75	35.00	2625.00	31.25	Labour to spray	Knapsacks	219	35.00	7,665.00	91.25
Harvesting	Bags	80	60.00	4800.00	57.14286	Insecticide spraying		12	2000.00	24,000.00	285.7143
Threshing	Bags	48	200.00	9600.00	114.2857	Labour to spray	Knapsacks	219	35.00	7,665.00	91.25
Labour to thresh	Man-days	5	400.00	2000.00	23.80952	Harvesting	Bags	560	60.00	33,600.00	400
Bagging	Bags	48	35.00	1680.00	20	Threshing	Bags	205	200.00	41,000.00	488.0952
Total cost (3 acres)				40,085.00	477.2024	Labour to thresh	Man-days	10	400.00	4,000.00	47.61905
Total cost per acre				13,361.67	159.0675	Bagging	Bags	205	35.00	7,175.00	85.41667
					0	Total cost per acre					3144.583
										264,145.00	
Income	Unit	Qty	Rate	Total		Total cost per acre				22,012.08	262.0486
Sorghum grain	Bags	48	2160.00	103,680.00	1234.286						
						Income	Unit	Qty	Rate	Total	
Production analysis						Sorghum grain	Bags	205	2160.00		5271.42
										442,800.00	
Production per acre	Bags	16.0									
Production per acre	Kilos	1440				Production analysis					
Gross income per acre	Kshs			34,560.00	411.4286	Production per acre	Bags	17.1			5271.42
Total cost per acre	Kshs			13,361.67	159.0675	Production per acre	Kilos	1537.5			
Net income per acre	Kshs			21,198.33	252.3611	Gross income per acre	Kshs			36,900.00	439.2857
						Total cost per acre	Kshs			22,012.08	262.0486
						Net income per acre	Kshs			14,887.92	177.2371

Source: Africa Harvest (2013).

Contact details of the generators/promoters of the technology/innovation

KARI Katumani
PO Box 340-90100
Machakos, Kenya
Tel: +254 44 20495
Email: karikkatumani@yahoo.com

KARI Alupe
PO Box 169-50100
Kakamega -Kenya
Tel: +254-056-30031
Fax: +254-056-30031
Email: Resource.center@kari.org
kari-kakamega@yahoo.co.uk

Dr Eric Cheruiyot
Egerton University
PO Box 536-20115
Egerton, Kenya
Tel: +254 51 2217877/2217878

Suggested road map for commercialisation

- Since the promotion and production of Gadam by EABL was very strong, it became a more dominant variety among producers targeting the beer market for lagers in East Africa. But according to Kamau, it is important to note that KARI Mtama 1 was not promoted by brewers because of the high costs and externalities involved although it has less tannins and higher brewing qualities. Therefore, there is an opportunity for promotion of KARI Mtama 1 targeting the feed processing industries due to the lower levels of tannins.
- Egerton University's research project has tested over 40 varieties for specific uses and identified varieties with superior attributes, depending on intended use. It is therefore recommended that stakeholders interested in sorghum for specific needs initiate partnerships with Egerton University for purposes of supply of the appropriate variety(ies). The identified varieties have special attributes for baking, brewing and ethanol extraction.

6.2 Organisational innovation in sorghum production and marketing

The problem that the technology/innovation seeks to address

As stated earlier, the problem of low yields in sorghum despite the many interventions by development partners remains a paradox to many. In their study on the influence of institutional factors on sorghum production in Nakuru County, Kenya, Ogeto et al. (2012) established that access to seed, access to extension, access to market information and access to group membership were significantly influencing sorghum production in the study area. In addition, only 28% of farmers had easy access to certified sorghum seed. The SVCDC business plan considers provision

of improved sorghum varieties seed and organisation of farmers to be a critical component in the success of the consortium (SVCDC Business Plan 2012).

Box 10: Overview of contract farming as an organisational innovation in sorghum

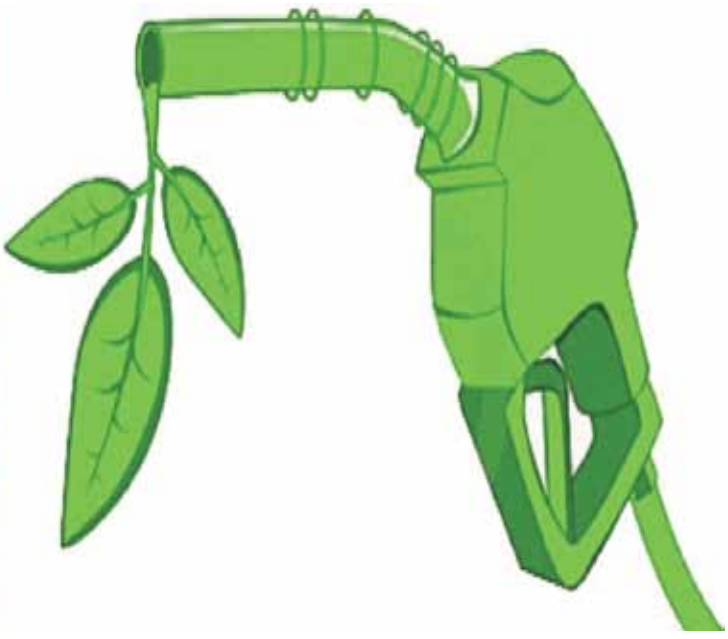
Contract farming is an innovative commercialisation model which helps to organise production and marketing of preferred sorghum varieties of high quality and desired quantities in a timely manner. The partnership is usually between previously scattered farmers, an industrial consumer such as EABL, the bank, transporters, local NGOs for group mobilisation, and the public sector for supply of basic seed and certified seed. The model is praised for its ability to increase market access for smallholder farmers and a change in mindset with most participating farmers transiting from subsistence to commercial sorghum production. Thus, this model is an important tool when introducing new technologies/innovations among smallholder farmers.

The challenge with contractual farming arrangements is the high cost of coordinating the diverse partners to remain on course. To reap more benefits of commercialisation, farm mechanisation is highly recommended, including mechanised harvesting, threshing and winnowing for better quality produce.

Sorghum for food: baking using sorghum bread.

Sorghum for fibre.

Sorghum for feed.



Sorghum for fuel.

The EABL was seeking an alternative for barley in beer production and identified sorghum as a suitable crop. The company had the potential to absorb 50,000 metric tons and therefore required a critical mass of farmers to ensure these quantities are met. Another challenge which had to be overcome was transition from subsistence to commercial sorghum production since at the time, sorghum production in Kenya was being done on a small scale, mainly for subsistence purposes. The total national output for all varieties was 118,227 tons in 2002 and 126,433 tons in 2003 (EPZA 2005). Therefore, EABL had to come up with an innovative way to organise farmers in order to meet the desired quality standards and achieve the required annual quantities, to maximise the industrial capacity.

A description of the technology or innovation

EABL forged PPP with several organisations with interest in sorghum value chain development. These were KARI, Smart Logistics, Equity Bank, the European Co-operative for Rural Development (EUCORD) and farmers. To effect the partnership, farmers were organised into groups and contracted by EABL to supply agreed quantities of sorghum at an agreed price.

Various other memoranda of understanding were drafted with partners to smoothen implementation of roles in the partnership and to govern the project. For example, EUCORD, which was on a mission to enhance production of sorghum in arid lands of East Africa, entered into a memorandum of understanding with EABL which stipulated that for every US$1 from EUCORD, EABL would give another US$1 to promote sorghum farming in arid and semi-arid areas where there was initially no sorghum (Muriithi 2013). Equity Bank provided input credit to smallholder farmers which would be deducted from sales proceedings and the rest deposited into farmers' accounts. Smart Logistics was contracted to aggregate the produce from the farmer groups and deliver the same to EABL at a commission of Ksh2 per kg delivered. The KARI Seed Unit was required to produce enough seed (approximately 115 tons) for farmers to meet the initial target of 24,000 metric tons of sorghum grain.

Since EABL wanted to attain a critical mass of sorghum producers, local NGOs were engaged to mobilise farmers into groups and to facilitate the contractual arrangement. One such NGO participating in the project was Hope Africa, which also trains farmers in sorghum production. Clustering smallholder farmers into farmer groups was considered the best approach to train many farmers within a short period, delivering advisory services, monitoring production and aggregating produce, and communicating with the project stakeholders. The group's capacity to manage agribusiness was also built through trainings and formalisation of groups, with set governance structures. The local NGOs also come in handy in negotiating the terms of contract farming with EABL and in resolving conflicts among group members. According to Kherallah and Kirsten (2001), farmer collectives are important in agricultural production and marketing because they lead to a reduction in transaction costs, both for the farmer and for the contractor, and also strengthen farmers' production and bargaining power.

PPPs are gaining ground in agribusiness development in Africa and considered as an important institutional mechanism for gaining access to additional financial resources, sharing risks, and addressing other constraints in pursuit of sustainable and inclusive agricultural development (FAO 2013). Through the PPP, EABL got the additional support of EUCORD to improve sorghum production in arid lands and hence acquire the desired sorghum for its industrial use. At the same time, the EABL PPP changed smallholder farmers' outlook on sorghum as a subsistence crop and has enabled the farmers to work towards maximising the potential of the sorghum enterprise. This effect has been documented by Ministry of Agriculture (2012), whereby production increased by 75% from 602,910 bags in 2008 to 1,055,051 bags in 2009; there were slight yield improvements to 6.09 bags per ha and also a 67% increase in the area under production from 104,041 ha in 2008 to 173,172 ha in 2009.

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

The EABL agribusiness partnership project is spread across Nyanza, Western and Upper Eastern in Kenya. The same PPP model was launched in 2011 in North Eastern Uganda and there were plans to implement it in Western Uganda (Kirimi 2013).

The Agribusiness PPP concept is applicable in any agricultural commodity value chain as long as there is strong political will and government's commitment through policy, supportive infrastructure development and creation of the necessary institutional framework for efficient markets which lead to development of the entire commodity value chains, and eventual growth in agribusiness (FAO 2013).

Estimated returns (local currency and equivalent US$)

The EABL agribusiness PPP model has had the following impacts:

- Yield improvement has been recorded among participating farmers
- Sorghum farming has improved farmers' living standards
- Improved prices of KES25,000 per ton (US$304.8)
- Change in mindset—from subsistence to (semi-) commercial farming
- Creation of a critical mass of trained sorghum producers, equipped with better management of sorghum enterprises, risks and farmer groups

- Enhanced access to credit, which previously was out of reach for such cereal crops
- Enhanced access to market
- Improved local sourcing of sorghum

Some of the costs expected in managing an agribusiness PPP are those related to oversight role, cost of provision of public goods like extension and advisory services, cost of monitoring farmer groups and enforcing the contracts. A study on agribusiness partnerships in Africa, carried out by FAO (2013), established that in many cases the leader in such partnerships takes up these costs, which is a disincentive for private sector partners. For example, EABL also had to manage varied partnership arrangements, which often introduced logistical challenges and transaction costs relating to different systems of procurement in partner organisations.

6.3 Innovations in animal feed production and processing technologies

Box 11: An overview of animal feed production and processing technologies

This technological bundle seeks to address the following challenges: limited use of sorghum in animal feed processing, limited commercial production of sorghum for fodder production, and limited access to technologies for various feed rations, targeting different livestock species and the associated equipment.

The selected technological bundle comprises promotion of sorghum varieties for fodder production, varieties for pigs and poultry feeds, processing of sorghum cake and recommended feed processing equipment.

It is proposed that these technologies be implemented as an innovation bundle comprising promotion of varieties for forage production, R&D for animal feed rations using sorghum and targeting of feed processors. It will also be prudent to establish linkages with feed processors for supply contracts and develop capacity for local level feed processing for different animals.

The problem that the technology/innovation seeks to address

Among the various uses of sorghum, its utilisation in livestock feed has remained at subsistence level, with few companies investing in the business. Frequent drought in the areas with high potential for sorghum production have led to inadequate livestock feeds despite the potential for processing sorghum-based feed concentrates (KAPAP 2011). Similarly, the feed concentrates are sold at exorbitant prices, even though their quality may not be guaranteed. This has affected dairy production in Kenya, with shortages of milk hurting farmers and consumers alike.

Some sorghum varieties registered in Kenya have forage potential of up to 8 tons per ha (KEPHIS 2013), and yet they are not being produced on a large scale. Sorghum, being a drought-resistant crop, has also been under-utilised in terms of commercial production for livestock feed. In addition, forage conservation in Kenya is minimal despite the seasonal variations in forage supply (CK Kamau, KARI-Katumani, personal communication, 26 April 2013). Another challenge mentioned was limited access to technologies for various feed rations, targeting different livestock species and the associated equipment, especially at smallholder level (Fred Oduke, AgriTrace Ltd. Personal communication, April 28, 2013) .

A description of the technology or innovation

This component should be implemented as an innovation bundle, comprising promotion of varieties for forage production, R&D for animal feed rations using sorghum, targeting of feed

processors in sorghum promotion and linking them to farmers and innovations in small-scale feed processing to benefit smallholder farmers.

KARI released two sorghum varieties which are suitable for use as fodder, lkinyaluka and KARI-SH2, released in 1996 and 2008 respectively. Kinyaluka variety, available at KARI-Kakamega, produces high quality forage and yields 8 t/ha in optimal conditions. KARI-SH2 is a dual purpose variety with grain yield potential of 4 t/ha and forage yield potential of 8 t/ha. It is also tolerant of rust and cold (KEPHIS 2013).

Sorghum is a potential alternative feed ingredient which can replace wheat and maize in animal feed formulations. A study on seven sorghum varieties and extensive testing on poultry flocks at University of Agriculture, Faisalabad, Pakistan (Ali 2012) established that low tannin sorghum is a good substitute in the diet of poultry. The highest recommended level of tannin in poultry diet is 1%. White sorghum varieties had lower levels of tannin and their use in poultry led to eggs with lower cholesterol, suitable for cardiac patients and health-conscious consumers.

In terms of feed processing, it has been established that fine grinding of grain sorghum can increase its digestible energy content by 3%. Particle sizes of approximately 500 to 600 microns are required to optimise both pig performance and milling efficiency. As for machinery for feed processing, research suggests that grain ground with a roller mill is more uniform in shape and distribution and hence will have greater flow ability than grain ground with a hammer mill (http://sorghumcheckoff.com).

Other than milled sorghum grains, KARI Katumani has also developed technology for making brick cake from sorghum stalks. The process involves chopping the stalks into fine pieces, mixing with any seed oil cake and baking it into blocks. The ratio of sorghum stalks to seed oil cake is 92 kg: 8 kg. The product is very good for both dairy and beef production (CK Kamau, KARI-Katumani, personal communication, 26 April 2013).

Where in the sub-region or country the technology/innovation has been developed and where is it suitable for upscaling/promotion

The above technologies are suitable for promotion among poultry, pig and beef farmers. They also provide useful information for feed processors and organisations involved in training farmers in local feed formulation. The sorghum varieties suitable for forage needs to be promoted among dairy keepers, since it can also be used in preparation of silage.

Estimated returns (local currency and equivalent US$)

A separate report (published in http://sorghumcheckoff.com), indicates that sorghum has many attributes that enhance its nutritional value for pigs and that diets formulated with grain sorghum require less supplemental inorganic phosphorus than those formulated with corn. Another benefit of using sorghum as a livestock feed is its drought-resistant nature, which allows it to flourish in semi-arid lands. If well conserved, it can help solve the problem of inadequate livestock feeds during dry seasons.

Contact details of the generators/promoters of the technology/innovation

KARI-Katumani
PO Box 340-90100
Machakos, Kenya

Tel: +254 44 20495
Email: karikkatumani@yahoo.com
http://sorghumcheckoff.com

Suggested road map for commercialisation

- Having established varieties suitable for pigs, poultry and dairy animals, there is a need to establish linkages with feed processors to negotiate for supply contracts.
- Sorghum for animal feed faces stiff competition from maize, which is cheaper in the Kenyan market and therefore preferred by feed processors. Stakeholders therefore need to work backwards to develop cheaper strategies for sorghum production to make it competitive in the market. In addition, aggregating the output will serve to assure processors of supplies.
- Farmer groups can be trained in local feed formulations and be encouraged to acquire processing machinery for their local use and small-scale enterprise development such as milling.

7 Synthesis of road map for commercialisation

After identifying the technologies/innovations with the potential for commercialisation, it is worthwhile to engage stakeholders in the specific value chains to chart a way forward towards commercialisation. Below is a summary which combines views documented during the fieldwork and lessons drawn from desk review of literature, pertaining to commercialisation of the technologies/innovations in the inventory.

7.1 Suggested road map for commercialisation of technologies in the banana value chain

- Commercialisation of improved and disease-resistant hybrids should take a PPP approach, which combines the varieties, innovations in mass multiplication and dissemination. The public sector will provide the technology (varieties), which can be produced in mass by the private TC laboratories and distributed through public and private actors. The capacity of each of the private laboratories should be built to achieve the desired levels of technology commercialisation and uptake. Thus, multiple layers of partnerships will deliver these technologies to farmers and at the same time ensure quality produce.
- It was also established that ABP currently does not have the capacity to meet the market demand for some of its products such as fresh vacuum sealed *matooke* and banana juice. Since these products are patented (others are in the process of acquiring patents), it will be vital for ABP to consider licensing the technology to smaller upcoming companies, to sustain the local market as well as the potential regional market. This will also help in developing other agribusiness enterprises and thus achieve the goal of UniBRAIN.
- In preparation for penetration into the regional market, ABP should consider conducting a rigorous market study to establish demand and willingness to pay for its products. This would be followed by assessment of potential to supply these markets, measuring the commercial viability of venturing into the regional markets and then continuously building the capacity of the consortia and other influential stakeholders to commercialise the most viable technologies/innovations.

7.2 Suggested road map for commercialisation of technologies in the coffee value chain

- The FOM forms the basis for commercialisation of the other technologies/innovations viz. improved coffee clones, mass multiplication via TC, product innovations such as natural sweeteners and new marketing strategies such as geographical indications.
- Geographical indications, being a first of their kind in the East Africa region, will require much sensitisation for stakeholders to appreciate its role in coffee marketing.
- In addition, it will be vital to commission a study to assess the potential of the proposed GI system for the emerging farmer-controlled coffee production and processing and establish the necessary support structures needed to ensure successful application of the GI system as a marketing tool.

- Continuous investment in R&D will be crucial to remain relevant in coffee product innovations and to expand the market for coffee-based products in the regional as well as export markets.

7.3 Suggested road map for commercialisation of technologies in the sorghum value chain

- To strategise on how best to meet the growing industrial demand for sorghum (for brewing, malting and livestock feed formulation), it will be important to conduct an assessment of the level of industrial demand and forecast future demand; this will be crucial in designing production plans and in forging sustainable partnerships with various actors in the VC.
- The SVCDC can leverage on the existing agribusiness-oriented farmer groups to introduce the varieties that have been identified as having specific attributes desired in the market.
- Product innovations such as bread and confectioneries, livestock feeds and threshing machines need to undergo consumer/customer validation, after which they can be supported for commercialisation.
- Marketing appraisal is needed to guide future strategies for sorghum production and marketing.

7.4 Conclusion

Over the years capacity building for technology development within NARS has received much support. However, capacity for technology deployment and commercialisation is still inadequate.

Technology commercialisation has been hampered by weak intellectual property (IP) systems in NARS. However, the IP landscape is evolving with new forms of sharing IP being adopted such as licensing of technology users, royalty payments, technology brokerage, and technology and business incubation, which allow commercialisation to take off. More research needs to be undertaken to assess the current IP management system's suitability to foster technology commercialisation. Research will also identify capacity gaps and provide suggestions for addressing emerging capacity needs.

In addition, there is need to go beyond generic capacity development approaches that focus solely on physical infrastructure and competencies to generate knowledge and technologies, towards building and strengthening of innovation capacity to put existing and new knowledge into sustainable use.

Financing for private sector engaged in agribusiness R&D and agri-based manufacturing was found weak in the three value chains. However, commercialisation of technologies more often than not stimulates forward innovations and market-oriented R&D, which financiers shy away from. Business incubators therefore need to come up with strategic decisions regarding the form of financial support and services offered to incubatees to sustain their ventures beyond the incubation period.

Overall, the technology inventory is a valuable tool for enabling stakeholders to engage each other to assess their synergies in optimising the potential of technological, organisational and institutional innovation to achieve agribusiness development. The process of commercialisation should be accompanied by documentation of impact, success stories, and pitfalls to avoid and best practices. These can provide useful information in shaping policy, research and future related agribusiness development programmes.

7.5 Areas for further research

There are five main areas for further research: (1) capacity building; (2) partnership and IPR arrangements; (3) financing mechanisms; (4) quality assurance and standards; and (5) knowledge and information support.

i. Capacity building

A major constraint to commercialisation is the limited ability in terms of technical capacity of existing laboratories to meet the growing demand for technology and products. For technologies which have been around for a long time, there is need for promotional capacity to conduct sensitisation campaigns and develop commercialisation strategies such as development of product, processing and packaging technologies.

ii. Partnerships and IPR arrangements

To maximise the potential of technologies, there is need to assess partnerships in technology development and deployment. This requires effective IP management to enable sharing or exchange of elite material in the region. For instance, scaling-up of proven technologies can be enhanced by sub-licensing emerging companies, targeting the local and regional urban market. However, the main challenge for the innovating companies is in establishing and managing a royalty payment scheme for the technology. Also, there is need to document partnership arrangements such as contract farming because they often build the capacity of farmers to access good quality seed and supply high quality produce.

iii. Financing mechanisms

Many financiers often avoid investing in product development even for a technology which has passed proof of concept and is at the growth stage. There is also need for developing financing mechanisms that meet the different needs of technology developers and users.

iv. Quality assurance and standards

There is need to study mechanisms for standards-setting and enforcement to enhance marketing, especially in the formal markets. This includes the need to develop and harmonise regional standards guidelines for technology development and product marketing.

v. Knowledge and information support

Many available technologies and innovations are still in the product development stage, implying a need for investment in R&D for product innovation and market research to establish product potential and commercial viability. Additionally, there is need to invest in continuous R&D for value-added niche products to remain competitive in the market. Organisational/ institutional innovations such as GI system and contract farming arrangements require investment in sensitisation, value chain governance and quality control systems.

Acknowledgements

We express our gratitude to the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) management for entrusting us with this assignment. Special thanks go to the three AIIC managers, namely Mr Joshua Atukunda (ABP), Mr Joseph Nkandu (CURAD) and Dr Willis Otieno (SVCDC) for their logistical support in conducting interviews with stakeholders for the respective AIIC. We are also indebted to our national resource person in Uganda, Mr Moses N. Makoha, for organising data collection in Uganda. The contributions of stakeholders in the sorghum, coffee and banana value chains in developing and revising this technology/innovation inventory are deeply appreciated.

References

ABP [Afri Banana Products Ltd]. 2013. An overview of Afri Banana products Limited. A paper presented at the UniBRAIN Workshop to link research to AIICs at the Lake Victoria Serena Hotel, Kampala, Uganda, 15–16 August 2013.

AATF [African Agricultural Technology Foundation]. 2009. *Review of tissue culture technologies for production of clean banana plants in the Great Lakes Region of Africa.* AATF, Nairobi, Kenya.

AATF [African Agricultural Technology Foundation]. 2011. *Feasibility study on Striga control in sorghum.* AATF, Nairobi, Kenya.

AHBFI [Africa Harvest Biotech Foundation International]. 2011. *Africa Harvest Annual Report, 2011*. AHBFI, Nairobi, Kenya:. .

Ali H. 2012. Low tannin sorghum has potential for poultry feed.. Available at http://www.allaboutfeed.net/ (accessed 17 June 2013).

Baiyegunhi LJS and Fraser GCG. 2009. Profitability in sorghum production in three villages of Kaduna State Nigeria. *Journal of Applied Sciences Research* 5(10): 1685–1691.

Byarugaba-Bazirake GW. 2008. *The effect of enzymatic processing on banana juice and wine*. VDM Publishing House, Germany.

EPZA (Export Processing Zone Authority). 2005. Grain production in Kenya. Available at www.epzakenya.com/UserFiles/GrainReport.pdf (accessed 12 April 2013).

FAC [Future Agricultures Consortium]. 2012. From technology transfer to innovation systems: Sustaining a green revolution in Africa. CAADP Policy Brief No. 007. FAC.

FAO [Food and Agriculture Organization of the United Nations]. 2013. *Agribusiness public–private partnerships—A country report of Kenya*. Country case studies—Africa. Rome. FAO.

Hui-Shung CC, Campbell G and Sniekers P. 2007. Assessing the use of geographical indications for the New England wine region in NSW. Paper presented to 51st AARES Annual Conference 2007, Queenstown, New Zealand.

Kamau GN and Kirigua V. 2011. Eighteen (18) inventory case studies, Kenya. Joint Learning in Innovation Systems of African Agriculture (JOLISAA).

KAPAP [Kenya Agricultural Productivity and Agribusiness Programme]. 2011. Enhancing sorghum production, processing and marketing for improved small-holder incomes and

livelihoods in Kenya. Cereal (sorghum) value chain baseline report. Available at www.kapp.go.ke (accessed 21 May 2013).

KEPHIS [Kenya Plant Health Inspectorate Services]. 2013. National Sorghum Variety list. Available at www.kephis.org (accessed 4 May 2013).

Kherallah M and Kirsten J. 2001. The New Institutional Economics: Applications for agricultural policy research in developing countries. Markets and Structural Studies Division, Discussion Paper No. 41. International Food Policy Research Institute, Washington, DC.

Kilimo Trust. 2013. Opportunities for commercialization and research in the banana value chain. A paper presented at the UniBRAIN Workshop to link research to AIICs at the Lake Victoria Serena Hotel, Kampala, Uganda, 15–16 August 2013.

Ministry of Agriculture. 2012. *Economic Review of Agriculture*. Nairobi. Ministry of Agriculture, Nairobi, Kenya.

Mugisha J, Akankwasa K, Tushemereirwe W, and Ragama P. 2009. Urban consumer willingness to pay for introduced dessert bananas in Uganda. *African Crop Science Journal* 16(4): 251–258.

Muriithi K. 2013. Sorghum farming transforms lives in Meru. Available at http://www.the-star.co.ke/news/article (accessed 10 April 2013).

Ogeto RM, Mshenga P, Cheruiyot E and Onyari CN. 2012. Influence of institutional factors on sorghum production in Nakuru County, Kenya. *Journal of Agricultural Economics and Development* 1(6): 130–137. Available online at http://academeresearchjournals.org/journal/jaed.

PAEPARD [Platform for African-European Partnership in Agricultural Research for Development]. 2012. *matooke*-agribusiness-incubator----charcoal. http://paepard.blogspot.com/2012.

Rangnekar D. 2003. *The socio-economics of geographical indications—A review of empirical evidence from Europe.* Centre for the Study of Globalisation and Regionalisation, Warwick University, Coventry.

Schamel G. 2003, International wine trade: analysing the value of reputation and quality signals. Humboldt University. Available at http://agecon.lib.edu (accessed 23 May 2013).

Spilsbury JS, Jagwe JN and Ferris RSB. 2002. Evaluating the marketing opportunities for banana and its products in the principle banana growing countries of ASARECA. International Institute for Tropical Agriculture, Ibadan, Nigeria. Available at www.foodnet.cgiar.org/scrip/doc (accessed 12 April 2013).

Taylor JRN. Undated. Overview: Importance of sorghum in Africa. Available at http://www.afripro.org.uk (accessed: 30 March 2013).

UBOS [Uganda Bureau of Statistics]. 2010. Statistical Abstract 2010. UBOS, Kampala, Uganda.

Undersander DJ, Lueschen WE, Smith LH, Kaminski AR, Doll JD, Kelling KA and Oplinger ES. 1990. Sorghum—for Syrup. Field crops manual. Available at http://www.hort.purdue.edu (accessed 10 May 2013).

URSB [Uganda Regulatory Services Bureau]. 2013. URSB rooting IP policy in Uganda. *Daily Monitor,* Friday 26 April 2013.

Weblinks

http://www.sorghumcheckoff.com

http://www.allaboutfeed.net

http://www.excelhort.com

ABP Business Plan, 2012.

CURAD Business Plan, 2012.

SVDC Business Plan, 2012.

Annexes

Annex 1: Checklist for data collection

Checklist for technology developers

Section A: Description of the technology or innovation

i. Background information on each incubation centre.
ii. Title of the technology.
iii. The problem that the technology/innovation seeks to address.
iv. A description of the technology or innovation.
v. Uses of the technology—does it have more than one use?
vi. Where in the sub-region or country the technology/innovation has been developed.
vii. Where is it suitable for upscaling/promotion?
viii. Year of technology/innovation introduction.
ix. Number of years of adoption.
x. Who is using the technology?
xi. Is the technology still in use? If not, why not?
xii. Contact details of the generators/promoters of the technology/innovation.

Section B: Profitability of the technology/innovation

i. What is the estimated and actual life of the technology (in years)?
ii. What is the capital cost of technology?
iii. Cost of operation and maintenance.
iv. Does the new technology require more or less labour than the old technology (if any)?
v. Estimated returns (local currency and equivalent US$) such as cost benefit or gross margin figures where applicable).
vi. Factors contributing to profitability and suitability of the technology.
vii. Factors constraining profitability and sustainability of the technology.
viii. Is it financially practical to develop?
ix. How competitive is the technology in the region—industry milieu.
x. What is the growth potential for the technology/innovation?

Section C: Commercialisation efforts

i. What is the market for the technology/innovation? Does the market exist?
ii. Who are the users of the technology/innovation?
iii. What is the identifiable commercial application of the technology?
iv. At which stage of commercialisation does this technology require support? (Technology development, product development, market access, viable business).
v. What risks can be anticipated in commercialisation of the technology? (Technology, product, market or innovation risk).
vi. Any attempts at commercialisation (activities that link with the private sector), results?
vii. What risk management strategies are in place/need to be put in place for successful commercialisation?
viii. In your experience what are the critical and essential factors for successful promotion and adoption of the technology/innovation?

Section D: Support for commercialisation

i. Does the technology enjoy any tax incentives? Please explain.
ii. What mechanisms have been employed to develop closer interactions between academic research and industry?
iii. What facilities and expertise are available in the parent institution to support commercialisation efforts?
iv. Is there a financial support system for emerging entrepreneurs interested in commercialising the technology? Expound your answer.

Checklist for NARS

i. What efforts have the NARS put in place to reorient R&D towards innovation and entrepreneurship?
ii. What mechanisms have been employed to develop closer interactions between research and industry?
iii. What technologies developed in NARS (banana, coffee or sorghum) need to be commercialised? Support your choices.
iv. Do the NARS have the R&D strength and expertise to support commercialisation of the respective technology/innovation? Expound.
vi. Any past attempts at commercialisation (activities that link with the private sector)? What were the results?
vii. What uptake mechanisms and marketing strategies have been used in the past for the selected technologies? Look out for entrepreneurship initiatives/opportunities around the technology.
v. Form of support offered to incubatees/entrepreneurs.
vi. In your experience, what are the critical and essential factors for successful commercialisation of the technology/innovation?

Checklist for incubatees/ private sector

Section A: Technology

i. What technology/innovation does your firm deal with?
ii. What aspect of the technology have you commercialised?
iii. Does your firm have the necessary skills and expertise to undertake commercialisation of this technology? Explain.
iv. Who are the users of the products?
v. What markets exist for the products?
vi. Level of competition.

Section B: Finance and profitability

i. What is the capital cost of technology?
ii. How much employment has been created in your firm as a result of commercialising this technology?
iii. Cost of operation and maintenance.
iv. Estimated and actual financial profits (gross revenues, costs of all cash inputs).
v. How did you raise the required capital to commercialise?

vi. What other potential sources of investment finance exist for the technology/innovation? How adequate are they? Explain.
vii. Does the technology enjoy any tax incentives? Please explain.

Section C: Best practices

i. In your experience, what are the critical and essential factors for successful commercialisation of the technology/innovation?
ii. State the lessons learnt about the best ways to get technologies or innovations used by the largest number of people?
iii. What gender issues/concerns (if any) were considered in the development and commercialisation of the technology or innovation?
iv. What challenges (if any) were encountered in respect to further commercialisation of the technology/innovation?
v. Provide recommendations for addressing the challenges.

Section D: Support

i. Form of support by host institution (describe the specific support provided).
ii. Indicate the total value of the support (in dollars or local currency).
iii. Is the support still ongoing or withdrawn? (1. Ongoing; 2. Withdrawn).
iv. If the institutional support is withdrawn, would the firm still function profitably? Give reasons for your response.
v. Specify any other support by government agencies, international public agencies or private enterprises/service providers.
vi. What other linkages do you have with the industry?

Annex 2: List of people interviewed

Value chain	Name	Position	Telephone	Email
SVCDC				
JKUAT	Dr Willis Otieno	Ag. CEO, SVCDC		Willis.owino@gmail.com
Agritrace	Mr.Fred Oduke	Marketing Director	+254 722461322	foduke@gmail.com
	Mr.Peter Okutuyi		+254 20 2373805	
KARI-Katumani	Dr C K Kamau	Sorghum breeder	+254 20-2311449	
Dryland Seeds Limited	Mr.Ngila Kimotho	CEO	+254710477122	Ngila.kimotho@gmail.com
Smart Logistics	Ms.Rose Mutuku	Grain Bulking Centre		info@smartlogistics.co.ke
Africa Harvest	Dr Nehemiah Mburu	Business Development/ Project Manager	+254710484232	nmburu@africaharvest.org
	Dr Rose Njeru	Director-Capacity Building and Technology Deployment		rnjeru@africaharvest.org
	Dr Silas Obukosia	Director-Regulatory Affairs		sobukosia@africaharvest.org
CURAD				
Makerere University	Dr James Ssebuliba	Co-Chair CURAD	+256772481323	
	Dr Mukasa Ssetumba	CEO, Macs Ltd	+256782670041	sbmukasa@gmail.com
AIIC Manager – CURAD	Mr.Joseph Nkandu	CEO, CURAD Manager/CEO, NUCAFE	+256 772595030	joseph.nkandu@nucafe.org www.nucafe.org
NUCAFE	Mr.Deus Nuwagaba	Entrepreneurship Services Manager	+256774300628	deus.nuwagaba@nucafe.org
Coffee Research Centre-NARO	Dr Africano Kangire	Director		
	Dr Georgina Hakiza	Plant Breeder	+256772445457	ghakiza@gmail.com
	Dr Patrick Wetala	Agronomist		
	Mr. Nakendo Saleh	Technology dissemination		
BrazAfriq	Mr.Robert Ayumi	Mechanisation and processing machinery suppliers	+256772602273	
Afri Banana Products Limited				
AIIC Manager-ABP	Mr.Joshua Atukunda	CEO	+256703858821	atukundajoseph@gmail.com

FREVASEMA	Prof Bazirake	Banana value addition technologies	+256776426578	gwbbazirake@gmail.com
NARO-Kawanda	Dr Alex Barekye	Plant breeder	+256712844097	alexbarekye@yahoo.com
Makerere University	Prof William Kyamuhangire	Banana juice technology developer		
Excel Hort Consult	Mr. Alex Ariho	CEO-Excel Horticulture Ltd	+256 485 661103	aariho@excelhort.com
	Dr Ainomugisha Andrew	Programme Director	+256-703-904344	aainomugisha@excelhort.com
Montpellier Foundation	Mr.Ndamila John	CEO		
Eco-Friendly Investments	Mr.Kimani Muturi	CEO Banana Textile Products	+256772467207	
	Mr.Godfrey Atuheire	CEO Banana biodegradable products	+256772584820	

Annex 3: List of proposed technologies

(a) Potential technologies/innovations along the banana value chain

Stage of value chain	Constraint	Technology/innovation
Production	Low-yielding varieties Diseased planting materials	Tissue culture varieties
	Weak seed systems	Commercialisation or multiplication of improved varieties
		Innovations in delivery of planting materials
Processing	Limited processing at farm level	Automated processing technologies
	Manual processing technologies	Market-oriented value addition technologies/ innovations
	Limited product diversification Few processing plants	Banana flavourings and blends Investment in decentralised value addition facilities
Ripening	Lack of synchronised technologies for ripening	Ripening innovations
Marketing	Weak market linkages and poor information flow	Marketing innovations, contract farming
Financing	Inadequate financing	Financial innovations such as group financing, seeking angel investors, bank guarantee credit systems
By-products such as stems, fibres and peels	Limited utilisation of by-products	Banana fibre craft technologies
		Small-scale brewing technologies
		Animal feed processing technologies, banana charcoal briquettes, sterilisation of banana fibre for use in wrapping edible insects such as nsenene or termites

(b) Potential technologies along the coffee value chain

Stage of value chain	Constraint	Technology/innovation
Production	Low-yielding varieties	Improved high-yielding varieties
	Untapped potential for specialty coffee	Mass multiplication of clones through TC
	High cost of labour	Investment in farm level mechanisation especially harvesters, spraying and transportation
Processing	Outdated primary processing equipment	Solar drying technology
	Limited farm-level processing	Village-level group processing
Marketing	Weak farmer/marketing institutions	Organisation of smallholder farmers into groups
		Investment in GI system for traceability and access to niche markets
		Processing of specialty coffees
Financing	Inadequate financial systems for collection and processing	Financial innovations
By-products such as coffee husks	Limited utilisation of by-products	Technologies for bio-char and bio-fertiliser production
		Charcoal-briquettes technologies

(c) Potential technologies along the sorghum value chain

Stage of value chain	Constraint	Technology/innovation
Production	Use of poor seeds and varieties	Promotion of improved and disease-resistant varieties bred for specific uses
	Striga infestation	Innovations in seed multiplication such as through smallholder groups
	Low-yielding varieties	Building capacity of local seed selectors
	Lack of varieties with specific attributes	Contractual arrangements
	Low capacity of seed producers	Create an accessible data base of available technologies
	Scattered smallholder systems	
Value addition	Non-standardised/informal local level processing	Promotion of small-scale brewing and malting technologies
	Limited processing for feeds and fuel production	Animal feed processing technologies
	Few value added food products	Bio-fuel production technologies
		Lobby policy change to allow utilisation of sorghum in value added products for human consumption
Marketing	Limited commercialisation	Contract farming for industrial production
	Low bargaining power for a smallholder farmer	Establish market demand for sorghum
Financing	Limited financing options	Financial innovations

Annex 4: Terms of Reference (ToR) for developing an inventory of technologies for commercialisation under the UniBRAIN initiative

Background

The Universities, Businesses and Research in Agricultural Innovation (UniBRAIN) initiative is a pan- African intervention coordinated by the Forum for Agricultural Research in Africa (FARA) and supported by Royal Danish Ministry of Foreign Affairs (Danida).

The immediate objective of the UniBRAIN initiative is to enable universities, business and agricultural research institutions to commercialise agricultural technologies and produce graduates with entrepreneurial and business skills through agribusiness incubator partnership.

The initiative intends to achieve the following outputs:

- Commercialisation of agribusiness innovations supported and promoted
- Agribusiness graduates with the potential to become efficient entrepreneurs produced by tertiary educational institutions
- UniBRAIN's innovative outputs, experiences and practices shared and upscaled

Three Agricultural Innovation Incubator Consortia (AIIC) in the ECA sub-region involving universities, businesses and agricultural research for development institutions have been selected to actualise realisation of the intended outputs. They are:

1. Incubation and Diversification of banana Products for Agribusiness consortium: (UniBRAIN-ABP or Afribanana): Kyambogo University in Uganda is the lead institution in the consortium. The purpose of the consortium is to facilitate creation and upscaling of banana sub-sector agribusiness enterprises through identification of viable technology innovations, promotion and facilitation of their commercialisation, and maximise revenues from bananas and their bi- products. The other partners in the project are KARI, Mbarara University of Science and Technology, Uganda Industrial Research Institute and Uganda Carbon Bureau.
2. Consortium for enhancing University Responsiveness to Agribusiness Development (UniBRAIN-CURAD): Makerere University is the lead institution in the consortium. The key partners are the National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE), Uganda Coffee Development Authority (UCDA), the National Agriculture Research Organisation's (NARO) Coffee Research Centre, University of Copenhagen, NIRAS International Consulting firm and Agriterra based in the Netherlands. The consortium also intends to collaborate with the Government of Uganda Presidential fund which is supporting value addition and entrepreneurial development to the Department of Food Science and Technology – Faculty of Agriculture.
3. The Sorghum Value Chain Development Consortium (UniBRAIN-SVCDC): Jomo Kenyatta University of Agriculture and Technology (JKUAT) as the lead institution is expected to collaborate with the Kenya Agricultural Research Institute, Pipal Limited, farmers, community based organisations, Unga Group Limited, Kenya Seed Company, Western Seed Company, Equity Bank, Keroche Industries and East African Breweries. This consortium will also involve working with the food, feed and fuel value chains.

The main role of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in UniBRAIN is to reinforce the research function of the three UniBRAIN AIIC through collaboration with the NARS in Kenya and Uganda. This will be achieved by providing relevant information that may be useful for the NARS to participate in the AIIC. ASARECA will also facilitate the NARS to develop an inventory of existing and pipeline technologies and innovations. These will be shared with the AIIC, which will in turn provide additional value added services to make the research products more competitive. To kick-start this process, ASARECA would like to seek expert services to develop an inventory of existing and pipeline technologies and innovations in Kenya and Uganda.

Objective of the consultancy

The main objective of the consultancy is to support UniBRAIN AIIC to identify new and existing technologies and innovations that are ready for incubation in Uganda and Kenya.
Scope of work

- Conduct a desk review to obtain a thorough understanding of the banana, coffee and sorghum value chains, including an analysis of the strengths, weaknesses, challenges and opportunities. Relevant documents will be obtained from the incubators or any other organisations involved in the three value chains.
- Develop an inventory of ready and pipeline technologies relevant to the three value chains that are available for commercialisation in the research institutions through discussion with research scientists in NARS within Kenya and Uganda.
- Identify the costs associated with commercialisation and the potential benefits of commercialisation of selected research innovations and technologies. This will include re-evaluation of commercial viability of the technologies that may have been adopted by the incubators.
- Participate in a meeting with the AIIC and partners to synthesise the information collected and suggest a road map for commercialisation of selected research products with clear outputs and timelines for each of the consortium members.
- Identify and prioritise new emerging research areas from the incubators that could be addressed in less than three years so that they can benefit the incubatees in the immediate to medium-term timeframe.
- Produce and submit a report at the end of the assignment to the Head of Unit, Partnerships and Capacity Development, ASARECA.

Deliverables

1. An inception report outlining the methodologies to be adopted in the consultancy, including a data collection tool.
2. A draft report detailing an inventory of priority viable technologies that could be incubated at each of the three UniBRAIN AIIC. The report should contain three sections representing each of the three AIIC. At least four technologies will be identified for each AIIC. For each technology in the inventory, the report will highlight:

- Background information on each incubation centre
- The problem that the technology/innovation seeks to address
- A description of the technology or innovation
- Where in the sub-region or country the technology/innovation has been developed and where it is suitable for upscaling/promotion
- Estimated returns (local currency and equivalent US$) such as cost benefit or gross margin figures where applicable
- Contact details of the generators/promoters of the technology/innovation (provide PO Box, telephone (both landline and mobile where possible) and email address

The draft report will be discussed and validated in a subsequent stakeholders' workshop scheduled in mid June 2013.

A final report will follow the June 2013 stakeholders' workshop.

Timeframe

This consultancy is expected to take a total of 17 days spread out as follows:

- 1 day for consultation with ASARECA
- 3 days for consultation with the 3 AIIC managers to obtain literature on the specific value chains, develop the detailed programme and necessary checklists
- 7 days for information gathering with NARS, that is 3 days in Kenya and 4 days in Uganda
- 1 day for data analysis
- 2 days for producing the draft report
- 1 day for facilitating the June 2013 stakeholder validation workshop
- 2 days for producing the final report

Role of ASARECA

ASARECA will provide the following:

i) Share the draft tool developed by ASARECA to collect information on new and existing technologies, innovations and management practices and any other relevant documents

ii) Ensure quality of reporting and general timeliness of the consultancy

iii) Work with the consultant to ensure their logistics including travel and accommodation are in place

iv) Liaison and communication as necessary

Timeliness and procedure of reporting

The draft report should be submitted by 30 March 2013 while the final report should be submitted by 30 June 2013 to:

The Head, Partnerships and Capacity Development Unit
ASARECA Secretariat
Plot 5 Mpigi Road
PO Box 765
Entebbe, Uganda
Email: j.methu@asareca.org copied to pcd@asareca.org

Part 2

Opportunities for commercialisation and research in sorghum value chains: Kenya country report

Simon Omondi

Kenya Agricultural Research Institute (KARI, now Kenya Agricultural & Livestock Research Organisation (KALRO))

Abstract

High poverty levels, food insecurity, unemployment, low incomes and climate variability are key challenges facing sub-Saharan Africa and Eastern and Central Africa (ECA) region in particular. Since agriculture is the main source of livelihoods and pillar for economic growth, developing regional and national value chains for strategic agricultural commodities, especially those identified by the AU Food Summit in Abuja, is essential for African countries to enhance their agricultural transformation and competitiveness. The AU/NEPAD Comprehensive African Agriculture Development Programme (CAADP) offers a joint platform for different stakeholders, including research and training institutions, to develop strategies for addressing various challenges in food security, income generation and economic development. A recent study by United Nations Industrial Development Organization (UNIDO) entitled Agribusiness for Africa's prosperity, opines that the green revolution facing Africa may take a different path from that of Asia through a shift from emphasis on production to an agribusiness development growth trajectory. Kenya's Vision 2030 under the economic pillar seeks to achieve a sustained 7% agricultural sector growth per annum by transforming agriculture from subsistence to market orientation through the agricultural products value chain approach (APVC).

Commercialisation of sorghum products value chain has the potential to contribute to improved livelihoods of rural households and to national economic growth through development, promotion and utilisation of various products for food, animal feed, biofuel and the brewing industry. Towards this endeavour, KARI adopted the APVC approach to agricultural research for improving the productivity, commercialisation and competitiveness of the agricultural sector. Through a participatory multi-stakeholder process, the sorghum value chain was analysed to identify target markets, key constraints and opportunities as well as priority research issues at different levels, from technology development to the marketing continuum. The results show that Kenya produces about 1.3 million bags of different sorghum varieties against a consumption of 1.0 million bags. However, demand for Gadam sorghum variety alone by the East African Breweries Ltd is estimated to be 100 million kg (1.1 million 90-kg bags). Only 10% is currently met from local supplies. Other markets such as the animal feed industry are equally under supplied. Overall there is increasing demand for sorghum products. However, the major constraints are on the supply side of the value chain continuum, namely: abiotic and biotic stress, key among them being bird menace, low utilisation of fertiliser, week seed system, inadequate Good Agricultural Practices, low mechanisation, unreliable rainfall and lack of chain platform and leadership. Priority research agenda focusing on: (1) varieties and seed system (2) sorghum grain/fodder production (3) sorghum value addition (processing) (4) technology packaging, dissemination and commerce (trading, marketing) was identified.

Access to technological products, credit, information and markets has provided farmers in Eastern, Western Kenya and parts of the Rift Valley with the opportunity to engage in commercial sorghum production for niche markets, such as the beer brewing industry for Gadam sorghum. This opportunity has a ramification in the form of releasing barley production areas (for the beer industry) to wheat farming. If this scenario can be up-scaled, then the wheat production deficit may also be minimised.

Promotion of newly-released sorghum hybrids and biofortification of the current commercial varieties offer a grand vista to the sorghum industry in Kenya, if only the nascent sorghum

technology platforms can be nurtured to realistic, robust and sustainable enterprises to the benefit of all stakeholders. In that event the twin issues of food and nutritional security and wealth creation would become a reality.

There is therefore an urgent need to strengthen the science, technology and innovation (STI) platform in the region, with emphasis on enhancing the link between knowledge created by universities and research institutes, exploited by laboratories, and commercialised by the private sector. A game-changer which attracts public private partnership to invest in a sorghum value chain agribusiness impact model would be a better option in delivery of food, jobs and incomes.

Introduction

Poverty, food insecurity, unemployment, low incomes and climate variability are five key challenges facing sub-Saharan Africa and Eastern Africa in particular (World Bank 2008). The majority of these countries depend on agriculture as the main source of livelihoods for families as well as the driver for national economic growth. However, decades of investments in the sector and interventions targeting production at farm level have not helped farmers to take off on a commercialisation path due to socio-economic, technological, institutional and political factors (AU 2006, Jaleta 2009). In view of these challenges, the AU Food Summit (2006) meeting in Abuja recommended a blueprint for countries to identify and focus on agricultural commodities with the highest potential to improve livelihoods and trade. In this endeavour the Comprehensive Africa Agriculture Development Programme (CAADP) was set up to provide a platform for joint action by governments, regional organisations, farmers, agribusiness and development partners to develop strategic value chains with the aim of enhancing competitiveness of agricultural products. The present share of total gross domestic product (GDP) of African agribusiness is very low. The World Bank (2008) report shows that the value of agribusiness production in Thailand matches that of the entire sub-Saharan Africa region, while that of Brazil is nearly four times the African total. Except for South Africa and Zimbabwe, agriculture's share of GDP exceeds that of agribusiness by 10 percentage points, highlighting the region's failure to add value to farm production. This relative inability to produce and process agro-industrial commodities limits the scope for industrialisation, and means that these countries are not benefiting from opportunities to add value and create jobs. Indeed a recent study by UNIDO (2010) opines that the Green Revolution in Africa may take a different path from Asia, that is, an agribusiness trajectory focusing on markets. The biggest dilemma facing governments, farmers and other actors is where and how to access markets for agricultural products. The value chain approach therefore becomes a useful tool for this purpose. Kenya's Vision 2030 seeks to transform agriculture from subsistence to market orientation through the agricultural products value chain approach (APVC). Sorghum is one of the priority commodities identified for upgrading. Commercialisation of sorghum products value chain has the potential to contribute to improved livelihoods of the rural households and national economic growth through development, promotion and utilisation of various products for food, animal feed, biofuel and the brewing industry. This paper examines the sorghum value chain in Kenya from production to marketing continuum and identifies potential business incubation opportunities and research priorities.

Sorghum value chain in Kenya

Importance of sorghum in national economy

In Kenya, sorghum productivity has remained low, despite the development of varieties with high yield potential (2–5 t/ha) (Ragwa et al. 1997). Constraints to sorghum production have been classified as abiotic (drought and poor soils), biotic (pests and diseases) and poor political, economic or social environment (unfavourable policies, unfavourable input and output markets and low adoption of improved technologies). Trade in sorghum is generally low because the levels of production are low. In the past most farmers produced sorghum to meet domestic requirements with little surpluses for the local market. Lack of structured markets contributed to low production of sorghum. Recently, however, the brewing industry has shown great interest in using sorghum for beer production. Currently the demand for brewing types of sorghum at the Kenya Breweries' East African Malting Limited (EAML) stands at 24,000 metric tons of grain. This is high demand considered against the national production which currently stands at 135,000 metric tons. The Gadam sorghum variety has been identified as suitable for beer production. The sorghum market therefore has a lot of potential for expansion and Gadam variety is already spurring renewed interest in commercial sorghum production. Due to increased health concerns and awareness among the majority of Kenyans, the use of both sorghum and millet products are recording a gradual increase as reflected by the quantities and range of processed products sold in local supermarkets. Sorghum is poised to be the key to food and income security in Kenya, especially in the semi-arid regions.

Sorghum production characteristics

In Kenya, sorghum ranks third after maize and wheat among cereals. The national average sorghum grain yield is low at 929 kg/ha (FAO 1999). Considering the vast semi-arid land available in Kenya where sorghum has adaptation advantage over maize and wheat, sorghum production has great potential for expansion. Sorghum has a higher yield potential than other cereals in conditions of low moisture supply (House 1985). The average yield of sorghum is 3000 to 4000 kg/ha in average moisture conditions and 300 to 1000 kg/ha in extreme drought situations (House 1985). Thus the potential of sorghum in industry is hardly exploited.

Major production systems

In Kenya, four regions clearly stand out in relation to sorghum production. The regions are: (1) the moist-mid altitude lands in the Lake Victoria basin; (2) semi-arid dry cool highlands in the Rift Valley; (3) the semi-arid hot, dry lowlands in eastern Kenya; and (4) hot dry to hot humid lands spanning Taita-Taveta to south coast region of Kenya. A sorghum production area map (Figure 2.1) is included for details.

Production area and yield trends

Most (50%) of the sorghum in Kenya is produced in the western areas of Kenya. The area under sorghum production declined from 155,550 ha to 135,000 ha in the period 1987–2007; the lowest over the period under review. This is attributed to poor rainfall and especially the short rains which are normally the most reliable in the low potential areas. In the past sorghum has generally been a subsistence crop with the little surplus being sold in the local markets. In 2009 Western Kenya and Rift Valley commanded 60% of sorghum production while Eastern and Central

Kenya accounted for 40%. However, there is more potential for expansion in Eastern rather than western Kenya.

Figure 2.1: Major sorghum production regions in Kenya.

Recently, market-driven demand for brewing sorghum has greatly increased. This is opening up new marketing channels to 'absorb' grain sorghum with preference to low tannin grain. There is high potential for a market niche for sorghum syrup which is not yet exploited. The number of breweries using sorghum is on the increase. Gadam (Gatiga) sorghum variety has been the flagship for satisfying the brewers' demand.

Sorghum marketing, trade and competitiveness

Major constraints to increased marketing include difficulties in bulking economic quantities of grain due to production in scattered small plots, increased transportation cost, few sorghum

based products and poor perception (sorghum is considered to be poor man's food). However in recent times, market-driven demand for brewing sorghum has greatly increased. The increased demand in the brewing industry for Gadam/Gatiga sorghum variety is opening up new marketing channels to 'absorb' grain sorghum, especially low tannin grains. Trade in sorghum is generally low because the levels of production are low.

Table 2.1: Trends in sorghum production in Kenya

Year	Production (metric tons)
2004	86,580
2005	150,127
2006	131,188
2007	147,365
2008	54,316
2009	115,293
2010	124,516
2011	134,478
2012	145,236

Source: Economic Review of Agriculture, Ministry of Agriculture, Kenya (2010).

Figure 2.2: Gadam (white sorghum) supply and demand trends.

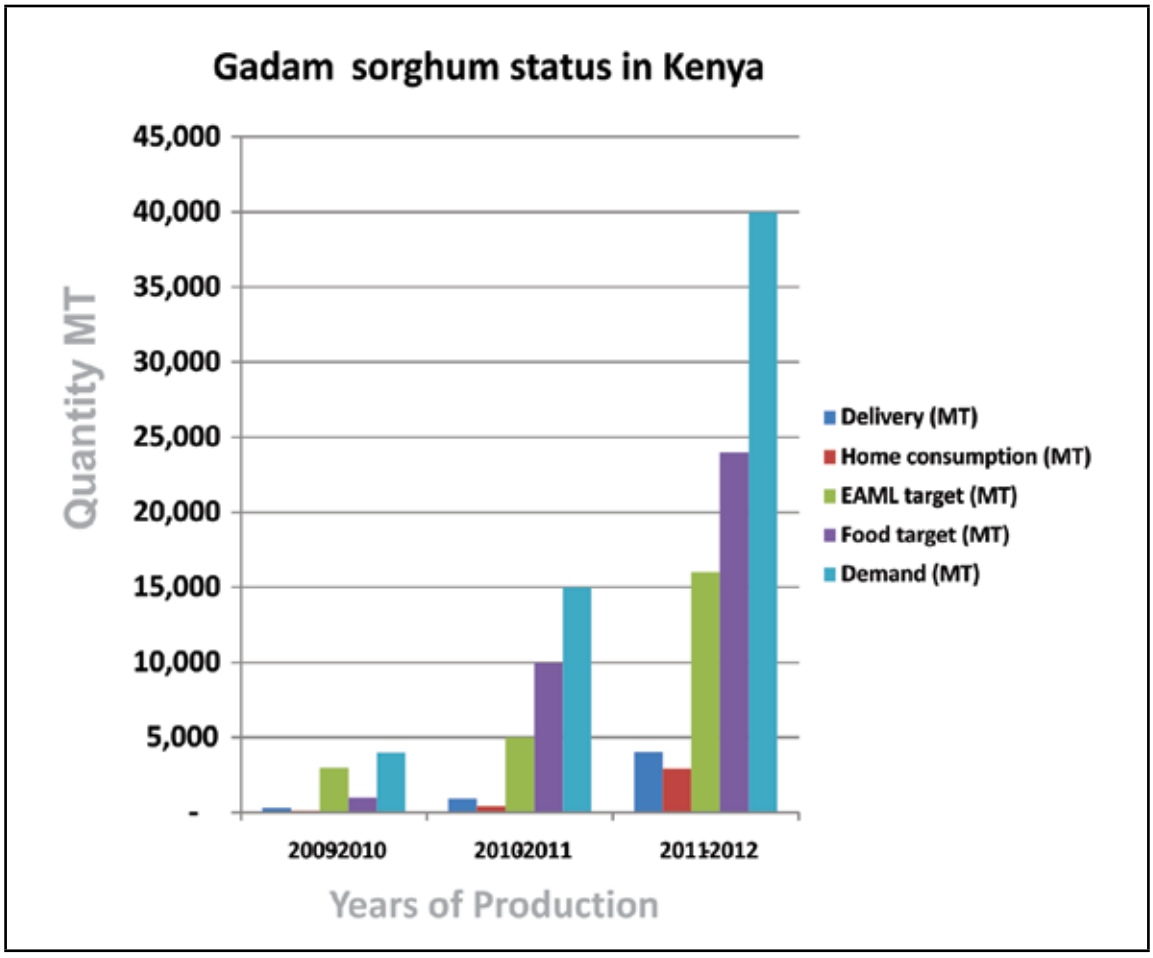
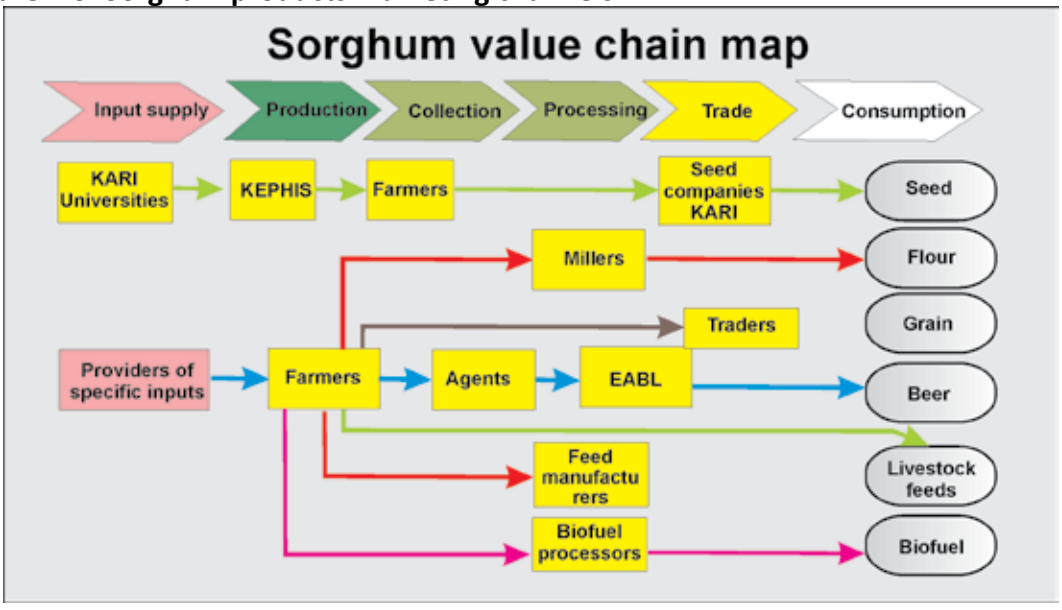


Figure 2.3: Sorghum products marketing channels.



Segment one: sorghum seed

Seed quality requirement is so exacting that a whole government institution, Kenya Plant Health Inspectorate Services (KEPHIS), has been created to deal with it. The starting point for seed quality is to consult that institution for guidelines. Legal permission must be granted by the owners of the variety to authorise its use in seed production. The starting seed must be recommended and certified by KEPHIS as "clean". The seed produced must be free from disease and noxious weed seed and must be inspected by the certifying body. Contracted farmers produce sorghum seed and it is inspected by the national seed regulatory body, KEPHIS. The seed is processed by the contracting companies, packaged and sold to wholesalers and retailers who sell it to consumers. Often the seed is purchased by the Ministry of Agriculture and NGOs who supply it as relief seed to farmers in drought-prone semi-arid areas.

Segment two: sorghum grain

Farmers produce sorghum grain using production technologies generated by researchers and disseminated by extension agents who consist of the national extension service, NGOs and sometimes input traders. The extension agents advise on the best farming practices; service providers (agrovet shopkeepers) for farm inputs; seed companies for seeds; and importers of farm equipment and machinery and the best products traded by these operators. The extension agents also advise on different distributors and retailers who deal in sorghum produce (grain) markets. In most cases sorghum is sold directly to the consumers or through middlemen in local markets. Sorghum is rarely sold to the National Cereals and Produce Board (NCPB). Generally, small, medium and large-scale traders sell the sorghum grain to flour millers. Millers then produce flour for sale directly to wholesalers and retailers. The farmers usually mill the grain for own use according to their requirements. Dehulled sorghum grain, called super mtama, is also used as rice in Kenya or can further be processed into parboiled rice-like sorghum products.

Segment three: sorghum flour (milled grain)

Milling may vary from cracking to dehulling and germ separation depending on the desired end-food product. The end products are bran, sorghum germ, flour or grits and dehulled whole

grain like super mtama. In the milling process, a fraction of the grain is lost. Dry-milled products generally have lower oil content than roller-milled product. To reduce milling losses, hard grain is required. Harder grain has lower milling losses than medium hard to softer grain. Grain that is too small will produce undesirably small dehulled grain, and spherical-shaped grain has higher milling losses than regular-shaped grain. Generally, grits contain 0.2–0.3% oil, 1% fibre and 0.7% ash. The recovery rate from hard grain is: grits 70%, bran 12% and germ 11%. On the whole in Kenya only the flour and dehulled grain activities are encountered.

Segment four: sorghum malt

Brewers have identified certain varieties for malting based on the content of fermentable sugar achieved at the end of fermentation. Brewers usually contract farmers and provide the starting seed as an input. If farmers start with own seed it is still acceptable as long as the variety is the right one. In Kenya, East African Malting Limited (EAML), a subsidiary company of East African Breweries, is interested in the Gadam sorghum varieties with demand currently standing at 24,000 metric tons. The production and marketing model for EAML, which facilitates bulking of the scattered small-scale producers' grain, was developed by the Kenya Arid and Semi-Arid Lands (KASAL) project. Small-scale producers are organised into production and marketing cells, each of which has an organising official. Some of the local banks are included to enable payment for the grain and to advance credit to eligible farmers. Marketing agents, such as Smart Logistics and Mwailu Enterprises, act as the collecting and marketing agents for EAML. Should sorghum replace barley for brewing, this would free areas currently used for barley and convert them for wheat production.

Segment five: Livestock feed (forage)

Sorghum is grown for livestock forage and harvested while green or dry for livestock. Livestock farmers may purchase or grow their own forage sorghum. For grain sorghum, the stover remaining in the field after harvesting, as well as bran from processing industries, is also sold to livestock farmers.

Segment six: Biofuel

Sweet-stem sorghum has been used in Brazil to produce fuel alcohol while in India it is used to produce syrup and jaggery (House et al. 2000 not in references). In Kenya firms like Spectre International are looking for suitable varieties of syrup to supplement their sugar cane stocks.

KARI institutionalised APVC approach to guide its research agenda in line with Vision 2030.

In the prioritising of cereal crop value chains done by stakeholders (actors: farmers, traders, processors, wholesalers, retailers, consumers, service providers and policy makers), a six-point weighting criterion was adopted. The criteria comprised:

- Competitiveness potential
- Impact potential
- Contribution to agricultural GDP
- Opportunities for intervention
- Contribution to quality of environment
- Social welfare

Work done by KARI on sorghum

Table 2.2: National sorghum variety release chart

Variety name	Official release	Year of release in Kenya	Owner(s)	Maintainer	Optimal production (metres above sea level)	Duration to maturity (months)	Grain (G) and Forage (F) yield	Special attribute
Seredo	Seredo	1970s	KARI/KSC	KARI/KSC	250–1750	4	2.7(G)	Wide adaptability
Serena	Serena	1970s	KARI/KSC	KARI/KSC	250–1750	3	2.7(G)	Wide adoptability
BJ28	BJ28	1978	KARI	KARI-Lanet	1750–2300	7		Dual purpose
2K*17	2K*17	1981	KARI/KSC	KARI/KSC	250–1500	3		Hard endosperm
IS76	IS76	1981	KARI/KSC	KARI/KSC	2500–1500	3		Semi-hard endosperm
IS8595	IS8595	1982	KARI	KARI-katumani	250–1800	3		Grain covered by glum
Gadam	Gadam	1994	KARI	KARI	0–1500	3		Brewing quality
IKINYALUKA	IKINYALUKA	1996	KARI	KARI-kakamega	1750–2300	7		Forage
IS8193	IS8193	1996	KARI	KARI	500–1600	4		Forage
Kat/PROI	Kat/PROI	1998	KARI/KSC	KARI/KSC	1000–1700			
KARI MTAMA-I	KARI MTAMA-I	2000	KARI	KARI-katumani	250–1800	3–3.5		Tolerant to stem borer
E1291	E1291	2000	KARI	KARI-LANET	1750–2300	7		Dual purpose, beverage quality
E6518	E6518	2000	KARI	KARI-LANET	1750–2300	8		High quality
Sila	Sila	2006	Agriseed co ltd	SEEDCO zambia	250–1800	3–3.5		Dual purpose
KARI 16 MTAMA 2	KARI 16 MTAMA 2	2008	KARI	KARI	500–1200	3.5		Resistant to birds
Legio	Legio	2008	KARI	KARI	1000–2000	4		High yield
Kaburu	Kaburu	2008	KARI	KARI	500–1500	3.5		High yield
KARIA-SH2	KARIA-SH2	2008	KARI	KARI	1500–2000	5.5		Dual purpose
LDT090	KIBUYU	2011	LELDET	LELDET	1500–1800	4–5	3–4 Months	Wide adaptability
P9518Ax	Hybrid Mtama 1	2012	KARI	KARI-katumani	900–1800	3–3.5 months	2–4 Monthsm	This is hybrid sorghum brown large seed

Based on the weighting out of 10 points, the outcome of the ranking exercise was as shown:

1. Finger-millet (6.84)
2. Sorghum (5.93)
3. Maize (5.64)
4. Wheat (5.24)
5. Pearl millet (5.24)
6. Rice (5.02)
7. Proso millet (4.75)
8. Foxtail millet (4.12)

Thus sorghum was ranked second, ahead of maize and wheat using this criterion.

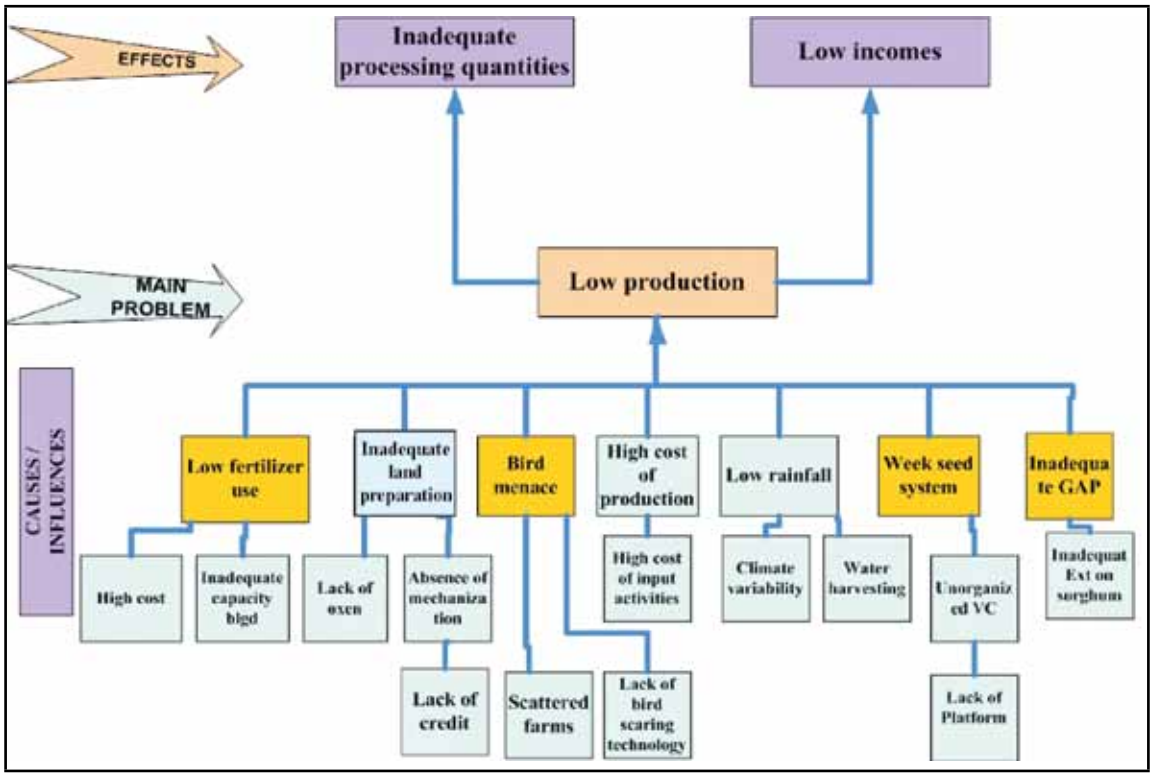
Table 2.3: Constraints in sorghum value chain

VC level	Key constraints	Opportunities
Input supply	Weak seed system, high cost of inputs	Knowledge information and technologies from research and training, existence of seed traders association
Production	Low production, birds, low input use	Commercial village approach, innovation systems, availability of GAP recommendations
Collection/ aggregation	Low volumes (scattered production)	Commercial village approach, aggregation agents
Processing	Low volumes + quality	EABL, livestock industry
Trading	Low volumes	Aggregation agents
Consumption	Inadequate value added products	Biofortification

The major problem in the sorghum value chain is low production whose effects are inadequate volumes for processing and low incomes for farmers. The low production is caused by the bird menace, which is due to scattered nature of production since the farms are far apart, as well as lack of bird scaring technology. Low fertiliser use is another cause of low production and is due to high cost of inputs and inadequate capacity building in sorghum good agricultural practices. Other main causes of low production along the value chain include inadequate land preparation due to absence of mechanisation, high cost of production, low rainfall especially in semi-arid areas of production and a week seed system.

Table 2.4 shows that sorghum seed harvest of 8 bags and above has the highest profit margin. Gadam sorghum is only profitable when the harvest is 12 bags and above due to high costs of production. Red sorghum is also profitable above 8 bags, while traditional sorghum is profitable even when the harvest is 2 bags due to low input. Overall, sorghum is only profitable when the harvest is 12 bags and above. This implies there is need for stakeholders in the value chain to focus on increased production if sorghum is to have any impact on livelihoods.

Figure 2.4: Problem tree for the sorghum value chain.



Research priorities and opportunities for business incubation

Demand for sorghum is growing, especially the following market segments:

- Seed system/varieties—biofortification
- Brewing industry
- Feed industry
- Flour (policy—blending standards)

These segments provide business opportunities and research priorities which should address and target:

1. Value addition: Higher yielding sorghum varieties for food through biofortification with zinc and iron; high biomass for fodder; and higher malting potential
2. Sorghum varieties not liked by birds but with brewing characteristics
3. Bird scaring technologies
4. Mechanisation: oxen- or tractor-drawn sorghum planters; threshers
5. Natural Resource Management Research

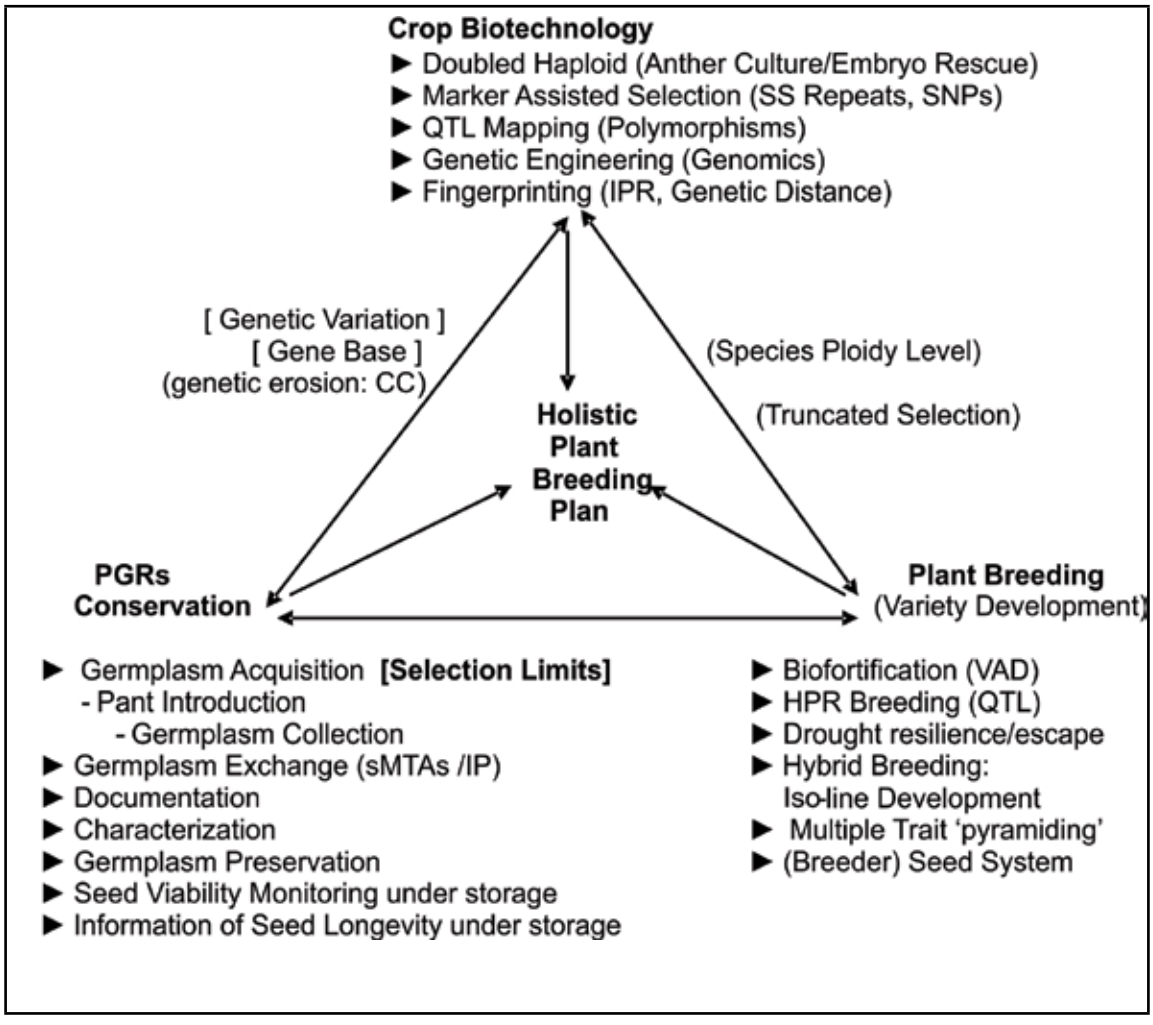
Table 2.4: Economic analysis of various sorghum product marketing channels

Value chain channel	Harvest per acre (90 kg bags)	Production cost/acre	Income @ Ksh55/kg sold as food Ksh25	Profit/loss
Sorghum seed	4	16,585	16,200	−385
	8	16,585	32,400	+15,815
	12	16,585	48,600	+32,015
Gadam sorghum			**Income @ Ksh23/kg**	
	4	16,585	8280	−8305
	8	16,585	16,560	−25
	12	16,585	24,840	+8,255
Red sorghum			**Income @ Ksh25/kg**	
	4	14,065	9000	−5,065
	8	14,065	18,000	+3,935
	12	14,065	27,000	+12,935
Traditional sorghum			**Income @ Ksh40/kg**	
	2	4910	7200	+2,290
	4		14,400	+9,490

Biotechnology is the term used to describe a range of advanced genetic techniques used to change the characteristics of plants, animals and microorganisms. It includes genetic modification, in which a range of techniques is used to transfer DNA in one or more different organisms into another organism, giving it modified or novel genes (transgenes) resulting in genetically modified crops (GMOs) that are limited and not in use in Kenya.

Various techniques such as the use of tissue culture (TC) to reduce varietal development, known as the doubled haploid technique, has almost halved this period. However, the frequency of mutation in targeted genes is usually low and recessive. Assessing the phenotypic effects, especially for quantitative traits such as drought tolerance, is expensive and time consuming, if possible at all, with very low success rates. But utilisation of marker-assisted breeding helps identify new improved varieties and allows for multiple QTL mapping during the evaluation of segregating populations at seedling stage, thereby reducing assay time for specific traits (M'mboyi et al. 2010). Among such developed drought lines was a mutant KM14 (later released as Njoro BW1) in Kenya (Mboyi et al. 2010).

A holistic sorghum variety development process

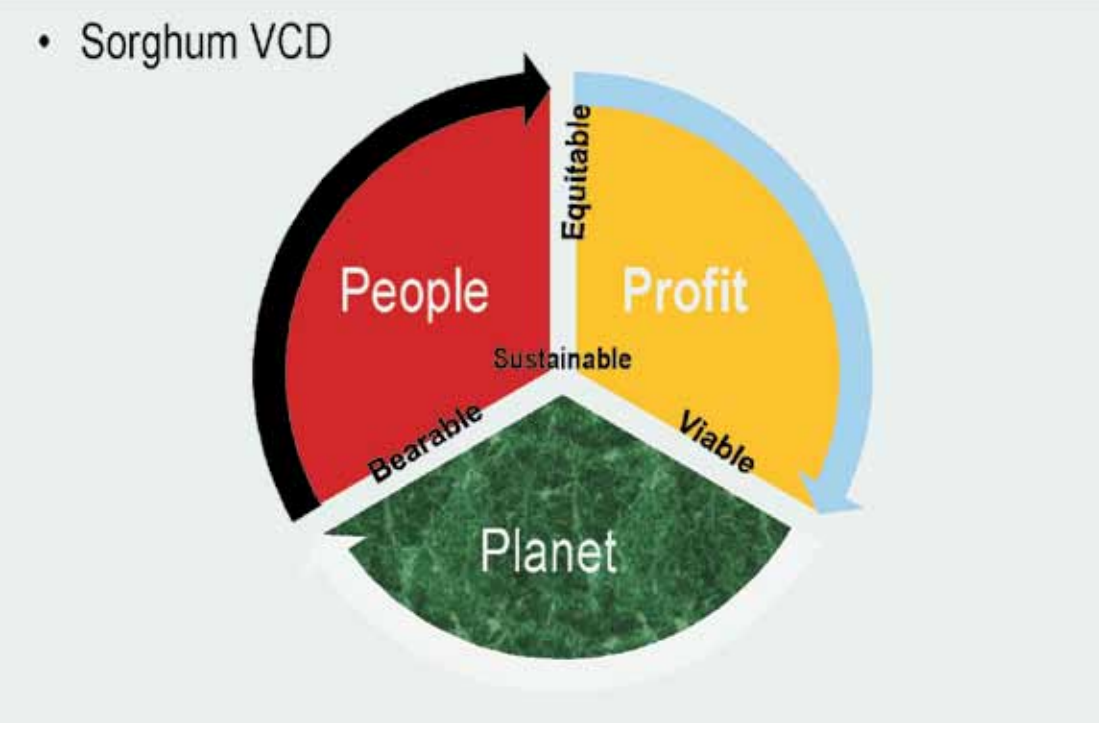


Agribusiness impact model for sorghum value chain

Research and training (incubation centres)
↓
Commercialised products
↓
Industry
↓
Final consumer

Sustainability of sorghum value chain: The 3P approach

Figure 2.5: People, profit, planet approach.



Interventions aimed at upgrading the sorghum value chain should have a people, profit and planet approach. People focus is on livelihoods: food security, incomes, employment; Profit focus is on incomes; and Planet focus, in other words environmental management, is on the effect on soils, water and air. Thus sustainability, that is, the well-being of people, profit and planet, is now at the core of value chain upgrading projects.

Conclusions and recommendations

Sorghum production, especially Gadam (white) variety for the brewing industry, hardly meets demand, implying that the major constraint still lies in the supply side of the value chain continuum. Value chain actors in the sorghum industry have now realised the untapped potential possible through linkages in the entire sorghum value chain. Promotion of newly released sorghum hybrids, and biofortification of the current commercial varieties, offer a grand vista to the sorghum industry in Kenya, if only the nascent sorghum technology platforms could be nurtured to realistic, robust and sustainable enterprises for the benefit of all stakeholders. In that event the twin goals of food and nutritional security and wealth creation would become a reality. There is therefore an urgent need to strengthen the STI platform in the region, with emphasis on enhancing the link between knowledge created by universities and research institutes, exploited by laboratories, and commercialised by the private sector. Technologies for bird scaring, mechanisation and biofortification are potential game-changers which could attract public-private partnership to invest in a sorghum value chain agribusiness impact model as a better option in delivery of food, jobs and incomes especially in semi-arid lands.

Acknowledgement

The assistance provided by Dr JAW Ochieng, Assistant Director, Food Crops Research Programme, KARI, and Mr Wambua, KARI-Katumani, in preparation of this paper is highly appreciated.

References

African Union. 2006. The Abuja Food Security Summit. Available at: http://www.africa-union.org/root/au/Conferences/Past/2006/December/REA/summit/Food_Security.htm

House LR. 1985. *A guide to sorghum breeding*. ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Nairobi, Kenya.

Jaleta M, Berhanu G and Hoekstra D. 2009. Smallholder commercialization: processes, determinants and impact. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project. Discussion Paper No. 18. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Kenya [Kenya Agricultural Research Institute]. 2009. *Strategic Plan 2009–2014*. KARI, Nairobi, Kenya.

Ministry of Agriculture. 2010. *Economic review of agriculture.* Ministry of Agriculture, Nairobi, Kenya.

Mboyi F, Olembo N and Oyugi K. 2010. African Biotechnology. Stakeholders Forum.

Ragwa LM, Bugusu B, Mburu C, Wanjohi M, Hudgens R, Ashiono G. 1997. A survey of on-farm seed practices of sorghum.

World Bank. 2008. *Bringing agriculture to the market.* World Development Report: Agriculture for Development. The World Bank, Washington, DC.

Part 3

Opportunities for commercialisation and research in the banana value chains: Case study of Tanzania and Uganda

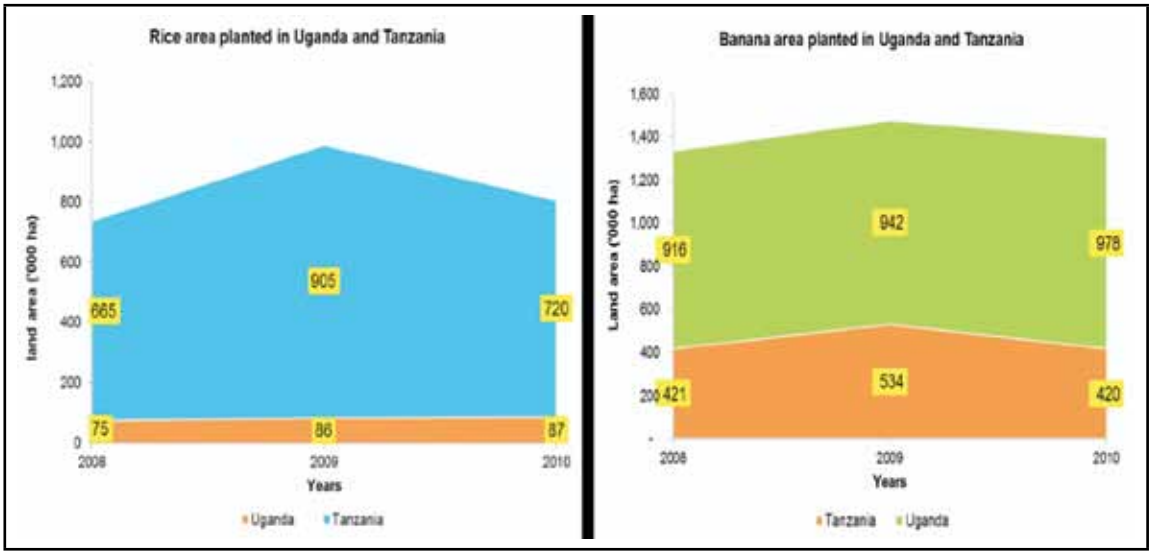
Christine Alokit
Kilimo Trust, Uganda

1) An assessment of the potential role that the banana value chain(s) can play in reducing poverty and eliminating hunger among rural and urban poor in Uganda and Tanzania was carried out through a comprehensive analysis of banana consumption and productivity in the two countries. The study also involved the scope of the challenges and opportunities for providing more efficient and enhanced production and marketing focusing on smallholder enterprises along the commodity value chain.

2) The study was undertaken by extensive review of published data and grey literature from national programmes across the East African Community (EAC) and international sources to establish the best available information on supply and demand for bananas. In view of the limited and unreliable nature of available data, an extensive structured survey was undertaken across the region involving producers, food vendors, traders (retailers, wholesalers), exporters/importers, consumers, institutional buyers, and key informants in order to better inform this study with expert consultations to validate the findings. Some of the key information captured included varieties grown by different farmer categories, volumes produced, volumes consumed at home, main markets, volumes sold, cost of production, crop management practices, challenges faced by banana farmers and consumer preferences.

3) The findings indicated that given the growing importance of rice as an alternative staple in the region, a comparison of rice and bananas as shown in Figure 3.1 shows that the total area occupied by banana plantations in Tanzania and Uganda is more than the area planted with rice. This implies that there are more households involved in banana production in the two countries combined in comparison to rice producers, thereby signifying the relative importance of bananas and the advantages of investing in the banana value chain

Figure 3.1: Comparison of areas planted with banana and rice in Uganda and Tanzania. (FAOSTAT 2012).

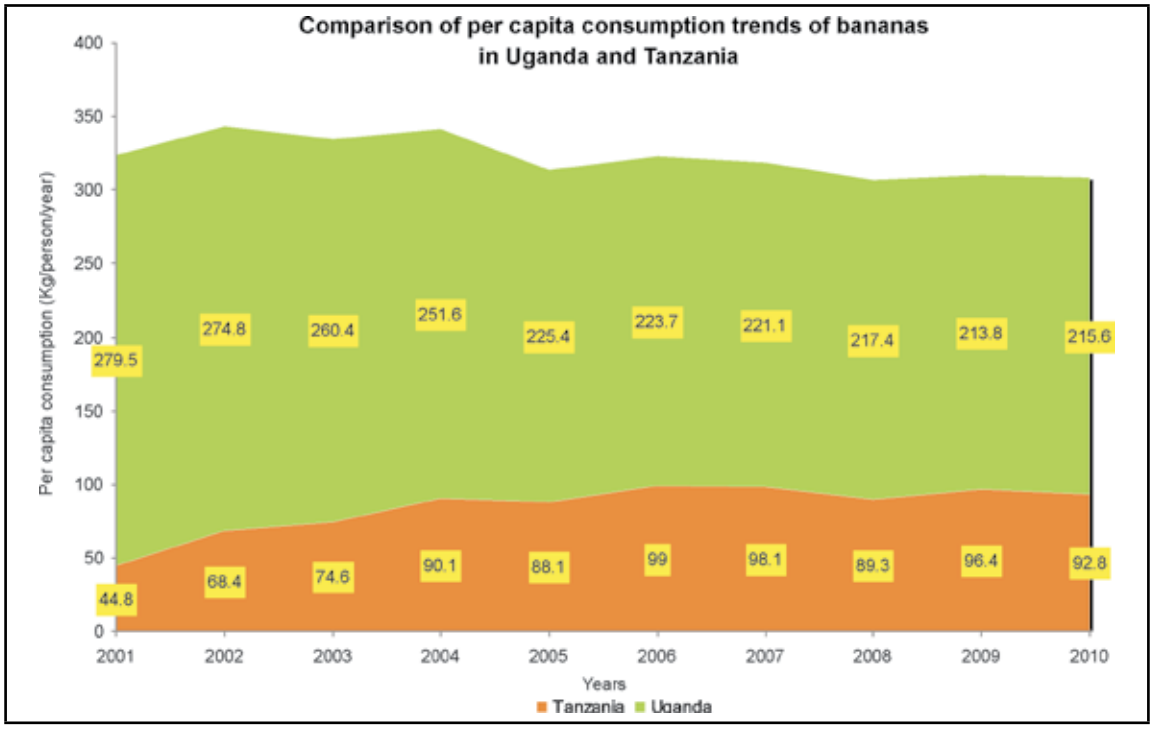


4) Bananas are the fifth largest agricultural commodity in world trade after cereals, sugar, coffee and cocoa. In EAC, more than 12 million MT are produced annually with an estimated value of US$7 billion, playing an important role in food and nutritional security. Annual banana

production is about 10 million MT in Uganda by over 75% of smallholders on 1.5 million ha. Tanzania ranks fourth in banana production in Africa and annually produces some 3.7 million MT from about 403,000 ha.

5) In the two countries, banana consumption (in total and per capita) is among the highest in the world providing 10% of the calorie intake of more than 70 million people. Domestic per capita consumption of bananas in Uganda is between 220—460 kg/annum and is the highest in the world. It is the major food staple supporting some 13 million Ugandans. In Tanzania about 30% of the 11 million populations derive their carbohydrates from green bananas with the annual per capita consumption standing at 93 kg. In Kagera and Kilimanjaro regions where over 60% of bananas are grown, it is a staple food for 75–95% of the population. Figure 2 indicates the comparison of per capita consumption trends in the two countries. The per capita consumption in Uganda from 2001 to 2010 declined by about 23% while in Tanzania for the same period the per capita consumption more than doubled. Major drivers for this include increasing urbanisation, population growth, emerging new markets across the borders in southern Sudan and DR Congo, improving road infrastructure and increasing demand for bananas for industrial use, especially in Tanzania.

Figure 3.2: Comparison of per capita consumption trends in Tanzania and Uganda (2001–2010).



6) Over 4 million EAC smallholder households cultivate bananas and plantain which provides an annual household income of about US$1244, one of the highest smallholder income generating agricultural commodities in the region. The bananas are grown in a wide range of environments and farming systems including pure stands, intercropped and livestock/crop farming systems. They fruit all year round, which puts them above other crops as a food and income security crop.

7) Bananas make an important contribution to environmental conservation – the crop is perennial and its roots and broad leaves help to maintain soil structure and provide protective soil cover throughout the year. All these factors position bananas as a key resource.

8) In Uganda over 90% of bananas are produced by smallholders cultivating farms of 0.15–1.0 hectares. Some medium-scale producers cultivate between 1 and 10 hectares with few large-scale producers. With the advent of climate change and many biotic factors that deter banana production, many exotic, high yielding and commercial cultivars were introduced to smallholders. These included the famous Cavendish bananas like Williams, Grande Naine, Chinese Cavendish, Paz and FHIAs. These are now widely grown and have revolutionised the banana industry. They have wide acceptance and are widely marketable in towns, cities and across borders. Banana production in Uganda is dominated by the East African Highland Banana (EAHB), which includes both cooking '*matooke*' and brewing '*mbidde*' types. The EAHB are the most extensively grown and most important in terms of food security, annual production, employment prospects and environmental conservation. The EAHB occupies more than 1.8 million hectares, equivalent to 38% of Uganda's arable land. Over 65% of the urban population depends on it; for instance, in Kampala 1 million MT of fresh bananas is consumed annually with actual demand at 3 million MT/annum.

9) Banana yields are highest in western Uganda (26.4 MT/ha) and lowest in central Uganda at an average of 5.5 MT/ha where production has been on the decline over the past 30 years largely as a result of pest and disease infestation. There is significant potential for increasing farm productivity. Research stations in Uganda and Tanzania are able to produce above 70 MT/ha annually compared to 5.5 MT/ha produced by smallholders in Uganda and 9.3 MT/ha in Tanzania. Even against world average production and compared to India (a major producer), the gap is still significant. Medium-scale farmers are generally in the top productivity quartile since they usually have access to services from researchers and extension as well as the latest methods of planting and crop care. In addition, they use clean planting materials and improved cultivars, irrigate, use fertilisers and pesticides and observe proper agronomic practices. This enables them to achieve higher productivity than most smallholders.

10) Most growers engage in banana farming as a business, selling on average over 60% of what is produced. Some engage in post-harvest activities such as ripening, covering with leaves and packaging in boxes, especially for those intended for export. But many sell their bananas in local markets and direct from the farm.

11) There are shared similarities in production in Tanzania and Uganda. Bananas are produced primarily by individual smallholder farmers. Some are grouped in Farmer Field Schools to enable them to practice improved banana farming. Bulking for ease of marketing is hampered by the tendency of traders to buy and tag on-farm before the crop matures.

12) Producers use a range of farm inputs such as fertilisers, manure, pesticides and herbicides, and implements such as hand hoes and machetes. Inputs are procured from local agro-dealer shops. In Kilimanjaro area most farmers use manure from their own livestock and use traditional methods to control pests and diseases. Producers use both hired and family labour although family labour (both men and women) is preferred, largely due to the high cost of hired labour. Most farmers (96%) interviewed do not have access to any financial services for banana production.

13) Extension services are provided mainly by the government extension officers in areas of training in banana production. Although producers can get information on market prices, this is usually via other growers. Most producers trade in raw/fresh bananas while a few sell ripe and beer bananas. There is little post-harvest activity by producers before going to the market and a lot of waste is experienced due to production glut, especially during peak seasons.

14) By developing the banana value chains, a number of sustainable and reliable income generating activities can be supported. Bananas are fast growing with high biomass yield, are popular and versatile and can be processed into food products, beverages (soft and alcoholic), snacks, feed, industrial spirits, crafts and medicines. As food, some varieties are sweet and tasty for dessert while plantains can be boiled, fried or roasted. Most banana production is limited to traditional cooking and brewing and so it considered to be a subsistence crop. Despite being the world's second largest producer of bananas (after India), Uganda does not feature among the important countries trading in bananas or banana products on world markets.

15) The main drivers of demand across the EAC include increasing population, family size, increased income, fair prices, nutritional value, and increasing price of banana substitutes. Other drivers include changing tastes and preferences, particularly for cooking bananas, a growing interest in secondary food products such as juices, confectioneries and crafts made from banana plant products. In Uganda, about 70% of harvested bananas are consumed at home by the producers themselves as compared to 60% in Tanzania as presented in Figures 3 & 4 respectively. Only 20% of the harvest is sold fresh to traders who then supply local, national (urban) and export markets with a small amount currently undergoing processing into secondary food products. These include gin, beer, wine, juice, crisps, figs, handicrafts, banana flour (in Tanzania), and confectionery products like biscuits and cakes. Apart from a few companies such as Banana Investments Ltd. in Tanzania (producing wine and beer), Jakana Foods Ltd. (producing juices) and Bella Wines Ltd. in Uganda, most of the products come from small-scale enterprises, most of which are cottage industries.

Figure 3.3: Banana end markets in Uganda.

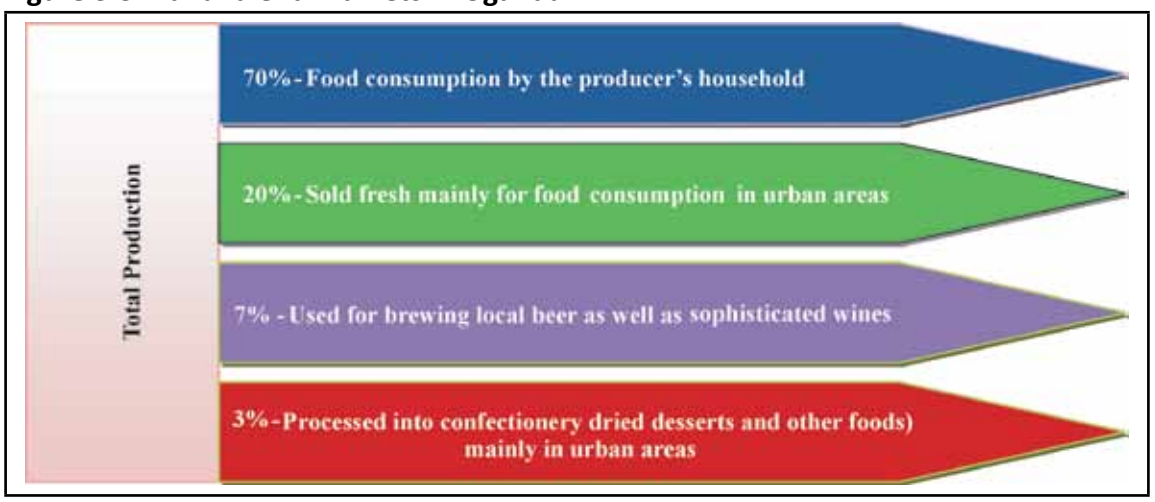
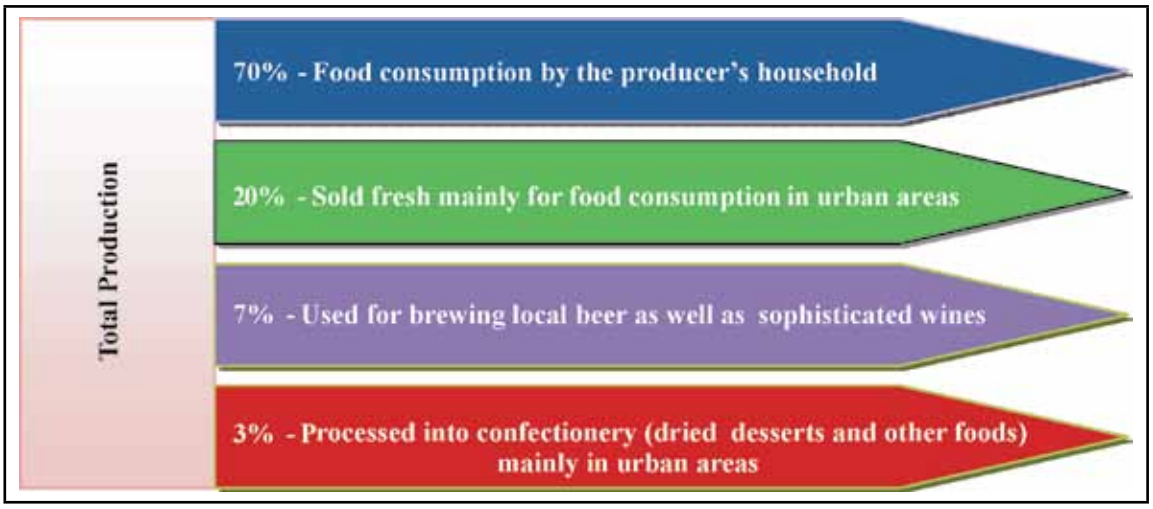


Figure 3.4: Banana end markets in Tanzania.



16) The study also revealed that bananas are a staple food for most individual consumer households across all income groups, with 50% of households interviewed consuming bananas daily in Uganda compared to 21% in Tanzania. In Uganda cooking bananas (*matooke*) were most popular followed by dessert bananas. But consumers also bought banana chips, banana juice, banana wine, banana pancakes (most popular product), banana alcohol/gin/ *waragi*, banana biscuits and handicraft items like baskets. Most consumers from all income groups bought their bananas directly from farmers or from open markets. Across the EAC, rice stands out as the main substitute for bananas, with other key substitutes being maize, especially in Kenya and Tanzania, and Irish potatoes in Rwanda and Burundi.

17) Institutional demand for bananas is increasing and in Uganda, schools and colleges consumed 62% of all bananas sold to institutions, hotels 35%, and hospitals 2%. Most institutions buy from open markets or direct from farmers.

18) Banana retailing in Uganda and Tanzania is mainly focused on fresh raw bananas and trade is dominated by women of all ages, including youth, with the majority being relatively young entrepreneurs aged between 31 and 40 years. Retailing is largely driven by five key factors: affordability, staple food, availability, high profit margins and ease of handling. The main suppliers to retailers include farmers, wholesalers, own farms, fellow retailers and importers. Bananas are transported to markets using lorries, pick-ups, bicycles, wheelbarrows and porters who carry them on their head or shoulders depending on gender. Women prefer carrying bananas on their heads while men prefer using their shoulders. Food vendors sell bananas as cooked and ready to eat food.

19) A comparative study of major staples in the East African Community (EAC) Region (Kilimo Trust 2011) indicated that bananas are among the least traded staples in the region. A very small proportion of bananas produced in Uganda and Tanzania is exported to regional and international markets. However, regional demand for bananas is high and mostly unmet. For example in 2010, the demand in Rwanda for dessert bananas was 23,772 MT and 129,309 MT for *matooke*. Cross-border trade in bananas exists but the volumes remain low and the trade is mostly informal. The value of informal banana exports from Uganda to the neighbouring

countries in 2008 was estimated at US$ 15,730. Officially Uganda annually exports 1200 MT of *matooke* and 5000 MT of dessert bananas to Kenya and 20,000 MT to Rwanda.

20) Apart from the insignificant quantities of dried banana exported to Germany, most of the bananas produced in Tanzania are sold within the country in local markets and other outlets. Exports from Uganda and Tanzania have increased over the past three years. This may be attributed to the growing scarcity of banana in other parts of the region as pests and diseases devastate plantations. In Tanzania banana exporters consider quality, transport and market availability as the key determinants of their business. In Uganda exporters consider bunch size, fruit appearance and quality as key determinants. The exporters include Amfri Farms Ltd., Ssemwanga Fresh Logistics, Fresh Foods Uganda, Tropical Fruit Ltd. and Baususu International Ltd. in Uganda. In Tanzania banana exporting companies include Saas, Bacha Bakery and Food Supply Ltd.

21) The public sector faces several challenges in supporting the banana value chain. These include inadequate long-term funding mechanisms, inadequate research infrastructure to carry out ground-breaking solutions to problems, policy failure underpinned by disharmony and clash of mandates between implementing bodies, increased pressure on available resources, limited early warning systems (EWS) and inadequate research–extension–farmer linkages to facilitate demand-driven research. These challenges equally present opportunities to assist producers to improve crop productivity and quality and to get better access to commercial markets. Despite increasing interest in banana sub-sector investment in recent years, the banana industry still performs poorly. Various factors inhibit private sector investment in the banana sub-sector including decrease in supply as a direct result of decreasing banana production, limited capital for expansion, limited export markets, poor infrastructure and limited utilisation of improved banana production technologies.

22) Following are some of the key recommendations drawn from this study:

- Promoting the adoption of integrated soil fertility management and water conservation in banana production systems.
- Promoting early maturing varieties in order to make better use of limited resources such as water and nutrients.
- Increasing availability of and access to clean planting material by establishing TC and pathology laboratory services, establishing macro-propagators in banana growing areas and establishing secondary nurseries especially in banana production areas for easy access.
- Investing directly in efforts to promote the universal Cavendish and *matooke* varieties in order to broaden banana production/productivity, utilisation, and produce sizeable spillovers. Cavendish varieties are multipurpose and are popular among many communities, in addition to being more readily traded for cash. Both varieties would contribute to the new sustainable development goals and the EAC Vision Statements.
- Reducing pest and disease infestation and the cost of crop protection by extending production into non-traditional banana areas where feasible.
- Supporting the development of banana-based enterprises especially for the processed secondary products to tap into the growing market.

- Focusing on production close to urban areas where prices are higher and transport costs are lower.
- Increasing industrial use of bananas by promoting value addition. This should be considered in the long run.
- Promoting banana farmer associations to enhance marketing among producers.
- Looking critically at banana post-harvest handling to reduce losses.

Part 4

Linking research to Agribusiness Innovation Incubator Consortia under UniBRAIN

A consultative workshop report

Joseph Methu and Doris Akishule
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)

Executive summary

The UniBRAIN workshop on linking research to Agricultural Innovation Incubator Consortia (AIIC) was primarily convened to familiarise participants from the agricultural research fraternity with the operations and functions of the UniBRAIN AIIC. Similarly, the UniBRAIN AIIC would learn more about agricultural research, which would enhance their collaboration. Secondly, the workshop was organised to share and validate the report of a previous study to inventorise technologies for commercialisation. Participants were drawn from the three AIIC, that is Consortium for Incubation and Diversification of Banana Products for Agribusiness (Afri Banana Products Limited), Sorghum Value Chain Development Consortium (SVCDC) and Consortium for Enhancing University to Agribusiness Development (CURAD), Kenya Agricultural Research Institute (KARI, now Kenya Agricultural & Livestock Research Organisation (KALRO)), National Agricultural Research Organisation (NARO), Uganda, Forum for Agricultural Research in Africa (FARA), Kilimo Trust, Kenya Industrial Property Rights Institute and the Agri-Business Incubation Program of the International Crops Research Institute for the Semi-Arid Tropics (ABI-ICRISAT).

In her opening remarks to the workshop, ASARECA Executive Director Dr Fina Opio recognised that ASARECA is committed to technology incubation as a means of enhancing commercialisation of research technologies and innovations. Mr Alex Ariho, the UniBRAIN Facility Coordinator, further emphasised the need for strong collaboration between research and the UniBRAIN AIIC. He further called on UniBRAIN partners, incubators and other value chain actors to work together towards creating a lasting impact in African agricultural transformation. Similarly, Dr Pia Chuzu, the UniBRAIN Programme Officer, further pointed out that the role of the UniBRAIN incubators is to provide business opportunities for start-ups, small and medium-sized enterprises (SMEs) and established businesses.

The workshop involved presentations from the three AIIC on the background of the incubators. These focused on the services provided by the incubators, innovations and products that have been developed through collaboration with their partners. These are:

- **Afri Banana products:** Biotechnological innovations in: a) primary fermentation of banana wine; b) secondary fermentation of vinegar (A. acetii); c) enzyme (PPO) inactivation—FREVASEMA-patented technology with UNCST/PSS in 2009 as STI 4 R&D; d) bio-reactor (digester) - biogas production TC banana (disease-free) seedlings. Some of the products include fresh peeled and vacuum sealed *matooke*, with a six-month shelf-life, banana wine, animal feeds from banana peels, briquettes, biodegradable bags from banana fibre, textiles from banana fibre and biogas processing.
- **CURAD** focuses on providing the following services: access to coffee value addition equipment, business development services such as stimulating business ideas, business planning and feasibility studies, commercialising innovations through product development, technology marketing and promotion, facilitating access to finance, facilitating curriculum reforms and Earn as you Learn Programme (ELP).
- **The SVCDC/S4F** consortium provides the following incubation services: Providing hand-holding services to start-up businesses from conceptualisation to graduation, supporting start-ups and SMEs with skills, expertise and facilities that they need in order to become profitable and grow, providing services to commercial clients that want to expand, diversify, enter new

markets, create new products and solve problems, as well as training and capacity building in agribusiness, business advisory services, technical backstopping, match-making and soft-landing services.

Presentations were made on the overview of the banana, coffee and sorghum value chains, while analysing opportunities for enhancing commercialisation.

- The presentation on the banana value chain highlights bananas as an important food and income security crop. However despite this, production is low. A recent banana sub-sector study by Kilimo Trust proposes some interventions to increase productivity. These consist of: value addition of bananas, natural resources management (NRM), pest and disease management and promoting marketing associations.
- From the overview of the coffee value chain, the following were identified as opportunities for enhancing commercialisation: availability of better seed and vegetative planting materials, packaging technologies and willingness of farmers to pay for services which were previously provided free by the government extension system.
- The opportunities for commercialisation in the sorghum value chain include the growing demand for sorghum as food and feed, raw material in breweries and substitute for wheat in bakeries. Priorities for research include value addition, bird-scaring technologies, mechanisation and natural resource management (NRM).

The study on inventorising technologies for commercialisation revealed some technologies in research which could be further promoted through the incubators. These are:

Banana: Tissue culture technology

Coffee: Tissue culture technology, farmer ownership model, which addresses challenges of limited farm value addition and geographic indication

Sorghum: Contract farming, varieties for forage production, research and development for animal feed rations using sorghum

Through sharing experiences with ABI-ICRISAT on working with research organisations, it was noted that a technology valuation and screening process is needed to prioritise technologies with potential for incubation. The presentation on intellectual property rights emphasised the need for patenting technologies as a means of protecting them. The process of patenting was also elaborated.

The workshop proposed the need for continuously updating incubatable technologies. Additionally, the need for capacity building of researchers and incubators on technology screening and valuation processes was identified as critical for enhancing commercialisation.

Introductory remarks

Dr Joseph Methu, Head of the Partnerships and Capacity Development (PCD) unit, ASARECA, welcomed members to the two-day workshop. He further noted that there was good representation of incubators and partners, which is an indication of their commitment to work together in the UniBRAIN Initiative. He further urged them to continue this spirit for lasting change and impact. He introduced the workshop programme and noted that the goal of the workshop was to share experiences from incubators with regard to linking with research organisations.

Remarks by the UniBRAIN Facility Coordinator

Mr Alex Ariho extended greetings from the FARA Secretariat and the UniBRAIN Coordination Facility. He informed participants that some of the upcoming priority activities involve visiting partners to establish how best FARA can work with them to advance the UniBRAIN initiative. He further appreciated the role of incubators and partners in the organisation of the workshop. He noted that the workshop was timely and fits well in the UniBRAIN results framework, especially the result on commercialisation of technologies and upscaling best practices and lessons.

Welcome remarks and background on ASARECA

Dr Fina Opio, Executive Director of ASARECA, congratulated Mr Ariho on his appointment as the UniBRAIN Facility Coordinator. She added that UniBRAIN activities are relevant to the work of ASARECA. In the past, ASARECA has developed technologies, innovations and management practices (TIMPs) and they need to transform the lives of farmers. The task at hand is how to integrate these into markets as a means of enhancing commercial farming and transformation of livelihoods. Agribusiness incubation is a key component of the innovation process, therefore UniBRAIN has the potential to move farmers engaged in the three value chains to the desired level. The partnership between FARA, ASARECA and national programmes is essential to ensure this is achieved. The ED further noted that discussions have been going on in ASARECA on how to make incubators work better. The workshop is therefore relevant because it helps to take stock of what has been achieved and creates a platform for sharing experiences from different areas. The workshop will also develop strategies for moving forward on incubation of agricultural technologies.

The Executive Director further briefed participants about ASARECA, emphasising that the Association was formed in 1994 by the directors general of 10 NARS in the ECA region, namely: Burundi, Democratic Republic of Congo (DRC), Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, and Uganda. ASARECA collaborates with FARA, Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA) and COMESA, especially on CAADP.

Background on the UniBRAIN initiative

Dr Pia Chuzu, the UniBRAIN Programme Officer, FARA, emphasised that UniBRAIN aims to enhance commercialisation of agricultural technologies and produce graduates with entrepreneurial and business skills. She further stated that the role of the UniBRAIN incubators is to provide business opportunities for start-ups, SMEs and established businesses.

UniBRAIN has established six incubators in Africa:

- WAARI in Mali which focuses on agroforestry, grains and fish
- CCLEAr in Ghana that focuses on livestock value chain
- AgBITin Zambia that deals with tropical fruits and vegetables
- ABP in Uganda focusing on banana
- CURAD in Uganda focusing on coffee
- SVCDC in Kenya focusing on sorghum

The role of the partners is to provide their members with knowledge, experience and expertise, while the role of the research is to produce appropriate technologies and ensure these reach the end users. The role of private sector is centred on uptake of the technologies and innovations as well as informing the research agenda.

There is growing interest in agribusiness incubation, and UniBRAIN is hungry for results. Through these partnerships, we should strive to ensure that the innovation leads to commercialisation.

Background on the workshop

Dr Methu shared that the purpose of the workshop was to:

- share and validate the study report on inventorising technologies for incubation
- familiarise participants from research with the operations and functions of the UniBRAIN AIIC
- share key research priorities on bananas, coffee and sorghum
- share experiences of other similar incubators involving linkages between research and private sector
- identify and prioritise key areas where research can work with the incubators.

Discussion

- UniBRAIN is an Africa-wide initiative. Is it institutionalised or does it work through partners? Currently, UniBRAIN operates as a project although the long-term goal is for it to operate as a business. Partners who are the major supporters access DANIDA funds for implementation. Some incubators have successfully leveraged additional funding. For example, CCLEAr SPELL OUT obtained US$800,000 from the World Bank through a national institution. Other funding has been obtained from the Government of India. The UniBRAIN model is supposed to lead to a unique model which is scalable. When the existing incubators grow, they are expected to lead to formation of other incubators. The plan is that in the long run, partners will be supported through the incubators.
- How relevant is the UniBRAIN Competitive Grants System to farmers' needs? There is a high tendency for the competitive grants to respond more to donor interests than actual farmers' needs.

  The donor's interest is to have the competitive grants respond to farmers' needs. Incubators support farmers indirectly. By supporting start-ups and SMEs to commercialise, incubators provide an opportunity for farmers to supply their produce. The other aspect is how we could review the strategy of implementation to respond to the current challenges.
- The three incubators in the ECA sub-region are located in Uganda and Kenya. Is there a plan to support scaling-up of SVCDC, CURAD and ABP to other ASARECA countries?

  UniBRAIN is currently operating a pilot phase. There is a lot of potential for support and scaling-up. What we need most critically is to demonstrate that the model works.

  ASARECA has developed markets as a new theme for Operational Plan (OP2). Promoting agribusiness incubation is one of the key components under this theme. The emphasis is placed on how we can identify other partners such as private sector to deliver on technology development and uptake.

Overview of the Afribanana incubator (ABP)

The ABP consortium comprises Kyambogo University, fresh vacuum sealed *matooke* (FREVASEMA), Uganda Industrial Research Institute (UIRI), Green-Heat U, Kenya Agricultural Research Institute (KARI), Mbarara University of Science and Technology (MUST), ExelHort Consult (EHC) and EFIL WHAT IS THIS?. ABP operations are hinged on six support units which initially held innovated products, technologies and services. ABP has 20 full-time staff including a secretariat.
Achievements so far are as follows:

- Establishment of an incubator working on banana value chains
- Biotechnological innovations in:
  - primary fermentation of banana wine
  - secondary fermentation of vinegar (A. acetii)
  - enzyme (PPO) inactivation – FREVASEMA-patented technology with UNCST/PSS in 2009 as STI 4R&D
  - bio-reactor (digester) - biogas production
  - TC banana (disease-free) seedlings

Products consist of:

- fresh peeled and vacuum sealed *matooke*, with a six-month shelf-life
- banana wine
- animal feed from banana peels
- briquettes
- biodegradable bags from banana fibre
- textile from banana fibre
- biogas processing

ABP intends to venture into new researchable areas such as:

- diversified products and technologies
- juices and sugar syrups
- combustion efficiency of biogas generated from food waste
- packaging edible insects (*nsenene*) using natural sterile banana fibre
- affordable sanitary pads for rural schoolgirls
- durable beads made from banana fibre

Presentation: Opportunities for commercialisation and research in banana value chain

This presentation highlighted key findings of a sub-sector study on bananas conducted in Uganda and Tanzania. The study observes that the banana enterprise has high potential for addressing the problem of food and income security. Bananas are a staple crop for over 13 million Ugandans.

Additionally, there is good market potential for bananas, both within the EAC and internationally. Export companies for bananas were found in the two countries with the export price ranging from US$0.5–8/kg. However despite this, productivity is still low. For example research stations in Uganda and Tanzania produce 70 mt/ha compared to commercial farms whose average productivity in the two countries is 60 mt/ha and 30 mt/ha respectively. The higher levels observed among commercial farmers is due to their adoption of improved multipurpose varieties. However, the productivity of small-scale producers is 9.3 mt/ha and 5.5 mt for Tanzania and Uganda respectively.

As a way forward the study proposes:

- increasing industrial usage of bananas through promotion of value addition
- supporting the development of banana-based enterprises
- promoting soil fertility management and water conservation in banana production areas
- inputs: boosting smallholder productivity and uniformity
- pest and disease management
- promoting associations to enhance marketing among producers
- post-harvest handling of bananas
- extending banana cultivation to non-traditional banana growing areas with irrigation potential

Discussion

What is the basis for selection of businesses to incubate?

The selection process begins with sensitisation of target groups. Interested parties then submit application forms highlighting areas of interest. Priority is given to graduate students; however, they are required to have registered companies with a bias in the technologies promoted by the incubator. If the applicants are SMEs, the selection will depend on what they are engaged in, and whether the incubator can help them develop the technology. Assessment is conducted throughout the incubation process on understanding the business model or plan.

What is the ABP policy on graduation? When do the first incubatees graduate and what indicators are used to show the incubatees are ready for graduation?

An assessment is conducted throughout the incubation period on understanding of the business model/plan. In addition, the quality of products from the incubatees is also assessed. This determines the extent to which the incubatees are ready for graduation.

Is ABP open to SMEs and small-scale farmers, or is the focus mainly on university students? How much do they charge for the services provided? Are there any plans for replication? Are the collection centres decentralised and what benefits have farmers enjoyed in terms of income?

A needs assessment is conducted for applicants. This is based on the ideas they have and how applicable these are. However, the incubator is open to all applicants. Considerations such as whether the company is registered and the kind of support it has are taken into account. Regarding scaling-out, ABP intends to replicate all technologies. Initially the focus will be on Mukono, Fort Portal and Masaka Districts and the plan is to target as many areas as possible.

With regard to benefits to farmers, the plan is to offer them better prices. With recently acquired modern facilities for transportation and processing, the cost of production is likely to reduce. The plan is to pay farmers at least Sh 3000 higher than middlemen.

ABP works in two countries, which gives the incubator high potential to attract funds for scaling-up.

Can the enzyme deactivation technology be adapted to cassava?

Preservation of cassava with the enzyme deactivation technique is possible since the technology has been successfully used in potato chips using sodium metabisulphite.

Does ABP envisage a time when there will be a policy on irrigation to facilitate year-round production of bananas?

If irrigation is a serious constraint, there is need to lobby for it. In Tanzania a whole Ministry has been mandated to deal with issues of irrigation. It is important to start exploring means of sustaining production.

The National Irrigation Board of Kenya has promised money for irrigating bananas. ABP is considering developing a proposal around irrigation to the United States Agency for International Development (USAID).

Statistics indicate that production is going to decrease while population will increase. This is a serious challenge

The trend in banana production is very worrying but there are various opportunities to reverse this, such as using clean planting materials, and mechanisms to control pests and diseases. Once the producers see the value, they will invest in the technologies. Tissue culture will address the issue of shortage of bananas by addressing the problem of diseases.

Overview of the Consortium for enhancing university responsiveness to agri-business development (CURAD)

The CURAD vision is to be the leading generator of young agribusiness entrepreneurs creating wealth and jobs in East Africa. Major customers include students, graduates, farmers and farmer organisations, start-ups and SMEs. Uganda has a high dependency on coffee and therefore this is one of the enterprises that can uplift incomes and livelihoods. The focus is on adding value to coffee at all levels of the value chain by facilitating several services such as:

- access to coffee value addition equipment
- business development services, for example, stimulating business ideas, business planning and feasibility studies
- commercialising innovations through product development, tech marketing and promotion
- facilitating access to finance
- facilitating curriculum reforms
- earn as you learn programme (ELP)

There are many growth opportunities for the coffee sub-sector both locally and internationally, such as increased awareness of the importance of coffee in reducing diabetes and other health complications.

Presentation: Opportunities for commercialisation and research in the coffee value chain

Despite the importance of coffee, its production has been on the decline over the last decade. The National Coffee Research Institute (NaCORI) has therefore prioritised the following themes:

- increasing coffee productivity and production through better seeds and vegetative planting materials, timely field preparation, use of appropriate inputs and good post-harvest management practices
- packaging technologies and translation
- training of key stakeholders in coffee production

Farmers have been accustomed to obtaining technologies free of charge and as a result, they place low value on the technologies. Commercialisation of coffee technologies is a good opportunity for raising additional resources for research.

Discussion

How is awareness for the products and services from the incubators created?

The satisfaction on the part of clients will influence demand; consequently the quality of services provided by the incubator is critical. At the level of governance, CURAD has good representation of its stakeholders on its Board of Directors. This also helps to market the products and services. The conventional way of conducting research is to produce technologies and pass them on to extension for dissemination, for which there are insufficient funds. This calls for a closer relationship between research and extension throughout the AR4D process.

The dissemination channels have to be reviewed and packaged to suit the different stakeholders. Pool factor—Communities are aware of the technologies. What is important is to illustrate the economics of adopting the technologies by making it attractive for private sector to invest. This enhances the public private partnerships. Microfinance caters for such needs. With value chain development, it is important to start with the needs of consumers and then work backwards.

Is there any research being conducted on the incubators and the challenges they face?

Funding is one of the key challenges. However, CURAD won a US$430,000 grant and a call will be made soon for incubatees to apply for funding for start-ups.

The other major challenge is working with academic institutions. Their bureaucratic processes often cause unnecessary delays in implementing key decisions. It is one year since CURAD activities commenced. The due diligence supported by FARA helped a lot to get started.

Who manages the value chains so that information flows among the stakeholders?

There is need to create a platform to enhance networking. The challenge is usually that it is difficult to get private sector to participate fully in such activities.

Overview of the Sorghum Value Chain Development Consortium (SVCDC), now S4F

The significance of sorghum is offered in its multiple functions as a source of food, animal feed, biofuel and fibre. SVCDC was therefore renamed Sorghum for Food, Feed, Fibre, Fuel (S4F) to reflect the alternative uses of sorghum. This agribusiness incubator is an autonomous public

private partnership comprising of the following institutions:

- Jomo Kenyatta University of Agriculture and Technology (JKUAT)
- Kenya Agricultural Research Institute (KARI)
- Farming Support International (FASI)
- Agritrace

S4F incubation services include:

- providing hand-holding services to start-up businesses from conceptualisation to graduation
- Supporting start-ups and SMEs with skills, expertise and facilities that they need for profitability and growth
- Providing services to commercial clients that want to expand, diversify, enter new markets, create new products and solve problems
- Offering training and capacity building in agribusiness, business advisory services, technical backstopping, match-making and soft landing services.

Presentation: Opportunities for commercialisation and research in the sorghum value chains

The major sorghum producing areas in Kenya are Lake Victoria region, Rift Valley, Eastern and coastal Kenya. The production volumes for the different varieties are estimated at 135,000 MT per annum. There is high demand for Gadam variety by East Africa Breweries Limited. Similarly, KARI has ranked sorghum as the second most important cereal following finger millet. The major constraints of sorghum production are:

- input supply—inadequate certified seed, low quality inputs and weak technology delivery system
- production—low quantity and quality of produce, pests and diseases, low adoption of improved technologies and low commercial orientation
- collection/bulking—poor storage system and high post-harvest losses
- processing—low value addition/limited agroprocessing
- trading—unorganised market segments
- consumption—limited product range, seasonal availability of products, quality variability, low competitiveness in export markets
- cross-cutting issues: weak vertical and horizontal linkages, lack of governance structures, weak policy environment and weak information system.

Suggested strategic objectives for upgrading the sorghum value chain are as follows:

1. Improve quantity, quality, safety, certification and branding of products to access national and export markets.
2. Build capacity of farmers/SMEs in value addition.
3. Conduct market studies on consumer needs, both local and for export, that inform competitive advantages of products.

4. Carry out policy studies and hold roundtables to foster a supportive enabling environment.
5. Strengthen linkages, coordination and integration of actors in various product value chains for group action, learning and innovation.

Opportunities for commercialisation include:

- growing demand for sorghum
- seed system/varieties—biofortification
- brewing industry
- feed industry
- flour (policy—blending standards)

Research priorities/potential areas for business incubation include:

- value addition: higher yielding sorghum varieties: food—biofortification; high biomass (fodder); higher malting potential
- sorghum varieties not liked by birds but with brewing characteristics
- bird scaring technologies
- mechanisation: oxen-drawn or tractor-drawn sorghum planters; threshers
- Natural resource management research

Discussion

Analysis provided in the presentation is based on yield. Are there any other important parameters to consider?

The study started by looking at markets for particular types of sorghum. The major driving factor was found to be yield levels. Kenya Breweries will only buy the Gadam variety of sorghum if the price/kg for sorghum is lower than that of barley.

On substitution of sorghum for wheat, are farmers able to supply the growing demand? Is it possible to plant sorghum during seasons of low bird infestation (based on the migration period for the birds) in order to maximise yields? Is there a law preventing killing of birds? How does Tanzania manage the problem of birds?

Research has attempted breeding sorghum varieties with horns to scare away birds, but this has not helped much. There is a strong law on protection of birds reinforced by the Kenya Wildlife Services; therefore any intervention on birds should not have adverse effects on either the environment or animals. This makes use of herbicides impractical. A 3P (People, Profit, Planet) approach is most favourable.

In Tanzania the priority of farmers is maize, followed by sorghum. Farmers tend to plant many varieties of maize, so birds are not attracted to sorghum.

The problem of birds has been intensified by limited support from governments as well as limited research. The farmer is therefore left to bear all the risk. The problem of striga is not widespread since it mainly occurs during short rains. Secondly, research has released sorghum varieties resistant to striga. Some private companies have invested in sweet varieties of sorghum which

could be a substitute for molasses. Sweet varieties have been put on National Performance Trials and should be released next year.

What is the level of engagement of seed companies in production and distribution of seed? Some farmers produce seed. How effective is this system?

Seed companies are engaged in the production of seeds. Research centres multiply seed by collaborating with farmers. This is mainly aimed at demonstrating the value of improved seed and production methods. However, seed companies also supply seed to farmers and this is a lucrative business.

Presentation: Inventory of technologies and innovations with potential for commercialisation

The study focused mainly on the following aspects:

1. Technology or idea that can be incubated—identifying the problem the technology is trying to solve, potential for job creation, description of infrastructural context
2. Knowledge and skills—facilities and expertise in the research institution that could contribute to development of skills and expertise for commercialisation
3. Markets—potential and existing markets, any past efforts on commercialisation and innovation presented by the technological product
4. Financing—costs associated with commercialisation, enabling policy environment, review of priority setting, legal and regulations, taxes and subsidies which may influence supply and demand of technologies and innovations in a sustainable manner.

The methodology used the value chain approach as a lens to access how the value chain actors are organised and how commercialisation takes place. The data collection methods for the study included literature review and consultation with AIIC managers and incubatees. Key informant interviews were conducted with research scientists in NARS in Kenya and Uganda. Private sector players involved in the three value chains who could serve as potential collaborators in achieving the commercialisation of technologies were also contacted.

Constraints to commercialisation

- Capacity in NARS for technology development exists, but this has not been adequately deployed
- Technology commercialisation has been hampered by weak IP systems
- Financing for private sector is weak

Some technologies with potential for commercialisation
Coffee value chain

1. Tissue Culture (TC) technology for micro-propagation of coffee clones bred with resistance to coffee wilt disease
2. Farmer ownership model, which addresses challenges of limited farm-level value addition
3. Geographic indication, which improves access to niche markets
4. Natural sweeteners derived from stevia to sweeten coffee. These are low in carbohydrates and sugar

Banana value chain

- Tissue culture banana—to control spread of diseases and increase yields

Sorghum VC

1. Commercialisation of sorghum varieties for specific uses
2. Contract farming as a form of organisational innovation and animal feed processing
3. Varieties for forage production
4. R&D for animal feed rations using sorghum

Discussion

Elaborate on the statement "capacity exists in NARS but there is no capacity for deployment"

Over 20 new varieties of sorghum exist with different attributes. A lot of capacity is needed to remove the technologies from the shelves. The challenge is the cost of commercialisation.

Why is the supply of briquettes unstable?

Most of these technologies were donor-funded and therefore faced a problem of sustainability. The aspect on commercialisation was not well catered for. However if more attention is given to commercialisation, there are good opportunities for incubation.

The cost of charcoal on the local market is much lower than that of briquettes. A low-cost recipe has to be identified to solve the problem.

There is need to position the technology along the value chain to identify the value added.

Is there an opportunity for conducting a similar study on more value chains? This is important especially if we are to scale-up the UniBRAIN model. Can we include more technologies?

Yes, it is possible to look at other technologies. The Terms of Reference indicated at least four technologies for each value chain. This was based on available resources and time frame.

The Government of Uganda has a lot of interest in biodegradable bags as a means of curbing the use of polythene bags. It is therefore important to list it among the banana technologies.

Is it possible to conduct an ex-ante analysis to indicate which technology is likely to create a lot of impact and pay-off?

The investment bit requires scientists to collect socio-economic data and normally they do not have much time for this. Is it possible for ASARECA to take up the role?

There is need for further capacity building on technology assessment and valuation.

How did the study define a technology?

There is no standard definition for technology; however, the word innovation is all-encompassing. In some cases a technology is defined as an input; at times as a fully-fledged technology in product form; and sometimes as a process.

Why were technologies not ranked by an incubator? For example in CURAD, what are the existing technologies and what is their order of priority?

The technologies were identified through a consultative process involving the three incubators.

Presentation: Understanding agri-business incubation

ICRISAT is a member of the CGIAR (formerly the Consultative Group on International Agricultural Research, established in 1972). ABI-ICRISAT started in 2003 with the aim of improving the well-being of poor farmers through the creation of competitive agribusiness enterprises via technology development and commercialisation. It is supported by the National Science and Technology Entrepreneurship Development Board (NSTEDB-DST) and Government of India.

The business framework for incubation comprises four components:

1. Research and development. This is achieved through:
    - access to R&D networks
    - IP identification and protection strategies
    - specialised facilities
2. Business planning
    - access to services
    - value proposition development
3. Business development
    - sales and distribution channel strategies
    - exchange of ideas
    - strategy development
4. Capitalisation
    - access to capital
    - networks and alliances
    - champions

ABI-ICRISAT, in partnership with the other incubators and research institutes, has established 22 incubators in India. The steps to commercialisation by the incubators involve:

a) Technology screening/evaluation process

1. Technology listing/compilation from host institute
2. Technology screening-cum-evaluation: technical attributes 30% weightage; business attributes 60% weightage; social attributes 10% weightage
3. Technology valuation process focusing on technical feasibility, innovativeness, complexity, developmental maturity, technology benefits, future scope for improvement, availability of technical expertise, technology readiness level

4. Business profiling of technology focuses on market demand, revenue potential, market entry barriers, comparative advantage, time to commercialisation, cost advantage, geographical market reach, regulatory acceptability, public perception
5. Social attributes: benefits to farmers, creating job opportunities, impact to society, health benefits, social recognition.

b) Commercial valuation of the technology

The following methods are commonly used:

- Discounted cash flow
- Benchmarking
- Development cost-based pricing
- Pricing based on market potential
- Mixed approach
- Technology cost to entrepreneur

c) Business profile of the technologies

- **Snapshot:** technology name, brief, innovator/developer/contact details, industry applicable, IP status, licensing status
- **Technology particulars:** basic technology principle, application of the technology, technology merits, prototype status, testing and trial results, publications and patents, licensing opportunity, expertise available
- **Brief description:** market potential through feasibility studies, comparison with existing products, terms and conditions of technology transfer, investment costs, market cost, technology cost, expected returns, business incubation opportunity
- **Technology commercialisation:** primary shortlisting, scouting of shortlisted technologies by the incubators through validating the technology potential at ground level using the information provided, second round of shortlisting, profiling through legal procedures and IP clearance, and memoranda of understanding.

Key challenges in technology commercialisation are:

- Technology ownership—research institute/scientist/technology commercialisation unit/ incubator
- Commercialisation process clarity—selection, valuation, technology profiling and readiness level
- Data and information collection
- Scientific support after commercialisation
- Laboratory scale versus commercial scale gap
- Duplication of activities—multiple departments in institutions engage in technology commercialisation.

Presentation: Intellectual property rights and business incubation

Categories of intellectual property rights are:

- Plant breeders' rights—derived from new plant varieties
- Copyrights and related rights—from literary and artistic works
- Patent rights derived from patents and utility models
- Design rights from industrial designs
- Know-how rights from know-how trade secrets
- Trade mark rights—from trade or service and certification marks

Features of IP:

- provides monopoly for a limited term
- all private rights are granted by state
- are territorial

A patent refers to a bundle of exclusive rights given by state or government to a person who makes an invention. They provide monopoly in the market, thereby resulting in an increase in shareholder value.

The process of application for a patent involves:

- application forms
- abstract
- complete description
- claims
- fees

Discussion

How long does it take for incubatees to graduate? How many have graduated?

The period ranges from six months to two years. Those that come for fully-fledged business support tend to take a longer time. This year, 20 start-up companies have graduated. ABI-ICRISAT has also incubated 40 seed business incubatees.

Recruitment of incubatees is a continuous process. A thorough assessment is conducted to prequalify using criteria such as strength of team members and financial source. Graduation is also very subjective. Normally the contract is for a specific period but sometimes there is need to extend. In a year, the number of incubatee companies that graduate ranges from three to four.

How do you register a trade secret?

Trade secrets are not registered. Mechanisms are put in place to restrict access to the trade secrets, for example by breaking up the process of production so that a particular industry produces only one component, and therefore only gets to know about that component. The

other way of restricting access is by binding people who have key information through enclosing a section on confidentiality in their contracts.

Comment: IP is a new, yet critical, area. There could be some risks, especially where the technology being incubated is already patented. Consequently there is need for a lot of capacity building to raise awareness on IP issues.

It is important to have an IP policy for incubation. This is based on IP activities that have a bearing on the organisation's mission.

How much is spent on an incubatee up to graduation? Is there any assistance after graduation? This is dependent on technology. Generally the graduation process is dependent on competence to run the business. After graduation, constant contact is maintained with incubatees. This is sometimes free depending on the nature of the problem. If there is need for further mentoring, business linkages and networking, this may attract some charges.

How do you determine which percentage is allocated to the incubator and to the innovator of the technology?

Normally 60% is allocated to the research institute. In cases where this is a consortium, this should be shared proportionately depending on the funds spent and time allocated. 20% is allocated to the research scientists and the remaining 20% to the incubator as revenue.

How do you determine ownership of the incubator? Is it possible to share ownership?

In cases where technologies are developed by an institution, ownership mechanisms are much simpler. Where it is developed by an individual, there are incidences when institutions give liberty to scientists to patent. If the technology was developed by a group, it may be important to determine who the lead scientist on the team is, or whether co-ownership is possible. Sometimes the innovator gives the incubator rights to commercialise the technology on condition that he/she will be paid off.

Is there a template to guide development of a capitalisation plan for incubatees? This will ensure they are able to get investment funds

There is a funding directory for incubators and incubatees. From this, they can pick potential donors, government schemes, angel investors, banks or venture capital funders. The directory also outlines the priority areas for funding by the various donors.

How does ABI-ICRISAT select technologies for incubation; is selection based on the potential for the technology, or what is proposed by the incubatees?

It is important to determine technologies necessary for impact. The focus is on market-oriented technology development. This is more efficient in terms of time, cost and impact.

Where are funds for incubation obtained from; is it from government support or payments by incubatees?

Initially, ABI-ICRISAT obtained funding from the Government of India for the first year. By the second year, new funds were being generated from the research and office facilities. ICRISAT charges ABI for use of their laboratories and scientists. All the parties involved, namely ICRISAT, ABI and the incubatees, are well aware of this. Most of the revenue is generated from clients. This is important for sustainability.

How do you negotiate licenses in terms of royalties to be paid on patents, copyrights, etc.?

This is dependent on expected incomes from exploitation of the technology. No one particular approach is used for valuation. Every approach is likely to give different values. These will serve as a starting point for negotiation.

What is the state of national IP offices in this region? The Kenya office looks advanced. Are there any plans to establish such structures in the other countries? India has been very creative in trying to get IPs to work for communities. How can we learn from this?

IP offices exist in East African countries, or at least there have been offices designated to handle IP issues. In some cases this function is designated to the registrar's office. Kenya appears different from the other countries because they have been accorded a fully-fledged centre: the Kenya Industrial Property Rights Institute. Some IP offices lack patent examiners; however in some cases, Kenya's patent examiners are being used to support regional causes.

Public funded institutions are good at developing technologies rather than commercialisation. On the other hand, industries need to have access to expertise in R&D institutions. To venture into industry one needs to license in order to protect the technology. In turn the industries will pay taxes, which go back to the public to enhance research. If a technology is not patented it will benefit people who did not put in any effort. This value therefore has to be guarded.

Group work

A. Group work on coffee value chain

Q1 (a) List at least three issues that you think should have been addressed but were not addressed by the study on developing an inventory of technologies for commercialisation

- The challenge of handling intellectual property issues and capacity requirements for the consortium should be addressed.
- There is no research by research institutions and networks on value added forms of coffee such as graded coffee, roasted beans and ground roasted coffee. At least an annex of products in this category needs to be provided even if they didn't make it to the top four.
- There is need to build the capacities of the incubatees in different nodes of the value chain as more and more value addition takes place.

1 (b) Mention any other areas of improvement that you would like to see in the report

- Report needs to highlight the potential role of all the UniBRAIN partners.
- Report is deficient in eye-catching presentation tools such as photographs, graphs and tables. For example, a table summarising the findings would be useful.
- Point out by way of prioritising the most recommendable model (innovation) for smallholder farmer empowerment in the profitable nodes of the value chain.

Q2 Identify three areas you consider most critical for research (ASARECA and research partners—NARO, KARI, etc.) in support of UniBRAIN incubators

- Development of technologies to minimise the impact of climate change, pests, diseases and poor soil fertility on coffee production.
- Diversification and quality improvement of coffee products up the value chain.
- Breeding for more coffee varieties that are resistant to pests and disease with adaptability to different agro-ecological zones and with high taste quality; and germplasm conservation, including the 7 CWD resistant varieties.

Q3 List at least two critical next steps for commercialisation of technologies by each incubator

- Allocation of sufficient resources such as capital and infrastructure.
- Development of the incubatable innovative technologies database which is updated from time to time to allow for commercialisation of new technologies which are constantly generated by the NARS.

B. Group work on banana value chain

Q1 (a) The three issues that should have been addressed but were left out in the study.

1. The technologies selected should have gone beyond the four and status, in other words can be commercialisation, those that need fine tuning, issue of criteria for ranking the four technologies. Maybe an annex. All available technologies need to be included: those ready, those to be improved upon etc.
2. The issue of ownership of incubators was not addressed.
3. How to monitor infringement on technologies and services (innovation) of commercialisation [licensing, equity advantages and disadvantages].

Q1 (b) Other possible areas of improvement in the report:

- More literature review to improve help relate WHICH OF THESE? the technologies, so we see how these are done
- Way forward – SWOT analysis – some of the strengths can also be treated as opportunities
- Cost/benefit analysis of the technologies under various scenarios, to allow for recommendation for uptake [partial analysis—GMs]
- Capacity building to empower incubators using ICRISAT experience to evaluate technologies (listing of capacity needs and costs?)
- Should come up with guidelines to streamline the graduation period for various incubatees for various technologies to give room for the recruitment of new ones.

2. 3 Areas most critical for research

a) Understand areas where the best soils for banana production are located.

b) Technologies/products are new; there is need for further market research to get what customers want or need. Technology assessment to include the component of market assessment.

c) Additional support needed in research of banana pests and diseases that reduce production and would affect the technologies being incubated such as FREVASEMA.

d) Investigate other options to reduce post-harvest losses at farm level.

Q3 The critical next steps for commercialisation of technologies by each of the three incubators

a. The need to decentralise these technologies widely from the current locations within the region.

b. The need to identify preferred banana varieties in different areas to aid commercialisation hence multiplication through TC (identification of the right cultivars) [R&D].

c. There is urgent need to engage incubatee farmers (contract farmers) to produce quality desired cultivars for the market.

C. Group work on sorghum value chain

1a. List three issues that should have been addressed by the study on developing an inventory of technologies for commercialisation

- Mention all the value chain technologies within the AIIC, in other words as an annexure. For example, no mention of the sweet sorghum trial going on within the country.
- Split the report into technology-specific modules or profiles. This will be more usable by the managers. [Add some info – this could be a text box with highlights as in our PowerPoint slides].
- Unique selling proposition of each technology. Why should the entrepreneur take up the technology? [Come up with criteria to prioritise technologies with potential success].

1 b. Areas of improvement in the report

- Mention key business users of the technology, for example, sorghum-based animal feed, banana TC.

ii. Demonstrate the impact of the technology on the various actors of the VC. Include the benefit cost ratio (BCR). Mention critical actors and their roles.

iii. Identify the specific game-changer technology that we have to invest in that will have far-reaching impact, for example, a technology that can address the bird menace. Game-changer technology for ICRISAT-India was sweet sorghum for bioethanol production. [Critical actor—justify their roles].

2. Areas most critical for research and research partners

a) Bird-scaring technology

b) Capacity building on technology management—(tech screening, valuation, profiling and commercialisation), IP issues, the VC and end market analysis. The research partner's facilitator for the establishment of technology platforms for sustainability of the incubators

c) Source of technologies that reduce drudgery in the VC; this will reduce the cost of unit production

d) Research funding calls should be in line with the key need of researchable areas; at times the donor interest for research funding is not in line with research need.

3. List two critical next steps for commercialisation of technologies by each of the three incubators Incubator takes the technology from the research institute, then to the entrepreneur for scaling-up.

- Market the identified technologies to the entrepreneurs. For instance, publish the technology via brochures, innovator gives presentations and so on.
- Develop a clear-cut commercialisation pathway. For example, finalise technology cost, Ministry of Agriculture format, scientific support assurance and payment method, revenue sharing mechanism (this will require additional data which may be difficult to obtain).

Conclusions and way forward

From the group work, it was resolved that additional information on the profile of the technologies should be included in the report to inventorise technologies. Pest and diseases were a critical issue affecting productivity and commercialisation of the technologies, therefore more research work in this area is needed. Additionally, there is need to build capacity for researchers and incubators on technology screening and validation since this is a relatively new area to most UniBRAIN stakeholders. Lastly it was proposed that reviewing the inventory of technologies be regularised to enhance their adoption and commercialisation.

Annex 4.1: List of workshop participants

UniBRAIN workshop to link research to Agribusiness Innovation Incubator Consortia (AIIC) held on 15 and 16 August 2013 at the Lake Victoria Serena Hotel, Kampala

Participants' list
UGANDA

Dr Kephas Nowakunda
Coordinator, NARL incubator
NARO
PO Box 7065, Kampala
Tel: +256 414 567 158
Mob: +256 774 456 334
Email: kephas@kari.go.ug or nowakunda@gmail.com

Atukunda Joshua
Business Manager
Afri Banana Products Ltd
Charles Lwanga Road, Ministers Village
Ntinda, Kampala
PO Box 37368
Mob: +256 772 603 449/03 858 821
Atujosh200630@yahoo.com or jktukunda@afribananaproducts.com

Luzinda Harris
Research Officer—Socio-economist
National Coffee Research Institute
NARO
PO Box 5902 Kampala
Mob: +256 712 848 408
+256 702 350 100
Luzindaharris2001@yahoo.com

Dr Olupot Robert
Research Officer/Plant Breeder
NARO, Serere, Nasarri
Tel: +256 454 463 665
Mob: +256 782 932 601/757 421 547
Email: olupotrobert@hotmail.co.uk, oluportrobert@nasarri.go.ug

Joseph Nkandu
Incubator Manager
CURAD, Makerere University Agricultural Research Institute
PO Box 1509, Kampala
Mob: +256 772 595 030
Email: josephnkandu@nucate.org, josephnkandu@curadincubator.org, curad.curad@gmail.com

Dr Georgina J Hakiza
Snr. Principal Research Officer
Coffee Research, Kasangati, Buyinja Zone
PO Box 16641, Wandegeya, Wakiso
Mob: +256 752 445 457
Email: ghakizaj@gmail.com

Damalie Akwango
M&E Officer
NAROSEC, Entebbe
Mob: +256 772 530 600
kakwango@naro.go.ugdakwango@gmail.com

Byarugaba Bazirake GW
Director, Afri Banana Products Ltd
Kyambogo University/ABP Incubator
Kyambogo Hill & Ministers' Village, Ntinda, Kampala
PO Box 7181
Mob: +256 700 393 107, 776 426 578
Email: afribananaproducts@gmail.com

Christine Alokit
Assistant Director
Kilimo Trust
Prince Anne Drive, Bugolobi, Plot 42
PO Box 71782 Kampala
Tel: +256 312 264 980/1/2
Mob: +256 772 496 039/701 496 039
Email: calokit@kilimotrust.org, calokit2@gmail.com

Margaret Masette
Program Leader, Food Bioscience & Agribusiness, NARL-Kawanda
PO Box 7065, Kampala
Tel: +256 414 566 844
Mob: +256 772 394 298
Email: mmasette@gmail.com

INDIA
Aravazhi Selvaraj
Manager ABI
ICRISAT
AIP, Patancheru, Hyderabad
India
Tel: +91 40 3071 3419
Mob: +91 961 888 9800
s.aravazhi@cgiar.org or arouzhie@yahoo.com

KENYA
Dr Hannington Odame
Executive Director
Centre for African Bio-Entrepreneurship
Family Health Plaza
PO Box 1285-00100, KENYA
Tel: +254 20 6000040
Mob: +254 724 226 893
Email: hsodame@gmail.com

Willis Owino
CED – Sorghum Value Chain
SVCDC
Jomo Kenyatta University
PO Box 62000-00200
Mob: +254 723 006 304
Email: willis.owino@gmail.com or willis.owino@sorghum3fs.co.ke

Margaret Onyango
Snr Principal Research Scientist
KARI
PO Box 523-40200, Kisii, Kenya
Tel: +254 712 344 721
Mob: +254 738 428 110
Email: maonyango2001@yahoo.com

Kangai Elsie
Program Manager
Centre for African Bio-Entrepreneurship (CABE)
Mai Mahiu Road, off Langata Road, Nairobi
PO Box 1285-00100
Mob: +254 721 256 983
Email: kangaielsie@gmail.com

Bidogeza Jean Claude
Post-Doctoral Research Associate
FARA UniBRAIN
PO Box 30786-00100
Tel: +254 703 119 532
Email: bidogezac@yahoo.fr, jcbidogeza@fara.africa.org

Ariho Alex
UniBRAIN Facility Coordinator
FARA
ABAR African Union – Nairobi
Tel: +254 700 294 028/+233 544436276

Mob: +256 772 467 207
Email: aariho@fara.africa.org

Wandera Foustine Peter
Manager – Agricultural Research & Development/NFP ASARECA – Kenya
KARI, Kaptagat Road, Loresho, Nairobi
Tel: +256 20 418 330/20
Mob: +254 721 737 708
Email: fpwandera@kari.org

GHANA
Pia Chuzu
Program Officer, UniBRAIN
FARA
12 Anmeda Street, Roman Ridge
PMB CT 173, Accra, Ghana
Mob: +233 541 904 360
pchuzu@fara-africa.org

ASARECA
Doris Akishule
Programme Assistant – PCD
ASARECA
PO Box 756, Entebbe
Mob: +256 772 765 809
Email: d.akishule@asareca.org

Dr Joseph Methu
Programme Manager, PCD
ASARECA
PO Box 756, Entebbe
Mob: +256 772 798 623
Email: j.methu@asareca.org

Moses Odeke
Programme Assistant—Knowledge Management
ASARECA
PO Box 756, Entebbe
Mob: +256 772 605 478
Email: m.odeke@asareca.org

Association for Strengthening Agricultural
Research in Eastern and Central Africa (ASARECA)
Plot 5, Mpigi Road,
PO Box 765, Entebbe (Uganda)
Tel: +256 414 320 212/320 556/321 885
Fax: +256 414 321 126/322 593
Email: asareca@asareca.org
Website:www.asareca.org

ISBN: 978-9970-484-09-6