



Bringing Science  
to Communities:

# Voices from the Field



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# Foreword

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) – a network of 85 universities in 35 countries in Africa – is happy to launch this new publication series, *Bringing Science to Communities: Voices from the Field*. This popular science communication product is intended to showcase the on-the-ground impact of research and scientific work of RUFORUM-sponsored graduates and their mentors and others they interact with. African universities



are increasingly embracing experiential learning as a key strategy for addressing gaps in higher education and training. Experiential learning addresses the challenge of producing proactive graduates with adequate skills to serve relevant stakeholders, including agricultural practitioners and communities working at grassroots level.

This publication series addresses concerns that university research findings are for the most part written in a language not easily understood by end users; the series will showcase, in popular and accessible language, examples of where RUFORUM alumni and other beneficiaries are using science and innovation to solve real problems faced by communities. This product is timely because stakeholders, eager to see more accountability for each dime invested, are asking critical questions about the impact of investments made in higher education and in science, technology and innovation (STI). It is, therefore, anticipated that *Bringing Science to*

*Communities: Voices from the Field* will serve as a gateway for university research findings into the mainstream uptake pathways and industry for enhanced adoption, thus demonstrating the role of universities in deploying STI to transform Africa into a knowledge-based economy.

This inaugural issue features the research of 13 RUFORUM alumni whose work has had a direct, positive impact on particular communities or industries. The topics covered range from fighting chronic malnutrition using indigenous and alternative foods such as insects, to deploying innovative technologies to reduce post-harvest losses in the horticultural sector. Other topics have implications for health as well as economic and environmental stability and food security. Above all, this publication highlights the role of science and its application in simple ways to solve bigger problems. The stories and photographs highlight a variety of ways in which science and science innovation are proving key to solving hitherto-insurmountable problems in Africa.

I hope you enjoy the read as we celebrate together the benefits that STI continues to manifest towards improved livelihoods for millions and towards the achievement of Agenda 2063 – The Africa We Want.

**Prof. Adipala Ekwamu**  
**RUFORUM Executive Secretary**

# An overlooked remedy for food insecurity: The case of crickets

***Carolyn Kipkoech shares how her passion for disease control in children led her to discover an unusual remedy for child malnutrition.***



Insects are a delicacy in many parts of the world, including Africa, but for many communities in Africa they do not constitute a major component of the diet. Crickets in particular have higher quality animal protein than some conventional sources, such as fish, and are more affordable in poor communities. Additionally, they thrive in various environmental conditions (including dry areas), multiply in a short time span (two months), require very little space, and feed on organic waste that they turn into high-quality protein. They can thus serve as a viable solution to food security challenges. Given the nutritional importance of crickets and other edible insects, I am keen, as a young researcher, to build a research agenda on the use of insects as food.

As a student, I always had a passion for disease prevention. That is why, after graduating in 2005 with a bachelor degree in microbiology from



JKUAT (Jomo Kenyatta University of Agriculture and Technology), I went on to a master of science in immunology at Moi University (from which I graduated in 2009). Thereafter, I worked with the Academic Model Providing Access to Healthcare (AMPATH) Programme, which exposed me to the broader field of public health, although still with a focus on disease prevention though improved nutrition.

In 2015 I was awarded a Danida scholarship through the GREEINSECT research project to undertake a PhD in food science and nutrition at JKUAT. For my thesis research, I am working on 'Use of edible crickets to improve child nutrition in Kenya'. My inspiration for this topic was derived from the fact that house crickets (*Acheta domesticus*), common across Africa, are a highly valuable yet neglected source of protein.

When I began my research on crickets, many of my friends and colleagues at the university wondered what I was up to. To them it was a laughing matter. Nonetheless, I soldiered on – and the first time I harvested crickets, everyone I ran into on campus stopped to look. I smiled as I proudly showed off the crickets, and some people even followed me to the lab to see what I would do next.



*House crickets*

“*We actually have plenty of food around us, but we do not exploit it.*”

Back at the lab, I immersed crickets in hot water for a minute and then set them out to sun-dry for grinding into a powder/flour to be used in making porridge, cookies and other sweet delicacies. Others I deep-fried to produce crispy crickets that would be eaten whole (by those brave enough). To my surprise, the deep-fried crickets were everyone's favourite because of their delicious aroma and taste.

The biggest endorsement of our cricket products occurred during the Sixth Tokyo International Conference on African Development (TICAD-VI), held in Nairobi in 2016. At a conference pre-event hosted at JKUAT, the vice-chancellor invited the conference participants to sample our crickets. Almost unbelievably, everyone was keen to have a taste, and sampled not once, not twice, but repeatedly, until no more remained! The enthusiastic reception of the cricket snack could also be attributed to the presence of participants from different countries, continents and cultures, some of whom had tasted crickets before, which helped to demystify their consumption as food.

Thereafter, the cricket snacks were in high demand at JKUAT and its environs, and the story made news in the Kenyan media.

With global population levels rising all the time, one of the strategies for improving food and nutrition security is to diversify diets using available food sources. We actually have plenty of food around us, but we do not exploit it. I look forward to the day when crickets will be widely accepted across cultures in Africa and the world over as part of the daily diet, so that more people will get access to quality, affordable protein.

Kenya is already taking modest steps towards exploiting the high protein value of crickets by using them in initiatives to address child malnutrition; a pilot project in Uasin Gishu County is currently providing cricket porridge to school-going children between the ages of 3 and 5 years. It is my wish that other countries and communities will follow suit and make use of this wonder food. 🌱

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## Deploying local solutions to global challenges:

### The secret contribution of locally available foods

***Mary Marcel shares insights on how to use locally available nutrient-dense foods to make a composite porridge flour that can be used in complementary post-weaning feeding.***



Wesley Charles, former National Director of World Vision, argued:

“ Nutrition is the basis of all our interventions with the children. If we don’t address adequately the nutritional needs of the children, our interventions may be jeopardized and the desired impact on the children’s condition jeopardized. Addressing the nutritional needs of our children means that we will be targeting the child in the context of his or her family and his or her community. ”

Taking this advice to heart, Tanzania has, through its national institute, the Tanzania Food and Nutrition Centre (TFNC), based in Dar es Salaam, been at the forefront of international efforts to promote a conceptual framework for nutrition. This is because good nutrition is both



a prerequisite for optimal human health and a key determinant of development for children and for society in general.

Poor diet and malnutrition have been the biggest factors responsible for the global burden of disease. Poor nutrition in the first 1,000 days of a child's life leads to stunted growth, which is irreversible and associated with morbidity, impaired cognitive ability, reduced school and work performance, and even mortality. Tanzania has experienced high levels of malnutrition, with children younger than 5 being the most seriously affected.

While the majority of children in Tanzania are born with the recommended weight of 2.5 kg and start their lives in sound health, their growth starts to decline during and/or after the introduction of complementary foods. Protein, energy and micronutrient deficiencies (mostly iron and zinc) also become a serious problem, as most of the complementary foods consumed do not supply adequate amounts of these nutrients.

The most widely used weaning foods in Tanzania are based on cereal and non-cereal substances such as maize, sorghum, millet, rice, cassava, potatoes, yams and plantains. There is a high rate of childhood undernutrition associated with the use of these starch staples in complementary feeding. Furthermore, such foods are high in phytates, which bind to and limit the absorption of nutrients such as iron, calcium, zinc, and in some cases proteins, which



*Amaranth grain*



*Pumpkin seed*



*Orange-fleshed  
sweet potato*



*Soybean*

are crucial to the infant development. Fortified, nutritious commercial complementary foods are available in cities but unavailable in the rural areas; where they *are* available, they are often too expensive for most families. Consumption among children of micronutrient-dense foods (e.g. animal products) is low and as a result micronutrient deficiencies are widespread.

This does not mean that there are no alternative foods that are affordable, locally available and easily adopted so as to improve the nutritional quality of the porridge used. Such foods *are* locally available – but their use in complementary feeding and their nutritional benefits are still unknown among the people.

After much research, I came up with the idea of using locally available nutrient-dense foods such as orange-fleshed sweet potato, soybean, pumpkin seed and amaranth grain to develop a nutrient-dense porridge flour that could be used in complementary feeding in Tanzania. The project was successful; the formulated porridge flour, when compared with the most commonly used flour from the market, was found to be richer in all nutrients assessed and to have a shelf-life stability of more than a month. Moreover, when compared with the porridge made from the commonly used flour, the porridge made from the formulated flour was mostly found to be acceptable in terms of sensory factors such as smell, texture and taste.

Therefore, we can still rely on our locally available foods to improve the nutrition status of our children and communities as a whole: local foods are affordable, available and user-friendly. 🌱

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## Can feeding young children a porridge made from insects improve their health status?



***Mercy Mmari reveals a cheap way to fight child malnutrition using locally available edible insects.***

Why does it seem so hard to eat edible insects, when they have been eaten by humans since the dawn of time? Critically examining our food choices, we can conclude that in most instances they are limited by our attitudes. Indigenous protein-rich foods, such as the edible insects common to many African countries, are overlooked and ignored, even as general rates of protein energy deficiency increase and children's diets run short of energy, protein and essential nutrients.

Edible insects, being rich in protein and essential fats, could play a significant role in supplementing plant foods for improved diets; the traditional complementary foods (for infant feeding) in most sub-Saharan African countries are deficient in protein, essential minerals and vitamins, resulting in sub-optimal growth and increased premature deaths among children younger than 5. Why not then overcome any sense of disgust

and use edible insects that are culturally acceptable in our societies to formulate food for children and reduce malnutrition rates?

In my MSc work, I used a case study of *senene* from Tanzania, a common edible longhorn grasshopper (*Ruspolia differens*), to enrich complementary food made from plant sources. *Senene* is one of many edible insects consumed by communities around the Lake Victoria Crescent and is known and revered as a traditional delicacy of the Haya tribe of Tanzania. The consumption of *senene* has been steadily increasing and spreading

to other ethnic groups and it is now common to find it with street vendors and at the supermarkets and stores in big cities. As urbanisation increases, cultural acceptance of *senene* is reaching new heights; no matter where it is being held, a Haya wedding is not complete without a bowl of *senene* offered at the entrance.



Mercy Mmari visiting the market to source long-horned grasshoppers, also known as *senene*

I studied both cultural attitudes towards the use of *senene* as a healthy food, and various processing

methods, to ascertain if it is fit for consumption by children. Porridge flour was developed from *senene*, soybeans and sweet potatoes mixed in different ratios to provide sufficient energy for a child aged 1–3 years. The porridge flours were tested to ensure they were nutritious and met safety standards. None of the three formulated flours were found to contain harmful microorganisms. The flours were also subjected to sensory evaluation to ascertain if their smell, taste, flavour and texture were similar to those of conventional infant foods. Finally, the flours were stored under

normal shelf conditions to see if they would remain fresh for at least five months of storage, and they did; after five months on the shelf, all the flours were still acceptable to the consumers.

The research highlighted five forms of *senene*, with traditionally made traps being used for commercial harvesting, and wild collection being done for household consumption. There were found to be two annual swarming seasons: April–June being the longest; and November–December being characterised by heavy rainfall and hence high volumes of *senene* swarming, with this season reaching its peak around 9 December. This day is also an important national holiday in Tanzania: Jamhuri Day.

The research also highlighted interesting traditions and taboos associated with the consumption of *senene*, and different processing and preservation methods were identified: boiling, toasting, deep-frying and smoking.

The flours formulated with *senene* were found to have nutrient and energy levels superior to commonly used flour from the market. Just a handful – 100 g – of *senene* proved capable of meeting the relative dietary allowance requirements of a child of 6 months–1 year.

When conducting the consumer acceptability study, I was worried that the flours might have a ‘*senene*-like’ smell and deviate significantly from consumers’ experience of normally consumed flours. Surprisingly, however, the flour with more *senene* (25%) was the most favoured, although the



*Fresh senene*



*Toasted senene*



consumers could not differentiate the formulated flours from the common flour to which they are accustomed. The mothers and children who had the opportunity to taste the porridge accepted it with enthusiasm. So yes, insects can stave off malnutrition – so why not use them to benefit our children?

Since it has been proven that the exploitation of *senene* as a source of nutrients for complementary food formulation is useful and beneficial for

resource-poor farmers, it would make sense to undertake further studies, with the aim of improving the existing indigenous technologies for harvesting, processing and preserving *senene* to fit current food-processing standards. Ultimately, the findings will

promote commercialisation of edible insects from being ‘just a bug’ to being a valuable component of food and nutrition security. 🌱

“ *Edible insects, being rich in protein and essential fats, could play a significant role in supplementing plant foods for improved diets.* ”

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## Towards achieving food and nutritional security: **Combating the scourge of cowpea scab disease in Uganda**

***Dr Emmanuel Afutu, a plant breeder and biotechnologist, talks about the fight against the cowpea scab disease.***



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*And he gave it for his opinion, that whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together.*

*Jonathan Swift (1667–1745)*

”

Though dating from long ago, this quotation suggests the very significant contribution that scientists and, for that matter, plant breeders would make were this to be achieved – that is, making two ears of corn grow upon a spot of ground where previously only one grew. My motivation for

a PhD study in the area of plant breeding and biotechnology was largely drawn from this quotation from Swift.

While the world's population is projected to reach 9.7 billion by the year 2050, the area of arable land under food production is not increasing at a commensurate rate. In addition, crop production is hampered by significant challenges, chief among them being changes in climate, the incidence of diseases, and the prevalence of pests. The result is that most countries of the world, and especially those in sub-Saharan Africa, live with food

and nutritional insecurity. One of the crops with the potential to play a dual role in helping to achieve food and nutritional security in Uganda and the sub-region as a whole, however, is the cowpea.



*Cowpea plant affected by cowpea scab disease*

Cowpea (*Vigna unguiculata* L. Walp) is the third most important legume food crop in Uganda. However, its mean yield is less than 400 kg/ha, although the crop has a yield potential of 3,000 kg/ha. The vast difference between achievable yields and current yields on farmers' fields has been attributed

to a number of factors, but most significantly the cowpea scab disease. Cowpea scab (*Sphaceloma* sp.) is a seed-borne fungal disease capable of causing yield losses of up to 100% as it affects all the above-ground parts of the cowpea plant. There has been a resurgence of the disease in Uganda leading to significant yield losses in farmers' fields. The seed-borne nature of the disease, in combination with other factors, has meant there has been little success in managing the disease. While the use of resistant cultivars in disease management is favoured as the most practical approach, because it is easily adopted and more environmentally friendly, only one out of the five improved cowpea cultivars released in the country in the past ten years proved moderately resistant to the disease.

The National Semi-Arid Resources Research Institute (NaSARRI) in Serere (Eastern Uganda) and the Department of Agricultural Production of Makerere University, Kampala, teamed up to conduct research into the dynamics of the scab disease and develop resistant cultivars for release to farmers in Uganda. The research group conducted field surveys of farmers' fields across different agro-ecological zones in the country, employed both morphological and molecular approaches to collect infected plant parts for isolation and characterisation of the scab fungus, and screened a total of 100 cowpea lines under different agro-ecologies for sources of resistant genes. Promising lines identified were further challenged under controlled environmental conditions using isolates obtained from the different locations, in order to help identify cowpea lines with wider horizontal resistance genes, for introgression into the current farmer-preferred but susceptible varieties and to determine the heritability and gene action of the genes that control resistance to scab disease.

Through this concerted breeding effort, six cowpea lines were developed. Preliminary trials at different locations across the country have revealed that these new lines have wider horizontal resistance to the scab disease and can produce grain yields of 330–623 kg/ha more than the yield potential of the highest-yielding improved varieties currently under cultivation in the country.

The new lines are currently under advanced yield trials across the country as part of the processes required towards their release for cultivation in the country. Once released, these new varieties will contribute to achieving both food and nutritional security in Uganda through the cultivation and consumption of the cowpea crop. 🌱

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## Prolonging post-harvest freshness: The physiological deterioration of Nakati, and understanding farmers’ preferences

***Pamela Kabod is using genetic improvement to tackle the issue of shortage of fresh vegetables at markets.***



The market in downtown Kampala is teeming with men and women eager to complete the daily purchase of fresh food with a portion of freshly harvested Nakati (*Solanum aethiopicum* Shum), a nutritious local green leaf vegetable popular in central Uganda. The vendors are carrying out brisk business before the heat of the day when the vegetables will not be as appealing to customers and they will have to keep sprinkling water on them to keep them looking fresh. By evening, these vegetables, only a day old, will be rejected and find their way to the huge piles of decaying leftovers from previous days.

There is an increasing demand for foods rich in micronutrients – especially fruits and vegetables – as knowledge about wellness becomes widespread

among urban dwellers, especially the increasing population of the middle class. Green leafy vegetables are easily available and at the same time highly perishable. Quality attributes are important for producers and end users alike: farmers, traders and consumers in the vegetable value chain. Currently, Nakati is a leading local short-season vegetable in terms of income but it remains fresh for only a day after harvest. Producers make about US\$2,000 a season (which lasts eight weeks). Farmers and traders along the vegetable value chain have to sell the commodity in the first few hours after harvest or risk losing their income due to rapid decline in the vegetable's freshness and corresponding taste. In a search for ways to improve and maintain the quality of this green leafy vegetable, it is suggested that inherent plant characteristics as well as environmental effects might be pivotal in determining its shelf life after harvest.

Nakati as a crop has not previously benefited from research efforts especially for crop improvement. This status though is changing as various actors have embarked on research activities in crop improvement for its efficient consumption and utilisation. Under the project 'Enhancing nutrition security and incomes through adding value to indigenous vegetables in East and Central Uganda', in 2014 a research team of Uganda Christian University initiated research activities for prolonging the shelf life of Nakati after harvest. My research is supported within this project and my aim was to understand the processes involved in prolonging post-harvest freshness of Nakati.

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*There is an increasing demand for foods rich in micronutrients – especially fruits and vegetables – as knowledge about wellness becomes widespread among urban dwellers.*

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As one of the starting points among the main activities, between 2015 and 2016 vegetable farmers in Eastern and Central Uganda were engaged



in participatory varietal selections, the main aim being to learn which among various local lines of Nakati varieties perform well on-station and on-farm and to obtain feedback from the farmers (potential end users). In this activity, farmers, scientists and local leaders together formulated the objectives of the participatory varietal selections, the activity plans, the roles and responsibilities of members and small working groups

among the farmers (to maintain the gardens) and working guidelines. The farmers provided the land on a hire basis for on-farm demonstration gardens and also established their own home gardens of preferred vegetables from the collection.



*Pamela Kabod in her garden*

Demonstrations and training interventions were an important component of the participatory varietal selections process. The training was multi-disciplinary along the vegetable value chain; it included agronomy and related

topics such as safe agro-chemical use; seed processing; nutrition and appropriate cooking methods; post-harvest handling; storage and preservation; leadership and gender issues. Safe use of agro-chemicals, for example, focused on the dangers of misusing them, the selection of the right products, their application, and first aid. Demonstration gardens were laid out for ten types of Nakati. Participatory varietal selections were done and evaluation data on farmer perceptions were collected using focus-group discussions, key informant interviews and sensory taste panels from germination, during the vegetative growth stage and at harvest.

The farmers generated a list of their preferred physical characteristics in the vegetables and then scored them for agronomic traits such as seedling vigour, plant height, branching habit, harvestable weight, and leaf area/



size, and quality traits such as keeping quality (shelf life), colour, texture and leaf colour. Fifteen farmer selection cues were identified, with the majority (13 of 15) being seedling and vegetative traits. This observation could explain why these vegetables are usually harvested and eaten before physiological maturity but also their poor keeping quality. At germination, emergence time and seedling vigour ranked highly. Tolerance to non-biological stress, leaf size, plant height and market preference were highly ranked at vegetative stage. Also, among commercial farmers, important characteristics for consumers – e.g. leaf colour – were found to be vital, implying that the market strongly influences farmers' selection cues. In terms of taste traits, moderately bitter, tender, and sweet odour were the preferred farmers' cues. This has enabled me to understand what cues inform Nakati vegetable farmers' selection criteria – i.e. their perceptions and preferences



*Crossover of fieldwork and lab work*

– in terms of which Nakati is suitable for what purpose. Farmers finally selected their three best Nakati varieties on the basis of their preferences, and these lines are now being advanced in further studies aimed at improving the crop through breeding.🌱

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# Pioneering a new paradigm of sunburn mitigation in apples

***Anthony Mwije suggests an alternative solution to ‘shielding’ apple fruits from the hot sun – a sustainable approach of boosting the physiological capacity of the fruit to resist sunburn.***



In March 2015, Cape Town became the hottest city in the world with maximum temperatures reaching a whopping 42°C! That was around the peak of one of the roughest summer heatwaves ever experienced in the Western Cape, South Africa. The summer of 2016 was not much different; in the second week of January, the temperature of areas in the Western Cape occasionally hovered around 40°C! Very high solar radiation and temperature episodes (heatwaves) have become regular aspects of Western Cape summers. The region also happens to be the largest producer of apple fruits on the African continent, and these fruits reach the roadside vendors or fruit stalls of other African countries, including my home country, Uganda. The harsh heatwaves experienced

in the Western Cape summers are a serious threat to the profitability of this highly valuable African apple industry. A particular problem is the development of unsightly blemishes on apple fruit surfaces (peels), a phenomenon referred to as ‘sunburn’ or ‘sunscauld’, which cause many first-class fruits to be downgraded to juice making or culled, depending on the extent of damage, leading to industry losses estimated in the millions of South African Rands. Although sunburn in apples is associated with myriad factors, high temperature and solar radiation levels are the chief culprits.

These disastrous weather conditions are one case where farmers are staring right in the ugly face of climate change. Indeed, studies in the Western Cape have shown that apple tree bloom dates have advanced and temperatures are on the increase. A slight advance in the apple bloom date pushes the apple fruit harvest maturity closer to summer’s harsh peak, thus increasing the risk of fruit sunburn damage. In another twist of events, water resources are facing enormous pressure in this region – more than ever before. The Western Cape’s main hub of fruit science production technocrats, HORTGROScience, has recently proven that water stress exacerbates sunburn. And as HORTGROScience and other researchers are concerned with maximising each drop of water spent in irrigation, it has also been proven that irrigation is not necessarily a remedy for sunburn in pome fruit. Thus, the puzzle of apple fruit sunburn overlaps with the Western Cape’s current water challenges.

“ *This new approach has a number of advantages, including having a low ‘water footprint’, and is easily adopted in other crops affected by sunburn.* ”

The use of shade nets and kaolin sprays in apple orchards to alleviate sunburn has been recommended for a long time now, with the idea that the sunburn-inducing factors (high temperatures) are kept or reflected

off the fruit surface. However, significant compromises in terms of the photosynthetic and physiological functions of both the apple tree and fruit have been observed, perhaps explaining the long observed inconsistent sunburn protection results associated with these approaches. Kaolin sprays may require more water to flush off residues at the fruit-packing houses, and shade nets too are very expensive to deploy on a commercial scale.

In 2014, a research team from the Department of Horticultural Science of Stellenbosch University noticed lower sunburn incidence in apple



*Sunburn browning on Golden Delicious apple in one of the experiment plots of this research at Applethwaite Farm (Pty) Ltd*

orchards that received particular foliar treatments of combined boron and calcium minerals, which were actually applied with the intention of reducing fruit bitter pit disorders. This interesting observation was the birth of my PhD study and research, and in 2015 I joined Stellenbosch University to further study and possibly unravel the mode of action by which a combination of boron and calcium reduces sunburn in apple fruits. Primarily, the target is reducing class 1 sunburn browning, which is

the most economically important form of sunburn, whose physiological nature and the development process is now understood and established.

My PhD research focused on physiological changes that occur within the apple peel after foliar applications of combined boron and calcium, including studying the spectral properties and profiling the photoprotection

and antioxidative pigments. These physiological changes were then related to the observed incidence of class 1 sunburn in three apple cultivars. We have firm evidence that the mineral applications influence the dynamics of key metabolites/pigments involved in antioxidant and photoprotection mechanisms of the apple fruits, and this influence has been observed in three distinct apple cultivars. These physiological changes in peel biochemistry by the foliar applications of combined boron and calcium minerals are coupled with appreciable reductions of class 1 sunburn.

Thus, we are pioneering a new course of direction, from the status quo of ‘shielding’ the apple fruit from the hot sun, to a sustainable approach of focusing on boosting the physiological capacity of the apple fruit peel to resist sunburn. This new approach has a number of advantages, including having a low ‘water footprint’, and is easily adopted in other crops affected by sunburn. What is even more exciting for consumers of apples is that the fruits produced using this new approach have increased levels of antioxidant nutrients as a result of both the mineral supplementation and the unlimited exposure to the sun. 🌞

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## Get fresh and nutritious fruits every day: Innovation in packaging and cold chain technologies

***Zaharan Hussein is developing a new technology to preserve fresh fruits that could guarantee the quality without compromising either the sensory or the nutritional attributes of packaged produce.***



The quality of fresh and minimally processed fruits and vegetables cannot be improved after harvest. Nevertheless, it remains possible to slow down the rate of deterioration and maintain the quality for a longer time. Fruit suppliers and processors have often used chemical-based treatments such as washing produce with sanitisers, antioxidant treatments and ozonised water as post-harvest preservation methods, with huge success. However, new levels of global interest in healthy, safe and chemical-free food have spurred the need for the fresh fruit industry to minimise the use of such chemicals. Apart from the health concerns, it has been reported that use of chemical sanitisers and washings



cannot guarantee the microbial quality of produce without compromising sensory quality.

In response to these challenges, researchers have been seeking alternative means of preserving fresh and minimally processed produce that could guarantee its quality without compromising either its sensory or nutritional attributes.

The application of modified atmosphere packaging technology combined with optimum cold chain maintenance was developed as an alternative technology for extending the shelf life of fresh and minimally processed produce. The ‘modified atmosphere’ in question is generated via a dynamic process balanced by produce respiration, on the one hand, and gas permeation through the packaging film, on the other. This technology, though widely used for produce, still poses challenges to food processors. A critical challenge remains the plastic film used; the commercial polymeric films typically used have several important limitations related to film structure and permeability to gases and water vapour. High barriers to water vapour characterise most polymeric films; the result is that small changes in temperature may lead to moisture condensation inside the package. This, in turn, increases susceptibility to microbial growth inside the package, which accelerates decay and limits shelf life.

*The application of modified atmosphere packaging technology combined with optimum cold chain maintenance was developed as an alternative technology for extending the shelf life of fresh and minimally processed produce.*

Packaging and cold chain technologies is one of a number of research themes of the South African Research Chair in Postharvest Technology (SARChI Postharvest) at Stellenbosch University. Renewed global interest in the health benefits of pomegranates has spurred a surge in demand and

consumption of the fruit, and is motivating research into pomegranate fruit packaging; the commercial production of pomegranates in South Africa is very recent and science-based solutions are required for this rapidly emerging sector.

In the interests of overcoming the limitations of conventional modified atmosphere packaging, SARCHI Postharvest research in this area has recently extended to a focus on modifying the permeability of the

packaging films to gases and moisture. We designed a research study to exploit the aforementioned modified atmospheric packaging limitations by use of perforations.



*Pomegranate fruit arils*

Perforation-mediated modified atmosphere packaging offers the possibility of preventing condensation inside the package and generating the desired in-package modified atmosphere in terms of safe ratios of carbon dioxide to oxygen concentrations. This technology relies on the use of perforations: either ‘micro-perforations’ (a diameter of 50–200  $\mu\text{m}$ ) or ‘macro-perforations’ (a diameter greater than 200  $\mu\text{m}$ ).

Thus, with regard to fresh minimally processed pomegranate fruit arils, our study was designed to investigate the effects of improved packaging and storage duration on: physico-chemical quality attributes, microbial quality, phytochemicals, and antioxidant activities. We packaged the fruit arils in polypropylene trays, heat-sealed with a commercial polymeric film POLYLID® and hand-perforated on the top of the film using a sharp needle. After 14 days of cold storage in a relatively high-humidity environment, the perforation-mediated modified atmospheric packaging – compared to clamshell and non-perforated

packages – was found to be suitable for the preservation of the physico-chemical, biochemical and microbial quality of pomegranate arils.

It was also evident that the use of perforations has the potential to significantly improve the gas and water vapour permeability of the synthetic polymeric films that are currently predominantly used by food companies. Thus, we concluded that the application of the perforation technique could provide a wide spectrum of commonly used polymeric films with better permeability results. This is good news, given that custom-made laminate films with the desired permeability properties remain much more expensive than the existing petro-based synthetic polymeric films.

Our findings came at the right time, when the quality deterioration and reduction of shelf life of fresh and processed food due to poor packaging has been identified as the major cause of high incidence of post-harvest losses. 🌱

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# A bioeconomic solution for managing fish stocks

***Dr Wales Singini offers rational advice for management of fish stocks in Malawi.***



In Malawi, with a population of approximately 18,397,018 people, fish is an important source of protein as it contributes 45% of animal protein consumed on a daily basis. Economically, fish contributes 4% of GDP and provides employment to more than half a million.

Unfortunately, there is growing concern that most of Malawi's natural fish stocks are either fully or over-exploited, with per capita consumption reduced from 12.9 kg in 1976 to 7.3 kg in 2016. In socio-economic terms, the decline of the fish catches has resulted in economic losses to the fisheries sector and the national economy. Despite this shortfall, the

supply of fish continues to contribute significantly to food security and nutrition within the country.

The decline of the Lake Malombe fish stocks is attributed to a number of factors but mainly overfishing, use of illegal fishing gear, habitat degradation, and non-compliance with regulations. The numbers of fishers and fishing craft and the amount of fishing gear have increased over time.

Attempts have been made to manage resources through restoring fish habitats, protecting juvenile and breeding fish, and reducing the amount of fishing. Yet, despite their sound biological basis, these interventions on their own have proved inadequate. What is more, further fish-stock management measures such as closed seasons and minimum fishable size have failed to address the problems of open access, resulting in increased fishing effort that has contributed to overfishing.

An alternative solution is a bioeconomic approach, which takes into consideration underlying stock dynamics and harvest levels in combination with the cost of harvesting and the economic value of the extracted fish (whether retained or discarded).

Such a model can address, for example, how quickly a fishery can be rebuilt so that stocks are increasing, while ensuring a level of harvest to maintain employment and markets. Bioeconomic modelling allows us to capture the interaction between the biology of the stock and the fishing behaviour/fishing effort/fish catch, whose optimal values are mutually dependent. 'Fishing effort' is a measure of the amount of fishing in terms of the level of *inputs* into the fishing activity: time spent fishing (hours/days), numbers of hooks used (in long-line fishing), kilometres of nets used etc. The total 'fish catch' is that quantity taken by the fishing gear and reaching the deck of the fishing vessel.

The simplest bioeconomic models employ a value-based predetermined fishing target to estimate sustainable catch levels and corresponding effort levels for maximising economic yield.

To minimise the risk of fish extinction that is associated with overfishing in Lake Malombe, a bioeconomic solution was tested in the lake through the PhD research I conducted. My findings indicated the need for a paradigm shift from biological and open-access management to bioeconomic management, which presents possibilities for sustainable fisheries management.

“ To minimise the risk of fish extinction that is associated with overfishing in Lake Malombe, a bioeconomic solution was tested in the lake through the PhD research. ”

Adoption of the bioeconomic solution would reduce the fishing effort, thus contributing to conservation of stocks in water bodies; the solution has the potential to reduce the existing fishing effort (which is based on biological management) by more than

half, and, in the process, the pressure exerted on the fish stocks would be reduced. In addition, adopting the bioeconomic solution would increase economic rent generated in the fishery by more than half of the current biological management approach; the reduced effort implies reduced costs of fishing, which in turn increases rent.🌱

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**Dr Wales Singini** (Malawian) graduated with a PhD in aquaculture and fisheries sciences at Lilongwe University of Agriculture and Natural Resources (LUANAR), Malawi. He is currently the Dean of Environmental and Natural Sciences at Mzuzu University in Malawi.

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# Poverty and lack of information flow as obstacles to food security in Africa

***Dr Oscar Koech Kipchirchir points out the importance of a collaborative approach in promoting developed climate-smart seed crops to increase food security in the face of climate change.***



Many African nations are working hard to fight increasing food insecurity in the face of climate change/variability. The Horn of Africa is significantly impacted by climate change. The latter is a major concern for local and international organisations alike working for global food security; individual states, regional and international partners, and development organisations have been investing heavily in seeking solutions to food insecurity in Africa. Yet, despite stakeholders' tireless efforts, success has been limited. Famine and hunger persist. This raises many questions: are the efforts being undertaken in the right way? Are the

main food production challenges being addressed? What could be the major challenge that has stood in the way of success?

Research has identified sorghum as one of the neglected crops that hold the key to the future of the arid and semi-arid lands in the Horn of Africa. Sorghum is an under-utilised crop, and one of the most important cereal crops in the semi-arid tropics; being drought-tolerant, it promises good prospects for increased adoption by communities, especially in the areas marred by frequent droughts and crop failures. In Kenya, sorghum production has recently been subjected to massive research efforts, with the aim of increasing productivity through plant breeding, improvement of agronomic practices and improvements in utilisation. The efforts to improve sorghum productivity in these environments have been successful, with good varieties developed, including multipurpose varieties suitable for agro-pastoral communities. The work of international research organisations such as ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) has been commendable. The extension services that one would expect around promoting sorghum production have also been carried out to some extent. However, we still note low adoption of improved practices and low productivity, even in areas close to the source of good agronomic information and improved plant varieties.

A case study was undertaken in the interests of understanding sorghum farmers' thinking and the challenges they encounter in adopting technologies aimed at increasing food security. This was a purposive survey involving sorghum farmers, to establish the root cause of low adoption, low productivity and low utilisation of sorghum in semi-arid rangelands of Makueni County, Kenya. The survey focused on the varieties used, source of seeds, fertilisers used, mode and time of fertiliser application, trends in yields, constraints on sorghum production and current strategies used for sorghum as animal feeds. The findings were timely in explaining the low adoption and productivity of sorghum in the study area.

It emerged that scientists are addressing problems that are well known to the community. Some of the important constraints, such as poor varieties

of sorghum, have been addressed. The gap, however, lies in the lack of community understanding of how to adapt the information to benefit their practices. To use an analogy: the efforts already undertaken in breeding and variety selection for different agro-ecological areas are like the design and development of an enviro-friendly smart car – but without considering eco-friendly fuel options and driver training to realise performance benefits. Most farmers who responded to the research are poor, living hand to mouth, have limited ability to access improved sorghum varieties, use no fertiliser in their sorghum farming, use no water-harvesting technologies, and cannot afford mechanisation. Consequently, the good outputs from the research on breeding are shelved, remaining in the custody of the researchers.

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***Sorghum is an under-utilised crop, and one of the most important cereal crops in the semi-arid tropics; being drought-tolerant, it promises good prospects for increased adoption by communities.***

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Furthermore, the farmers reported very limited access to sorghum farming information through extension staff, and the few who did access such information did so through short-lived donor projects. Most importantly, many farmers were found to rely on farmer-to-farmer information sharing; this was the case even where farmers' own saved seeds were being used in sorghum production.

The research clearly highlighted a gap in terms of the flow of useful information and technology to the end users.

However, the strong farmer-to-farmer information flows that were observed present an opportunity, if a few lead farmers who are also part of the

community can take responsibility for sharing scientific information that is well packaged for their use to increase production. This underscores the need for a collaborative approach in promoting developed climate-smart crops such as sorghum. We can only succeed in increasing food security in the face of climate change if all stakeholders – farmers, government, researchers and other development agencies – have an understanding of the main constraints on technology and knowledge adoption.

The Kenyan counties should invest in mechanisms to ensure the accessibility and affordability of inputs to farmers, which might require the costs of inputs to be subsidised. Extension services also need to be assured. Furthermore, the link between researchers and extension services should not be ignored, if useful information is to be applicable to the farmers.

To achieve the Sustainable Development Goals (SDGs), investment into science and technology development alone may not be the solution; of critical importance is also serious consideration of issues of access and affordability on the part of the intended information end user. It is high time that the resources allocated to finding food-security solutions cut across the relevant science development to encompass considerations of farmer support in terms of information access, affordable technology and affordable inputs. This means that all actors must be afforded a clear and active role in finding solutions to food security – and that the valuable outputs of the research process must be harnessed to benefit the end users: the farmers. 🌱

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# Improving productivity of indigenous chicken farming in Northern Uganda

***Christine Nakkazi shares her commitment to improving food security through improving rearing conditions of indigenous chickens in Uganda.***



**M**ore than 80% of rural households in Northern Uganda keep chickens, mostly local breeds kept under the free-range production system. However, these indigenous chickens exhibit low turnover and low growth rates due to poor management and inadequate feeding, which limits their ability to play their role as sources of food security and income.

The Enhancing Local Chicken Productivity through Strategic Breeding and Nutrition Management in Northern Uganda (ELOCHIP) Project, funded by RUFORUM under the competitive grants system, sought to enhance the productivity of indigenous chicken-rearing in this region through improved nutrition and breeding.

As a graduate student and member of the research team, I was engaged in the nutrition and chicken management component of the project. My



research aimed at improving the performance of indigenous chickens through improved feeding and management. Since the majority of farmers allowed their chickens to scavenge freely, the birds did not meet their nutritional requirements for optimal growth and production because scavengeable feed resources were scarce, highly variable and of questionable nutritional value. Therefore, it was prudent to identify local feed resources in the area, determine their chemical composition, formulate diets, and encourage farmers to adopt better management systems of

rearing indigenous chickens, such as semi-scavenging and intensive systems.



*Safe from predators: mother hen and chicks under the semi-scavenging system*

Together with 120 farmers, the project team identified the local feed resources available for feeding chickens as well as the prevailing management practices in Northern Uganda, and used this information to design feeding strategies. The research revealed that feeds were not compounded into simple diets; farmers were indiscriminately providing

energy-rich grains such as maize, sorghum and millet to all chicken groups. After determining the chemical composition of the local feedstuffs, the team formulated diets with varying levels of protein and energy and tested them on-farm to select the diet that resulted in the best growth performance of the indigenous chickens. Farmers were engaged at all stages of the research and were trained in aspects of improved flock management such as brooding, disease control, record keeping, and synchronised hatching.

Given increasing market demand, some farmers sought to commercialise their chicken production. These farmers made use of the diets recom-



mended by the study under the intensive management system. These farmers were also trained on how to synchronise hatching and brooding using locally made pots as a source of heat to allow the mother hens an early return to lay. With these improvements, the chickens reached market weight in 4.5–5 months compared to the 6-month minimum required in the traditional management system.

To improve the semi-scavenging system, the study team together with the farmers designed portable cages made using local materials. These cages were intended to confine chicks and their mothers in the mornings, when they would be given the formulated diets, after which they were let out to scavenge. This system prevented the chicks from being totally dependent on scavenging, which could not meet their nutritional requirements and thus rendered them susceptible to diseases. Scavenging also exposed the chicks to predators, contributing to high mortality rates before weaning age.

Interestingly, it was observed that whenever the chicks were released from the cages, they did not wander far from the homestead, since their food needs had already been almost satisfied. This reduction in locomotion resulted in improved growth rates. Practising farmers also reported a reduction in the incidence of predation compared to the free-range system. The semi-scavenging system reported, on average, a survival rate of 80% for the chicks during the early growth phase (day-old to 6 weeks) compared to 60% reported under the free-range system. Farmers that could not afford to use the intensive management system for their chickens were nonetheless able to benefit from the improvements offered by adopting the more affordable semi-scavenging approach. 🌱

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**Ms Christine Nakkazi** (Ugandan) is an MSc student at the College of Agricultural and Environmental Sciences, Makerere University (Uganda). Her research was part of the ELOCHIP Project funded by RUFORUM under the competitive grants system. Email: [christinenakkazi@yahoo.com](mailto:christinenakkazi@yahoo.com).

## Discovering camels: The ‘agricultural gold’ of the drylands

***Salamula Jenipher Biira discovers the potential of camel production in nutritional and economic resilience to climate change in drylands.***



The first time I travelled to Karamoja Region, over 400 km northeast of Uganda’s capital, Kampala, the journey was a long and tiring one. However, the distance and fatigue did not compare to the level of excitement I felt at the thought of getting up-close with the ‘giants of the domestic’: camels.

I visited Karamoja a total of three times during my masters research. On all these visits, I interacted with the native Karamojong, which gave me the opportunity to appreciate the rich culture of this community of pastoralists. My biggest fascination, however, was with the camels.

Since they were the focus of my research, I gained vast knowledge and experience with them.

Although I had never seen camels in my life, I learned that they are widely reared in the Karamoja Region. I am glad that I have graduated from the cohort of Ugandans whose minds race to Somalia, Ethiopia, and Kenya whenever asked to mention any country with a large population of camels. Camels do exist in Uganda and they are thriving and offering a livelihood.

Conversations with camel and non-camel herders alike revealed that camels are highly valued as domestic animals because of their tremendous ability to support livelihoods and increase the resilience of pastoral people to climate extremes. Most of them emphasised that, compared to other livestock, camels produce a higher and more consistent amount of milk all year round. Moreover, those involved in animal trade claim that they earn more from the sale of camels than from other livestock. Camel herding is also considered a very cost-effective venture since the animals, being both grazers and browsers, have a wide choice of food and can survive for many days, even months, without water. Sad stories of long treks with livestock in search of pasture and water during dry seasons are unheard of among camel herders.

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*As a Ugandan, I believe camels are the ‘agricultural gold’ of the drylands that needs to be ‘mined’, especially as we grapple with adaptation to climate change and climate variability.*

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For those unfamiliar with camels, the thought of herding such a large beast might send shivers down their spines. I was one of those, and was dumbfounded to see that 5–10-year-old children were the main herders of these gentle giants.

Camels are innately suited to thrive in harsh environments characterised by sporadic rainfall patterns, low rainfall intensity, high temperatures and scarce vegetation. It is no wonder that they are referred to as the ‘kings of the desert’.

With climate change in Uganda, several areas, especially along the cattle corridor, are increasingly becoming desert-like. This makes these areas more suitable for camel rearing and less for other livestock. Knowing that camels can survive harsh conditions and still produce milk in sufficient quantities throughout the year, yet are cost effective to manage, I can confidently say that they are faithful supporters of livelihoods. Some household heads who had benefited from camels assured me that they would rather die of hunger than sell their camels. What a powerful and disturbing statement – but one that highlights just how strongly the Karamojong value their livestock.

Little research has been conducted in Uganda, however, on these desert kings; more scientific research and publication is needed to explore the importance and potential of camels to our country, in the interests of increased adoption of camel herding.

My wish, as a scientist, is to see many more people get exposure to this livelihood opportunity. As a Ugandan, I believe camels are the ‘agricultural gold’ of the drylands that needs to be ‘mined’, especially as we grapple with adaptation to climate change and climate variability.🌱

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**Ms Salamula Jenipher Biira** (Ugandan) graduated with a masters in environment and natural resources from Makerere University (Uganda). Her research was funded by RUFORUM under the 2015 sixth call of its Graduate Research Grants. Email: [biirajenipher@gmail.com](mailto:biirajenipher@gmail.com).

# Making use of exogenous enzymes for more affordable fish breeding and feeding

***Chloe Kemigabo explains how to utilise nutrient bio-availability in plant-based diets using exogenous digestive enzymes to boost fish farming.***

The human population is projected to exceed the world's carrying capacity of 9 billion by 2050. This makes 'feeding the world' one of the greatest challenges of the 21st century, as foretold by politician Mike Pompeo.

The supply of conventional health foods, including fish meal, is inadequate, especially in Africa. This shortage has escalated human malnutrition,

micronutrient deficiency and hunger on the African continent. In an attempt to reduce malnutrition, intensive artificial breeding and farming of fish has been initiated in cages and ponds; however, this requires the use of specialised feeding systems. Feeding domesticated high-value species such as the African catfish has always been as costly as feeding fish to humans.



*A harvest of African catfish farmed with Nile tilapia*

The ancient practice of feed processing using microorganisms is being used to reduce the cost of feeding fish. The microorganisms produce enzymes that accelerate the breakdown of the feed materials to make the embedded components available. Endogenous enzymes have historical applications in the nutrition of fish fry (hatchlings) during the first 7–9 days

after hatching, when the fry lack functional digestive tracts. The fry are fed on the cysts/larvae of the brine shrimp *Artemia*, whose endogenous enzymes self-digest the prey.

It is unfortunate that these *Artemia* cysts are mainly restricted to saline water seas, thus becoming expensive for freshwater fish breeders. This concern aroused the interest of the researchers in establishing whether feeding fish fry on dry plant diets (55% crude protein) that were mixed with microbial enzymes would yield similar growth effects to feeding these fry on the brine shrimp (*Artemia*) larvae. Fish diets incorporated with phytase and protease enzymes were fed to two-day-old catfish hatchlings and these were compared with similar hatchlings that were fed on the brine shrimp larvae as controls.

The researcher observed survival rates as high as 52.75% in catfish hatchlings that were fed on protease-incorporated diets. The weight gain, food conversion ratio (FCR) and profitability of catfish hatchlings that were fed on brine shrimp larvae never differed from those of the hatchlings that were fed on diets incorporated with protease enzymes.

The research findings suggest that incorporation of protease enzymes in dry fish larval diets can be a cheaper dietary feed alternative to the brine shrimp larval diets. It is recommended, however, that a follow-up study on growth performance parameters of the fry fed on enzyme-incorporated diets in grow-out systems be undertaken with the aim of ratifying and assessing these findings for sustainable feeding of fish fry in large-scale, intensive fish production. 🌱

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**Ms Chloe Kemigabo** (Ugandan) is awaiting graduation with a PhD in aquaculture and fisheries science from Lilongwe University of Agriculture and Natural Resources (LUANAR), Malawi. Her research was funded by RUFORUM. She currently works as a research scientist level 2 and leader in the Livestock and Aquaculture Research and Development Programme at NARO, Uganda. Email: [c.kemigabo@gmail.com](mailto:c.kemigabo@gmail.com).



# From community psychologist to agricultural change agent

***Margaret Gumisiriza shares her life-long commitment to transforming the livelihoods of smallholder farmers through community mobilisation.***



Studying community psychology nurtured my dream of becoming a change agent in the community. By the time I completed my undergraduate degree in 2009, this dream was strongly ingrained in my aspirations.

My resolve to make an impact on people's livelihoods was strengthened when I worked with farmers in the Masaka and Ngora Districts in Uganda on projects implemented by the National Livestock Resources Research Institute (NaLIRRI). Through interaction with these farmers, I realised that they faced grave challenges as a result of climate variability and change, of

which they, like myself, had little understanding. I thus set out on a journey to search for ways of transforming their livelihoods through optimising information and technology innovations. As a first step, I planned to enrol for a course of study to build my knowledge on the dynamics of climate change – a course that was to set me on a new career path.

I enrolled for the masters in climate and society programme at Mekelle University in Ethiopia. The programme improved my understanding of

climate change and how to transform society through innovation and community participation.



*Farmers in Eastern Uganda*

Energised by the masters programme, I applied for a RUFORUM Field Attachment Programme Award (FAPA), which provided me with my first opportunity to give back to society. I worked with the farmers and communities that had supported my research. Together we planted 180 fruit trees and introduced

the practice of silage making. We also tackled the farmers' challenge of access to credit by encouraging them to form groups and savings and credit cooperatives (SACCOs) in order to enable them to mobilise finances and increase their prospects of accessing agricultural financing. Although this initiative has not been successful yet, because individual farmers continue to borrow from microfinance institutions at high interest rates, I still have my sights set on it as a game changer.

Opportunities to facilitate the change process in communities continue to emerge. For example, in 2015, I received the Africa Climate Change Adaptation Initiative (ACCAI) Alumni Grant from the Open Society

Foundation for a proposal on ‘Enhancing food and feed security among smallholder crop-livestock farmers in Uganda through improved sweet potato usage’. The project has enabled me to help livestock farmers facing the challenge of limited feed during dry seasons by training them to conserve sweet potato residues as animal feed in the form of silage. Working with Zainah Nampijja, a colleague pursuing a masters in animal science at Makerere University (whom I met at a conference and with whom I have since worked on several projects relating to climate science and climate change), I have been able to train 90 farmers and potentially impact 540 people in Central and Eastern Uganda.

Being a change agent requires one to be able to identify and address the challenges facing the community. Through this process, Zainah and I pinpointed the need for an organisation to champion the change we envisaged, and formed Climate Change and Environment Associates (CCEA). The CCEA trains youth and farmer groups on climate change adaptation and mitigation. Currently, we are training a small youth group ‘Bavubuka Tweekembe’ to adopt climate-smart agricultural technologies as income-generating activities. 🌱

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**Ms Margaret Gumisiriza** (Ugandan) is admitted to the University of Nelson Mandela in Arusha (Tanzania) for a PhD in life sciences specialising in sustainable agriculture. This story is mainly inspired by her MSc work. Email: [m5gundas@gmail.com](mailto:m5gundas@gmail.com).



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Copy editing: Jacquie Withers  
Design and layout: Neil Butcher & Associates  
Photographs per story were supplied  
by the authors.



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