

Global Center for Food Systems Innovation

# FOOD SYSTEM INNOVATION PROJECTS

*Stories from the field*

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## Cell Phones as a Lifeline for African Beekeepers

In its 2009 National Beekeeping Policy, the Kenyan government estimated that the nation is producing only a mere 15 percent of available honey, and harvesting just over one percent of potential beeswax. To help beekeepers get more out of the hives, a group of seven researchers launched a grassroots-style, cell phone-based, data collection initiative aimed at identifying best management practices and most productive landscapes for honey bees.

“There’s a lot of anecdotal information about beekeeping, but there’s little scientific data,” said Maryann Frazier, a beekeeper and extension associate at Pennsylvania State University who partnered with Benjamin Muli, of South Eastern Kenya University (SEKU). “We’re trying to get hard data from the beekeepers that can be utilized to increase their honey and wax production. We’ll model the data they provide and create recommendations for them and deliver these via cellphone, which is how we’re collecting the data... We’ll be making recommendations to the beekeepers in the next couple months.”

Funded by a 2015 Early Innovation Grant from the Global Center for Food Systems Innovation (GCFSI), the project consists of nearly 40 beekeepers who have been providing researchers with data for the last year, generating over 400 records that were used to create a map that indexes the landscape in relation to honey production.



Utilizing a cellphone and a pre-paid SIM card, participating beekeepers tell Janet Kilonzo, project manager and recent graduate of SEKU, how much honey and wax they produce and when, and what circumstances they experience throughout the year. Beekeepers report what plants are blooming, if they’ve encountered problems with drought, and whether or not there’s been colony loss due to ants or issues with honey badger attacks. They also record and report how many of their hives are occupied, and the time at which the bees abscond or recolonize the hive.

“We have recorded the GPS coordinates for each beekeeper’s hives and Eric (Lonsdorf), a specialist in landscape ecology, used satellite imagery to index the land cover, rating it in terms of quality for honey bee foraging. Our preliminary results show that we can see the impacts of landscape quality on honey production. Using these tools, we hope to be able to help beekeepers predict where they are likely to have the healthiest colonies and produce the most honey,” said Frazier.



As for the beeswax, there is a high demand from the international cosmetics industry for clean, pesticide-free wax, characteristic of many of East Africa's hives. However, many beekeepers in Kenya and elsewhere are unaware that the wax – which is commonly thrown away – could provide extra income. To encourage beekeepers to harvest the wax, each project participant was given a solar wax melter to aid with processing.

Other hive-based products include bee venom, royal jelly, brood, pollen and propolis. Each has the potential to contribute to income generation, employment creation, and enterprise development.

Aimed at collecting data and disseminating information, resources, and equipment, the GCFSI-funded project helps to advance Kenya's goal of developing a more robust beekeeping industry – one that can improve the livelihoods of rural farmers.



*Beekeeper calls to report data*



*New combs in traditional log hive*



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## Mobile App Helps Farmers Work Smarter, Not Harder

FarmVille, a farming simulation game, is among the most popular social networking games ever launched. Since its 2009 debut on Facebook, the virtual game has been played by over 400 million users in 215 countries. Ever wondered how a game like FarmVille could actually be used to improve agriculture? That was the challenge accepted by two researchers, Emilia Tjernstrom, of the University of Wisconsin-Madison, and Travis Lybbert, of the University of California-Davis.

Unlike flipping on the hose or starting the sprinklers, most African farmers rely on unpredictable rain to irrigate food crops. In such variable conditions, learning about the benefits of improved maize varieties or fertilizer is costly and risky. And, when farmers' livelihoods depend on the success of their crop, experimentation is curtailed.

Seeking a comparatively low-risk method to assist farmers in selecting best practices, Tjernstrom and Lybbert leveraged a grant from the Global Center for Food Systems Innovation (GCFSI) to develop Mahindi Master, a game-like mobile app inspired by FarmVille.



Translated from Swahili to English as “Maize” Master, the game allows users to virtually experiment with different fertilizers, seeds, and other agricultural inputs to predict how each would likely affect crop yields on the farmer’s particular plot. By populating a maize crop model with real world data from soil samples, the app calibrates the interactions of inputs that affect growth, particularly fertilizer and weather conditions. After running through multiple growing scenarios as part of the game, the user will see which combination of inputs was most fruitful for their virtual yield.

As players proceed through the different modules of the game, they can select from three different fertilizers – diamonium phosphate (DAP), calcium ammonium nitrate (CAN), or lime – to see how their maize harvest is expected to respond to each. Reflecting on the pretesting conducted in Rongo, Kenya, Tjernstrom said, “Farmers felt that the app was conducive to learning about fertilizer and expressed a desire to play the game again once it was calibrated to their plot’s soil characteristics. (We) received valuable feedback on the animations, which will enable us to adjust certain colors of the seeds and fertilizers to reflect their actual appearance in Western Kenya, and to present the weather scenarios in a clearer way.”



Further pilot testing is scheduled to occur in Kenya and to encourage participation by the target audience, the research team will provide incentive in the form of valuable resources for farmers to use in the upcoming growing season.

“After farmers complete their module on the app, they will be given a cash allowance and a menu of agro-inputs, such as seeds and fertilizer. They will identify a demo plot of specific dimensions and then purchase the inputs they would like to use for the demo plot,” said Lybbert, noting that the materials will later be delivered to the actual demo plot, which will be managed by the farmer as part of the pilot test.



*A screen shot of Mahindi Master, a game-like mobile app that allows farmers to virtually experiment with agricultural inputs, such as fertilizer.*

“By (evaluating) their input choices from the menu, we’ll be able to assess how much they trust what they have learned. It’s innovative in the sense that it turns agricultural extension into an interactive, customized experience. One of the underlying principles is that people learn best when they actively seek to understand something new or more deeply. By gamifying farming in a way that is salient to them, the app aims to encourage farmers to discover, on their own, how inputs affect productivity.”



*Kenyan farmers play Mahindi Master during pilot testing.*



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## Wild-Caught Protein: Grasshoppers and Locusts Help Curb Malnourishment

Proteins are known as the body's building blocks, but for many people in Kenya, protein sources are too expensive, leading to nutrient-poor diets linked to diseases and cognitive development problems. To improve availability of protein-rich food, researchers John Nduko and Anthony King'ori, of Egerton University, turned to wild-caught protein, namely grasshoppers and locusts.

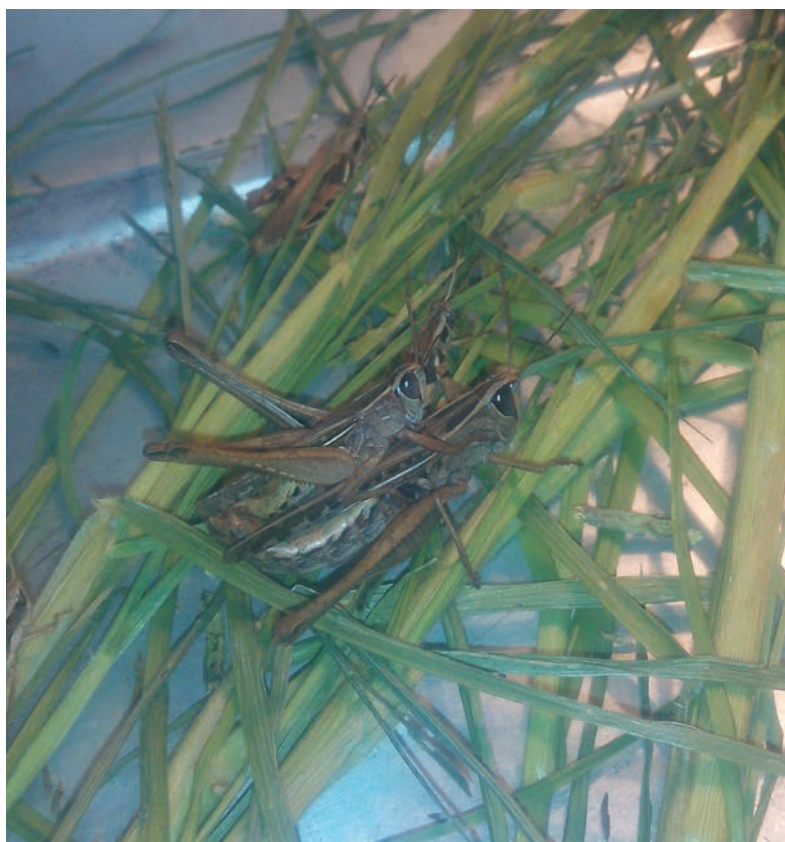
Collected in Kenya's Nakuru and Baringo counties, the research team launched the project by foraging about 50 insects, mostly locust, in 2016. "It was difficult to find them," said Nduko. "Climate change has had an effect, and this made us expand the geographical areas to find the most abundant insects."

Kept in small cages, the bugs continue to multiply while researchers work to establish the best incubator conditions for reproduction and hatching. "In one month we'll have a huge number. After we have lots of insects, we'll freeze dry them and they'll be ground into a powder."

Funded through a start-up grant from the Global Center for Food Systems Innovation, Nduko and King'ori partnered to develop a toolkit that would make insect rearing and processing available to smallholder farmers, providing a cheap and low-risk method of generating more protein for human consumption and animal feed. Once dried and ground, the insect powder can be fed to babies in sorghum or millet porridge, and can be fed to fatten up chickens, rabbits and other non-ruminant animals.

When used as animal feed, locust and grasshoppers can save farmers money, and offer a much-needed alternative to traditional feed sources.

"With increased population, and increases in living standards, the demand for protein-rich foods is increasing, and this in turn increases demand for animal feeds, which have serious environmental effect. A lot of animal feeds are sourced from fish, and because of climate change, some fish from the wild are becoming extinct. Dairy and beef cattle are becoming a challenge because the amount of available land is shrinking, and most small-scale farmers cannot do that," said Nduko. "The small-scale farmer can rear non-ruminant animals, such as poultry, however, the cost of feeds hinders productivity and this keeps most farmers under the cycle of this poverty. 70 percent of the



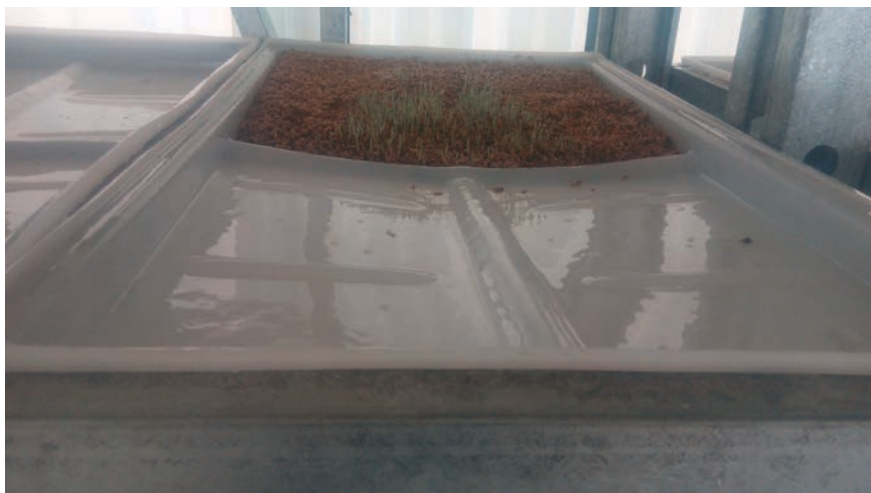


production cost for chicken is just to feed them. But, if you use insects that eat grass, it's cheap and requires only a small space."

By facilitating the rearing and processing of grasshopper and locust for food products, Nduko said, "We foresee a situation to provide inexpensive food and feed, to contribute to the end of malnutrition, and contribute to food security in Kenya and Africa. The market is there."

With the pilot in full swing and small scale production underway, researchers are focused on scaling up the model, and collaborating with industry leaders. In a stakeholders meeting in March, Nduko and King'ori will discuss the project with representatives from the baby food and chicken feed industries.

"Despite challenges, we are moving well so far. The number of people who expect our project to develop into an inexpensive method of obtaining proteins is overwhelming, at the same time encouraging," said Nduko.



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## Towards Zero-Waste Cassava Processing

An important subsistence crop in Tanzania, cassava is grown in all regions of the country, yet processing constraints make it difficult for small and medium scale farmers to compete with large scale operations. To level the playing field, two researchers developed a low-cost processing system that produces high-value cassava flour with virtually no waste.

Currently in the pilot stage, the new system has the capacity to mill 500 kg of cassava flour per day. Developed by Anselm Moshi and Humphrey Ndossi, both of the Tanzania Industrial Research and Development Organization, the system is powered by renewable energy and utilizes the entire crop, including plant material previously wasted.

“The overall goal of this project is to improve income of small to medium scale farmers in the cassava value chain through innovative processing technology,” said Moshi, who was awarded a start-up grant in 2015 from the Global Center for Food Systems Innovation. “There is a lot of cassava grown and it grows very quickly, but there needed to be a better system.”

The researchers found room for improvement at the processing level – particularly in the drying stage.

The mills that local farmers traditionally have access to do not dry the crop in a uniform fashion, which results in discoloration of the flour. “When they use the local mills to dry the cassava, they end up with a brown flour which means it is not a high quality flour and they cannot sell the low quality flour at markets at a high price,” said Moshi. “We have designed a very innovative type of hybrid dryer which uses all renewable energy sources, but specifically allows for uniform drying.”



*AD-solar system for efficient drying of cassava grits*



*Women peeling cassava for processing into cassava flour;  
Most of the cassava processing groups are women*

Typically, converting raw cassava into cassava flour produces an enormous amount of bio-waste in the form of peels, fiber, and even liquids. But, in Moshi and Ndossi’s design, the bio-waste is converted to ethanol and used to power the cassava grating machine. Additionally, biogas is generated and then combined with solar power to run the dryer. The fibrous part of peels is used to produce a special type of polysaccharides, called prebiotics, utilized at the end of processing to fortify the flour with nutrients that can lower cholesterol.

“Cassava is a very perishable product, but it is a valued product. When you process cassava you lose about 50 percent of the tuber in the peels and pulp, and 16 percent of the tuber in liquid and gaseous waste. If you are just throwing this away, it is a big loss of product and nutrition,” said Moshi. “People are most excited about the high quality flour, and (that) they can sell it at the high quality markets. But the process that generates and utilizes renewable energy, to them, is very cool because now they can get the better price and better product, which means more income for their families.”

There is plenty of room in the flour market for economic growth from male and female farmers, and Moshi said the innovative system can help fill the gender gap. “There are a lot of women farmers in our groups that get involved. They join processing groups, or they grow cassava themselves.”

Once the pilot phase of the project is complete, researchers plan to build a large demonstration site in the southern coastal zone of Tanzania.



*Upgraded biogas (>95% CH<sub>4</sub>) is collected in a gas bag and used to heat the hybrid dryer for drying cassava grits*



*Grating cassava tubers using a grating machine*



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## Power of Sweet Potatoes: Tanzanian Women Build Vitamin-A Enterprise

Introduced to Sub-Saharan Africa as a crop that could alleviate vitamin A deficiency, especially common in women and children, the orange-fleshed sweet potato is a biofortified intervention that adds nutritional value to the community, while at the same time spawns economic activity and empowerment among rural women.

“We now see that women growing the orange-fleshed sweet potato are able to make more money, a small level of increase of income, and most importantly, have vitamin A-rich food,” said Channa Prakash, of Tuskegee University, who partnered with Theobald Moshia, of Sokoine University of Agriculture (SUA), to train Tanzanian women in food processing, product development and business management activities associated with the particular orange-fleshed sweet potato variety. Supporting approximately 200 women with seed money from the Global Center for Food Systems for Innovation, researchers helped the budding entrepreneurs establish a network of Village Community Banks (VICOBA), purchase processing equipment, and learn about food safety, marketing skills, and profit margin calculation.

Project manager and recent graduate of SUA, Domina Leonce Swai, worked on the ground with the women to help them become familiar with the nontraditional tuber, and troubleshoot their way through starting a business. “She lived with them for six months and they treated her as one amongst family. She was easily accepted into the village group. And their children now have access to healthy food to eat more readily because now (the sweet potato) is in a form that is much more fun to eat,” said Prakash, noting that the women were taught recipes for cookies, French fries, and tortilla-like bread made from the orange sweet potato flour.



Citing improvements from the Green Revolution, Prakash said, “We’re able to feed people in a reasonable manner but, they’re not getting quality food. They’re missing vitamin A, iron, and zinc – three major nutrients. It’s not a high-tech solution, people have already been growing and eating sweet potatoes, but we provided a variety that has an orange color and that makes it more rich in nutrients, and our body gets vitamin A. It’s a solution that’s helped by changing the diet a little bit.”

Before encouragement from the African government and international aid groups, Tanzanian farmers traditionally grew a different type of sweet potato, along with cassava, both “white foods,” said Prakash, which are drought tolerant but lack crucial micronutrients.



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When the new variety was introduced to farmers, “the problem was, they were not able to make the traditional sweet potato foods the same way, so we helped them with a whole range of recipes.”

Started in 2014, the project emphasizes capacity building and outreach, and leverages cell phone technology to facilitate the development of microenterprises. Currently in the final phase of study, researchers are focused on evaluating impact. “We know they’re eating (the orange-fleshed sweet potato), and we want to make sure it is making a difference in health and growth,” said Prakash, noting that stunted growth and night blindness are frequent results of vitamin A deficiency.



“We have developed a questionnaire and now are getting detailed data on how the women feel, and on how much economic activity—how much extra money—they have been making. Like us, there are many people who are working on popularizing the orange-flesh sweet potatoes. Many are doing it, and I think collectively it has made a difference. I’ve been involved with sweet potato breeding the last 27 years. Today, we’re looking for how we can scale this up.”



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## SoilDoc + Climate: Researchers Improve Farmer-Centered Forecasting Device

Forward-thinking researchers Clare Sullivan and Johnson Semoka, two grantees funded through the Global Center for Food Systems Innovation, are piloting a new and improved version of the mobile soil management tool known as SoilDoc, first developed through the Earth Institute (EI) at Columbia University with support from the Alliance for a Green Revolution in Africa.

Renamed SoilDoc + Climate, the updated app incorporates data related to climate forecasts that gives farmers more information from which to make decisions. Sullivan, of EI, and Semoka, of Tanzania's Sokoine University of Agriculture, are currently managing the project as it undergoes field testing in the Morogoro, Junbue and Mbeya regions of Tanzania.

By harnessing data from the built-in GPS function, or generating data from manually-entered GPS coordinates, the app provides the user with information about historical precipitation trends, and the effects of El Nino and La Nina global temperature patterns.

Designed to be used by agricultural extension service providers, agro-input dealers, and importers, Sullivan said the app can improve income generation, and ultimately enhance food security and resiliency. By integrating weather and soil conditions to better predict the seasonal changes, SoilDoc + Climate can help reduce risks and maximize investments for farmers and extension workers.

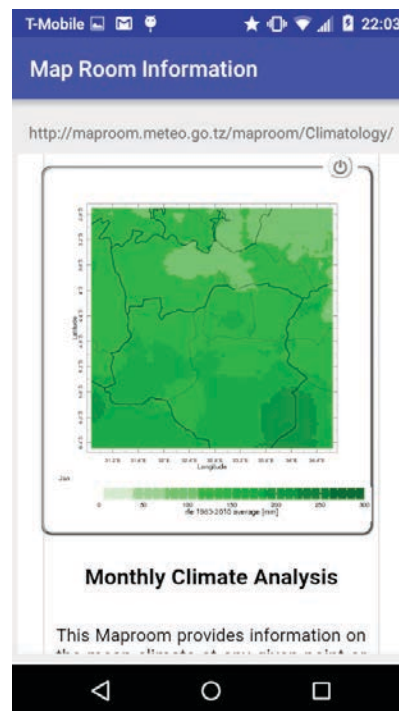
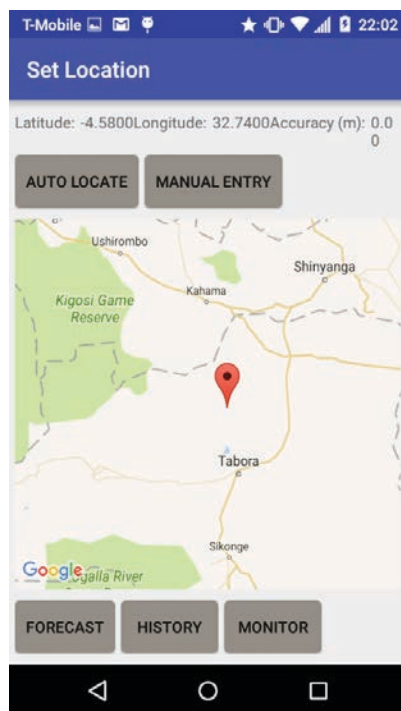


“Decisions based on site-specific soil conditions and weather forecasts will provide cost-effective use of inputs, such as fertilizer, and higher returns on investment, combined with surplus production,” Sullivan said.

So, how does it work?

SoilDoc + Climate diagnoses soil in a farmer's field using mini-versions of laboratory meters to perform a suite of tests that assess nutrients and soil physical properties. All the instruments are battery powered and provide on-the-spot tailored results and recommendations, even in the most remote locations.

Designed to be used with 7-inch tablets, the app works on Android devices and is available through the Google Play.



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## Cooking, Cooling and Cultivating with Waste

When properly processed, decomposing human and animal waste has the power to change lives. While it might sound – and smell – funny, the power of poop lies in biogas, a renewable energy source produced during anaerobic digestion, or the breakdown of waste. Sped up through a system of digesters, the process yields a gas of about 60 percent methane that can be used for cooking, refrigeration, and other basic needs. Moreover, the waste itself can be processed and applied to fields to enrich the soil and improve crop production.

Researchers Rebecca Larson, assistant professor at the University of Wisconsin-Madison, and Vianney Tumwesige, CEO of Green Heat, a Ugandan energy company, teamed up on a host of projects in Kampala, Uganda that demonstrate new ways to transform waste to resource. Funded through the Global Center for Food Systems Innovation (GCFSI), the team developed and continues to evaluate a biogas-powered refrigeration unit; a waste separation system that yields no-cost fertilizer; and a dual-fuel stove that cuts down on deforestation while easing cooking challenges at a local school.

Traditionally, the cook at Kampala's Lweza Primary School prepared meals for the students over a wood-burning stove. While reliable, the smoldering indoor fire caused poor air quality in the kitchen and contributed to the relentless harvest of timber. Seeking an alternative, the school switched to a biogas-powered stove, but struggled with the problem of burning through the biogas supply before the food was fully cooked.

To solve the problem, Larson and researchers designed a second-generation biogas stove that has the option to run on biogas or firewood. With the grant from GCFSI, the team refined the design and settled on a solution that gives the user flexibility to switch from biogas to firewood, or vice versa. Since being provided with the new dual-fuel stove, Lweza Primary School is able to improve indoor air quality and reduce wood consumption.

Building on the success of the dual-fuel stove, a team member from Green Heat modified a natural gas-powered refrigeration unit to run on biogas, which is cheaper and more accessible than natural gas. Like the stove, the modified cooler can run on more than one source of energy. "If you run it on biogas first, you can switch to electricity, and if the electricity goes out, you can switch to biogas," said Larson. In a region that has unpredictable electrical service, multiple power options provides increased dependability.



But, harvesting the potential of waste doesn't stop there – the waste itself can be put to use.

The team in Kampala successfully implemented a new low-cost slurry separation system that divides liquid waste, called effluent, from solid waste. Once the separated solids are dried, they can be applied to fields to enrich crop production. More desirable to handle than raw manure, and more economically viable than purchasing chemical fertilizers, the separated solids are a good alternative for cash-strapped farmers.

“The solid-liquid separator is very popular. We installed 50 of the systems. We designed it, and with this (GCFSI) grant we refined our design,” said Larson. “Green Heat built their inventory and have been installing them in Uganda, and will install some in Ethiopia. A lot of people weren’t managing the effluent, and it was going to the wastewater treatment, or worse off, running into a stream. We wanted a system to allow them to better manage the effluent from the digester.”

With the systems installed and refinements made, the team is busy evaluating performance and determining best practices for field application, water conservation, and other considerations.

Field data on the impact of separated solids on agricultural plots shows promise. Findings indicate that while actual grain production is consistent across different nutrient sources, use of separated solids on maize increases plant biomass, like leaves and stalks, which can be fed to livestock, or used to generate more biogas – continuing the cycle.



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## Contextualizing Irrigation Challenges in Rural Uganda

Irrigation is a high-priority issue in the largely rain-fed agricultural communities of Uganda. Without it, farmers struggle to adapt to tough growing conditions, from severe drought to disastrous flooding. However necessary, upfront system costs and top-down approaches have left many valuable crop plots at the whim of the weather.

Researchers Kate Scow and Abraham Salomon, both of the University of California-Davis, work in eastern Uganda, collaborating with local farmers, social advocates, and engineers on irrigation interventions that are flexible and community-managed. “Currently, a lot of vegetables are grown in other regions, often considerable distances away, and brought in even though the potential is there locally,” said Scow. By installing and maintaining an adaptable irrigation system that allows tomatoes, cabbage, beans and other vegetables to thrive in the dry seasons and the unpredictable rainy seasons, communities gain food security.

Funded by a grant from the Global Center for Food Systems Innovation, Scow and her team took a decidedly participatory and adaptive research approach to design irrigation systems that suit local conditions and farmers’ needs, and that are adaptable to unforeseen challenges.



Researchers work at six sites meeting regularly with groups of farmers, who formed farmer committees tasked with developing plans for an irrigation system for the local farmers.

Near the town of Jinja, said Scow, “The farmers and engineers agreed that the best plan was to install a centralized irrigation system that brought water to a large plot of land. Then, a large land owner would rent out small plots of the irrigated land to farmers.”

Everything was installed successfully, but the farmers were not leasing the plots. Discussion with farmers revealed that many of them, especially women, were uneasy about relying on land owned by just one landlord. “They were afraid if they invested in it, they wouldn’t have big enough plots to be able to actually make an income. Also, they were worried the rent would fluctuate with the water supply and access to the equipment.”

The local committee went back to the drawing board and designed a very different, decentralized system, where water was delivered to multiple small plots distributed throughout the landscape. Now the water would be controlled by the actual users themselves. “Though it required pulling out the original system, the second time we all

tried to really listen to one another and pay better attention to the needs of everyone.”

Scow said that the Jinja site showed the importance of developing an irrigation system that is flexible and can be adapted to changing needs and the dynamics of human relationships. While irrigation is a high-priority issue in Uganda, she said it is pointless to develop a system that is not flexible to the social dimensions and tensions of the farming community.



“Flexibility is required in dealing with the social norms and constraints that must also be considered in setting up the shared infrastructure often typical of irrigation projects. Some of the social aspects are more complicated than the technologies themselves, and they can make or break implementations of a good irrigation system,” said Scow.

“The ultimate goal of the participatory research is an empowering process for farmers to handle challenges and influence the direction of their own lives. We thought we would be focusing on irrigation technology intervention, but often finding ways to deal with the challenges of complex social interactions is the type of innovation most needed.”

Going forward, researchers will continue to receive feedback from stakeholders at the six sites. Their on-the-ground experience serves to more fully identify emerging issues that lead to greater, or lesser, empowerment over the farmers’ use of irrigation.

“All of these activities are feeding into our final goal of co-creating a framework and planning tool for organizations to consider the real needs of African smallholders, especially women, when developing irrigation programs,” said Scow.



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## Dual-Platform Bean Thresher Reduces Burden from Women's Backs

After receiving a technology evaluation grant from the Global Center for Food Systems Innovation, Michigan State University graduate Adam Lyman traveled to Zambia in 2016 to evaluate the effectiveness of a bicycle-powered bean thresher. Originally developed to thresh pigeon peas grown in Guatemala, the thresher concept was adapted and re-created to effectively shuck common beans, a staple food in the northern province of Zambia.

Arriving in the small town of Kasama last April, Lyman began assembling the thresher, which he constructed on the campus of MSU with support of faculty researchers Ronald Averill and James Kelly. Compared to other project challenges, transporting the thresher was a no-brainer. "I packed it in suitcases," he said, "I packed it with my socks!"

While mechanization of farming practices has increased throughout much of Africa, including southern and central Zambia, northern Zambia remains more traditional, and the foundation of mechanization is still being established.

"Currently, bean threshing is performed by heaping plant material onto the ground and beating it with sticks. After beating, bean seed is collected and placed into shallow, round baskets. These baskets are then raised above the laborer's head," said Lyman, "and poured into an additional basket on the ground. As the seed falls from one basket to the other, dirt and small plant debris are blown from the seed. This process is called winnowing, and is repeated several times until most of the unwanted material has been removed."

Designed to shuck beans four times faster than the manual method, the bike-powered bean thresher speeds up processing and eases physical strain felt by laborers, who are mostly women.

"I can say we're reducing time, but what I perceive as the problem is different than what they perceive as the problem. If I ask the men, 'No, there's not a problem,' they say. But, they're not always doing the work. In talking to the women," Lyman said, "yes, time was part of the problem, but a large part of the problem with threshing is physical discomfort. Dust in the eyes and mouth. Back and wrist pain. And that information helps to solidify the design. The problem I'm trying to solve is not necessarily bean threshing rates – rather, we're trying to increase bean production to help alleviate poverty and malnutrition. This is an intensely complex problem and increasing bean production in no way will be a silver bullet."



Working with the Zambia Agriculture Research Institution, Lyman gathered feedback from local farmers through a survey and a participatory evaluation.

“We drove around in a convoy—a Land Rover packed with people to administer the surveys, and a pick-up truck with the bean thresher strapped in the back. I showed up with a working prototype, but first surveyed (the community) as if there was no machine.”

The baseline data collected during the survey gives researchers insight to the overall problems associated with bean processing, and contextualizes the issues that would ideally be addressed by the bean thresher. Following the survey of 270 farmers, 135 participants took turns hopping on the stationary bike and pedaling their way to a heap of clean beans.

Since the evaluation phase, Lyman has been working to modify the thresher in response to user feedback. “The majority of farmers were content with the bike,” he said, “but some requested motor power... Based on their scale of production, and level of income, some farmers thought a solar powered device would be more appropriate.”

Harnessing the eager minds of MSU engineering students, Lyman sponsored a project through Brian Thompson’s Humanitarian Engineering class in the fall of 2016. Working with Lyman, the group developed a prototype of a solar-powered platform, designed specifically for the bean thresher. “The point was to develop a new iteration on users’ feedback,” said Lyman. “The bicycle platform was also modified, and the second option, solar, can be presented back to farmers and ask, ‘How does this fit into your production scheme?’”

Back in East Lansing, Lyman continues to paw through over 5,000 pages of survey responses and evaluation data. In hopes of returning to Zambia and testing the new solar power platform, he’s also judiciously seeking sources of follow-on funding. “If we continue to get supported to finish the project, that’s how farmers will see the impact.”



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## Advancing India's Food Security with Low-Impact Refrigeration

While hunger plagues a quarter of India's 1.3 billion people, food losses continue to stack up, rotting and wilting during post-harvest and processing. To improve on-farm food storage and divert food waste, a team of researchers funded through the Global Center for Food Systems Innovation are implementing two types of evaporative cooling (EC) technology.

Led by Sangeeta Chopra, of the Indian Agricultural Research Institute (IARI), and Randy Beaudry, of the Department of Horticulture at Michigan State University, the team has constructed four EC structures on the IARI campus in New Delhi. Designed to stand alone or be retrofitted with a refrigeration system to improve cooling, the storage structures keep food cool through two types of evaporative cooling technology.

The first – high porosity bricks – enhances evaporation and cooling potential, similar to how a clay pitcher keeps water cool in hot environments. The second runs on a solar-powered refrigeration unit, keeping electricity costs low and making it more practical for farmers to use. The solar-powered unit also provides a renewable energy source for activities in village communities.

Explaining the science behind the cooling technology, Chopra said, "The walls of the structure are wetted at a controlled rate to achieve maximum evaporative cooling. The design and material for the roof and floor have also been finalized for lowest heat transfer."

Aimed at increasing the capabilities of smallholder farmers in India, the team is comparing the performance of different materials used in the storage container walls, which include pervious concrete, traditional brick-sand-brick layering, and mesh-supported fabric. The results of the tests are used to validate mathematical models that predict performance.

Discussing preliminary results, Chopra said, "A fabric-covered mesh structure with low thermal mass and high thermal transmittance outperforms other designs, cooling faster and obtaining lower temperatures. (It) also cost significantly less to build, and was easier to construct than brick- or concrete-based designs."

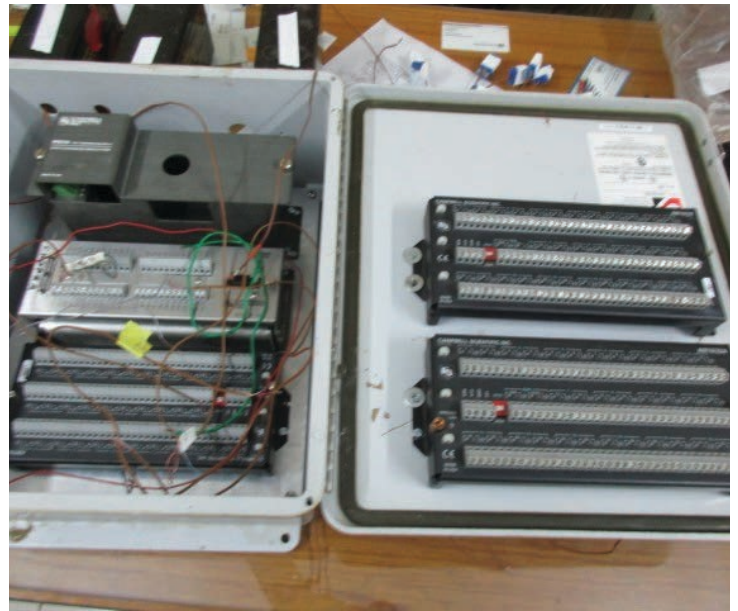
Back in the States, the team has partnered with Turbo Ventures to develop a specialized solar-powered refrigeration compressor at Michigan State University.

With advanced cooling technology and improved refrigeration capacity, low carbon footprint storage containers decrease food waste and enhance food security. Even if just one-fourth of the food lost globally were saved, it would feed 870 million hungry mouths.





Prototypes of cool storage structures



Solar refrigeration system



Testing the AAC blocks for strength



Hydrogen bubbles in the AAC block keeps them afloat



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## Modeling Cassava, the “Rambo” of Food Crops

Referring to the film series starring Sylvester Stallone as a brute survivalist, researcher Julian Ramirez-Villegas joked, “cassava is the ‘Rambo’ of the food crops.” Extremely resistant to variable climate conditions, the starchy tuber is the focus of a new simulation model that recommends best practices for the popular crop.

Leveraging a grant from the Global Center for Food Systems Innovation, Ramirez-Villegas and his researcher partner, Tin Maung Aye, both of the International Center for Tropical Agriculture, developed a computer model that simulates cassava growth based on field data the team generated while working in Vietnam.

By utilizing data on water balance, phenology, photosynthesis, and carbohydrate distribution within the plant, the model considers climate, crop strain, fertilizer, and soil type and predicts the best growing conditions for maximum yields.

“We’re going to use that model to define appropriate management recommendations to increase yields and increase livelihoods in Southeast Asia,” said Ramirez-Villegas.

“It is not practical to think that the local farmers will be directly using this model, as that would require a desktop computer to be common household technology.”

Instead, a farmer will work with an extension agent who will put the farmer’s growing conditions into the model, and tell them the ideal situation to maximize cassava yield.

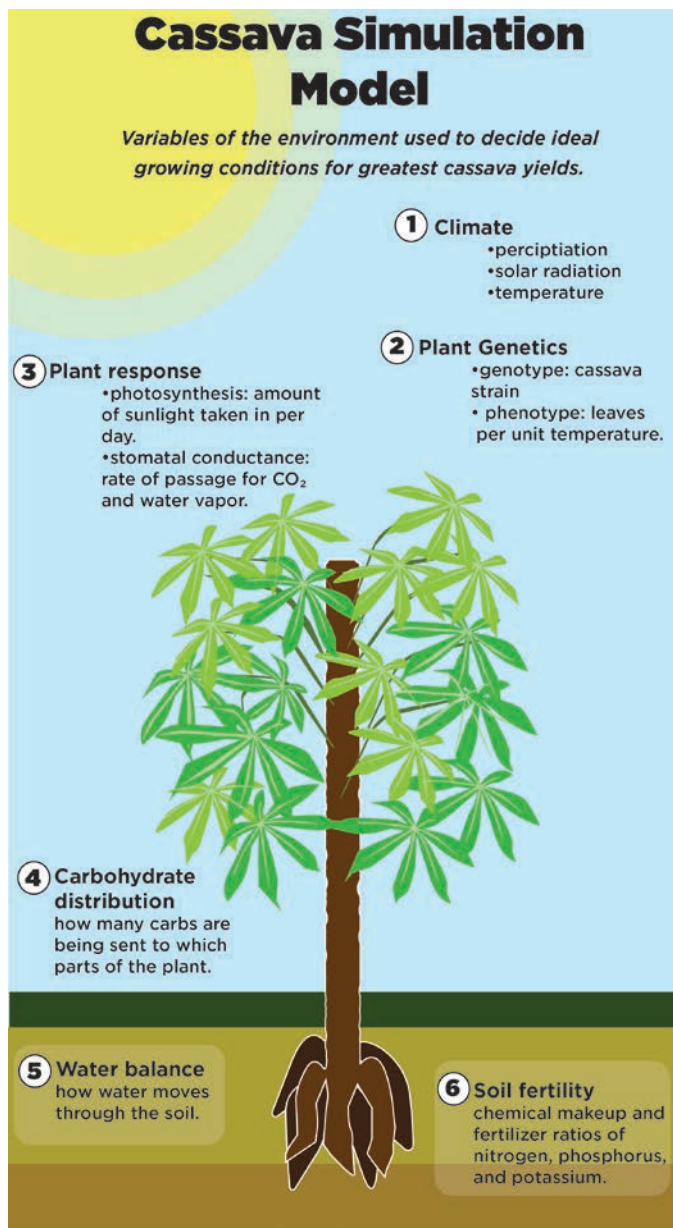
The agent will visit the farmers plot, and collect data from the plant itself and the surrounding environment. By collecting data the simulation device can diagnose growing conditions that are not favorable to yields, such as nitrogen deficiency in the soil, unfavorable energy distribution among the plant parts, or use of a less than ideal strain of cassava.

Also called yucca, cassava is commonly used to make flour, and is popular to grow due to its ability to adapt to weather fluctuations.

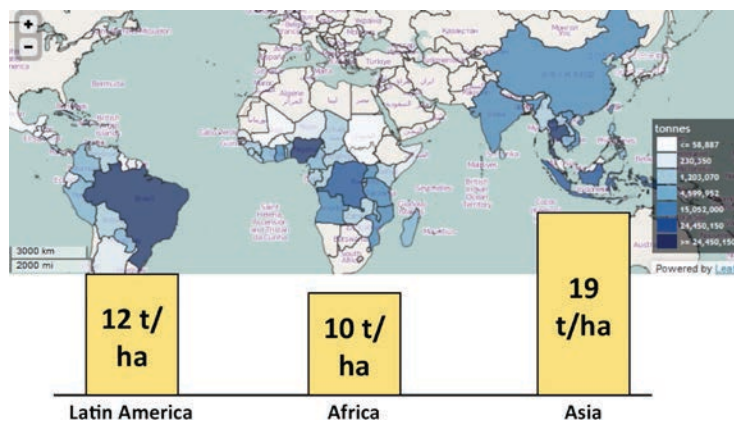
“If it is too dry, the crop shuts down and waits for a couple weeks or even a month for favorable conditions to come back. If it’s too hot, its yields do not go down, at least not as quickly as wheat, maize, or rice,” Ramirez-Villegas said. “It also requires very little income, so anyone can grow it. It’s ideal for resource-poor farmers.”



According to the team's research, when grown in optimum conditions, cassava yields have the potential to increase substantially. And, by utilizing the simulation model to test different "what if" scenarios, farmers are given insight to make further educated decisions. The combination can lead to enhanced food and income security for smallholders in Vietnam and beyond.



*The six attributes highlighted in the diagram – climate, plant genetics, plant response, carbohydrate distribution, water balance, and soil fertility – indicated the variables tested by the simulation model.*



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## Coconut Farmers Receive Valuable Warnings Via Text

Contrary to its name, the coconut is not a nut – it's the largest stone fruit in the world. Sold in the food and beverage industry, harvested for construction purposes, used in cosmetics, and transformed into decorative objects, the coconut has many applications. While a quarter of the world's coconut production stems from the Philippines, the country's coconut farmers are the poorest around the globe. With earnings hovering at \$2 a day, stagnant wages are exacerbated by low production, climate hazards, pests and unfavorable market conditions.

To improve the viability of coconut farming in the Philippines, researchers Ana Herrera and Leo Tobias leveraged a grant from the Global Center for Food Systems Innovation to implement FarmerLink, a Grameen Foundation project that connects farmers with agents who can provide insight into operating a successful coconut farm.

One component of FarmerLink is the Early Warning System, a large-scale digitally connected program that alerts farmers to potential hardships posed by natural shifts in the environment. "We envision the Early Warning System to use on-the-ground data from our field agents (on) weather information and pest and disease models to produce SMS messages sent directly to farmers to warn them against extreme weather events and potential pest and disease outbreaks," said Herrera.



By early 2017, Herrera and her team trained and deployed ten FarmerLink agents from the Philippine Coconut Authority and Franklin Baker Company of the Philippines. The training focused on the FarmerLink program, communication skills, engaging farmers effectively and the mobile tools. Content development of the coconut mobile tool kit included the design and development of mobile surveys that register farmers so they can receive SMS alerts on weather, pests and diseases, good agricultural practices and financial literacy training.

"Apart from the text messages sent directly to farmers, reports and dashboards will also be available for private and public sector partners to enable them to make decisions for quick response and pest and disease control," Herrera said.

The project is first of its kind, and aspires to benefit over 2,000 coconut farmers. Project partners include Philippine Coconut Authority, Palantir Technologies, aWhere and engageSPARK.



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## About GCFSI

Michigan State University's Global Center for Food Systems Innovation addresses critical pressures on the world's food supply by creating, testing and enabling the scaling of solutions. GCFSI takes a multidisciplinary approach that encompasses the entire food system and considers major environmental, economic and social trends, as well as workforce development needs that will impact future food security. Launched in 2012, GCFSI is one of eight development labs established through the Higher Education Solutions Network of the United States Agency for International Development.



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