

RUFORUM Case Studies

Rebuilding Agricultural Research Systems
in Burundi: RUFORUM Regional
Postgraduate Scholarships

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So pressing are Burundi's needs for well-trained agricultural researchers, that when Micheline Inamahoro arrived at Makerere University in Uganda in 2008 to complete a masters degree in plant breeding and seed systems, she was eight months pregnant. As a budding researcher with the Burundian national agricultural research institute, ISABU, she had a prized scholarship to study plant breeding, and it was an opportunity she was not going to pass up.

Working in a national institute devastated by the war, she was among a handful of scientists in a tightly constrained system that was in a state of prolonged collapse, suffering from a dearth of resources and people to help support farmers, who are the backbone of the economy in the tiny yet densely populated country.

Burundi was one of the countries targeted by the SCARDA (Strengthening Capacity for Agricultural Research and Development in Africa) initiative of the Forum for Agricultural Research in Africa, aimed at building capacity in research systems hamstrung by systemic weaknesses, often resulting from post-conflict stresses. And Inamahoro was one of five young Burundian researchers who completed their masters degrees with SCARDA support. The Regional Universities Forum for Capacity Building in Agriculture, or RUFORUM – an advanced research and training network and consortium of 45 African universities in 22 different countries – is the lead service provider for East Africa, and its engagement with this tiny, post-conflict country has provided a critical lifeline to Burundi's struggling national agricultural research system.

Endowed with rich soils and a variety of growing conditions, Burundi's agricultural sector is ripe for transformation, yet has lacked the human capital needed to drive this transformation.

Studying in Uganda was a challenge, to say the least. As a Kirundi and French speaker, Inamahoro needed extra tutoring to keep up with her coursework in English; and as a young, first-time mother, she endured sleepless nights and full days of lectures where, during lunch and tea breaks, she would have to race back to the house where she stayed, to nurse her baby. As she recalls, the support she received from RUFORUM was critical to her success: "It was not easy having a baby, doing studies, learning English – I don't know how I managed everything," she recalls. "RUFORUM arranged facilities for me; I had a big house nearby."

After completing her masters, which focused on studying root development in banana stems and evaluating clones for resistance to harmful nematodes (wormlike parasites that inhabit the soil and feast on plant roots), Inamahoro returned to Burundi with newfound confidence and skills, inspired and committed to making a difference at home.

Indeed, each of the five Burundian scientists trained through SCARDA has returned empowered with the passion and skills to create a ripple effect in the system.

Burundi depends heavily on subsistence farming, and around 60% of the population is food insecure. Following a devastating decade-long conflict, which destroyed basic infrastructure along with agricultural research systems, the country has sunken into deep poverty. Between 1993 and 2000, life expectancy dropped precipitously, from 51 to 44 years, while the poverty rate doubled over the same period. The recovery process has been slow.

Endowed with rich soils and a variety of growing conditions, Burundi's agricultural sector is ripe for transformation, yet has lacked the human capital needed to drive this transformation. The economy is heavily agrarian but is largely stuck at the subsistence level, as agricultural development has been stymied by weak capacities throughout the system.

The training received by Inamahoro and her colleagues in RUFORUM-sponsored postgraduate training programmes has been an important development that has helped to pull Burundian researchers out of isolation and into a regional community of scientific collaboration. The war had destroyed the research system, and in the post-conflict era there were virtually no resources available for rebuilding it.

Since returning to ISABU, Inamahoro and her colleagues have been slowly but steadily sowing changes. In 2011, following her research into the Irish potato, Inamahoro was appointed head of the national tissue culture laboratory at ISABU, and in early 2014 she started her PhD studies at Stellenbosch University in South Africa, where she is working on the physiology of dormancy in apple buds grown in areas with insufficient chill accumulation. Apples are not currently cultivated in Burundi, but there is great potential for the crop in the cooler, highland areas.

Her colleagues trained under SCARDA have also returned to Burundi, and are contributing in a variety of ways. One of them, horticulturalist Cyrille Mbonihankuye, now works with farmers to improve the availability and quality of highly nutritious indigenous vegetables, helping farmers to diversify their crops, reach new markets, and improve dietary diversity in the country.

One of the farmers, Jean Ndabeme, leases three hectares of land from the prison in Bujumbura, where he grows amaranth – valued for its leafy, spinach-like greens – interspersed with some onions to deter pests. The soil is rich and fertile, and he has no need for chemical fertilisers. In some of these fields, women from the local market are busy harvesting the amaranth in order to sell it. Ndabeme points out the difference between plots that are planted with the old and the new varieties of amaranth. The traditional varieties flower early, and are fringed with reddish and yellow fronds. In the past, his plants grown from mixed seeds would mature at different times, and he would produce a mixture of amaranth greens, some of which were not popular at the market. The new varieties, by contrast, are prized at the market for their thick, luxuriant greens.

Before Ndabeme came to Bujumbura, he and his family farmed rurally. When he arrived in town he started to grow vegetables, but because he does not own the land he cultivates, he is not able to invest in the improvements he would like, such as establishing a plot for seed production and intercropping with other cereals and maize in order to maximise his production. Amaranth is well suited to the lease arrangement he has, because it has a short planting and harvest cycle, he says.

Amaranth is also the most popular vegetable at the market, and is preferred over cabbage. The customers like this new variety because it is not all mixed up with different early-flowering varieties. His greens grow in the field for a long time without flowering, which increases their biomass, so that the large green leaves can be harvested, he says.

Ndabeme owes his discovery of this productive new variety of amaranth to his engagement with Mbonihankuye, who has been working to develop the potential of farmers to produce a more diverse and lucrative array of crops.

Most Burundian farmers still rely heavily on traditional seeds and farming methods, yet at the same time face growing constraints due to population growth and land pressures, increasing problems of crop diseases and pests, and soil and fertility issues. Extension services are weak, as are water and irrigation systems.

The first wave of destruction in the country's agricultural sector was the crash of the tea- and coffee-growing industries during the early 1990s – both of which were key cash crops before conflict broke out in 1993. The second wave was the ten-year conflict. The war had a devastating impact on agriculture, as fighting destroyed agricultural infrastructure and thousands of people fled from their farms to escape the conflict. Research ground to a halt, and economic ruin put costly fertiliser and machinery imports beyond the reach of most people.

Each of the young scientists trained through SCARDA brings with him or her new dimensions of expertise that can be harnessed to rebuild the system as a whole.



New varieties of amaranth, a nutritious indigenous crop, have improved its popularity at local markets.

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Horticulturalist Cyrille Mbonihankuye (right) has been working with farmers, including Jean Ndebeme (left), to introduce varieties of amaranth that are well adapted to local climates and tastes.



Gloriose Habonayo is pioneering new approaches to soil fertility in Burundi.

"Horticulture can be a source of income for farmers and development for the country."

Cyrille Mbonihankuye



SCARDA-supported graduate Micheline Inamahoro is pursuing her PhD at Stellenbosch University in South Africa and will soon become one of only a handful of Burundian agriculturalists to hold a doctorate.

For Mbonihankuye, for example, SCARDA presented the opportunity to develop his expertise in horticulture, which his work as a researcher in ISABU's fruit and vegetable programme had taught him was an important gap in the agricultural system. He did his MSc in horticulture at Sokoine University of Agriculture in Morogoro, Tanzania, his masters studies focusing on the effects of different methods and intervals of pruning on the yield and quality of tomatoes. *"We do not have a specific programme for horticulture, and it is a very important area for the development of the country,"* he explains. *"Horticulture can be a source of income for farmers and development for the country."*

Instead of regenerating coffee cultivation, which is heavy on land use – quite apart from the fact that Burundi lacks a competitive edge in such a well-trodden and heavily globalised industry – farmers would do far better to take advantage of Burundi's rich soils and diverse growing conditions, and focus on developing markets in new and improved horticultural crops, such as the amaranth that Ndadabeme is growing.

"There are many crops – like strawberries and marrows – that are easy to grow and have a short growing period of a few months, so farmers can harvest and get income," he says. *"These can be grown as food or exported."*

He continues: *"We have various micro-climates. In the highlands we can grow temperate crops like peas and even apples; and in the lowlands we can grow tropical crops, which means a diversity of crops can be grown in the country. The climate is good for crop production, the labour is available and we have a high proportion of land that is fertile. The only problem is to apply good agricultural practices."*

Mbonihankuye's recent contributions include participating in a project with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) to work on seed production of indigenous vegetables, primarily amaranth and African eggplant, working with farmers to help them produce their own, good-quality seeds. Via another ASARECA programme, he has worked to integrate crop and livestock production, helping farmers to optimise the use of manure in composting.

Through the project, an innovation platform called *Ikirezi* (which means 'something brilliant'), farmers have forged mutually beneficial relationships with traders, developed techniques in composting and rainwater harvesting, and expanded and diversified their range to produce items such as cabbage and kale, which were previously scarce or unavailable. Such arrangements are boosting farmers' incomes and helping them to develop new markets, such as supplying schools.

After Mbonihankuye finished his masters coursework, he gained further advantage from a small RUFORUM field attachment grant to conduct research while awaiting graduation. He took the opportunity to develop a new

policy for tomato cultivation, aimed at educating growers and consumers about best practices in phytosanitary controls, as well as pesticide and fertiliser usage – looking, for example, to curb harmful practices such as spraying pesticides too close to the time of harvesting.

Now his work focuses on developing seed systems for indigenous vegetables. This involves conducting participatory trials with farmers to test new varieties of amaranth, cabbage and sweet pepper so that they can test the suitability of these varieties, particularly for local markets. Initially ISABU had imported germplasm from the Asian Vegetable Research Centre, but then ran into problems as these varieties succumbed to diseases.

The amaranth, however, is a local Burundian variety adapted by ISABU, and Mbonihankuye is very proud of it. *"It was very interesting because a seed system for amaranth did not exist in Burundi,"* he says. *"It was an innovation."*

Slowly but surely, he and his colleagues are developing an indigenous seed bank at ISABU. *"Now we have collected local varieties of African eggplant, amaranth, and others,"* he says. *"We compare this germplasm with the imported ones."* The project supplies seed to farmers and helps them to become producers of their own seed, which they can then also sell to others, generating new sources of income as well as the means of expanding the reach of the newer, more productive varieties.

The benefits of the project include better yields and improved incomes for farmers. Previously, farmers used mixed seeds and, as a result, *"half the production was staying in the garden because it was not appreciated by the market"*. The more bountiful harvests have also improved the health of farmers and their families, providing them with access to a greater variety of more nutritious food. The nutritional qualities of amaranth, for example, are on a par with, and possibly even exceed, spinach and other leafy greens.

One of Mbonihankuye's colleagues, Gloriose Habonayo, a researcher in soil and water management at ISABU, also attended Sokoine University through a SCARDA sponsorship. Since returning to Burundi, she has focused on improving organic manure through composting. She has been conducting participatory research with farmers, and also working to build capacity in extension services by equipping extension workers and technicians with knowledge of soil fertility management.

In her masters research, she compared the efficacy of using NPK (nitrogen, potassium and phosphorus) fertilisers, farmyard manures and cowpea residues, respectively, with regard to maize yields. Her reason for embarking on this research was to explore whether the benefits to the soil of growing cowpeas as nitrogen-fixing legumes could be expanded by using the crop residues to further enrich the soil after harvesting. The benefits of animal manure for enriching the soil are of course well known, but since many families keep few livestock this manure is often insufficient, and there is a need to find other sources of material for sustainably enriching the soil with nutrients. Due to land shortages, the government has instituted a zero grazing policy, and families often struggle to find sources of feed for their animals. Additional problems result from lack of knowledge: for example, families often apply manure before it has fully decomposed, and consequently derive little benefit to the soil while increasing the risk of contamination from harmful bacteria and pathogens found in the animal dung.

"It is known that farmyard manure can help to improve soil fertility. I wanted to see if the cowpea could also contribute to soil fertility – I wanted to see if we could compound the quantity of nitrogen in the soil with cowpea residues."

Adding organic matter to the soil from cowpea crop residues has other advantages for soil health, Habonayo continues. It retains water in the soils, reduces erosion, and reduces acidity, which is a common problem throughout the region.

Soil fertility management is an increasingly pressing issue across the region as land pressures multiply with population growth. Burundi has one of the highest population densities in a region that already has some of the fastest population growth rates in the world. The scarcity of land means that the traditional methods of leaving land fallow to recover after several growing seasons are no longer feasible. Families are crammed onto small plots, and even if they keep every scrap of land under constant cultivation, their yields are often insufficient to meet their food and income needs. With every new generation, the land is divided into ever-smaller parcels, and the need for intensification grows.

Habonayo has also done research on using a common weed found in the south of Burundi, *Tithonian diversifolia*, to replenish the soil with important nutrients such as nitrogen, potassium, calcium and even phosphorous. Farmers used to pull it out, but now that they understand its multiple benefits to the soil, they encourage it to grow amidst their crops. *"When you plant it in the soil, it acts like organic manure and releases nutrients very fast into the soil,"* she says.

"It is known that farmyard manure can help to improve soil fertility. I wanted to see if the cowpea could also contribute to soil fertility – I wanted to see if we could compound the quantity of nitrogen in the soil with cowpea residues."

Gloriose Habonayo

She has been able to spread this knowledge far and wide across the country, so far training 14 different Farmer Field Schools as well as 30 extension workers and technicians posted across the country.

As she explains, her knowledge also has equipped her to collaborate effectively with colleagues. Fulgence Niyam, for example, is a rice breeder who trained in the plant-breeding and seed systems masters programme at Makerere University in Uganda, also through SCARDA sponsorship. Rice, along with maize, cassava and sweet potatoes, has been identified as a priority by the Burundian government. Currently Burundi produces about 100,000 tonnes of rice per year, but relies heavily on imports from neighbouring Tanzania – a situation Niyam is working to reverse as the crop gains popularity. Consumption per capita has grown from 1.5 kg per year to 20 kg per year. *"Some time ago, rice was consumed in the cities only. In the rural areas it was consumed during parties, but nowadays it is getting more popular,"* he says.

In his masters research, he searched for resistance genes against *Magnaporthe grisea* – a fungus that affects upland rice – in the progeny of a parent line that was a cross between susceptible and non-susceptible varieties, in order to study how resistance is passed down from parent to progeny. When Niyam joined ISABU in 2006, the rice-breeding programme was in its infancy, and his own knowledge was thin. *"I was working and learning at the same time,"* he recalls. *"Before, some of the theories were lacking, but now I understand everything. I keep learning and I keep improving."*

Now Niyam heads the rice programme, and is working with farmers to conduct field trials of NERICA (New Rice for Africa) varieties, testing them for yields and resistance to biotic stresses, and adapting them to thrive in local conditions. He and Habonayo are also planning to collaborate on a project looking at rice breeding and soil fertility.

One of the major challenges of any agricultural research system is to coordinate and use all the specialised knowledge that exists in that system – and that is where the area of research methods came in. A major RUFORUM contribution was to design and initiate a masters programme, hosted by Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya, with the aim of producing professionals whose expertise includes the research process itself – including methodology and software but also a broad conceptual understanding of the design, implementation and application of research.

Ntukamazina Nepomuscene completed his MSc in research methods at JKUAT, and now occupies the role of research specialist at ISABU. His is a crucial role: he supports scientists across Burundi in conducting research. From planning to publishing, to software, statistics and biometrics, Nepomuscene does it all. He helps to develop research proposals and protocols, and assists researchers with collecting and analysing data, using statistical packages, and getting their results published. He now heads the biometrics and information unit of ISABU.



RUFORUM's engagement with ISABU has also brought the University of Burundi into the network, offering the prospect of building up existing research in areas such as mushroom cultivation.

Since returning to ISABU in 2011, he has become a critical resource, and shares his knowledge with colleagues in each of Burundi's six research stations. He has trained colleagues in the field, sometimes even in such basics as using Microsoft PowerPoint and the effective use of Excel spreadsheets – but also in the use of sophisticated software packages such as GenStat and SPSS. Often he provides guidance, over the phone, to researchers located at remote research stations, in the finer points of data collection, particularly if they get stuck somewhere in the process. As he explains, there are many intricacies, for example, to gathering data on plants, such as a scoring system to capture the levels of disease in different plants.

Since research encompasses so many different areas of knowledge and expertise, knowing how to access knowledge is almost more important than having the knowledge itself. Here, the relationships Inamahoro formed with his classmates at JKUAT have proved immensely helpful. He explains: *"My classmates are working at some of the other universities and research institutes in the region. We discuss things on Skype. It shows the course was really relevant for people in the National Agricultural Research Institutes. Most of the time when a scientist comes into my office and asks me a question, I go to my folders and get answers and guidelines on how to help them."*

He is also able to take a big-picture view of ISABU's research agenda, which focuses broadly on the areas of combating climate change, fighting crop diseases, assessing crop varieties that are suitable for local conditions, enhancing nutrition and linking farmers to markets.

Agricultural value chains are not well established in Burundi. Inamahoro says that ISABU is taking seed systems as the starting point for building value chains, as the availability of abundant produce of a good and consistent quality is key to building the whole system. There is a long way to go. According to Inamahoro, a survey conducted in 2012 of nationwide potato production revealed that 90% of farmers were cultivating from traditional seeds. The lack of capacity within ISABU as well as the lack of market penetration in rural areas makes it difficult to put improved seeds in the hands of farmers.

Capacity building likewise remains a huge challenge across the system. Currently ISABU has only three PhD holders, with an additional three, including Inamahoro, currently working on their doctorates, thanks to RUFORUM support. Infrastructure is poor: laboratory facilities in ISABU are run-down, and most of the other research stations lack laboratory facilities altogether. The system has, in total, some 70 scientists and 120 technicians, most of the latter holding only a technical secondary school qualification. The low levels of researcher training in the system have meant, for example, that foreign principal investigators are needed for complex or high-level research projects.

Another challenge is to retain scientists after they gain new qualifications, as increasingly they tend to leave for better-salaried positions in the university and for international NGOs. In addition, says Inamahoro, researchers often feel pressure to take on consultancy work to compensate for their low salaries.

As ISABU has focused on capacity building in the past ten years, levels of qualification are slowly being raised. The institute now has 30 scientists with MScs, having benefited from other programmes in addition to SCARDA. *"Before SCARDA, we were not ready for PhDs,"* says Inamahoro. *"Now if we can train 20 PhDs the institute can be strong and competitive."*

The relationship between ISABU, RUFORUM and the University of Burundi, a RUFORUM consortium member, has paved the way for PhD training to commence. SHARE, launched in January 2013, is an exchange programme providing for masters- and PhD-level training of students from selected universities, including the University of Burundi. RUFORUM helped to secure European Union funding for SHARE, and the host universities include Haramaya University (Ethiopia), JKUAT (Kenya), the Lilongwe University of Agriculture and Natural Resources (Malawi), Makerere University (Uganda), Stellenbosch University (South Africa) and Université d'Abomey Calavi (Benin).

It is thanks to SHARE sponsorship that Inamahoro is currently working on her PhD at Stellenbosch University. She is the only Burundian PhD student in the programme. And through SHARE, eight Burundian students are being trained at masters level at different universities across Africa.

"The programme will have a very good impact: the University of Burundi was involved in the writing of the proposal, and so the masters specialisations are according to our needs," explains Dr Maxime Ndayizeye, vice-dean in the Faculty of Agronomy and Bioengineering at the University of Burundi. *"We don't have experts in water resources, plant breeding or biodiversity on our staff. This means the students will come back and automatically get jobs in our faculty."*

Collaboration has proved an important theme in the SCARDA- and RUFORUM-supported initiatives in Burundi. Collaboration within ISABU has been strengthened. At the same time, the support of regional organisations (particularly ASARECA) has made a big difference in involving Burundi in collaborations on a regional scale. And for Inamahoro on a personal level, embracing a mindset of collaboration has helped her to advance in her career. *"The MSc opened my mind, to collaborate with people and to link with other researchers,"* she says. *"I have had many trainings and attended many conferences not because of ISABU but because of those relationships."*

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Regional Universities Forum for
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