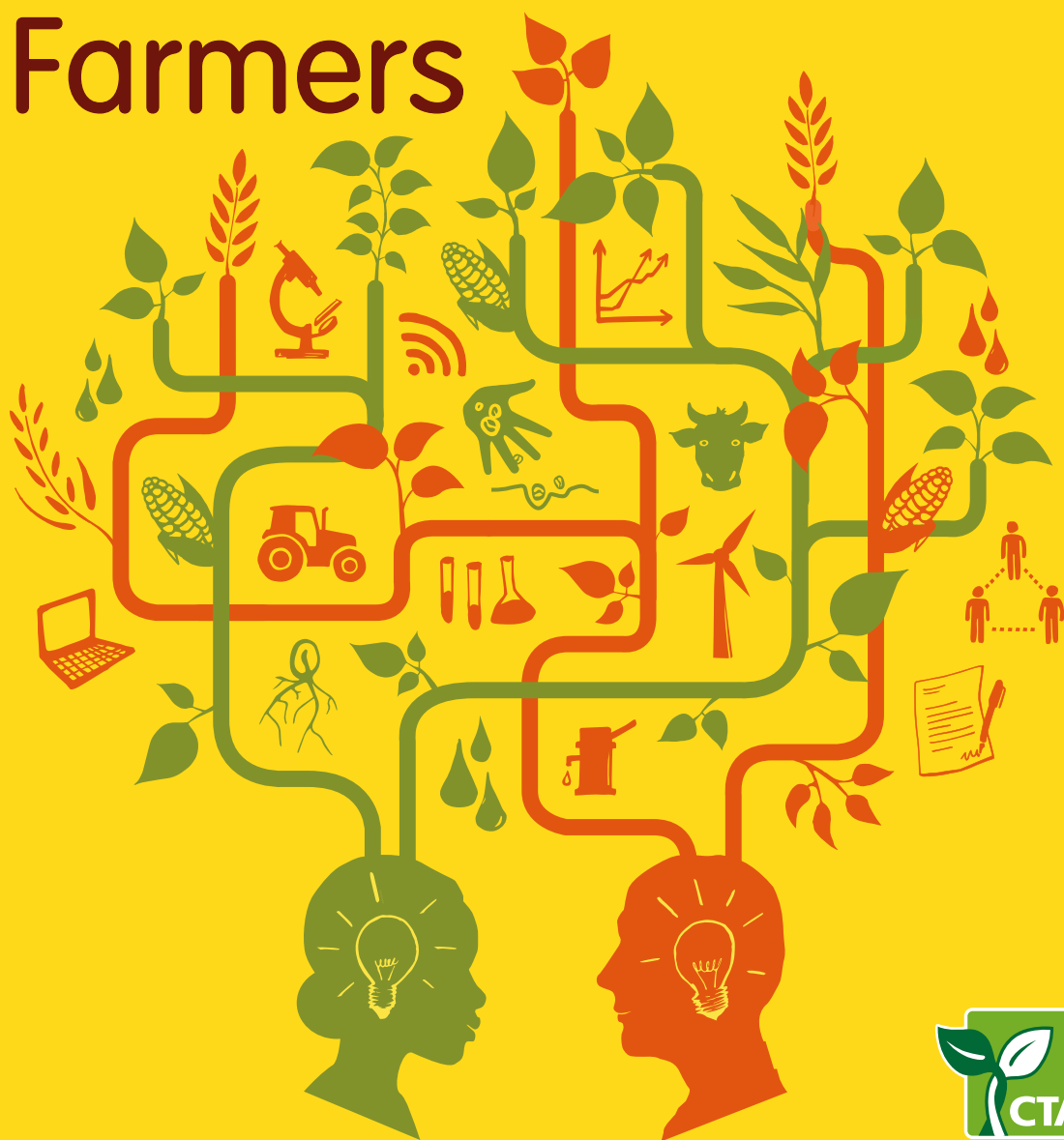


CTA Top 20 Innovations that Benefit Smallholder Farmers





About CTA

The Technical Centre for Agricultural and Rural Cooperation (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities.

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CTA Top 20

Innovations that Benefit Smallholder Farmers



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CTA recognizes and acknowledges the contributions of all the case-owners, authors and co-authors, the illustrator who captured the stories in an appealing manner and the editorial and design teams. We are also grateful for the experts; Mr Wim Andriessie – The Netherlands, Dr Workneh Ayalew Kebede – Papua New Guinea, Mr Jethro Greene – St Vincent and the Grenadines, Dr Aminata Niane Badiane – Senegal and Dr Margaret Najjingo Mangheni – Uganda, who assisted CTA in the screening and short listing of the *CTA Top 20 Innovations*.

We commend the Caribbean Farmers' Network and the Eastern African Farmers' Federation for the consultative process they used and their dedication in the selection of the final *CTA Top 20 Innovations*. This has ensured that these twenty innovations are truly reflective of the priorities and are addressing the needs of ACP smallholder farmers. We also thank all our national, regional and international research, scientific and academic partners who have endorsed the *CTA Top 20 Innovations*.

Special mention is made of our Judith Ann Francis, CTA Senior Programme Coordinator, Science and Technology Policy who had the overall responsibility for the project including this publication and Ellen Mulder and Caroline Andriessen, CTA Project Assistants and Romain Leyh, CTA Intern who supported her in the collation, compilation and copy editing of the various papers.

Foreword

Innovation is the engine of economic development and social progress. CTA and its partners have an important role to play in facilitating learning and continuous innovation for ensuring the sustainability of agri-food systems in the African, Caribbean and Pacific (ACP) Group of States. This involves not only promoting stakeholder engagement in science and technology development, but also catalysing processes aimed at influencing the design and implementation of policies and programmes that foster creativity and talent and the uptake and use of research outputs and technologies for spurring agro-industrial-led economic growth.

Over the years, CTA has contributed to building ACP capacity to understand innovation processes, strengthen the agricultural innovation system and embed innovation thinking in agricultural and rural development strategies. The *CTA Top 20 Innovations* project set out to prove that innovation is taking place in ACP agriculture and in the process has demonstrated that smallholder farmers are beneficiaries as well as partners in agricultural innovation. The *CTA Top 20 Innovations* that were selected from among the 251 submissions that had been received from 49 countries showcase the ingenuity of numerous stakeholders who are innovating and by their collective efforts are making a difference in the livelihoods of ACP smallholder farmers and their families.

CTA will build on the knowledge gained and the momentum generated through the *CTA Top 20 Innovations* to raise awareness of farmers' priorities, the gaps and opportunities and the institutional mechanisms that need to be addressed by governments, the research and academic communities, farmers and the private sector for enhancing innovation in ACP countries. In so doing, CTA will be contributing to improving the enabling environment; policies, institutions and markets, and harnessing the creativity and innovation potential of multiple stakeholders for the realization of the goal of inclusive growth for the economic and social benefit of all; especially smallholder farmers, women and youth.

Michael Hailu, Director,
ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA)

Innovation, entrepreneurship and governance for sustainable agri-food systems

Her Excellency, Mrs Ameenah Gurib-Fakim, President of the Republic of Mauritius

Key messages

1. Build the human capital.
2. Take advantage of growth in urban markets.
3. Provide an enabling environment for innovation.
4. Strengthen public-private partnerships and research collaboration.
5. Increase public investments in education, science, technology and infrastructure.

Introduction

Modernization of the agricultural and food sectors in the African, Caribbean and Pacific (ACP) Group of States is a priority for responding to the challenges and opportunities associated with increasing urbanization, growing international competition and changing consumer needs and market demand. While high-level political leadership and commitment provide a sound foundation for entrepreneurship and agricultural-led socio-economic development; higher investments in education, research and innovation in products, processes, markets and services are needed. The disparate elements of science, business and capital need to converge and be collectively energized.

Bringing science and innovation to the centre of the economic renewal in the ACP region will require bold executive leadership, innovative science and innovation policies and financing models, and highly motivated social capital to drive the desired changes. Redefining the crucial role of the private sector; local, regional and international and the mechanisms for strengthening their partnership with governments, research, academia and the farming communities, is now critical.

Innovation systems

The key element of innovation is learning and this is linked to the uptake and use of knowledge products. Innovation systems encompass the interactive processes involving multiple stakeholders; government, knowledge institutes, industry and civil society to produce, diffuse and use knowledge for societal and economic gain. Innovation, continuous learning and adapting to changing circumstances are therefore synonymous.

Significant upgrading of society's knowledge base for adapting to societal challenges – including economic, energy, food, nutritional and climatic challenges – will allow trends to be identified and responses to be designed. Promoting prosperity, creating robust economies and building resilience of communities; farmers, farm families and the wider society should be a central concern of leaders.

Technological innovation and infrastructure development

Unlike in the 1950s, when developing countries faced enormous technological challenges, the phenomenal growth and rapid penetration of modern information and communication technologies have increased access to the world's pool of scientific and technical knowledge. Relative successes in several countries have demonstrated that there is a clear link between technological innovation, improved productivity and income growth and that such linkages are benefitting smallholder farmers and their families.

The *CTA Top 20 Innovations* demonstrate numerous cases of the ingenious and innovative ways that farmers, the scientific and academic communities and other partners are collaborating in the generation, use and uptake of new and existing knowledge, and overcoming resource constraints to increase agricultural productivity and improve livelihoods. For example, improving supply chains and adding value to fresh produce (*CTA Top 20 Innovations: Climate-Smart Hydroponics; M-Fodder; and POMP*), can give producers and processors a comparative advantage on domestic, regional and international markets as well as curb imports of some commodities. Improved data analytics and reliable long-range (multi-month) weather forecasting models will help farmers adjust their agricultural operations to climatic conditions by determining the optimal time for sowing or transplanting, maximising their use of inputs and increasing yields (*CTA Top 20 Innovation: Innovative Tropical Weather Forecasts*).

No new technology, however cutting edge and effective, can improve production and process efficiencies, if people are unable to access and use it (*CTA Top 20 Innovations: Controlling Aflatoxin in smallholder groundnut systems; and Chelelang – The Wonder Bean*). Farmers need to have the capacity to understand new technologies and the system must empower them (*CTA Top 20 Innovations: Farmerline; Low-cost Feed for Chicken Farmers; and Cassava Drying – From Sun to Steam*). Since most ACP smallholder farmers are women, an important component of the system will be to include women in all parts of the process: education, capacity building and technological innovation.

Infrastructure development stimulates technological innovation and is also a strategic way to build technical capability. This is best achieved by linking technical training institutes and universities to large-scale infrastructure projects. A lesson that ACP countries can learn from more advanced economies is the importance of linking investments in infrastructure development (especially in key areas such as transportation, energy, water and telecommunications) to specific programmes including those in the agricultural sector. ACP leaders must think and act creatively on how best to mobilise the requisite human resources. For example, engineering capabilities of militaries, as is done in Senegal, can be harnessed to implement infrastructure projects.

Traditional knowledge, human capital and entrepreneurship

Traditional knowledge and practices, though neglected during the colonial era, is increasingly valued, recognised as effective and considered a powerful tool for strengthening agricultural innovation systems. Lost, neglected and underutilised crops and livestock have been determined to have commercial and social value. Advances in

science are casting new light on the innovation potential of indigenous traditional crops and livestock. The ACP academic and research community, in partnership with researchers and the private sector from the North and South, can build on the genetic makeup of indigenous species to produce higher yielding, nutrient-dense, drought-resistant and heat-tolerant varieties (*CTA Top 20 Innovation: More Productive Local Chicken*), control pests and disease (*CTA Top 20 Innovations: Barakuk; Protecting Mali's Rivers; and Biological Control of the Millet head Miner*) and improve on traditional practices (*CTA Top 20 Innovations: Cowpea then Maize; and Chinadango Local Fertilizer*).

Acknowledging that sustainable agriculture is more than a valued traditional lifestyle, but a knowledge intensive activity as well as a driver of economic growth, also requires changes to educational programming. ACP agriculture has to expand beyond the informal private economy and governments need to prioritize education in a holistic way and adopt more community-driven models (*CTA Top 20 Innovations: Rural Resource Centres; and Extension goes Digital*). Encouraging basic education – both primary and secondary – and eschewing fundamental reforms in existing tertiary learning institutions, especially universities and research institutes, and strengthening partnerships with the private sector, will go a long way towards achieving these goals. A better understanding of the network relationship, as well as clustering of enterprises and actors, is critical.

Entrepreneurship has the potential to spur innovation and steer innovation processes and can be better exploited. The New Rice for Africa (NERICA), which was a scientific break-through in rice breeding, has been a success because the private sector was able to convince the government to adopt new policies. This resulted in more economic opportunities, attracted more self-organised entrepreneurs and completed a 'healthy' cycle of economic and technological improvement thereby bringing much relief to the people in terms of access to an important staple. Two of the *CTA Top 20 Innovations* have been effective in reforming farmers' organizations such that farmers can participate more effectively in all aspects of the agricultural value chains and influence policy processes (*CTA Top 20 Innovations: The Farmer Ownership Model; and Producer Business Group Model for Value Addition*).

Governance in complex environments

Agricultural innovation will take place in an even more complex and uncertain world. Long-term responses to the complexity of transforming agri-food systems will require foresight and political, social and technical changes. Leaders and other stakeholders will have to anticipate the scientific, technological and other developments (e.g. intensive crop breeding; new protein sources for livestock feed; migration corridors to facilitate ecosystem integrity etc.) as well as profile and project future consumer needs for products and services. More fundamentally, issues related to science, technology and innovation will need to be addressed in an integrated way and strategically at policy level. A state-of-the-art systems approach to problem solving will need to fuse monitoring, modelling, simulation, forecasting, forward planning and experimentation to confront the emerging and projected scenarios. It also requires high-level coordination and Heads of State may have to take on the role of 'concept champions'.

Policy-makers should also be aiming at innovation systems approaches that shift economies towards low-carbon, fuel efficient, and multiple product and diverse pathways (*CTA Top 20 Innovation: Sunflower Water Pump*). The essence of traditional agriculture will change and the process of social and technological innovation will increasingly be recognised as key to resilience building and transformation. Governments will need to give increasing priority to science and innovation as part of their sustainable and economic development strategies, and inclusive approaches should be integrated into governance strategies, especially the adoption of technology-oriented agreements. Fundamentally, the ability to innovate will possibly be the greatest test of a country's capacity for social learning. The promotion of local innovation will contribute to the emergence of sustainable, well-integrated agri-food systems that can withstand shocks and deliver socio-economic development.

Conclusion

Agricultural innovation has the potential to transform ACP agriculture but only if robust structures are put in place to build and energize the human capital base to create, disseminate and optimize critical best practices and technological breakthroughs. Linkages between farmers, fisher folk, firms, universities, schools, research and training centres, and governments could be much stronger. Although new telecommunications technologies such as mobile phones have the potential to strengthen linkages, it is important not to lose sight of the fact that geography will continue to matter, regardless of the new forms of communications. Local, national and regional authorities must carefully assess where agri-food and other agro-industrial clusters may prove most successful and lay out clear plans for cluster development. Clusters need to be nurtured, and throughout the process, public and private institutions must work cooperatively. Regional integration will provide greater flexibility and geographical space for such learning processes.

The private sector, foundations and philanthropists must be willing to transfer knowledge and encouraged to make funding and even personnel available in the early stages of cluster development. But for innovation to be mainstreamed in all facets of the socio-economic growth and development agenda, the public sector should further support collective action and broader public-private partnership programmes. Synergies need to be created by combining market-based and knowledge-based interactions and moving beyond stronger linkages within and beyond the value chain to an innovation strategy that is holistic in nature and that focuses on, in particular, strengthening the interactions between key public and private and civil society actors in the agri-food system. Governments must provide the enabling policy and regulatory framework.

Cowpea then maize: An innovative approach to intercropping

Gabriel Y. A. Adukpo¹



In 2001, Kwabena Mensah and his wife Mary Gwanwaa, like many other farm families in Ghana's Eastern Region, experienced a second consecutive year of almost total crop failure. Growing maize and cowpeas on a one acre (0.4 ha) piece of land was a challenge. Their crops had withered and died when rains stopped during the growing season. This experience led them to re-assess and adapt their farming methods, which brought about a change in fortunes that offers new hope to many more farmers.

Mensah and Gwanwaa's innovation was simple. The couple had followed a typical approach to intercropping maize and cowpea crops as recommended by the extension officers. This consisted of planting alternate rows of maize and cowpea, but only sowing the cowpeas once the maize had reached the tasseling stage. Having previously lost both crops due to rain failure, they reasoned that the chances of a harvest would be improved if they changed the sequence and planted the cowpea first. This, they believed would enable the maize to benefit from nitrogen fixed in the soil by the leguminous cowpea crop, increasing the chances that both crops would reach maturity and yield a harvest should the rainy season be cut short again.

Farmers innovate

In 2002, the couple sowed cowpea 10 days before the maize. The results were significant. Firstly, both crops reached maturity, with the maize yielding approximately 2 tonnes/ha, 11% more than the average for other farmers in the district. They also harvested around 400 kg of cowpeas, which they sold for €320. Their success encouraged several of their neighbours to follow their lead; 14 farm families in their vicinity have adopted the cowpea-first sequence. The practice has also been recognised by the local extension

¹ Department of Agriculture, Obuasi Municipal Assembly, Obuasi – Ashanti, Ghana.

officer, who is happy that many other farmers have adopted this innovative approach to intercropping; cowpea production – previously little practised in the area – is more popular as a result.

Farmers need to follow good agricultural practices when using the technique. The alternate rows of maize and cowpea should be spaced 40 cm apart, with precise spacing for the plants within the row – 20 cm for cowpea and 40 cm for maize. While most farmers prefer the early maturing ‘Asontem’ cowpea variety, which matures in just 60 days, more than one variety should be planted, including erect and semi-erect types.

NPK fertiliser is essential for maize if soils are poor, and can also benefit cowpea crops. However, top dressing of maize with nitrogen fertiliser – normally carried out when plants are knee-high – is not necessary as the cowpea plants are fixing atmospheric nitrogen in the plant root zone which the maize plants can access. Other recommendations include timely weeding, control of insect pests in cowpea at 10-day intervals, and use of insecticides to control stem borers in maize. Finally, to maintain a healthy field, farmers are advised to rotate their maize/cowpea intercrop with cassava, vegetables, and include a fallow.

Multiple benefits

Eliminating the need to apply top dressing fertiliser reduces overall production costs and is one of several benefits offered by this innovative intercropping technique. Crop productivity and soil health are also improved, with the maize plants able to make immediate use of nitrogen fixed by cowpea. Previously, some of this nutrient would have been lost to leaching, evaporation or weed uptake. Importantly, although labour requirements are not reduced, the demand for labour is better spaced and therefore more manageable. When using the traditional cropping method, both crops needed to be harvested in close succession, which puts pressure on families – especially women – and made it difficult to dry the crops properly before storage. Under the new system, the cowpea is harvested several weeks before the maize and these problems are avoided.





For extension officers to be learning from farmers like Mensah and Gwanwaa, and sharing the innovative approach to intercropping more widely, is relatively uncommon in Ghana. While Research-Extension-Farmer Linkage Committees (RELCs) meet annually at national, regional and district levels to identify researchable problems, communication of solutions tends to be top down. Ideally, the new planting sequence should be further tested and evaluated under a variety of conditions and, if appropriate, be disseminated by extension officers through demonstrations, farmer field schools and other channels. Researchers should also be encouraged, through the RELCs, to conduct further studies on the technique, investigating issues such as pest and disease control, plant spacing and socio-economic impacts.

Meeting the potential

Additional research would help to ensure that the potential of this innovative approach to intercropping is fully realised, bringing with it wide-ranging benefits. Successful intercropping can help farmers maximise food production, strengthening food and nutrition security. Cowpea, in particular, is an affordable source of good quality protein. More productive farming also has knock-on benefits for health, job and wealth creation and sustainable livelihoods, and can help to reduce rural-to-urban migration.

At the field level, well managed intercropping reduces soil erosion and, by supporting diversification, reduces the risk of total crop failure in the event of erratic rainfall. Socially, better spacing of crops across the season relieves some of the pressure that falls on women associated with harvesting, drying and threshing. Kwabena Mensah and Mary Gwanwaa's innovation, though seemingly simple is easy to adopt and quick to bring results. It offers real hope for improved livelihood and quality of life, social fairness and environmental sustainability.

Farmerline: Voice-activated information

Alloysius Attah and Emmanuel Owusu Addai¹



With improved access to information, rural farmers can increase their yields and incomes using their mobile phones. Since its launch in 2013, Farmerline has provided around 10,000 smallholder farmers in rural Ghana with locally-relevant agricultural information. Farmers receive agriculture-related information directly to their mobile phones in the form of voice calls.

Anna Deblu, a soybean farmer from the Lambusie-Karni district of Ghana, is reaping the benefits of Farmerline's innovative service. Information on rainfall patterns, sent via voice messages to her mobile phone, has enabled her to effectively plan when to plant. Deblu has tackled low yields and postharvest losses and increased soybean production from 3 kg per ha to a substantial 40.5 kg per ha. As well as being preferred by farmers, this method of using audio content in local languages – rather than information sent by SMS – overcomes literacy barriers in rural areas and has proved to be very effective.

Addressing the gap

The innovative approach is comprised of three unique mobile phone services: an outbound voice messaging service; interactive mobile surveys for monitoring and reporting; and a dedicated support team that farmers can contact with specific questions. Crucial data including weather forecasts, best farming practices, financial tips, and market information are communicated directly to farmers. Farmer-based organisations and NGOs are also able to reach farmers in their local languages using interactive surveys.

¹ Farmerline Ltd, Ghana.

Farmerline helped Appiah Kubi, a cabbage farmer from the Fomena district in Ghana to meet the rising demand brought on by a partnership with a large-scale buyer. “Now that Farmerline has linked us directly to big buyers, I am hoping to raise my farm’s income and expand our production,” says Kubi. “I will be able to pay the school fees of my children and reduce the time they spend on the farm. My son, Joseph, he should be concentrating on his books so he can become a doctor.”

In touch with local communities

To measure the impact of its services and offer additional training in the use of its mobile technology, the team schedules follow-up visits with local farming communities every 6–8 weeks. These meetings help to ensure that the voice messages on agriculture, weather forecasting, market information and farming techniques are being successfully delivered to the mobile phones of registered farmers.

Farmerline currently provides mobile services that improve the livelihoods of over 10,000 rural farmers through communicating timely and relevant agricultural information (weather alerts, best farming practices, financial tips and market prices) through voice messages in local languages directly to the mobile phones of farmers. Farmerline also supports global food companies (Hershey, Ecom Trading and Armajaro), governments and agribusinesses with farm management communication, data collection, and traceability to better manage over 200,000 smallholder farmers and their entire supply chain across five countries in Africa.

Outbound messaging



Monitoring and reporting with mobile surveys



Dedicated support line



Barakuk: A natural protector for onion seeds

Joseph Ayembilla¹



Planting good quality seed with a high germination rate is the foundation for a healthy, productive crop. But for smallholder farmers, who typically save seed from one harvest for planting in the following season, protecting that seed from damage by insect pests presents a major challenge. Onion farmer John Akugre, from Bawku West district in northern Ghana, found a solution for the problem. The son of a cereal farmer, Akugre decided to venture into onion production after his father's death, but insect infestation resulted in poor germination and, at times, a total failure of the seeds to germinate. Unable to afford the cost of chemical pesticides, Akugre turned instead to an organic and cheaper solution – one originally discovered by his late father.

Barakuk (*Chamaecrista nictans*) is a strong smelling shrub which grows wild in northern Ghana. Akugre remembered how his father had decided to try the plant, thinking that its strong smell might deter insects from infesting his stored cereal crops. It was an effective solution, protecting the stored grain for several months; as a result, it was adopted by other farmers in the community. In 2008, Akugre decided to put the barakuk plant to the test to protect his stored onion seeds. A natural innovator, he experimented with a new method: burning the plant leaves to form ash and then mixing the ash with his onion seed. The results were impressive; over 90% of the seeds germinated, and his onion yields increased by 40–80%.

With this success, and keen to spread the method to other farmers, Akugre prepared clear instructions for others to follow. After collecting the plant from the wild, farmers are advised to dry the leaves in the shade before burning them and grinding the ash into powder. Two tablespoons (30 g) of the powder are then added to dried onion seeds in a standard-sized (330 ml) soda bottle, and mixed thoroughly. The bottle is then sealed and hung in an airy space – such as a thatched roof – and can be kept for up to 12 months.

¹ Navrongo-Bolgatanga Catholic Diocesan Development Office (NABOCADO), Ghana.



Multiple benefits

Over the last 6 years since Akugre first developed and launched this innovative solution, he has helped 180 other farmers in his area to adopt the technology. According to Akugre, the benefits of using barakuk are considerable. The method is easy to follow and low cost. As well as improving germination rates and increasing yield, the healthy seeds produce good quality onions which attract high prices. These benefits have been endorsed by a local NGO, the Navrongo-Bolgatanga Catholic Diocesan Development Office (NABOCADO) and by other local stakeholders, including the district office of the Ministry of Food and Agriculture.

NABOCADO is keen to support his work, and up-scale the technology to 500 more households. More scientific research is needed to commercialise the product. Key areas of research recommended by NABOCADO, include domestication of the plant and understanding its agronomy and suitability for other locations, identification of the active ingredient, standardising the product and determining optimum application rates, identification of appropriate packaging and optimum storage conditions.

In reflecting on the impacts that the use of barakuk has had, Akugre says that planting healthy onion seed has increased food availability in his home as well as his income, helping him to pay his children's school fees and renew his family's health insurance each year. He has also improved his status and prominence, becoming a valued source of knowledge on protection of stored seed in several local communities including his own.



Biological control of the millet head miner: In the bag

Ibrahim Boukary Baoua¹, Malick Bâ Niango², Clementine Dabiré² and Mamadou N'Diaye³



Pearl millet is one of the most important food crops in the Sahel region. It is grown by over 70% of farmers and constitutes the staple diet of 500 million people in countries including Burkina Faso, Mali and Niger. The millet head miner moth (*Heliocheilus albipunctella* De Joannis) is a serious threat to millet production, causing grain losses of up to 60%. In years with severe outbreaks, as much as 95% of crop can be affected.

Protecting crops from the moth's larvae is a priority; eggs are laid on young millet crop heads, which hatch to destroy the millet's flowers and grains. Unfortunately for farmers, the damage is only apparent at a later stage of production. However, a tiny parasitic wasp known as *Habrobracon hebetor*, which is indigenous to the region, uses head miner moths to complete its own life cycle, paralyzing the moth larvae and then laying its eggs on their bodies. When the eggs hatch 2 or 3 days later, the wasp larvae feed on the now dead moth larvae.



Adult *H. hebetor* on a grain of millet



Moth larvae parasitized by *H. hebetor*

¹ Université de Maradi, Niger.

² Institut National de l'Environnement et de Recherches Agricoles, Burkina Faso.

³ Institut d'Economie Rurale, Mali.



Millet head attacked by miners and recovered after the releases of *H. hebetor*



Millet head infested by the miner

First discovered by scientists in the 1980s, field trials of the wasps were carried out during 1985 and 2000 in Niger and Senegal, where laboratory-bred *H. hebetor* were released into millet fields. The results were encouraging in the reduction of head miner infestation, but a challenge remained of how to take the biocontrol strategy to scale given the scope of the infestation across the Sahel. Fortunately, an environmentally-friendly biological control has been developed and tested.

In the bag

'Release bags' have been developed by a collaborative regional research project to solve the problem. Small jute bags containing 30g of millet flour, 50g of millet grain, 25 larvae of a common insect species – *Corcyra cephalonica* – and two mated *H. Hebetor* females are kept sealed for 48 hours in order to grow the parasitoid population.



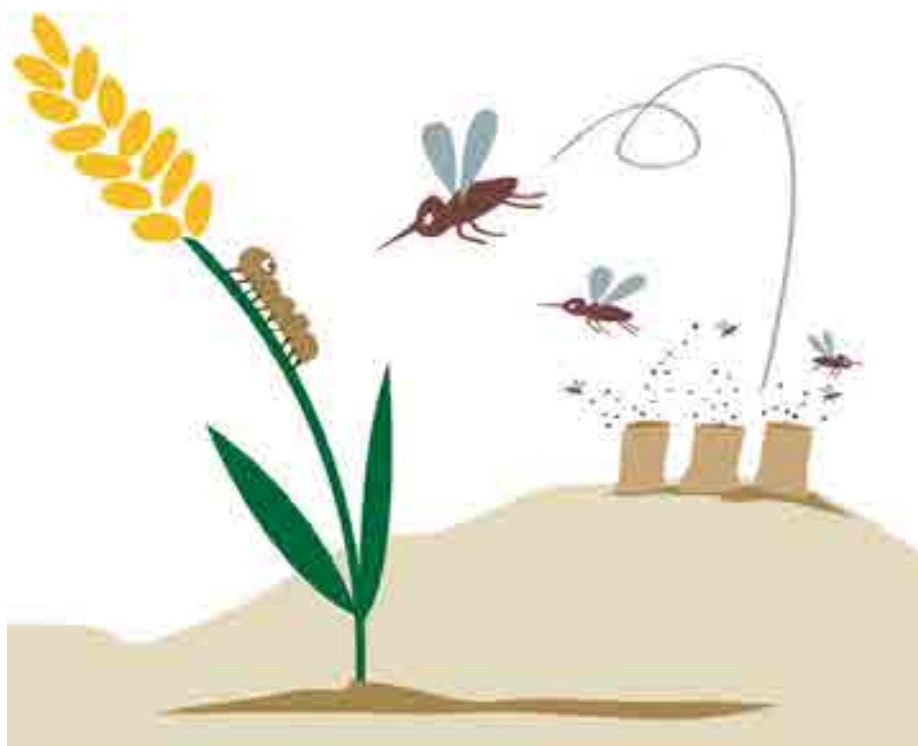
H. hebetor release bag

To protect against the millet head miner at the beginning of an infestation period, 15 jute kit bags containing the parasitoids are placed in granaries, or other areas surrounding a village, in groups of three. After a week, some of the eggs have already developed into adult wasps, and over the next two weeks an average of 80 wasps emerge from each bag to enter the fields and begin to parasitise the head miner moth larvae. Over the following month, three to four more generations of wasps are then produced from the original population released from the bag, greatly increasing their numbers and causing a mortality rate in head miner moth of over 70% over a 15 km radius around the village.

Between 2006 and 2013, release bags were tested in 385 villages in Burkina Faso, Mali and Niger, involving seven Masters students, 200 extension agents and over 2,000 farmers who were all trained in how to prepare and use them. *H. hebetor* females were provided by the research institutes, *C. cephalonica* larvae were collected locally, and the jute bags made at a cost of around €3 per bag.

Using the technique around the villages has increased millet production by at least 34%. And, as a low-cost effective pest control strategy, the technology has proved very popular with farmers. “It was a pleasant surprise,” says Harouna Boubacar, a member of the Harai Ban de Tera farmers’ union in Niger involved in the release bag trials. “All the pest larvae dried out and we had good harvests. In 2013, we even had visitors from other groups in Dosso region to share the results of the biological control. Our union is now committed to the effective dissemination of this environmentally-friendly and very affordable technology.”

During 2013 and 2014, more than 6,400 release bags were produced in Niger for the treatment of more than 2 million ha of millet. NGOs, such as Care International, Concern, PASADEM, Mercy Corp and Caritas have included this ‘natural pest control bag’ innovation in their activities. The developers are recommending wide-scale promotion by public extension services, NGOs, producer organisations and the private sector.



Sunflower water pump: Powerful and efficient

Quentin Baynes and Toby Hammond¹

In sub-Saharan Africa, it is estimated that just 5% of cropland benefits from irrigation. This means that the vast majority of farmers are entirely dependent on rainfall which is becoming increasingly erratic and unpredictable. A lack of access to irrigation means that farming activities are limited to short growing seasons, leading to instability in income – and food availability – across the year.

Although a number of irrigation technologies are available, these are not always practical for small-scale farmers. Manual irrigation, for example using a hand or treadle pump, is labour intensive and can only be used to irrigate a small area. Typically, this work falls on women and children, taking them away from other more productive activities. Engine-driven pumps are another option. However, whilst relatively cheap to purchase (€180 for a low-cost model) and able to pump high volumes of water, their lifespan is relatively short (often less than 5 years), spare parts and maintenance can be difficult to access, and fuel is a recurring cost.



¹ Futurepump Ltd, UK.



Simple and efficient

To help overcome these challenges, the Sunflower solar water pump has been developed by the PRACTICA Foundation, a Dutch centre that specialises in developing robust designs for low income consumers. Unlike other solar pumps, it avoids complex electronics and instead uses a simple piston pump which, in energy terms, is the most efficient way of moving water. The pump is driven by a DC motor, which receives its power from an 80 watt photovoltaic (70 x 80 cm) solar panel. In order to optimise the water flow, the pump operation can be adjusted according to the relative height of the water body being pumped and the intensity of light falling on the panel. Most importantly, the Sunflower pump is easy to repair and maintain, including by farmers themselves.

The Sunflower pump is designed for shallow and surface water (e.g. rivers and lakes) and can be used to pump up to a height of 7 m; in full sun, it can pump up to 2,000 litres per hour, or as much as 13,000 litres a day, which is sufficient to irrigate around 0.2 ha. The pump is also powerful enough to move the water over a distance of 200 m with minimal loss of flow. In addition, the pump can be connected directly to a drip irrigation system or a raised storage tank making it possible for small-scale farmers to carry out year-round production of high value crops, such as vegetables, especially during dry spells.

Research suggests that profits from a small vegetable farm can increase by 45% using the pump, while field trials in Ethiopia found that use of a Sunflower pump, on a 600 m² growing area, led to a doubling of household income.

Clustered approach

Commercialisation of the Sunflower is being led by Futurepump, which is using a clustered approach for promoting the pumps to farmers in areas where they are particularly suitable. One strong advantage of this approach is that it allows the company to offer a high level of after-sales servicing including pump maintenance and supply of spare parts.

The first of these clusters is located on the shores of Lake Victoria in Homa Bay County. Five pumps were installed in 2014 on various farms in the area, which are reportedly performing very well and have generated a lot of interest among local farmers. The company is scaling-up production to meet demand from several hundred farmers but, with a retail cost of 35,000 Kenyan shillings per pump (€315), very small-scale farmers may not be able to afford the technology unless innovative financing schemes are explored.

Financing growth

Futurepump is therefore looking to partner with one or more major banks and other financial institutions in Kenya to offer the pump under a payment plan. Farmers would buy a pump with an initial deposit of 12,000 KSh (€110), and pay back the remainder in €27 monthly instalments. According to the company, this may be the first time that this kind of ‘asset financing’ arrangement has been introduced for an irrigation technology. Futurepump is also looking to link up with outgrower schemes. Under this system, a company would buy pumps on behalf of its outgrower farmers, who would then be able to pay back the cost of the pump in the same way they refund other input costs – including seeds and fertiliser – from the payments earned under the cropping contract.

A range of mechanisms for scaling out the use of the Sunflower pump, including finance, distribution and commission incentives for sales agents, will be tested in the Homa Bay pilot area over the next few years. Lessons from these trials will be used to support distribution partners in other areas. If the Sunflower proves to be a valued appropriate, affordable and reliable technology, it has the potential to transform smallholder production, reducing the need for manual water pumping and dependency on highly-priced fossil fuels such as diesel and gasoline.



Chinadango local fertiliser: Increases yields, improves soil fertility!

Francis Chilenga¹ and Franklin Msiska²



This innovation in the use of organic waste for improving soil fertility was pioneered by Chinadango Mhango, a Malawian farmer. Like many areas of sub-Saharan Africa, Karonga district in the north of Malawi is experiencing increasingly erratic rainfall. Dry spells during the rainy season – sometimes extending into lengthy droughts – are severely impacting on crop production, not least for farmers growing maize, the main staple food crop. Land resources are also under pressure; continuous cultivation year after year, with no fallow period to allow soils adequate time to recover lead to soil degradation. The price of chemical fertilisers is also very high, and farmers use very little or none at all given the risk of crop failure in times of poor rains.

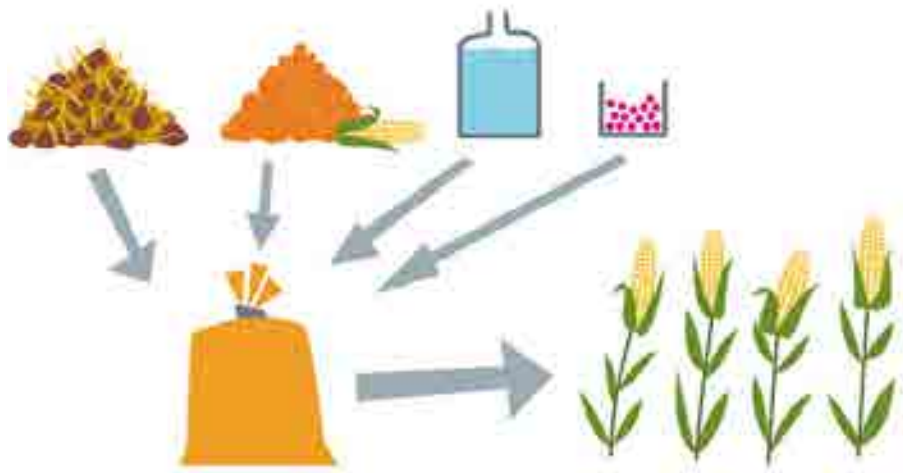
Facing such challenges, Karonga farmer, Chinadango Mhango, set out to find an easy and affordable solution to his soil fertility problem. Mhango had always applied organic manure in his maize field but, in 2009, he began experimenting with a mixture of inorganic – either urea or nitrate, phosphate and potassium (NPK) – and organic fertiliser (e.g. maize or rice bran) in his fields. He soon observed that maize grown in areas where the mixed manure was applied did far better than those grown in soils where only organic manure was used.

The difference in yields was significant. Inspired by these results, Mhango invited his local extension agents to see the impact of his innovation and was encouraged to host a

¹ Ministry of Agriculture and Food Security, Malawi.

² Catholic Development Commission, Malawi.

farmers' field day. Farmers as well as officials from the Malawian Ministry of Agriculture and Food Security observed that, despite frequent dry spells which had occurred during that season, Mhango's maize had performed much better than that of surrounding farmers. The Ministry of Agriculture and Food Security recommended that the results be verified by the research department and scaled out to other farmers. By early 2014, around 1,000 farmers had adopted the innovation.



Recipe for success

Making the fertiliser is a straightforward process: 40 kg of organic manure, 40 kg of bran, 40 litres of water and 5 kg of chemical fertiliser are mixed evenly and then stored in heavy duty plastic sacks for a minimum of 7 days. After this, the innovative Chinadango manure fertiliser mix is ready for use. One 50 kg bag of chemical fertilizer, either NPK or urea, can be used to make ten 50 kg bags of Chinadango manure.

During the cropping season, the fertiliser is applied twice. At planting time, one handful of manure is applied at each maize planting station, using a spacing of 25 cm between stations and 75 cm between rows, and one plant per station. For this basal dressing, Mhango recommends using NPK as the inorganic fertiliser ingredient. Three weeks after planting, a second handful of fertiliser, known as the top dressing, is applied to each station. For this batch of fertiliser, urea is recommended as the inorganic ingredient. In terms of the quantities required, one 50 kg bag of Chinadango fertiliser can be applied to 0.08 ha of land; five bags are enough to fertilise a 0.4 ha field (1 acre). A farmer is therefore able to save one 50 kg bag of chemical fertilizer per 0.4 ha.

According to Francis Chilenga, a senior agricultural officer, farmers using this suggested rate of application can expect to harvest 30–50 sacks (of 50 kg each) from 0.4 ha of maize, compared to 22 sacks if they use organic manure alone. Thus, use of Chinadango fertiliser enables higher yields, while also reducing costs for using chemical fertilisers. Importantly, the Chinadango fertiliser also improves soil structure and water retention.

As a result, crops are better able to withstand dry spells, reducing the risk of crop failure during periods of erratic rainfall.

Spreading the benefits

As a lead farmer in his area, Mhango works hard to promote farmer-to-farmer information and knowledge exchange. Special farmer tours have been organised so that other farmers can learn and benefit from his innovation. Making the fertiliser also presents an opportunity for income generation; Mhango sells 50 kg sacks of his fertiliser for €8, a much more affordable option for local farmers than the €50 cost of inorganic fertiliser.

To scale up the technique further, Chilenga recommends use of the mass media to stimulate awareness among farmers and extension workers, and production of a video documentary on preparation and use of the fertiliser supported by on-farm demonstrations and field days. Use of the fertiliser in the production of other crops, such as fruit trees, or on pasture land can also be evaluated and if the results are as successful, they can be up- and out-scaled.

There is still more research and development work to be done on the Chinadango manure. In this context, research is needed to determine the chemical composition and to standardise the application rates. Further experimentation with different combinations of the raw materials are also needed in order to determine the optimum mix. In future, the product could also be commercially packaged and branded while still ensuring that it remains affordable to smallholder farmers. Large-scale promotion and adoption of the technology could have several key benefits enabling more smallholder farmers to engage in profitable maize farming and helping resource-poor farmers to improve crop yields thereby contributing to increased incomes and household food security, particularly during years affected by dry spells. At a landscape level, the use of Mhango's innovative Chinadango manure fertiliser could help to restore fertility to degraded soils and increase the sustainability of smallholder farming systems.



Protecting Mali's rivers: Bio-herbicide for eco-management of water hyacinth

Karim Dagno¹, Mamourou Diourté¹ and Haissam M Jijakli²



As a landlocked country in the heart of West Africa, Mali's agriculturally-based economy revolves around two rivers, the Niger and the Senegal. These rivers are a vital source of energy, transport and irrigation, and livelihoods. However, water hyacinth (*Eichhornia crassipes*) invasion in the rivers is threatening food security and power generation. Over the last 20 years, water hyacinth infestation has affected 80% of the River Niger hampering fishing, boat transport, hydro-electric power generation and irrigation facilities.

The invasive weed is a threat to rice production, covering nearly 100,000 ha of land; irrigation for substantial sugar production and off-season vegetables are also at risk. For the fishing industry, losses are estimated at 5%. Proliferation of the weed also reduces biodiversity and promotes the spread of waterborne diseases. A bio-herbicide has been developed and tested which could effectively and ecologically control this invasive pest.

A safe solution

Tackling water hyacinth presents a challenge. Use of chemical herbicides is a hazard for fish and aquatic plants, as well as a danger for people and animals who use the river as their source of drinking water. In 2010, a research team from Mali and Belgium identified a new species of pathogen, '*Alternaria jacinthicola* Dagno & MH Jijakli' whilst investigating fungal diseases of water hyacinth growing in the Niger. This formed the basis for the production of a new and highly effective bio-herbicide.

¹ Sotuba Regional Agricultural Research Centre, Institut d'Economie Rurale, Mali.

² University of Liège, Belgium.

Tests carried out along the banks of the Niger River in Badalabougou area in the Bamako district showed that spraying hyacinth with the bio-herbicide caused the leaves to break up, disrupting the plant's photosynthesis. Within 4–6 weeks, over 60% of the plants were dead. Greenhouse-based tests were even more effective causing up to 90% destruction of the leaves. The bio-herbicide was also tested on 18 different crops – including rice, tomato, okra and beans – and found to have no effect on them. The research team is now keen to see mass production of the bio-herbicide by farmers' organisations and local enterprises.

To make the product, powdered water hyacinth plants are inoculated with the fungal pathogen and fermented in barrels for 2 weeks. The biocontrol agent can then be removed and incorporated within a vegetable oil or palm oil-based formula suitable for spraying. The bio-herbicide is applied twice a year – in January and June – using general purpose spray equipment, typically from a canoe. Sixty litres of the herbicide are needed per ha, at a cost of around 5,500 FCFA (€8.45) for the palm oil-based spray and 4,500 FCFA (€6.91) using an indigenous vegetable oil (*Carapa procera* oil).

Clearing the river, security for smallholders

Currently, the Sotuba hydroelectric dam is under constant threat from upstream hyacinth infestation, which leads to costly shortfalls in energy production and makes hyacinth control a high priority. Clearing the river would secure irrigation for over a million rice and vegetable farmers in the Koulikoro, Mopti and Segou regions, and it is estimated could save the Niger Office up to 137 million FCFA (€209,000) per year normally spent clearing irrigation networks.

Tackling the water hyacinth infestation would also help to protect the jobs of 285,000 people working in the fishing industry and up to 10 million small farmers in Mali as a whole, according to the research team's estimates. Local authorities, as well as the Ministry of the Environment and Energy, and irrigation companies in Mali are potential customers for this bio-herbicide.



Extension goes digital for Zimbabwean livestock farmers

Abisha Damba and Thembinkosi Nyathi¹

In Zimbabwe, providing information and other services to remote rural communities is an ongoing challenge. In Mbire district, north-east Zimbabwe, crop farming is severely hampered by highly erratic rainfall; most smallholder farmers depend on cattle and small livestock production. Podcasts in local voices have proven to be highly effective in reaching previously inaccessible communities. Compared with radio, they are cost-effective and ideal for sharing more in-depth, lengthy explanations on livestock production, disease prevention and diagnosis. They can also be used to target specific audiences and be re-played by communities when needed.

Local languages and voices

Animal health services have been traditionally provided by government extension staff but insufficient funding and understaffing have affected smallholder farmers. A pilot project to test audio podcasts in Mbire was initiated by Practical Action Southern Africa in 2008, targeting farmers with limited access to electricity, communications infrastructure and broadcasting services. To ensure that services provided would be demand-driven and appropriate, local community-based organisation and project partner – the Lower Guruve Development Association (LGDA) – began by identifying communities' knowledge needs, literacy levels and administrative structures. The project ran until 2010.

The results led to the development of 50 advisories on livestock management, which included topics such as immunising cattle, dehorning and castrating bullocks, tick control and disease diagnosis. These were created in collaboration with government extension services and the departments of Livestock Development and Veterinary Services, translated into local languages and recorded as podcasts, using the voices of community members and extension agents, and uploaded onto inexpensive mp3 players.

Seventy volunteer community-based knowledge workers – or community animators – selected by LGDA were trained to play podcasts at community meetings. Typical meetings involved 50–100 people and podcasts were chosen according to the group's needs. After the podcast, farmers discussed the topic and animators kept note of farmers' questions, which were passed on to project partners to obtain answers as well as to inform the development of future content.

¹ Practical Action Southern Africa, Zimbabwe.



Breaking down communication barriers

The podcasts' accessible format for all, regardless of literacy, age and gender is the key to its successful uptake. Practical Action estimates that 75% of the local population targeted were reached through the podcasts, compared to an estimated 50% reached by traditional extension methods. While initially intended to target 15,000 farmers, rising demand and spread of podcasts to non-target areas led to the successful expansion of the service to 20,000 people.

Through the podcasts, over 600 cases of livestock disease were recorded and measures taken to save the animals. Analysis of livestock productivity suggest that animal deaths during the rainy season in the podcast areas fell from 10% to 1% of the cattle herd during the project period.

“Podcasting has changed our lives here in Mbire, giving us access to vast knowledge resources on demand,” says farmer Sheba Majoka. She is now able to vaccinate her herd of 25 cattle against common diseases, a service previously delivered by the Department of Livestock Development.

Practical Action Southern Africa has now adopted podcasting and has established a knowledge centre in Gwanda district, which is using various digital formats, including podcasts, to provide information on agriculture, agro-processing, water and sanitation to at least 50,000 farmers.

It is clear that locally-produced podcasts that meet local needs strengthen capacity and knowledge exchange for the benefit of the farming community. To develop the podcasting system further, Practical Action believes that a more comprehensive monitoring mechanism needs to be set up to ensure continuous feedback between communities and those making the podcasts. Beyond that, further scaling up and long-term sustainability may depend on the government adopting digital extension and providing the necessary funding.

Rural resource centres: Farmer-centred approach to extension

Ann Degrande¹, Zac Tchoundjeu¹ and Roger Kwidja²



In an ever-changing global context, farmers need continuous access to locally-available sources of knowledge and information to update their skills and practices. The Rural Resource Centre (RRC) concept is driving innovation in the delivery of extension services that responds to the needs of farmers. RRCs use a farmer-centred approach, which focuses on developing farmers' capacity to innovate at all points in the agricultural production and marketing chain. The centres facilitate interactive learning and networking – among farmers and between farmers, researchers and other stakeholders. Assessments have shown that there is potential for income generation, enhanced livelihoods and environmental rehabilitation.

As training and demonstration hubs, RRCs have proved to be particularly effective for promoting new technologies that are relatively 'knowledge intensive'. Farmers learn new

¹ World Agroforestry Centre (ICRAF), Cameroon.

² Association Nationale des Centres de Ressources en Agroforesterie et Agriculture Durable (ANACRAD), Bangangte, West region, Cameroon.

skills and experiment and adapt the technologies according to their specific physical, climatic, economic and social circumstances. This innovative approach to extension and the active engagement with researchers and other key stakeholders empowers farmers as they are actively involved – not only during the research process – but also in the implementation or scaling up of new agricultural techniques on-farm.

This innovation in extension came about when the World Agroforestry Centre (ICRAF) observed that there was low uptake of new and improved agroforestry products and practices that they had developed in West and Central Africa. The spread was limited to trial sites and wide-scale adoption had not happened despite successes on pilot farms. ICRAF began testing the community-based approach to extension in 2006. This included sensitisation meetings prior to the selection of farmers and communities followed by needs assessments, training of the RCC staff in key areas such as nursery and post-harvest management, tree planting, marketing and finally the establishment of tree nurseries. Smallholder farmers, including women and youth, have benefitted.

A learning and knowledge sharing platform

Riba Agroforestry Resource Centre (RARC) is one such centre operating in mountainous northwest Cameroon since 1995. The mountainsides surrounding Riba are crucial to regional biodiversity and local ecosystems. They have been heavily logged and degraded resulting in a loss of soil fertility and overall economic security for the local population. The community-based organisation promotes sustainable tree-based farming to rehabilitate watersheds and degraded land and generate income for the local community.

RARC oversees 26 satellite farmer groups of up to 45 members each. The members own and manage demonstration sites, which they use to train other farmers, both from within their community and beyond. Training topics include agroforestry and nursery management, watershed protection, beekeeping, microfinance, and marketing of tree seedlings and farm produce. The Cameroon Ministry of Agriculture and Rural Development is a partner.

RARC focuses on helping farmers to improve soil fertility and crop yields by encouraging them to plant 'fertiliser trees'. RARC also supports farmers in domesticating superior varieties of indigenous fruit trees, reducing farmers' dependence on one or more cash crops, such as cocoa and coffee, which are subject to price fluctuations.

The RARC model has been shared with over 80 different communities and actively replicated in 18. Critically, this extension approach has successfully halted deforestation and improved soil fertility in the region, and sales from tree and honey nurseries are supporting sustainable livelihoods amongst the local population. In recognition of its outstanding community efforts to reduce poverty through conservation and sustainable use of biodiversity, RARC was awarded the 2010 Equator Prize.

Sustainable changes in agricultural practices

The RRCs have harnessed the collective capacity of communities to achieve positive, sustainable changes in agricultural practices. Data have shown that by 2014, six RRCs in Cameroon were supporting 100 producer groups representing close to 1,000 farmer households. Nearly half of those working with the RRCs on a regular basis were women and 11% were youth (i.e. under 35). By the end of 2012, a total of 315 small-scale nurseries were producing improved seedlings of agroforestry species in Cameroon, as well as in the Democratic Republic of Congo and Nigeria. Over 5,300 farm households were actively involved with domestication nurseries, producing around 6.3 million plants between 2011 and 2013.

However, there is still much more to do to build on the promising successes of the RRCs to date. Strong grassroots community-based organisations are vital for promoting learning and innovation and for improving livelihoods of rural communities. It is therefore important, at a structural level, to strengthen the technical and organisational capacity of farming communities so that the centres can better communicate, market and deliver their products and services. Extending outreach is also essential, not only to reach more farmers in existing sites, but also to engage with communities in other areas. The sustainability of RRCs will depend on community ownership and their ability to raise funding from among their members and the support of local authorities, the private sector, government and the research community.



More productive local chickens: All in the genes

Julius Kofi Hagan¹

In Ghana, smallholders have almost doubled their meat and egg production using improved local chicken varieties. By crossbreeding local heat-tolerant chickens with exotic chicken species, these better adapted birds mature quicker and are more productive. This innovation is benefiting rural communities and improving incomes and livelihoods, particularly for women and young smallholder farmers who have little capital for investing in large-scale production of layers or broilers.

Local chicken breeds are often relatively unproductive, small in size, mature later and produce limited amounts of meat and eggs in comparison with more productive imported breeds sourced from temperate countries. However, simply introducing exotic breeds into communities has failed to benefit rural people. In Ghana, for instance, a government programme to introduce exotic breeds of chicken for meat and egg production was not successful as the birds were unable to adapt to the tropical heat and humidity, resulting in low productivity.

Unfeathered necks, frizzled feathers

Julius Kofi Hagan, a lecturer and a research scientist at the Department of Animal Science, University of Cape Coast, Ghana, capitalised on the genetic characteristics of local chicken breeds which give them a greater tolerance to heat, making them productive in a hot, humid, climate. These characteristics are also expressed in physical traits, with birds having naked, unfeathered necks, and 'frizzled' (up-curved) feathers. Through crossbreeding, Hagan has transferred heat-tolerant genes into the more productive, exotic chicken breeds in order to produce birds that can cope with Ghana's higher temperatures and provide more meat and eggs per chicken.

To produce the hybrid breeds, male local birds (with the naked neck and frizzle genes) were first crossed with exotic female birds. From these offspring, Hagan ran two parallel breeding programmes, one focussing on producing birds with higher egg production and the other on producing quick-maturing birds that produced more meat. By back-crossing the offspring from the original cross-breeding with productive exotic birds over five generations, Hagan developed a new type of 'local' naked neck frizzle chicken, which was more productive than the indigenous variety and also able to withstand the heat and humidity better than the original exotic breed.

¹ University of Cape Coast, Ghana.

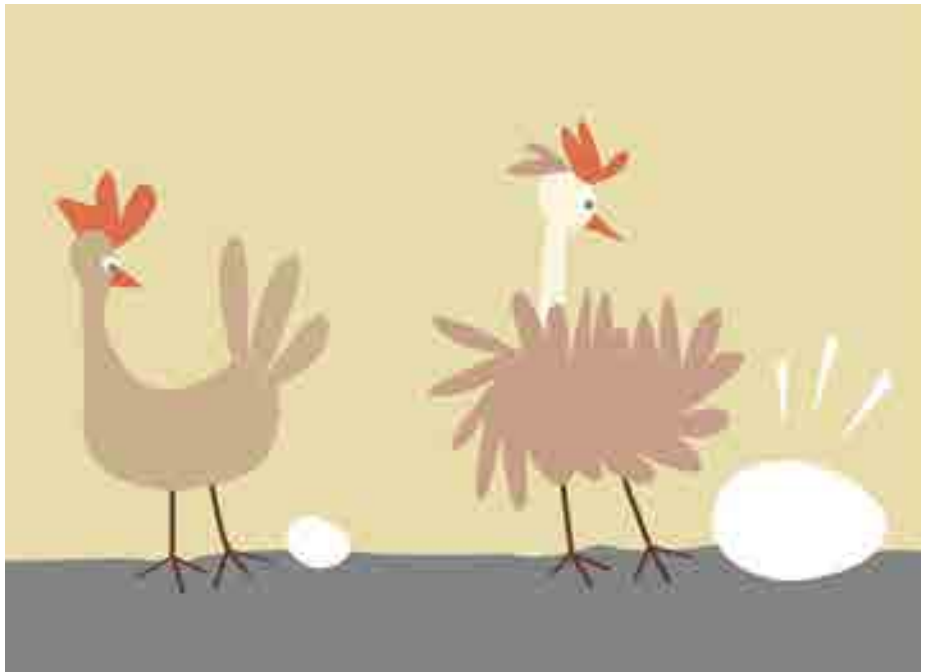
Nutrition and value

The results from on-farm trials have been encouraging. Fifty smallholder farmers (including women and youth) from Oyoko village in Ashanti region received 8-week old chicks – either pullets (females) for egg production or cockerels for meat production.

“The cross-bred pullets laid between 100 and 120 eggs per year compared to the 50 to 80 eggs that were obtained from our local birds,” noted Frank Adjei, chairman of the Oyoko smallholder farmers’ association. This almost doubling in production has resulted in increased income from egg sales, greater egg consumption contributing to improved nutrition and creation of employment.

“The cockerels reached market weight within 14 weeks, significantly faster than the 20 weeks taken by the birds we kept before,” says Adjei. The crossbreeds also had increased meat production compared to local cockerels. Another benefit is that naked neck and frizzle feathered birds – which were previously only raised for ritual purposes – are now recognised as having a productive value. This is helping to promote the conservation of these breeds and their valuable genetic resources.

Hagan’s crossbreeds are enabling smallholders to enhance food security through increased egg and meat production and also to improve their diets, income and employment. Efforts are underway to source funding to continue this valuable work for multiplying and distributing cross-bred birds to over 1,000 farmers in Ghana and West Africa. “We would be very grateful if other farmers also benefit from this innovation the way we have in Oyoko village,” said Adjei.



Low-cost feed for chicken farmers in Papua New Guinea

Pikah Kohun¹, Michael Dom¹, Janet Pandi¹, Fred Besari¹, Maima Sine¹, Workneh Ayalew¹ and Phil Glatz²



Chicken is the most popular meat in Papua New Guinea (PNG). Every year, around 6 million birds are produced by about 60,000 households on a small to semi-commercial scale. However, the profitability of these small businesses is under threat. Over the last decade, the rising cost of imported food grains such as wheat, sorghum and soybean has driven up the price of poultry feed by between 56% and 110%. Poultry producers also face increasing competition from low-cost, imported chicken meat. Consequently, many PNG poultry producers are struggling to stay in business.

In 2001, reducing the cost of livestock feed was identified as the highest priority for livestock development in PNG. Semi-commercial and commercial broiler chicken production, in particular, was recognised as a sector that could benefit from reduced feed costs if competitively priced local feed was available. The PNG National Agricultural Research Institute led a research project with the support of the Australian Centre for International Agricultural Research to develop, test and introduce low-cost poultry feeds using locally available material. Project partners included the South Australian Research and Development Institute, the PNG-based Lae Feed Mills, two provincial government agencies, and an NGO which was responsible for interactions with farmers.

¹ Papua New Guinea National Agricultural Research Institute.

² Australian Research and Development Institute.

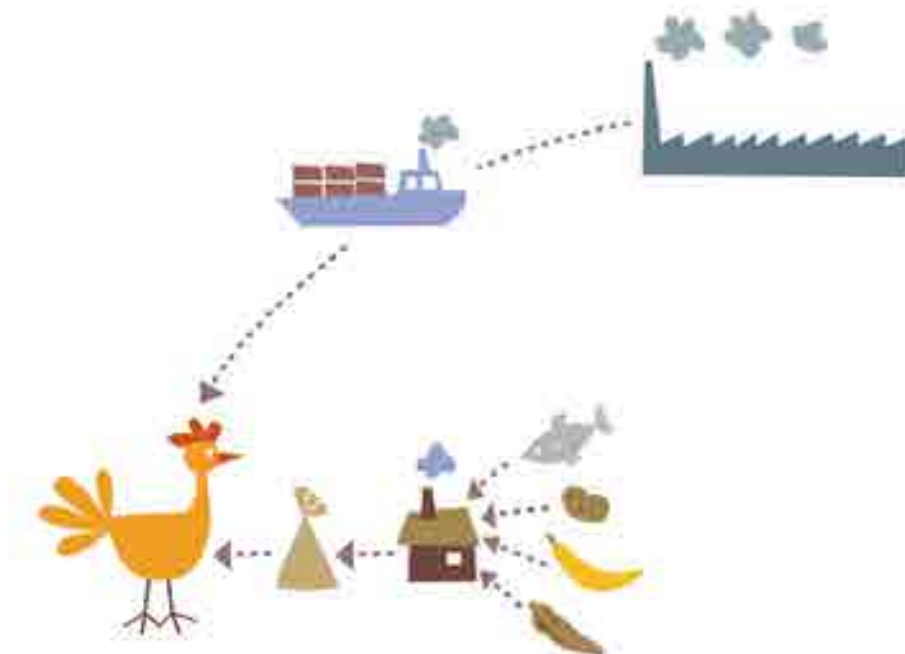
A testing approach

A quality-assured feed testing facility was set up to support the research process and several local feed ingredients were tested for their suitability, including seasonal variability, availability and cost. These included sweet potato, cassava, banana and taro, and industrial by-products such as copra meal, palm kernel meal and fish meal. Feed rations were then tested in on-station trials; those that proved successful were then field tested by poultry farmers in different locations, taking into account regional variations.

The initial product development and validation research was supplemented by two further initiatives. Firstly, new concentrate feeds of either high or low energy content were developed that could be blended with local feed ingredients in order to produce an optimum feed. For example, farmers wanting to produce a feed based on sweet potato were advised to blend the dried and milled sweet potato chips with a low energy concentrate feed. Farmers using cassava as the local ingredient blended it with a high energy concentrate in order to achieve a properly balanced feed. A second innovation was the introduction of mini feed mills, for the production of low-cost feeds on a semi-commercial or commercial scale.

Reducing costs, improving profits

Poultry farmers have been able to make significant savings and improve profit margins using the locally blended feeds and introduced technology. On-farm research suggests that those sourcing local feed ingredients from the market have reduced their feed costs by 14% on average; those who are able to supply the ingredients from their own fields have achieved a 30% saving. One community is now producing feed on a commercial scale – using sweet potato, cassava, copra and fish meal in their mini feed mills – and processing and selling frozen chicken meat to commercial outlets.



Jhan and Duma Lukua of the Western Highlands province acknowledge the impact the innovation in feed production and processing has had: “Instead of the normal 3 bags of starter ration and 4–5 of finisher rations, we are now able to raise one batch of broiler chickens with 2 bags of starter and 1 bag of broiler concentrate combined with sweet potato. We have seen an increase in our profit margins from K400–K500 (€130–€163) to K900–K1000 (€293–€325) now that we have adopted the broiler concentrate technology.”

The innovation in local feed systems has the potential to benefit 60,000 smallholder and semi-commercial broiler farmers in PNG and hundreds of sweet potato and cassava producers, through the supply of dried chips to mini feed mills. Increased availability and access to low-cost feeds could improve profitability in the industry by an estimated €31 million per year, through reductions in cost of production. At a national level, widespread adoption and use would help to stabilise local poultry prices. At the farm level, the approach can create employment opportunities for women, potentially improving their status within the household, as well as contributing to food security, poverty reduction and improved nutrition and health.

The low-cost local feed innovations have a clear applicability for Pacific poultry producers, and have already been introduced in the Solomon Islands and Vanuatu through collaborative research projects. The approach could also be used in pig and pond fish production; if taken up by commercial producers, the local feed technologies could help to restrict price increases on animal-sourced foods and reduce cheap meat imports. National-level policies and support for the use of low-cost feeds – for example in facilitating farmer training and awareness – and innovative financing models for the establishment of mini feed mills, whether by individual entrepreneurs or farmer groups, would further cement and expand this innovation in the processing and sale of local feeds.



'Climate-smart' hydroponics: Growing more with less

Stuart LaPlace¹



Growing high value vegetables for the local hospitality industry and export market is a lucrative opportunity for farmers in the Caribbean. In St Kitts, the tourism industry helps to boost year-round demand for quality fresh produce. But many producers are constrained by a lack of fertile land, in particular younger farmers who struggle to access land. Vegetable production is also very seasonal and needs a reliable source of water. With rainfall in short supply at certain times of the year, and erratic on other occasions, farmers are discouraged from taking advantage of these high value markets.

In 2011, Stuart LaPlace, a science lecturer and hydroponics specialist at the Clarence Fitzroy Bryant College in St Kitts, submitted a proposal to the management of his institution to set up and run a 300 plant hydroponics system. The college had started an agriculture studies programme but limited land was available for providing practical lessons. The hydroponics plan was approved and La Place was given a 6 m x 7.3 m area on which to construct the system. One of the key advantages of the hydroponics system, compared to soil-based farming, is that much higher crop yields can be achieved in a relatively small space. A wider variety of horticultural crops, including broccoli, peppers, eggplant, lettuce and strawberries can also be grown using the system as LaPlace has developed specific nutrient formulae for the different crops and at different growth stages.

¹ Clarence Fitzroy Bryant College, St Kitts.



Maximum production from limited space

On the available land, La Place erected a shade house under which he built the hydroponic system based on 12 PVC pipes, each around 5 m long and 12.7 cm square, and set on supports of 0.6 m above the ground. Along the top of each pipe, a series of 7.6 cm diameter holes were cut at regular intervals – 300 in total – into which mesh cups filled with ‘hydroton’ clay pebbles – the growing medium for the plants were placed. The system cost €4500 to construct and, once set up, requires little further investment.

Traditionally, farmers practising hydroponics use transplanted seedlings rather than sowing seed. However with this innovation, seeds are directly planted into the clay pebbles. The system is irrigated using a small electric pump, which propels the water-based nutrient solution through the PVC pipes. Three or more plants can be grown in each mesh cup, with a total number of plants potentially in excess of 1,000. Vine plants, such as cucumbers, are particularly suitable, as they can be trained to grow up vertical trellises hung from the roof of the shade tent. Planting three different plant types in each cup, such as a string bean, a cucumber and a tomato plant, has also proved very successful.

Increasing the number of plants requires proportionate increases in the quantity of water and nutrients needed. However, unlike some hydroponic systems which depend on reverse osmosis to produce purified water, LaPlace’s innovation uses rainwater or tap water, helping to reduce running costs. Management of the system has been carried out

by students in the agri-studies programme, particularly those in their final year, to give them practical experience of hydroponics.

Results are impressive: an area of 7.3 m x 7.3 m, for example, can produce around 113 kg of cherry tomatoes every two weeks. Yields are increased by 300–400% from the same growing area compared to soil-based farming and plants also mature roughly twice as fast. Compared to soil planting, sowing to fruiting time in the hydroponic system is typically 45 days, with the produce benefiting from high nutrient quality and longer shelf-life. Research on various crop types suggests that a small farm family operating the system could earn around €445–670 per month from the sale of vegetables, depending on which crops they choose to grow. Farmers can also earn additional income from other employment as the system is easy to operate and maintain. One part-time St Kitts farmer, who has adopted the system, is earning €660 per month supplying vegetables to a few homes and a restaurant, while continuing with a full-time job.

Climate-smart and gender friendly

For farmers interested in adopting the system, basic knowledge of hydroponics is helpful. The relatively low maintenance needed is an attractive factor for would-be adopters. Importantly, the system can be maintained while being operated. Daily routine checks, including testing water quality, pH and nutrient levels, as well as basic plant management tasks such as pruning and harvesting, take around two hours to perform. The hydroton pebbles can also be washed and reused many times, reducing the environmental impact. The system is also gender-neutral; it can easily be assembled and managed by one person – man or woman – and if necessary can be quickly taken down if a storm is forecast. Once the storm clears, the farmer can have the system reassembled and ready for planting within the same day, minimising interruptions to production.

The system is being promoted as a climate-smart technology, since it allows year-round production and can be easily dismantled and reassembled under extreme weather conditions. This hydroponics model has since been adopted by farmers in Guyana, Nevis and St. Eustatius (Dutch Antilles). Farmers in Antigua, Barbados, Haiti and Trinidad have also expressed interest in using the system.

For farmers with no access to land and limited water supply, this innovative low-cost hydroponic system offers a chance for intensive and financially competitive production of vegetables and some types of soft fruit in a confined area. Research is ongoing to test its suitability for other crops.

Controlling aflatoxin in smallholder groundnut systems

Bryan Sobel¹, James Rhoads² and Patricia B. Wolff³



In 2013, Haiti was found to have the highest risk of liver cancer in the Caribbean. Although disturbing, this finding was not altogether surprising; earlier research had found Haitian communities to be critically exposed to aflatoxins – natural poisons produced by *Aspergillus* fungi. In adults, long-term exposure to aflatoxins is known to cause liver cancer. In

children, consumption of contaminated foods is linked with low birth weight, suppression of the immune system and stunting. The contamination of cereals (particularly maize) and legumes such as groundnut is quite common in the tropics. Control of aflatoxins is therefore increasingly recognised as a priority, not only to protect the health of farm families and wider populations, but in enabling farmers to produce high quality grains which are safe for human and animal consumption and which can be traded in national or international markets.

Established in 2003, an NGO based in Haiti – Meds and Food for Kids (MFK) – has been implementing a multi-pronged strategy to reduce aflatoxin contamination and change the lives of smallholder farmers. MFK feeds malnourished children and supports economic development in Haiti through production of a fortified peanut butter known as Medika Mamba ('peanut butter medicine' in Haitian creole). The NGO is also an approved supplier of groundnut-based 'ready to use therapeutic foods' to the UN Children's Fund (UNICEF) in Haiti. It is estimated that MFK's food products have saved the lives of over 120,000 children.

Control throughout the value chain

Having access to aflatoxin-free groundnuts is vital to MFK's work, hence the organisation has developed and supported an effective strategy for controlling aflatoxin contamination, which was undertaken in collaboration with Haiti's Ministry of Agriculture, the Christian University of Northern Haiti and several international partners*. It recognises that the

¹ Independent Consultant-Dakar, Senegal.

² Peanut & Mycotoxin Innovation Lab, USA.

³ Meds & Food for Kids, USA.

causes of contamination and the solutions to control are found throughout the entire value chain, making a holistic approach essential to achieve significant reductions in contamination. Through a combination of collaborative research, farmer education and market incentives, considerable progress has been achieved. As a result, between 2008 and 2012, MFK was able to purchase 140,636 kg of aflatoxin-free groundnuts from Haitian farmers, supporting economic development in local communities and lowering their overall aflatoxin exposure.

Under the MFK strategy, aflatoxin control begins in farmers' fields. *Aspergillus* enters the groundnut crop during times of stress, such as drought, pest incidence or poor soil fertility. So all aspects of production which improve plant health result in a reduced risk of contamination, and controlling the problem at field level has the added benefit of increasing groundnut yields. Through MFK's extension teams, farmers are encouraged to plant improved cultivars which are drought-tolerant, early maturing and disease-resistant. Farmers are also advised to practise crop rotation in order to break disease cycles and improve soil fertility, to plant early to avoid late season drought, and make use of appropriate pesticides and fungicides. However, accessing such inputs can often be challenging. To help overcome this issue and in collaboration with the Clinton Giustra Enterprise Partnership, MFK established a system for 'intermediary agriculture enterprise' (IAE), supporting a network of rural entrepreneurs and certified field agents who sell high quality seeds, fungicides and fertilisers to farmers.



Another critical point for controlling aflatoxin is during the days following harvest. Even high quality groundnuts will often have a small level of contamination, which can easily spread during storage, especially in hot, humid conditions. MFK-led farmer training has focused on several recommended practices and a number of post-harvest innovations. These include timely harvesting to avoid over-maturing and pod rot; drying of the crop immediately after harvest to less than 10% moisture; and sorting to remove all damaged, immature or rotten groundnut pods before long-term storage. Pods are dried on tarpaulins rather than on the ground and are stored in breathable bags that prevent moisture build up, helping to limit aflatoxin contamination. Through the IAEs, the pods are aggregated and kept for long-term storage in weather-proof depots.

Price incentives support change

Aflatoxin testing and quality grading at the point of purchase is also the IAE's responsibility. Using a simple dipstick test, groundnuts are tested before aggregation, ensuring traceability to a single farmer and enabling highly contaminated samples to be isolated so that the exact cause can be diagnosed. For farmers who are able to produce groundnuts that fall within an acceptable limit, the reward is a reliable market with MFK.

In order to help open up new and better markets for Haitian farmers, since 2012 the MFK model has been expanded to new regions through a private supply chain company, Acceso Peanut Corp. During the first two years, Acceso purchased over 100 tonnes of low-aflatoxin groundnuts from more than 800 small and medium-scale farmers. By providing training in good agricultural practices, and by facilitating farmers' access to credit for quality seed and other inputs, Acceso has also helped farmers to increase their yields by 30% and to double farm incomes. Meanwhile, through the manufacture of safe, groundnut-based foods for children, MFK is contributing to lowering the risk to aflatoxin exposure in the country.



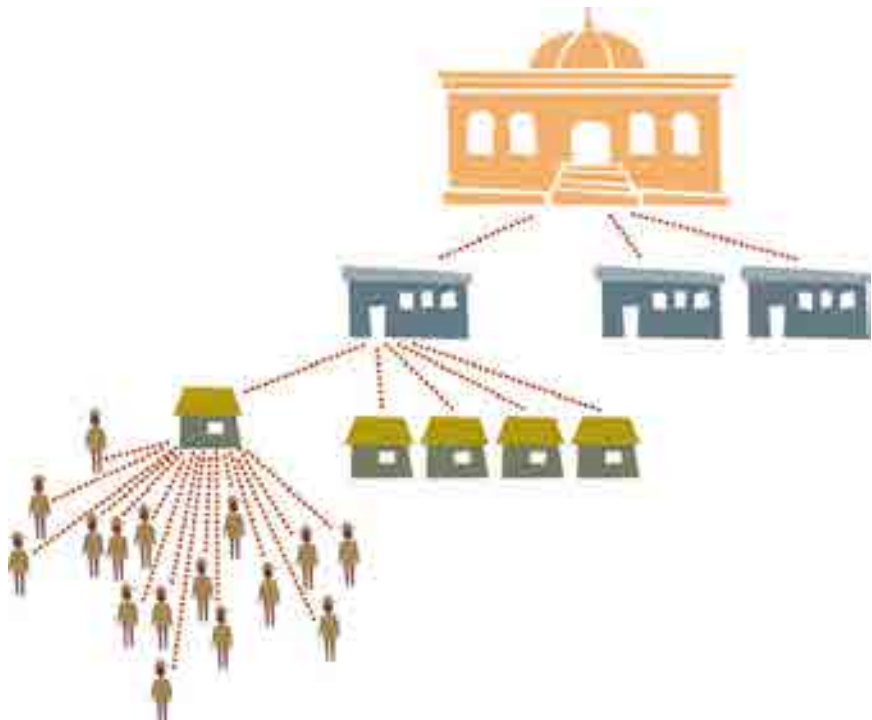
* International partners include USAID's Peanut Mycotoxin Innovation Lab in collaboration with researchers at the University of Georgia, Cornell University, and the University of Florida.

Producer business group model for value addition

John K. Mutunga¹

In Kenya, an innovative model in farmer organisation is enabling smallholders to collectively bulk, grade, add value and sell their produce. Producer Business Groups (PBGs) are already showing their worth in promoting entrepreneurship, joint problem solving, easy access to goods and services, and serving as an entry point for other initiatives.

Developed by the Kenya National Farmers' Federation (KENAFF), an umbrella farmers' federation that works with farmer groups across the country, the PBG model connects three different levels of organisation: firstly, common interest groups (CIGs) which produce at the grassroots level; secondly, PBGs and community-based enterprises (CBEs) which bulk and store produce; and finally, agro-enterprise agencies which process, brand and market produce to rural and urban markets.



¹ Kenya National Farmers Federation (KENAFF).

Commercial potential

The need for effective cohesive farmer organisations is clear: individual farmers who sell produce at farm-gate prices earn substantially less than in commodity markets. Adding value – by grading or carrying out basic processing – enables smallholders to command premium prices for their produce. Without this opportunity to tap into remunerative markets, smallholders have no incentive to invest in improved production or postharvest storage facilities. As a result, crop losses can be high and farmers' ability to make a profit is limited.

Under the PBG model, farmers are sensitised on opportunities for agricultural enterprise development that have the greatest potential in their area. Those who are interested in joining together in producing a single commodity within a defined area are supported to form CIGs, usually comprising 30 to 40 farming households. Even this relatively simple level of organisation can make a significant difference in helping farmers to shift to a more commercial agribusiness approach.

Improved farming practices and marketing opportunities are shared by CIG members. Groups can also access services, including training, more effectively than individuals and can establish a system of savings and credit for group members. Most importantly, the farmers support each other to adopt a consistent, well-planned approach to crop production in order to meet market requirements.

Longer-term business

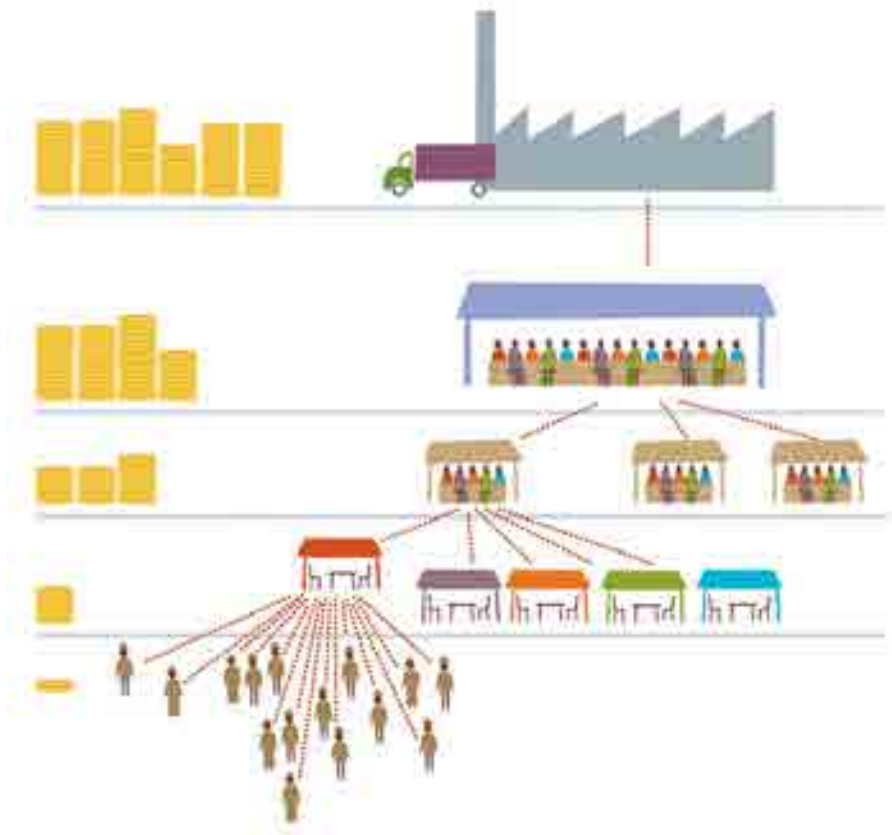
The next stage of the process is for about ten CIGs to join together to form PBGs, which are registered legal entities and large enough to aggregate commercial volumes of product. The PBGs operate according to mutually agreed rules and regulations, with reward and penalty measures as part of well-articulated membership rights and obligations. As respected legal entities, they are able to engage in long-term business activities and benefit from reduced costs through joint procurement of inputs and sales of produce. Regular consultations are held to discuss challenges facing their member CIGs for joint problem solving.

Support for the groups has taken a number of forms, including capacity building on leadership skills, group dynamics, value chain analysis and business planning. KENAFF has also organised value chain committees in each county in which major stakeholders (such as the government, banks and private sector) come together. This has helped the PBGs to benefit from public investments, contracts with companies and finance schemes. The groups have also gained access to 16 produce collection centres to support their collective marketing.

Trust and communication

The KENAFF producer model has been implemented with support from a Dutch agro-agency, Agritererra. Between 2011 – when it was first developed – and the end of 2013, 643 CIGs had been formed, as well as 90 PBGs, 65 of which had been registered as cooperatives or community-based organisations. The initial success of the PBGs has led to an increase in membership. Trust and communication are at the core of this innovative farmer organization business model.

“The PBG model has reintroduced mutual trust and support and genuine communication between farmers, boosting the cohesiveness of groups and strengthening farmers’ willingness to take part in joint ventures,” says KENAFF’s John Mutunga. Farmers’ access to extension and other technical services has improved, and, by achieving higher quality and consistency in their output, they have been able to enjoy improved market access as well as benefit from better prices for their produce.



POMP – Adapted technology: Improved crop processing

Godfrey Mwinama and Wilson M Baitani¹



Tanzanian researchers have developed an adapted power tiller operated processor to reduce labour requirements, increase yields, and improve the quality of harvested grains throughout the year. The Power-tiller Operated Multi-crop Processor (POMP) is a multi-crop primary processing machine, specifically for maize shelling, groundnut de-shelling, forage chopping, and wheat and sorghum threshing.

Manual threshing and shelling of crops is a tiresome and time-consuming task. At peak harvest times, machinery for these ‘primary processing’ operations are scarce in Tanzania. They are also costly. Many farming families also face labour shortages, preventing timely harvesting and processing and contributing to high postharvest crop losses.

¹ Center for Agricultural Mechanisation and Rural Technology (CAMARTEC), Tanzania.

POMP is an affordable, appropriate solution developed using locally-available materials at the Center for Agricultural Mechanisation and Rural Technology (CAMARTEC) in Arusha, Tanzania. The idea for the technology originated in 2010 when a large number of power tillers were imported as part of the government's 'Kilimo Kwanza' (agriculture first) initiative to help farmers increase productivity. Many underperformed during land preparation operations in upland farms but performed well in haulage and lowland land preparation, particularly rotavation in rice fields. However, the equipment remained unused for many months of the year.

POMP is especially adapted. It is equipped with a shelling drum for maize, a threshing drum for other cereals, a chopping unit for forage and de-shelling bars for groundnuts, as well as a number of differently-sized sieves that can be interchanged according to the crop being processed. To make the whole unit highly mobile, POMP is bolted on a trailer so that it can be towed behind a power tiller. In operation, the processor is unhitched, bolted to the front of the tiller and then connected by a drive belt to the tiller engine.

Serving rural communities

POMP was first used by smallholder maize farmers in Arumeru district, in northern Tanzania between August and October 2013. Over a 2 month period, more than 60 tonnes (t) of maize were shelled, with the machine averaging 2.5 t per hour. Farmers paid up to €1 (2,000 Tanzanian shillings) for each bag of shelled maize. In 2014, POMP was trialled again for maize shelling in the neighbouring Mbulu district. Costs incurred by farmers were found to be half of what they would normally have paid for manual shelling. In addition, the quality and profitability of the shelled maize grain was increased due to timely processing and reduction of contamination by dust and mould. More edible fodder of smaller sized pieces were available for feeding livestock.



For local entrepreneurs, owning and hiring out the processor provides a valuable business opportunity. The combined costs for a power tiller and a POMP amount to around €5,300; however, the income earning potential is good. Shelling 60 t of maize in 2013 earned farmers around €4,000, of which 40% was net profit. A key advantage of the equipment is its mobility. With most smallholders farming less than 5 ha in close proximity to each other, being able to move quickly between farms and villages in order to process relatively small quantities in an efficient manner is important for the viability of the business.

Taking POMP to scale

In 2014, having witnessed POMP in operation in Arumeru, the Farm Mechanization and Conservation Agriculture for Sustainable Intensification project ordered two machines to be constructed at CAMARTEC in Arusha. However, significant scaling-up of the technology now requires training of local manufacturers, so that these multi-purpose machines can become widely available in rural areas. No highly specialised equipment is required for the manufacturing process; tools such as angle grinders, pillar drills, welding equipment and metal sheet rolling machines – which are available in most local metal workshops – are sufficient for construction.

More work is needed in designing, building and field-testing prototype processing components for a wider range of crops. In-depth socio-economic and market studies are also needed to evaluate the cost-effectiveness and any potential barriers to wide-scale adoption of the technology, and to quantify the potential size of the market – not only in Tanzania but in other African countries.

Chelelang – the wonder bean: Improved beans outperform commercial varieties

Mbaka Njoka¹, Peter Kamau¹, Lena Kinyua¹, Mary Mwenda¹
and Bernard Towett²



Common beans (*Phaseolus vulgaris*-L.) are the most widely grown and consumed grain legume in eastern Africa. They are a vital source of protein, and also help to maintain the fertility of soils through nitrogen fixation. Beans are also the second most important food crop after maize. But yields have been on the decline in Kenya, averaging 350–750 kg/ha. Moreover, commercial varieties – traditionally grown by smallholder farmers for sale and for home consumption – are vulnerable to a number of pests and diseases that result in significant losses. These varieties are also susceptible to drought, which is occurring more frequently due to climate change. Although large parts of Kenya are suitable for bean cultivation, the country is a net bean importer. However, the combination of poor yields, and low tolerance to drought and pests and diseases have triggered innovation in bean production.

Breeding better beans

Improved bean varieties suitable for a wide range of farming conditions and locations in East and Central Africa (ECA) were developed by breeders and agronomists from the East and Central Africa Bean Research Network (ECABREN). Funded by ASARECA*, the breeders selected parent plants with the desired traits from bean varieties held by the International Centre for Tropical Agriculture. Sixty-four improved varieties were multiplied and distributed to farmers across the ECA region. In Kenya, this screening process led to the original 64 lines being narrowed down to 49, then to 25, 10, five,

¹ Kenya Methodist University, Kenya.

² Egerton University, Kenya.

and finally to just three lines known as Chelelang, Ciankui and TASHA. These top three lines were then sent to the Kenya Plant Health Inspectorate Service (KEPHIS) for final evaluation.

Once approved for release by KEPHIS, senior scientists linked with commercial seed dealers in order to multiply and supply superior variety seeds. This enabled farmers to grow the new varieties over several seasons in a wide range of environments with encouraging results. However, some varieties performed better than others in different environments. Chelelang proved to be the highest yielding variety of the three, averaging 1,750 kg/ha, with very wide adaptability enabling it to be grown in many different cropping zones with varying rainfall, altitude and other conditions. It also proved popular with farmers and extension workers because of its high tolerance to pests, diseases and drought, its uniformity at maturity, and in its ability to provide significantly more fodder for livestock. Chelelang beans produced over three times more bean haulms, than traditional varieties. The improved beans also had relatively high levels of zinc and iron, which are of particular importance for pregnant women and children under five.

Farmer-guided selection

There was need to create a multiplier effect so that more farmers will adopt the superior germplasm. This prompted the idea of using 'farmer-initiated bean selection' to improve understanding of which beans were most suitable for which areas, and also to scale up the cultivation of the improved bean varieties. In particular, agronomists, seed scientists and rural development specialists from the Kenya Methodist University in Meru county, and Egerton University in Nakuru, embarked on a Farmer Initiated Bean Selection Project in Isiolo and Meru counties where farmers intercrop beans with a variety of other crops such as maize, sorghum, cassava and banana. The FAIDA Seed Company supported seed multiplication and distribution. This collaboration between farmers, the private sector and the academic and research community motivated farmers to grow the new varieties, hence boosting national production and processing as canning companies are interested in purchasing the beans from farmers and possibly for exports. Looking more broadly, ECABREN researchers are aiming for the improved beans to be adopted by over 2 million farmers across the region in the next five years and for the canning industry to process the beans produced.



The farmer ownership model: Uganda's coffee revolution

Joseph Nkandu¹



In recent years, Uganda has seen a transformation in how coffee is processed and sold. This has brought significant benefits to smallholder coffee farmers and is beginning to inspire change in other commodity sectors.

Traditionally, coffee farmers have been price takers, selling their unprocessed coffee beans for whatever a buyer will offer. In many cases, farmers would sell their stake in the coffee beans even before they are ripened and at such low prices that they may not recoup their costs. However, change has been initiated by Joseph Nkandu, who realised that low coffee prices could only be overcome by farmers organising themselves into strong business groups and retaining ownership of their coffee beans much further along the value chain – potentially right up to when the finished product reaches the consumer.

Changing perspectives

Nkandu's 'Farmer Ownership Model' organises farmers at village level into groups of 25 to 35 members; at least 10 village groups then join together to form an association. Led by the National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE) over 700,000 farmers are involved in 175 associations.

Belonging to the network of associations allows farmers to access key services to add value to their coffee, including bulking and the first stages of coffee processing. Such benefits are then continued through NUCAFE, which works to increase farmers' productivity and income by adding value along the coffee value chain. Activities include providing secondary processing and manufacturing, training and marketing.

¹ National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE), Uganda.

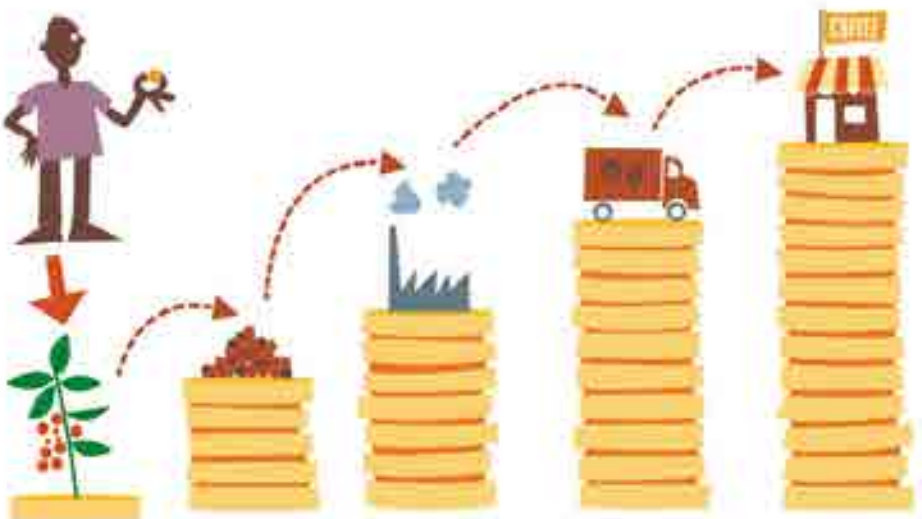


According to Nkandu, joining together under the Farmer Ownership Model has required a complete change in perspective. Farmers have come to appreciate that to be empowered, they need to work together collectively to change power relations in the coffee value chain.

A convincing example of the power of the farmers' collective voice came in 2008, at the 3rd Uganda National Coffee Farmers Convention, at which the Prime Minister of Uganda was guest of honour, and where the farmers demanded the formulation of a national coffee policy which would allow the smooth implementation of the farmer ownership model. Five years later – in December 2013 – the Ministry of Agriculture launched the National Coffee Policy, the first policy of its kind to be driven by farmers and unanimously supported by coffee sector stakeholders.

Completing the value chain

NUCAFE farmers have won the Uganda National Taste of Harvest competitions in 2012 and 2013/2014 for the best quality coffee. As a result, farmers have increased their incomes by at least 30% per kg of graded coffee. Through NUCAFE, coffee associations have also started selling coffee directly to coffee exporters and roasters, including the Italian coffee roaster Caffè River. Approximately 20,000 farmers have also benefited from an initiative to sell finished coffee directly to consumers, with 'amazing results' as described by Nkandu. The success has motivated them to invest in coffee processing infrastructure that will enable them to take responsibility for the complete value chain.



Kakooza Hassan Mulagwe of the Kabonera Coffee Farmers' Association in Masaka, a NUCAFE member, offers his own testimony to the value of the Farmer Ownership Model. "At every stage, from the household, group, association up to NUCAFE, there are well-structured administrative units to streamline the day-to-day activities," he says. There have been additional benefits as a result of the increased income earned from their coffee production: increased quantity and quality of coffee; construction of good houses; and improved schooling, transport and clothing.

Looking ahead, advocacy continues for the full implementation of the National Coffee Policy to empower over one million coffee farming families in Uganda over the next decade. Investment in processing infrastructure will also enable an increase in Uganda's domestic coffee consumption, reducing the sector's dependence on export markets. The Farmer Ownership Model has also been adopted for agribusiness development in other sectors besides coffee, notably by the Consortium for enhancing University Responsiveness to Agribusiness Development (CURAD), a public-private partnership initiative to attract young agribusiness entrepreneurs.

Cassava drying: From sun to steam

Samuel EB Nonie¹, Braima D James² and Samuel J Alpha³

A steam dryer is enabling smallholders in sub-Saharan Africa to increase their production of cassava flour, access higher-value markets and improve incomes. Using steam is a solution to currently inadequate solar-drying methods.

Rich in carbohydrate and an important source of energy, cassava is grown and consumed by millions in many sub-Saharan African countries. The root crop is very versatile and can be processed to provide a range of food products, confectionery, sweeteners, glues, plywood, textiles, paper, biodegradable products, monosodium glutamate and medicines. Cassava chips and pellets are also used in animal feed and alcohol production.

Adding value, from root to flour

Fermented Cassava Flour and the unfermented High Quality Cassava Flour (HQCF) are two important value added products. Unfermented, HQCF is gaining popularity on the market for its suitability as a wheat flour substitute in bakery and pastry products. Traditionally, the production of cassava flour involves grating fresh roots into mash, pressing the mash into wet cakes, sieving the wet cakes into particles, drying them to approximately 5% moisture content and milling the particles into flour. The process from harvesting the root to drying should be completed quickly – in 24 hours for HQCF – to assure product quality. Sun-drying the fresh root is slow; it may take 3–5 days depending on the weather, and is inefficient and impractical for year-round drying. Expanding the drying technology options is therefore a major linchpin for improving processing efficiencies. However, high-end dryers such as flash driers are unaffordable, motorised and expensive to maintain for small and medium enterprises in rural communities.



¹ Fourah Bay College, University of Sierra Leone.

² International Institute of Tropical Agriculture, Sierra Leone.

³ J&M Engineering Services, Sierra Leone.



Moving from traditional sun-drying to labour-saving and innovative steam drying technology

To address such challenges, a steam dryer has been developed by the University of Sierra Leone and the International Institute of Tropical Agriculture (IITA). The dryer comprises a steam-generating boiler connected to 1–4 drying chambers. Copper coils take steam from the boiler and circulate it through the chambers, releasing heat which dries the cassava. Excess water is driven off by an air current through narrow horizontal vents at the top and bottom of the doors.

About 350 kg of dried processed cassava can be produced per day when using two drying chambers containing 11 trays operating for 8–10 hours; one dryer has a surface area of 17m² and is operated by two people. Drying should no longer be a major bottleneck in the commercial production of sufficient quantities of quality cassava flour as it is predicted that cassava factories owned by smallholder farmers could produce between 1–3 tonnes of flour each day using the steam dryer. Since there are no moving parts and operational problems caused by friction are non-existent, it can be successfully used in rural areas. Contamination of the finished product is reduced and it is also gender-friendly.



Arrangement of the steam drying system

New possibilities for women smallholders

“My fellow women and I were in cassava flour production for over 2 years before the delivery of a steam dryer to our cassava factory,” says Hawa Bio, coordinator of the Muamia Women’s Cooperative in Bo district, Sierra Leone. “Daily flour production had been low: 100 kg every 2 days in the dry season and less than 25 kg over 3 weeks in the wetter months of the rainy season. Since IITA equipped our cassava factory with a steam dryer, we have experienced many benefits. Sun drying is no longer needed, minimising contamination from the environment. We make more cassava flour all year round – over 250 kg a day. Our cake business – with farm gate cassava processors – has been enhanced and flour production earns us more income than gari production. We also dry other food items such as mushrooms, pepper, cassava leaves and starch with the dryer.”

In Sierra Leone, the steam dryer is being used by seven smallholder cassava factories in selected areas in the northern, eastern and southern provinces, which were constructed with the support of USAID and the United Nations Industrial Development Organization. It is expected that when organised into associations, smallholder cassava factories using steam dryers would be able to compete with those using flash dryers and expand income opportunities for small-holder farmers.

M-fodder: Sourcing hydroponic fodder by SMS

Elvis Ouma and Angela Atieno¹



In Nakuru, Kenya, dairy farmer Harl Ochieng has seen a dramatic change in his milk production. As a keeper of dairy cows, his earnings from milk sales have risen by around 1000 Kenya shillings (€9) per day since he began feeding his animals with hydroponically grown fodder. The system he uses to obtain the fodder is also new: an innovation in mobile phone-based texting service called ‘m-fodder’.

The m-fodder service has been set up by Elvis Ouma, an IT specialist, and Angela Atieno, also IT-savvy

and with an interest in hydroponics, both from the University of Nairobi. Together, they have developed a fodder production and supply service which has already been adopted by around 200 Kenyan dairy farmers.

The hydroponic fodder system involves sprouting seeds in mineral-rich solution rather than soil. It takes 7–10 days for the grass (oats, wheat, barley) to reach around 45 cm high. Livestock keepers send a text to a call centre to order fodder 8 days in advance, stating their location and the amount of fodder they require; the cost of the text is €0.03. The call centre then forwards the message to a network of hydroponic fodder producers, and within 3 minutes the farmer can expect to receive a call from a producer to arrange the fodder delivery.

Growing more with less

The impacts of the system are impressive. Currently, many dairy farmers struggle to feed their animals consistently throughout the year, which severely affects milk production and income. Feed prices in Kenya have been rising steadily and, in dryland areas, feed may be extremely scarce at certain times of year. The trend for land to be broken into increasingly smaller units is also hindering fodder production, and the fodder that is generally available is often of low nutritive value.

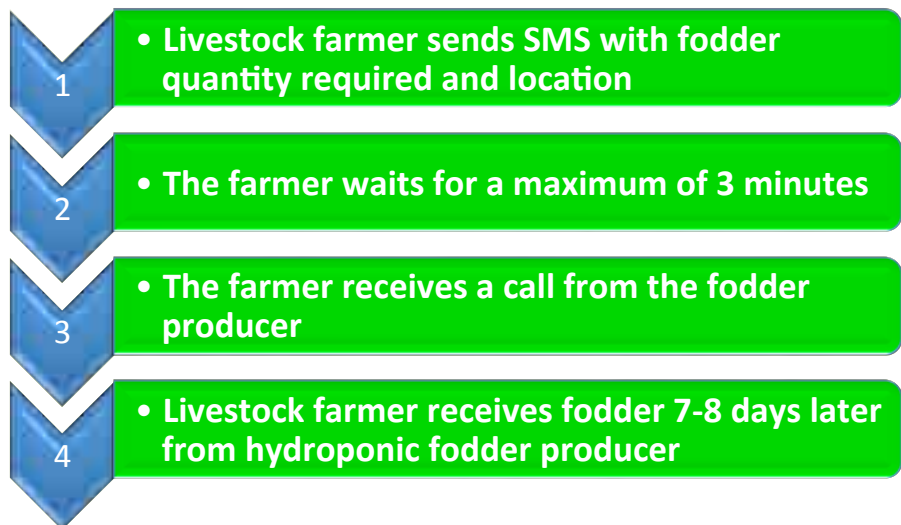
¹ University of Nairobi, Kenya.

In contrast, hydroponic fodder can be grown in a relatively small space: a 60 m³ area (5 m x 4 m x 3m) produces approximately 200 kg of fodder per day all year round. Nutritionally, hydroponic fodder is also superior to conventional fodder, with higher levels of protein and calcium, leading to an increase in livestock productivity. Kenyan farmers adopting the m-fodder system have witnessed a 40% increase in milk volume.

The adoption rate among smallholder livestock keepers who are introduced to m-fodder is 60–80%, not least because of the simplicity of the ordering system and the affordability of the fodder. There is also a web-based app which can be downloaded to farmers' smartphones, which includes a mobile payment platform enabling easy purchasing. Hydroponic producers are charged €6 per month to access the SMS database and pay a commission of 3% on all fodder sales to the m-fodder service provider.

The m-fodder developers believe their system, which they co-own, has the potential to link dairy farmers to hydroponic fodder producers across much wider areas, even across borders, given the widespread use of mobile phones in Africa. Livestock farmer, Harl Ochieng, offers his own endorsement: "M-fodder will enable more farmers to get real-time information on available fodder," he says. "I believe this will greatly impact their lives, as it has done to mine."

The developers have presented the M-fodder in several other countries; Tanzania, Botswana, Germany, Italy, Malawi, and Namibia, and the University of Nairobi has since adopted it for use with other types of fodder including lucerne and hay.



How M-fodder works

Innovative tropical weather forecasts for farmers

Liisa Petrykowska¹



For farmers worldwide, having access to reliable weather forecasts is a huge advantage as it enables them to make informed decisions about the timing of numerous activities, from production to harvesting. But for those living in the tropics, even the most reliable forecasts have typically been only about 40% accurate. Tropical weather is more localised. Unlike temperate/mid-latitude areas, where the weather is largely determined by areas of high and low pressure, over 99% of weather events in areas close to the equator are built by convective processes – i.e. by pockets of warm, rising air. As a result, these events could not be accurately predicted by the climate models developed for the temperate latitudes.

The iska™ weather forecast, which was launched in May 2013, represents an exciting development in tropical meteorology for Africa. Developed over a 4–year period by the private sector company Ignitia, the iska™ service is based on several key innovations. Firstly, Ignitia’s team of meteorologists and physicists carried out in-depth studies into

¹ CEO, Ignitia Ltd., Ghana.

the physics of convective weather development, which led to the creation of advanced formulae for weather prediction. Secondly, with tropical areas typically lacking the infrastructure for traditional weather data collection, the team also worked on a forecasting system based on data provided by satellites, combined with some non-traditional data – such as incidence of lightning which correlates strongly with heavy rainfall. In drawing on information provided by both European and US satellites, the team was able to optimise the data collected to the point where information from manual weather stations was no longer needed. Making the weather forecasts affordable, as well as accurate, was also a high priority so that the iska™ service could be available to small-scale farmers.

Significant amounts of time (and therefore expense) are usually spent to develop a forecast. Meteorologists need to make manual corrections of climate model data. But, by developing new software and methods, Ignitia was able to reduce the time taken per forecast to less than an hour, achieving a substantial reduction in costs. As a result, the entire iska™ system, from collection of data to delivery of forecast is around 99% automatic, making it highly cost-effective.

Daily forecasts by SMS

Launched first in Ghana to coincide with the rainy season of 2013, the iska™ service has been delivered in partnership with the MTN telecommunications company. During the 2013 season around 3,400 farmers subscribed to the service, receiving a two-day forecast on a daily basis for their precise GPS location, as well as a seasonal outlook and a predicted rainy season start date. Each daily forecast – delivered in the form of an SMS message – gives a prediction of rainfall probability (low, likely or high chance), whether the rain will be heavy, and approximate time when it will fall. Training was also given to farmers and their representatives to explain the concept of ‘chance’, and what it would mean to the crop cycle if rain were forecast. Subscribers paid just under €0.04 per SMS, deducted in micro-instalments from their pre-paid phone credit.

The degree of accuracy provided by the forecasts proved to be highly location dependent, and was generally lower in areas with more complex geography, for example where different features such as hills, lakes and savannahs were concentrated in a small area. Nevertheless, the service achieved an average 85% accuracy in its rainfall predictions, more than 40 percentage points higher than the best alternative forecasts. The service also had a less than 0.1% drop out rate among subscribers over the season, testimony to its value in supporting their farming operations. For instance, in northern Ghana, subscribers delayed their planting, having been alerted to the late arrival of the rainy season, and consequently managed to achieve a much better harvest than those who planted early.

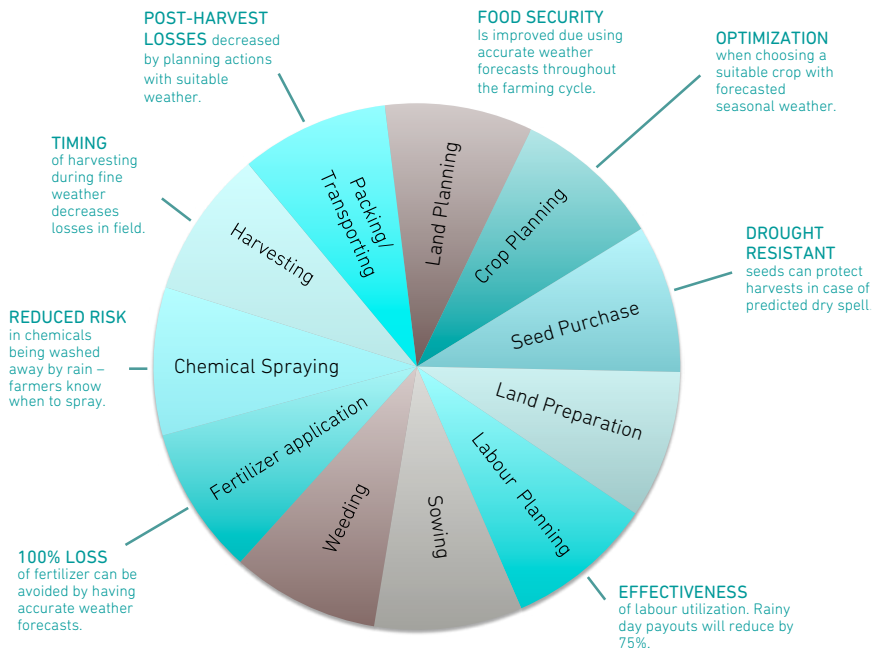
After the first season, Ignitia gathered feedback on the usefulness and accuracy of the forecasts through direct contact with subscribers and farming organisations based on a survey carried out by the Masara Narziki organisation. The report stated: “Over 90% of farmers actually did find the message useful and say they used it in determining how and

when to apply inputs in some sort of way. It also seems many farmers (81%) appreciate getting extension services on their mobile phone. This is positive for weather forecasting. Lastly, the comments made by farmers indicate they understand the positive effects weather forecasting can have for them and that they link it to both activity planning and optimising their input effectiveness.”

Rapid adoption

Building on their initial success, the iska™ service expanded considerably in 2014. Through inexpensive marketing tools, such as bulk SMS, awareness was raised among thousands more farmers. As a result, within the first 6 weeks of the rainy season, 9,000 subscribers were using the service, three times the anticipated number. In a pilot study of iska™ subscribers, 93% reported that they consulted the forecasts when planning their daily farming activities; the drop off rate for the service also remained very low – at less than 5% – and the accuracy rate was maintained, averaging 84% over the first two seasons.

Currently, work is progressing to translate the service into four local languages in Ghana, and to launch iska™ in Nigeria. Beyond this, the model is ready for use in a further 13 West African countries, dependent on Ignitia forming partnerships to support the roll out – including with NGOs, telecommunications companies and others in the private sector. Ignitia also plans to develop more advanced forecasting products, such as SMS-delivered crop forecasts based on satellite data and their unique forecasting model.



Benefits throughout the farming cycle

Lessons learned and implications for research, innovation and policy

Judith Ann Francis, CTA, The Netherlands

Key Lessons

1. When scientific, technical, local and business knowledge converge to drive innovation in agri-food systems, smallholder farmers benefit.
2. Clustering of smallholder farmers into producer business groups provides economies of scale and fosters learning and innovation.
3. For innovations to be scaled-up, they must be validated within a given context; deemed relevant, practical and cost effective, provide multiple benefits and attract investments.
4. An enabling policy, legal and regulatory framework, access to financial services and a well resourced knowledge infrastructure are critical for sustaining innovation processes.

Introduction

The *CTA Top 20 Innovations* project has demonstrated that innovation is taking place in agri-food systems and that smallholder farmers in the African, Caribbean and Pacific (ACP) Group of States are benefitting; socially and economically. All the characteristics normally associated with innovation – ‘new creations of knowledge’, have been exemplified. Stakeholders have optimized resources, scientific discoveries and technologies and created new forms of organization which have contributed to higher earnings, efficiency gains and cost savings; although in a nuanced way. Smallholder farmers have led the direction of search, in some instances, and have partnered with scientists and other stakeholders to overcome challenges and take advantage of opportunities.

The goal of the *CTA Top 20 Innovations* project was to boost awareness of the many innovations, ‘low hanging fruits’ that were benefitting ACP smallholder farmers. A sub-objective was to unearth research and development outputs including technologies that had been generated by universities and research organizations and were being used by smallholder farmers. The 251 ‘innovations’ that were received in response to the global call for submissions, were evaluated using different lenses and the final top twenty have been endorsed by the ACP farming, academic and research communities.

In a nutshell, the *CTA Top 20 Innovations* had to have value, not only for those who have generated and creatively used the available knowledge but also for a wider cross-section of agricultural stakeholders across multiple continents. These innovations are to be widely promoted to farmers, researchers/scientists, government officials, donors and

the private sector, and so too the lessons learned, to attract increased public and private sector investment for research and innovation. This responds to commitments that have been made by several ACP governments to enhance the performance of agriculture and related agro-food industries, improve livelihoods, increase incomes, achieve food and nutrition security targets and ensure eco-system sustainability. Scaling-out and scaling-up successful innovations is essential.

The 251 submissions

Within the last two decades, innovation systems thinking has pervaded the international science, technology and innovation agenda as well as the agricultural transformation agenda in ACP countries, but to a limited extent. This conceptual approach promotes innovation as a process and is much broader than technology adoption and technological change. In analyzing innovation processes, consideration has to be given to the inputs, the outputs and the context – specifically the stakeholders including their competencies and the policy and institutional framework that affects their behavior. The farm/firm is central to the innovation process; it is the enterprise that makes the final decision to innovate or not.

CTA received 251 submissions through the open call that was launched for innovations that were benefitting smallholder farmers in ACP countries. These were categorized, *inter alia* by, ‘type of innovation’, lead agency, intervention area and commodity focus. Four ‘types of innovation’ were identified: technological (53%), process (24%), organizational/institutional (19%) and social (4%); five submissions were not classified. The innovations were either; farmer-led (31.5%), research-led (28%), university-led (17%), NGO-led (15.5%), private sector-led (5%) or government agency or ministry-led (2.5%). Four main ‘intervention’ areas were determined: production including land and water management (53%), extension (15%), marketing (15%) and post-harvest (14%); and three percent (3%) were not classified. Sixty-nine percent (69%) of the innovations were commodity specific, namely livestock (14% e.g. cattle, pigs, poultry, small ruminants), cereals (13% e.g. rice, sorghum, wheat), legumes and high value crops (12.5% e.g. soybean, cashew, sunflower, flowers); root and tuber crops (9% e.g. potato, sweet potato, yam), vegetables (7%), fruits (5%), integrated crop/livestock/fish production systems (5%) and indigenous crops, oil palm and fodder (3.5%). The other 31% of the submissions addressed other agriculture related issues (e.g. irrigation, packaging, soil fertility). Women and youth were mentioned in 5.5% of the submissions in relation to technologies for reducing drudgery, empowerment, and skills development.

It has emerged, from the review of the submissions, that there is no ‘blueprint’ guiding the agricultural innovation process and more so for the benefit of smallholder farmers. The diversity has underscored the challenges to and opportunities for enhancing innovation in smallholder agri-food systems. Multiple and complex issues have to be addressed (e.g. cost of inputs – feeds, fertilizers, irrigation; versatility of equipment/machinery; quality of seeds/breeds; pest control; weather forecasting). Several sources of knowledge (e.g. scientific, local/indigenous) and entry points have to be exploited, demonstrating that both ‘the demand’ and ‘the offer’ – two important innovation drivers

– and other enabling factors have to be addressed in a more integrated manner to fuel the agricultural innovation process. A more joined-up approach is needed.

The CTA Top 20 Innovations

The rigorous evaluation process – firstly, by having the multi-disciplinary team of ACP and EU experts develop a shortlist of forty innovations and secondly, by having farmers’ organizations in Africa and the Caribbean, select the final top twenty from the shortlist – had its challenges. Agreement had to be reached on what constituted an ‘innovation’ and whether it had gone beyond the proof of concept phase. Consensus was also needed on the score and weight to be assigned to each evaluation criteria; technical/scientific merit, impact, originality and scalability. There were differences between the rankings of the African and Caribbean farmers’ organizations and between those of the farmers’ organizations and the multi-disciplinary team of experts. These were resolved through discussion and consensus building and resulted in general concurrence on the final *CTA Top 20 Innovations*. The difference in farmers’ innovation priorities between regions and those of the experts confirm that the context, the supply and demand and inherent biases of the various stakeholders are relevant when guiding the innovation process and in scaling-out and scaling-up innovation. The overview of the final *CTA Top 20 Innovations* is provided in Table 1.

Technological innovations led by universities and research centers were dominant and have generally responded to challenges impacting on farming communities. Farmer-led innovations were either organizational, process, social or technological in nature and driven by their need to overcome specific constraints, minimize risks, reduce costs, improve yields and increase earnings. Private sector-led innovations responded to commercial interests but were also underpinned by science and knowledge of the market conditions. The different motivations; scientists, farmers, private sector, as have been exemplified, correspond to the ‘science or technology push’ or the ‘demand pull’ nature of the innovation process. Yet, when all things are considered, smallholder farmers used the innovations and benefitted. A key lesson is that a combination of science, technology, local knowledge and business interests as well as organizational realignments, is needed for pursuing an innovation-led agricultural transformation agenda.

Scaling-out and scaling-up the CTA Top 20 Innovations

A wider group of multi-disciplinary experts, including intellectual property rights (IPR) lawyers, reviewed the *CTA Top 20 Innovations*, interrogated the case owners, and determined that the majority could be scaled-out and scaled-up but under certain conditions (Table 2). These essentially include, *inter alia*, capacity building, marketing and promotion, product and process standardization, additional research, product development and wider validation trials, IPR protection where applicable, and building partnerships with other actors especially the private sector for commercialization (going to scale) – expanding product offerings, ensuring reliability of supply and increasing market share even beyond national boundaries. The importance of science, good governance (e.g. regulations and standards), market research, economic analysis and involvement of the private sector are critical for scaling-up innovations.

Table 1: Overview of *CTA Top 20 Innovations* by type, intervention area, lead agent and impact

CTA Top 20 Innovations	Type of Innovation	Intervention Area	Lead Agent (impact)
Cowpea then maize	Process	Production (planting)	Farmer-led (increased yields)
Farmerline	Technological	Extension	Private sector (increased yields and income)
Barakuk	Technological	Pre-production (pest control of stored seeds)	Farmer-led (low cost pesticide; quality seeds; increased yields)
Biological control of the millet head miner	Technological	Production (pest control)	University & research organization (low cost pesticide; increased yields)
Sunflower water pump	Technological	Production (irrigation)	Private sector (low cost irrigation; increased yields)
Chinadango local fertilizer	Technological	Production (fertilization)	Farmer (low cost fertilizer; increased yields)
Protecting Mali's river: Bio-herbicide	Technological	Environmental protection	Research organization & university (low cost bio-herbicide; improved livelihoods)
Extension goes digital	Technological	Extension	NGO (improved innovation capacity)
Rural resource centre	Social & Organizational	Extension	International research centre (improved innovation capacity)
More productive local chicken	Technological	Pre-production (improved breeds)	University (increased yields & income)
Low-cost feed for chicken farmers in Papua New Guinea	Technological	Pre-production (local feed substitute)	Research organization (reduced cost of production)
Climate-smart hydroponics	Technological	Production (planting)	University/college (increased yield and income)
Controlling Aflatoxin	Social & Technological	Value chain	NGO & university (increased yield & income and improved food safety)
Producer business group for value addition	Organizational	Value chain	Farmer (improved market access & increased income)
POMP – Adopted technology	Technological	Post harvest	Mechanical/engineering (increased productivity/ yields & improved product quality)
Chelelang – the wonder bean	Social & Technological	Pre-production (improved seed)	University/research (increased yield & processing)
The farmer ownership model	Organizational	Value chain	Farmer (increased income & value addition; policy change)
Cassava drying: From sun to steam	Technological	Post harvest	University & research (improved productivity, yields, product quality)
M-fodder	Technological	Production and marketing	University (improved productivity & yields)
Innovative tropical weather forecasts	Technological	Pre-production (planning; planting)	Private sector – but underpinned by scientific research (improved efficiency)

Table 2: Scaling-out and scaling-up the *CTA Top 20 innovations**

CTA Top 20 Innovations	Scaled-out?	How?	Scaled-up? IPR?	Research & Development?	How?
Cowpea then maize	yes	Farmer field school; demo plots; model farmers	yes; no IPR	Validation trials & under various soil types & with other crops; cost/benefit analysis	Partner with universities/research organizations
Farmerline	yes	Marketing & promotion	yes; IPR (patent)	Cost/benefit analysis & market study - wider range of services & target groups	Expand offerings; partner with private sector
Barakuk	yes	Farmer field schools; model farmers; document & promote impact stories	yes; IPR (patent)	Chemical characterization; product & dosage standardization; shelf life testing; economic analysis	Commercialize; package, label & brand; partner with private sector
Biological control of the millet head miner	yes	Awareness campaigns; document & promote impact stories	yes; IPR (patent)	Product standardization; environmental impact & economic feasibility; market analysis	Commercialize; partner with private sector
Sunflower water pump	yes	Awareness campaigns; producer business group, document & promote success stories	yes; IPR (patent)	Improve robustness; expand use to deeper well; install battery to store solar energy	Expand unit production; develop distribution channels; partner with other actors
Chinadango local fertilizer	yes	Model farmers; demo plots	yes; no IPR	Chemical & soil analyses; product standardization; Evaluate under multiple soil types	Commercialize. Improve packaging & branding
Protecting Mali's river: Bioherbicide	yes	Awareness campaigns; document & promote success stories	yes; IPR (patent)	Chemical characterization & environmental impact assessments	Partner with universities/R&D organizations in other countries; standardize product; partner with private sector
Extension goes digital	yes	Awareness campaigns; document & promote success stories	yes; IPR (patent)	Sustainability issues; farmers' ability to pay	Partner with farmers & development organizations and governments
Rural resource centre	yes	Awareness campaigns; document & promote success stories	yes; no IPR	Sustainability issues; farmers' ability to pay	Partner with farmers' & development organizations and governments
More productive local chicken	yes	Increase availability of cross-breeds; awareness campaigns; document & promote success stories	yes; IPR (breeders' rights)	Advanced breeding techniques/genetic engineering	Partner with regional and international R&D organization; commercialize – partner with private sector

CTA Top 20 Innovations	Scaled-out?	How?	Scaled-up? IPR?	Research & Development?	How?
Low-cost feed for chicken farmers in Papua New Guinea	yes	Training; farmer field days; trade fairs; document and promote success stories	yes; IPR (patent)	Chemical & nutrient analysis; growth rate	Commercialize – partner with private sector feed mills
Climate-smart hydroponics	yes	Trade fairs; farmer field days; document & promote success stories	yes; IPR (patent)	Reduction in unit costs; operational efficiencies under environments	Partner with private sector
Controlling Aflatoxin	yes	Awareness campaigns; farmer field school & days; document & promote success stories	yes; no IPR	Protocols applied to other crops & other countries and regions	Partner with development agencies, farmers' organizations, universities and R&D organizations
Producer business group for value addition	yes	Strengthen governance of cooperative; develop expansion strategy to include more groups	yes; no IPR	Farmer adoption & satisfaction surveys; returns on investments for farmers	Branding & marketing; partner with universities; R&D organizations & other farmers'/commodity organizations
POMP – Adopted technology	yes	Trade fairs; farmer field days; document & promote success stories	yes; IPR (patent)	Cost/benefit analysis	Commercialize; partner with private sector
Chelelang – the wonder bean	yes	Increase seed availability; farmer in seed production	yes; IPR (breeders' rights)	Economic analysis; seed viability testing; nutritional analyses	Commercialize; partner with private sector; expand seed distribution
The farmer ownership model	yes	Awareness campaigns; Document & promote impact stories	yes; no IPR	Farmer adoption & satisfaction surveys; returns on investments for farmers; comparative analysis with other models	Promote and showcase success stories & benefits
Cassava drying: From sun to steam	yes	Trade fairs; document & promote impact stories	yes; IPR (patent)	Cost/benefit analysis	Partner with private sector
M-fodder	yes	Trade fairs; model farmers; document & promote impact stories	yes; IPR (patent)	Cost/benefit analysis	Partner with other private sector actors and farmers' organizations
Innovative tropical weather forecasts	yes	Trade fairs; model farmers; document & promote impact stories	yes; IPR (patent)	Cost/benefit analysis; continuous evaluation of higher accuracy	Partner with other private sector actors & farmer's organizations

* Integrates the feedback of the senior level ACP and EU experts attending the CTA 2014 International Forum Unleashing Science, Technology and Innovation for Food and Nutrition Security - with special focus on Africa, Caribbean and the Pacific.

Conclusion

The *CTA Top 20 Innovations* project has demonstrated that agricultural innovation is taking place in diverse ACP smallholder agri-food systems and that multiple challenges are being addressed. Smallholder farmers are generating, adopting and modifying technologies, creating new forms of organizations, improving processes and expanding options. While the capacity to generate and/or access knowledge and use it creatively and effectively exists, and is contributing to improving livelihoods and ensuring the sustainability of ACP agri-food systems, the cumulative impact of innovation; be it technological, process, organizational/institutional or social, is small. The capability to innovate and scale-up innovation needs to be strengthened if the ambition of 'leap-frogging' ACP agriculture into the 21st century is to be realized.

The CTA project has also confirmed that technological innovation alone, even when technologies are combined (e.g. *CTA Top 20 Innovation* M-fodder; hydroponics and mobile phones), will not deliver the much-needed agricultural transformation and socio-economic development. For smallholder farmers to take advantage of knowledge and technologies including ICTs and innovate, an enabling policy and institutional framework and a well-resourced knowledge infrastructure are also necessary, especially when going to scale. For example, to scale-up M-fodder, private sector investment and IPR issues must be addressed. The *CTA Top 20 Innovation* NUCAFE also showed that by restructuring and strengthening the farmers' organization, farmers access to inputs, technologies and markets was increased, which enabled them to capture more profit along the value chain. Hence, while a technological push is necessary to modernize ACP agri-food systems, other forms of innovation – organizational, institutional and social – as well as the supply and demand factors, including a well-resourced knowledge infrastructure and well-functioning markets, must be addressed to drive the agricultural innovation process.

The CTA project has also shown that the genesis of innovation does not only lie in scientific and technological breakthroughs. While research and technology development remains important, farmers' knowledge, traditional practices and willingness to experiment, confirm that local knowledge is valuable in driving innovation. For example, the *CTA Top 20 Innovation* Barakuk powder for reducing pest infestation on stored onion seeds; *CTA Top 20 Innovation* - Cowpea then maize, and the *CTA Top 20 Innovation* Chinadango low cost organic-inorganic fertilizer mix, all had their genesis in farmers' and traditional knowledge and farmers' willingness to experiment. However, scientific research, product and process development and validation trials under varying conditions and economic and market analyses are vital to support the business case for commercialization and scaling-up these innovations. On the other hand, the *CTA Top 20 Innovation* Innovative tropical weather forecasting, though underpinned by science and offering a technological solution for addressing a major challenge, needed to be validated at the farm level to attract additional public and private investments for going to scale.

Farmers' willingness to purchase technologies (e.g. *CTA Top 20 Innovation* Sunflower water pump), pay for accessing services (e.g. *CTA Top 20 Innovation* Innovative tropical weather forecasting) and replicate innovations (e.g. *CTA Top 20 Innovations* Cowpea then maize; Chinadango local fertilizer and Climate-smart hydroponics), demonstrate the need for innovations that are affordable and for innovative financing mechanisms when scaling-up. The policy and institutional framework for attracting and sustaining investments for enhancing agricultural innovation in ACP agri-food system must be strengthened.

In conclusion, the agricultural transformation agenda must be in tandem with education, trade, fiscal, science, technology and innovation policy priorities. Policy instruments and programmes should be responsive to the peculiarities and the differing contexts of the ACP agri-food system which is populated by smallholder farmers. They must be flexible and ensure that all stakeholders especially smallholder farmers can take advantage of the opportunities for 'leap-frogging' ACP agriculture into the 21st century. The agriculture innovation process must be inclusive; take on board, farmers' circumstances and adopt a longer term perspective. New capacities for research, science, innovation and business need to be developed and nurtured and the knowledge infrastructure to support the domestication of the innovation systems approach, strengthened. Policy coherence, strategic visioning, increased investments in research and innovation are urgently needed.

CTA Top 20 Innovations that Benefit Smallholder Farmers

About the Publication

This publication showcases the *CTA Top 20 Innovations* that are in use by farmers across Africa, Caribbean and the Pacific (ACP) of States. It is the direct output of the call for proposals for the *CTA Top 20 Innovations that Benefit Smallholder Farmers* that was launched in December 2013. The *CTA Top 20 Innovations* were selected through an exhaustive process from among the 251 submissions that were received. An initial screening resulted in a shortlist of 70 which were evaluated using an established scorecard. An expert group then selected 40 innovations using agreed criteria which were further evaluated by members of ACP farmers' organizations who selected the final *CTA Top 20 Innovations* also using agreed criteria. Authors and case owners of the *CTA Top 20 Innovations*, technical experts, editors and designers worked together in the preparation of guidebooks, factsheets and posters during a *CTA Top 20 Innovations Cross-learning Write-shop* which was held from 13-17th October, 2014 in the Netherlands. The *CTA Top 20 Innovations* have been endorsed by lead organizations in ACP countries.

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