IITA
Transforming African Agriculture
CGIAR

2017 Annual Report

50
1967 - 2017

years of research and development:
serving the African farmers and communities

IITA 2017
Annual Report

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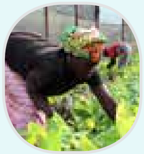
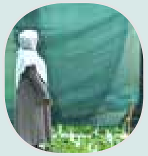




From the Board Chair and the Director General

The mission of IITA is to be the leading research partner facilitating agricultural solutions to overcome hunger, poverty, and natural resource degradation throughout the tropics. IITA sees a bright future for Africa, a continent that can become a world leader in agriculture and sustainability. The Institute's 2012-2020 Strategic Plan established an ambitious goal of lifting 11 million people out of poverty and revitalizing 7.5 million hectares of degraded land by 2020. IITA is committed to providing leadership in the region in achieving these goals.

A five-year period of unprecedented growth of IITA leveled off in 2017. The budget of the Institute, which almost tripled from 2011 to 2016, declined slightly. This reduction was felt by almost all the research centers in the CGIAR system resulting from a continued reduction in core (Windows 1 and 2) funding and a reduction in contributions from large donors for certain programs. Through sound cost control in the management of the Institute, IITA was able to maintain its scientific staff and programs, avoiding the layoffs that occurred at some other centers. The increased science capacity, improved infrastructure, and updated scientific equipment that occurred during the period of growth have greatly increased IITA's capacity to conduct research to deliver on its mission and strategic plan. Effective resource mobilization will be a priority to allow the Institute to continue to improve this capacity.

In the new CRP portfolio, which began in January 2017, IITA is a key partner in five CRPs: Roots, Tubers and Bananas; MAIZE; Climate Change; Agriculture for Nutrition and Health; and Policies, Institutions and Markets; as well as three Platforms. IITA's research programs are well aligned with the CRPs to achieve the CGIAR's system-level outcomes.

Several years ago, IITA established a Business Incubation Platform (BIP) at its headquarters in Ibadan to support the delivery and impact of technologies developed from its research programs. In 2017, there was increased production and distribution of the three products from this facility: Aflasafe, which greatly reduces poisonous aflatoxins in cereals and legumes; soybean inoculum (Nodumax); and breeder and foundation seed of new IITA cultivars from the GoSeed facility. Aflasafe production facilities are now being constructed or planned in several other African countries.

The Technologies for African Agricultural Transformation (TAAT) program, funded mainly by the African Development Bank, was approved in 2017. This program will facilitate the delivery of proven CGIAR technologies to African farmers. IITA will play a key coordinating role as executing agency for this program, which involves other CGIAR centers and numerous partners throughout Africa. The Youth Agripreneur program, pioneered by IITA, continues to grow. It has now been extended to many African countries under the ENABLE Youth Program, funded by the African Development Bank. The IITA Agripreneur program in Ibadan will provide advice and service to groups that are being established in other countries. The goal of the ENABLE program is to get African youth more involved in agriculture, driving innovation in the sector, and addressing youth unemployment.

A highlight of 2017 was the celebration of IITA's 50th Anniversary. General celebrations took place throughout the year at the various IITA sites with the core celebration in July, and an international science conference in November, at Ibadan. The core celebration was attended by dignitaries, partners, alumni, and staff and included the official commissioning of the Akinwumi A. Adesina Agripreneurs Building. Over the year, IITA reflected on the many achievements of its first 50 years and the many new initiatives that will foster even greater contributions as the Institute enters its second half-century.

It has been an honor to have served as Chair of the Board and Director General of this Institute over the last six plus years. We would like to thank our colleagues on the Board for their dedication to IITA's success. The Board also expresses appreciation to DG Sanginga and the senior management team for their significant accomplishments and for their vision for the future. We congratulate the scientists and support staff for the excellent research being conducted. Finally, we express our appreciation to our funders who recognize the importance of the work being done and have confidence in the Institute's ability to do it.

Dr Bruce Coulman
Chair, Board of Trustees

Dr Nteranya Sanginga
Director General

Africn Development Bank President Akin Adesina commissions the Agriserve Building during the IITA50 celebration. Photo by IITA.

IITA celebrates 50 years of service to African farmers and communities

Katherine Lopez and Kwesi Atta-Krah
IITA-Ibadan

IITA celebrates 50 years or service to farmers and agricuture in sub-Saharan Africa. Photo by IITA

For a long time subsistence agriculture has been seen as the way of life for poor smallholder African farmers, contributing to their livelihoods and creating employment. Agriculture, however, can drive economic development and wealth creation. To maximise its potential for transformation, agriculture needs to be seen as a commercial business at all levels.

The birth of IITA

IITA was established by the Ford and Rockefeller Foundations in 1967 to contribute towards global food and nutrition security. It was created based on the need to have an African version of the Green Revolution that transformed Asia through increased agricultural production in the 1960s. It became the first African link in a network of international agricultural research centers.

As a research-for-development center supported by numerous donors and partners, IITA focuses on three strategic objectives: (1) increasing food security and availability, (2) increasing profitability of foods, feeds, and other agricultural products, and (3) sustainable management of natural resources.

Its research is organized around several core themes: Improving crops, Making healthy crops, Managing natural resources, Improving livelihoods, and Enhancing nutrition.

The Institute also works on special initiatives including youth engagement in agribusiness, commercialization of technologies in a business incubation platform, empowering women, developing seed systems, protecting and conserving biodiversity, and big data and open access.

Farmers show off good cassava harvest.
Photo by IITA.

In 2017, IITA celebrated its 50th year of service to African agriculture and smallholder farmers.

Impact on agriculture

Presently, IITA has become the largest international agriculture research center in tropical Africa, contributing to food and nutrition security in the region. Its research has produced many improved varieties in most major African staples that include banana/plantain, cassava, cowpea, maize, soybean, and yam; improved overall agricultural productivity; and created wealth for farmers and value chain actors, while making significant contributions to national economic development.

IITA has spread from its original location in Ibadan, with hubs created in East Africa, Central Africa, and Southern Africa, while the Ibadan facility doubles as Headquarters and the West Africa Hub. Each Hub is equipped with research facilities and fields, with operations engaging countries within the Hub in a spectrum of research and delivery activities.

The impacts of IITA's research for development on smallholder farmers are evident in the development and adoption of improved varieties in most of the major staples in the continent. For example, adoption of almost 400 varieties of cassava with increased yields and better resistance to pests and disease and environmental stresses; more than 100 IITA-bred materials or genebank accessions of cowpea; 327 maize varieties—70% of which have IITA germplasm; 78 improved yam varieties developed; introduction of soybean as a food and cash crop in West Africa; adoption of drought-tolerant maize in 13 countries in eastern, western, and southern Africa with projected economic gains of US$907 million; introduction of cowpea and soybean for nutrition; and nutritional benefits of biofortified yellow cassava.

The development of a biocontrol product called Aflasafe™ against aflatoxins in maize and groundnut and its commercialization in IITA's Business Incubation Platform is now helping some African countries go back to trade in groundnut and maize and making food supplies safer.

In Nigeria, IITA has been working with the Federal Government on its Agricultural Transformation Agenda.

Poverty reduction in sub-Saharan Africa

IITA's impact assessment studies in several countries showed that as of 2016, at least 4.3 million people had been lifted out of poverty in sub-Saharan Africa through the adoption of improved agricultural technologies developed by the Institute and its partners.

In Nigeria, two technologies—improved cowpea varieties and drought tolerant maize varieties—have contributed to getting an estimated 3.5 million people out of poverty.

One study found that by 2012, 58% of cowpea farmlands was cultivated to improved varieties with yield gains of 254% over local varieties. It also established that the nutritional status of children below five years was higher among those who had adopted the technologies compared to the non-adopters.

A 2015 baseline study of the African Development Bank-funded Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) and an impact study of the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) on improved crop varieties combined with crop management practices, integrated pest management practices, and marketing strategies collectively showed further that almost a million people were lifted out of poverty in association with IITA technologies.

Food security improvement

In 2016, IITA received the Al–Sumait Food Security Prize for Development in Africa. The prize was awarded jointly to the International Potato Center (CIP) and IITA for the groundbreaking research on the causes of undernourishment and for providing solutions to agricultural challenges.

IITA was cited as "a leading Africa-based crop center and a member of CGIAR, focusing on research and development of the key African food crops: banana and plantain, cassava, cowpea, maize, soybean, and yam. The team's efforts developed and deployed safe and more nutritious food crops such as legumes, cereals (vitamin A maize), with the first released orange maize varieties from it, and tubers (cassava) through biofortification, use of efficient and affordable biocontrol products against aflatoxins, and made these available to smallholder farm families in the region to balance calories, diversify diets, and safeguard health and nutrition."

In support of AfDB's programs, including the Feed Africa initiative, IITA leads the implementation of the AfDB-funded multimillion dollar initiative to transform African agriculture called Technologies for African Agricultural Transformation or TAAT. Over the next 10 years, AfDB will be investing US$24 billion in agriculture, focusing on agricultural value chains, agribusiness, and agroindustrial development.

A key component of AfDB's strategy is providing support to Agripreneurs who will drive agriculture and development in Africa in the future. This will be achieved in a flagship program known as ENABLE Youth. This program was based on an approach that IITA piloted and is designed to develop the next generation of millionaire/billionaire farmers and agribusinesses. In 2016, AfDB financed almost $800 million for the program in eight countries. In 2017, another 15 countries were planned to be financed.

Capacity development

IITA has also contributed massively to the capacity development of African researchers and scientists in agriculture and supported national agriculture research systems in the continent.

Since inception, IITA has trained over 140,000 individuals from 68 countries—more than 40,000 of them women. These professionals have advanced their knowledge and acquired skills directly through IITA's training programs and indirectly through knowledge passed on to them.

Future orientation

In the next 50 years IITA will intensify its efforts in three areas: (1) The transformation focus of its research which aims, through massive scaling out efforts, to have an impact on changing livelihoods of farmers and the economies of African countries; (2) Youth in agriculture and agribusiness, which provides solutions to the issue of youth unemployment and unearthing opportunities for youth in agriculture and agribusiness; and (3) Strengthening research to address direct and indirect impacts of climate change in partnership with other institutions, to ensure food security and incomes through agriculture.

Finally, IITA will strengthen efforts in aligning its research and delivery operations with the strategic goals and targets of priority countries in partnership with other research and development entities, including stronger engagement with NARs, regional and subregional organizations, and continental policy and political processes. This will be done in parallel with its historical mandate of developing international public goods to enhance science and agricultural productivity.

50 years of improving African food crops

Michael Abberton
Head, GRC, IITA-Ibadan

Genetic Resources Center Head Micheal bberton briefs visitors to the gene bank. Photo by IITA.

From inception, the rationale for the existence and work of IITA had a major focus on plant breeding. It is noteworthy that this included crop quality as well as yield and that distribution of planting material of improved varieties to other centers or institutes was a key output. However, variety development was not seen in isolation; it was an integral part of farming systems together with improving soil fertility and other key factors. At the same time, a strong commitment to capacity development, training, and effectiveness in terms of impact was also evident.

By 1974, IITA was working on a relatively wide range of crops; not only the current "mandate"—maize, cowpea, soybean, banana/plantain, cassava, and yam, but also sweetpotato, rice, cocoyam, lima bean, pigeonpea, winged bean, African yam bean, and velvet bean. A key development was the opening of the Genetic Resources Unit (now Genetic Resources Center, GRC) with a mission to collect, conserve, characterize, and distribute African grain legumes, rice, and root and tuber crops. The "geographical domain" of IITA was agreed to include all humid and subhumid tropical zones. The current focus of mandate crops developed in the early 1990s and included the transfer of sweetpotato work to CIP and the regional rice mandate to WARDA (now AfricaRice).

Maize

In the early years, maize improvement focused on lowland rust and lowland blight, which had been seen for a long time as the major factors limiting yield in lowland West Africa. Together with rapid selection for key agronomic traits, this focus resulted in very successful varieties grown over large areas in West and Central Africa during the 1980s.

A recurring feature of plant breeding efforts at IITA throughout the 50 years has been the need to address new challenges particularly with respect to pests and diseases. In the 1970s for maize this was maize streak virus (MSV) with the basis for success being the development of a robust protocol to screen for resistance and the working together of IITA scientists from different disciplines. These successes were achieved through breeding open-pollinated varieties, but in the late 1970s and early 1980s a program of inbred line and hybrid development was initiated. These allowed the production of higher yielding varieties and supplied NARS in the region with inbred lines carrying good characteristics including disease resistance. The development of hybrid maize at IITA was an important factor in the emergence of a number of seed companies, particularly in Nigeria.

Great progress has been made in recent years in the development and release of maize varieties resistant to the parasitic weed *Striga,* a major threat to maize production in many parts of sub-Saharan Africa, and varieties with increased levels of micronutrients, especially provitamin A.

The release and adoption of early maturing varieties has allowed the expansion of the area where maize can be grown to include semi-arid parts of Burkina Faso, Mali, and Niger.

Cassava

An early focus of cassava improvement, from 1971, was on resistance to cassava mosaic disease (CMD). This was achieved in a triumph of classical plant breeding that had a massive impact in sub-Saharan Africa. Combining resistance to CMD with that for cassava bacterial blight (CBB) and high root yields turned cassava from a crop used in times of famine to a major source of calories for people in both rural and urban areas. This was an achievement that demonstrated clearly the impact that well-focused plant breeding could have on food security. In 2002, a new and successful battle was fought against a more virulent strain of CMD in Nigeria.


Cassava


Maize

Through various iterations of its strategy, IITA has maintained a pan-African approach to cassava improvement and this continues with breeding programs in all four subregions of sub-Saharan Africa. In the 1990s, IITA and the National Agricultural Research Organisation (NARO), Uganda developed a strong partnership to fight CMD in that country. Partnership with NARS through the Southern Africa Root Crops Research Network and the Eastern Africa Root Crops Research Network in the 1990s were important in the introduction and collaborative development of new cassava varieties in the two subregions. A major current focus in Eastern Africa is understanding the genetic control of, and breeding for, resistance to cassava brown streak virus.

Researcher at the Biosciences. Photo by IITA.

The adoption of released cassava varieties with increased levels of provitamin A under the HarvestPlus program since 2009 is important, particularly for the nutrition and health of mothers and young children.

Soybean

IITA soybean breeding essentially developed this species as a viable crop in many parts of sub-Saharan Africa. The development and introduction of soybean lines with "promiscuous nodulation" and the bringing together of this trait with desirable production characteristics, greatly increased the yield of soybean, particularly in Nigeria. To these was added greater seed lifespan to overcome decline of viability before planting. Until their development starting in the early 1980s, high-yielding varieties successful in other parts of the world, could not be grown in sub-Saharan Africa without rhizobial inoculation. The impact of greater soybean production from adoption of new varieties and the promotion of its utilization in various food forms were seen in the enhanced nutritional status of children. New varieties have been developed and released in Nigeria that combine high yields with resistance to soybean rust that threatens increase in, and stability of, production of the crop.

Yam

Yam is a key staple crop for West Africa and the focus has been on the breeding of the two most widely grown species: water yam (indigenous to Asia) and white yam (indigenous to West Africa). Improved varieties have been developed and released in Nigeria and other countries with higher yields, good quality and storability, and increased disease resistance. For clonal crops, improved propagation methods go hand-in-hand with varietal development. IITA working together with the National Root Crops Research

Yam

Institute, Nigeria, developed and promoted the minisett method of rapid propagation and later introduced other methods based on vine cuttings and aeroponics.

Cowpea

Cowpea is indigenous to sub-Saharan Africa and IITA's GRC houses the global collection"of more than 17,000 accessions, many of which have been used extensively in variety development. The early collection of more than 8,000 accessions was screened for disease and pest resistance from the 1970s and varieties were developed and released for both the humid areas and savannas. In the late 1980s, the cowpea breeding program moved from Ibadan to Kano with a focus on breeding for savannas and dual grain and livestock fodder purposes. The impact from adoption of these varieties has been well demonstrated, especially enhanced food security during the "hungry season" of the savannas. Fast maturing (60 days) cowpea varieties with increased disease resistance were particularly important.

Banana/Plantain

East African highland banana and plantain in West Africa are important sources of income and nutrition and IITA has breeding programs for both these categories of the crop. A major success was the development and distribution of black sigatoka resistant cooking banana. These were developed through a collaboration between IITA Onne station and partners including the Agricultural Development Program at Owerri. This had a major effect on the acceptability and cultivation of cooking banana in Southeastern Nigeria. Work continued to develop black sigatoka resistant hybrids in plantain. Improved hybrids have now been distributed in many countries inside and outside Africa.

Collaboration and Capacity Development

A continuing preoccupation of IITA and its breeding programs, from the outset, has been to work closely with NARS. This involves transfer of breeding lines, joint varietal testing, and training. In general varieties developed by IITA and partners are released through the NARS.

The Future

IITA's breeding programs continue to develop new varieties for adaptation to changing environmental conditions and market preferences in selected target regions. The programs increasingly use new tools and approaches to raise the efficiency and effectiveness of breeding and selection and they collaborate with colleagues in ancillary disciplines and the private sector to improve seed systems. Among other things, these improvements will reduce the periods required for coming up with new varieties that are superior to those currently in use and speed up the delivery of their seeds and planting materials to end-users.

Much of this article is based on the book "IITA: 50 Years After" compiled by Rodomoro Ortiz.

Cowpea

Bananas

50 years of natural resource management research in sub-Saharan Africa

Bernard Vanlauwe
R4D Director, Central Africa Hub
Nairobi, Kenya

Young people start early taking care of the environment.
Photo by IITA.

The beginning of soil and soil fertility research at IITA

Low and declining soil fertility has for a long time been recognized as a major impediment to intensifying agriculture in sub-Saharan Africa. Consequently, from its inception, soil and soil fertility management have been part and parcel of the IITA research portfolio. The period 1967–1982 was a time of great expectations due to the early successes of the Asian Green Revolution and IITA, alongside other international research centers, was created to bring the benefits of modern agricultural science to the African farmer. The aim was to replace traditional, and assumedly outdated production systems with new, more productive ones.

IITA's founding fathers, among others, were concerned with the low and declining land productivity in the face of growing populations and the inadequacy of traditional farming methods to curb this trend. Therefore, early research efforts were on land clearing, soil erosion, and zero tillage, combined with chemical weed control and small or medium level mechanization (Fig. 1). From the mid-1980s, attention began to shift towards existing production systems and their capacity for change and sustainable intensification (SI).

Alley cropping and planted leguminous fallows were on the agenda for several years, but were eventually replaced by technologies which were closer to the farmers' own experience, such as dual-purpose legumes. These became part of the tool box of Integrated Soil Fertility Management (ISFM) (Fig. 2), which today is the pillar for soil and soil fertility management research. Its principles are aligned with those of SI, which encompass (i) increased production per unit of land, (ii) maintenance of essential soil-based ecosystem services, and (iii) resilience to shocks, especially climate change.

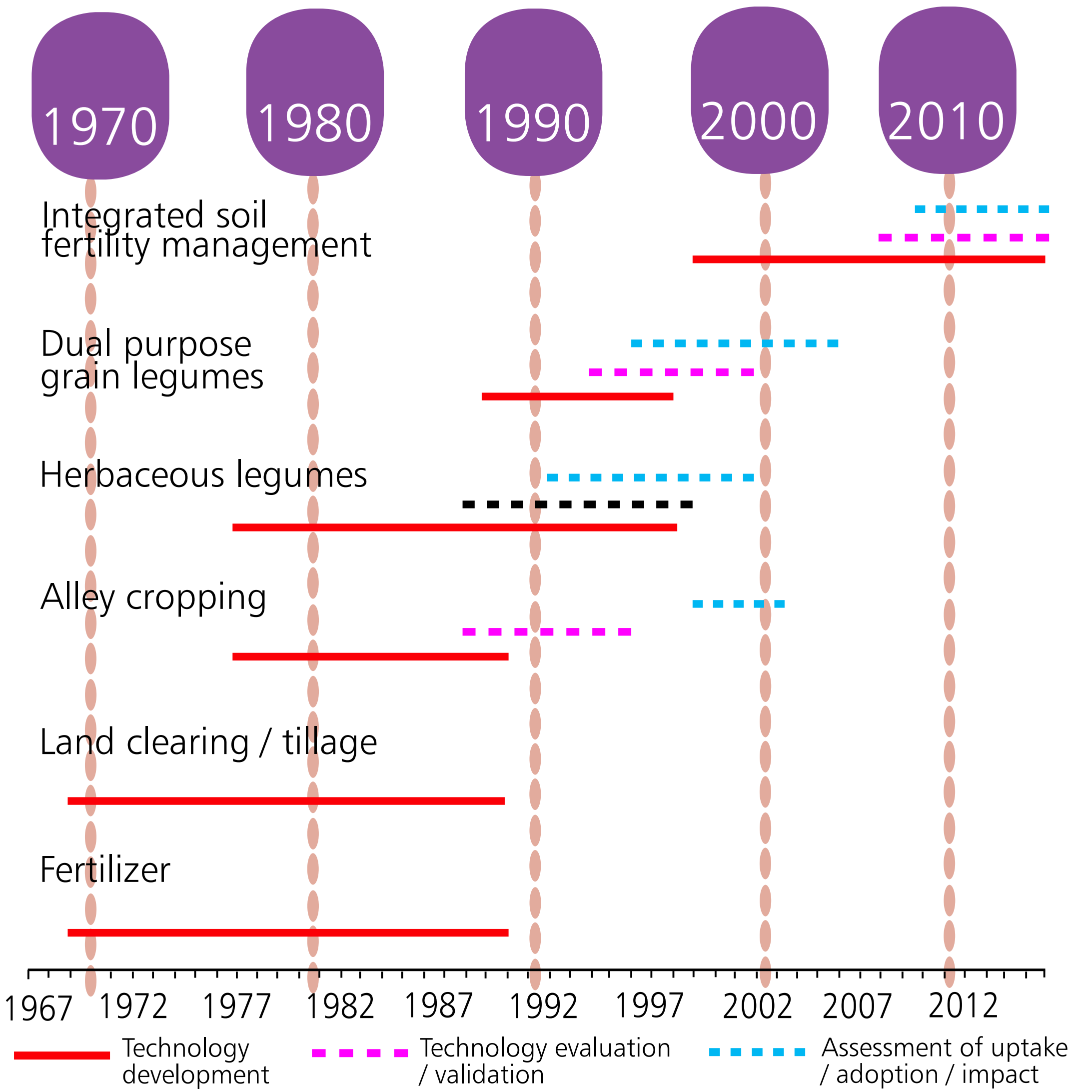


Figure 1. Evolution of the technologies and interventions prioritized by soil and soil fertility research initiatives with an indication of the technology development, evaluation/validation, and uptake/adoption/impact phases from 1967 till today. Source: Vanlauwe et al, 2017.

Search for the holy grail in soil and soil fertility management

From the late seventies, substantial efforts were made to develop and fine-tune "low input", technologies such as alley cropping and herbaceous legume-based systems (including rotations, relay cropping systems, and live mulch systems). This was partly driven by the initial failure of Green Revolution approaches and the lack of favorable conditions for the use of agro-inputs on food crops.

The approach used in developing and promoting alley cropping systems followed the traditional technology transfer model where a lot of efforts went to fine-tune the systems before they were exposed to farming communities and promoted through development-oriented efforts (Fig. 1), as illustrated by the AFNETA (Alley Farming Network for Africa) project. Initial evaluations of herbaceous legume-based technologies established that the main interest of farming communities of a *Mucuna* fallow was the suppression of *Imperata cylindrica* rather than improved soil fertility. There was a massive effort in the second half of the 1990s to disseminate the *Mucuna* technology to farmers in Benin, by various investors and development organizations.

However, from the late 1990s, it was becoming clear that alley cropping and herbaceous legume-based technologies

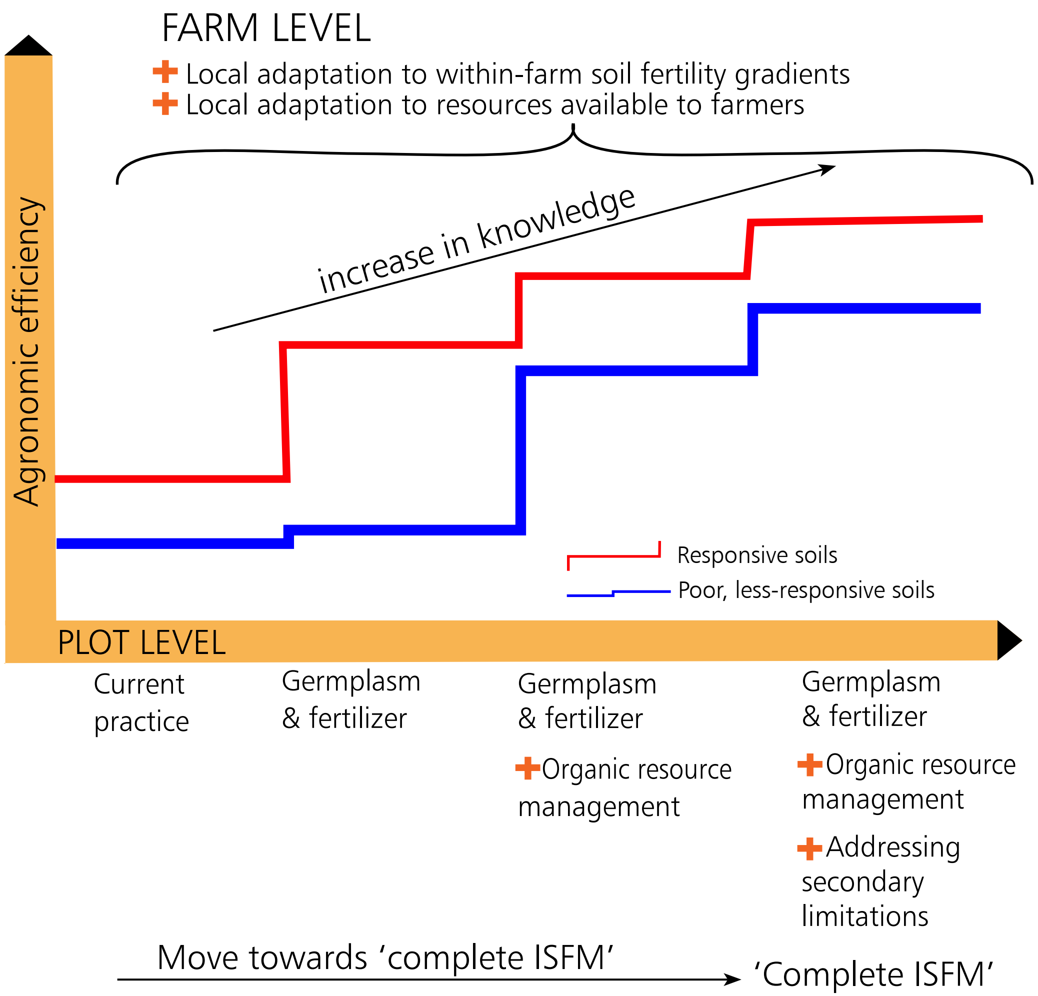


Figure 2. Revised conceptual framework underlying Integrated Soil Fertility Management (ISFM), adapted from the original version. The current version distinguished plot from farm-level 'local adaptation' interventions. Conceptual relationship between the agronomic efficiency *(AE)* of fertilizers and organic resource and the implementation of various components of ISFM, culminating in complete ISFM towards the right side of the graph. Soils that are responsive to NPK-based fertilizer and those that are poor and less-responsive are distinguished. The 'current practice' step assumes the use of the current average fertilizer application rate in SSA of 8 kg fertilizer nutrients ha^{-1}.
Source: Vanlauwe et al (2015).

were not attracting the necessary farmer interest, mainly due to the lack of immediate returns on investment in land and/or labor. The focus moved to integration of grain legumes that led to the breeding of soybean for dual-purpose properties and promiscuity (Fig. 1). This was a commendable example of effective cooperation between a breeder and a soil microbiologist at IITA. The interest of farmers was immediate since such legumes not only provided immediate income through grain production but also the effects of the rotation on the subsequent maize crop were visible. Following its success, efforts were expanded to include cowpea and more recently groundnut and beans, supplemented with limited and targeted amounts of fertilizer, as research by the BNMS (Balanced Nutrient Management Systems) project.

The ISFM approach (Fig. 2), which is the cornerstone of today's soil and soil fertility management R&D, is building on these earlier successes and complements the need for fertilizer with the necessary implements, including varieties, organic inputs, and other amendments, towards maximizing the use efficiency of these inputs. ISFM also recognizes that there is not one fit-for-all solution in relation to soil and soil fertility management, and that decision support tools are required to assist smallholder farmers in finding the right solutions for specific crops, production objectives, and overall environmental and institutional conditions.

Nodumax, an effective rhizobium inoculant, produced at the Business Incubation Platform at IITA, can increase soybean yields by 25% and facilitate biological nitrogen fixation to the equivalent of 100 kg of fertilizer N per hectare. This work is supported by the N2Africa project.
Photo by K. Fred, IITA.

Evidence of impact of investments in soil and soil fertility research

The early work of IITA did not warrant impact assessment since the technologies developed were not applicable to existing farming systems. Only with the shift to alley cropping and herbaceous legume-based interventions were efforts started to disseminate fine-tuned (most often under on-station conditions) solutions to farming communities.

For the *Mucuna* technology—the only herbaceous legume of the many evaluated that was promoted at scale—profitability for farmers was high as long as NGOs purchased the seed, artificially turning the species into a commercial crop. When this stopped in 1996, the adoption declined by 25%.

The decline in adoption of *Mucuna* and the abandonment or neglect of many alley cropping fields, revealed by impact studies, led to the virtual abandonment of these technologies by research and development organizations. Up to the mid-1990s, the impact of IITA's soil and soil fertility management R&D on farming communities was low to nil although it must be recognized that many scientific outputs had been generated. Thus, in practical terms, impact-oriented NRM R&D at IITA started during the late 1990s.

No full-fledged impact study has been carried out to date in the savannas of Nigeria where the dual-purpose legumes were promoted, in combination with BNMS technologies although indirect evidence shows a large scope for meaningful impact (or important interest in uptake at pilot scale). Recent work in the CIALCA region indicated that while few farmers in the area have reached 'full ISFM', some components were taken up by substantial proportions of the target population with the uptake of specific technology components occurring sequentially rather than simultaneously.

A recent impact study in the CIALCA region showed that adoption of agricultural research-for-development technologies reduced the probability of being poor by 13% and that a large share of this poverty reduction is causally attributable to adoption of improved crop varieties (32%) followed by adoption of postharvest technologies (28%) and crop and natural resource management (26%). These studies indicate that ISFM practices have scope for large-scale uptake although only formal adoption studies will provide the necessary evidence. Such studies are planned for some major investments in NRM (e.g., the N2Africa project).

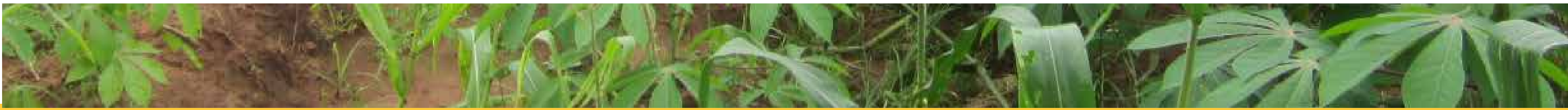
The next 10 years

The concerns of IITA's founding fathers remain as valid as ever, or even more so, with growing populations, ever-declining availability of good agricultural land, and new challenges such as climate change. Solutions for addressing soil and soil fertility management constraints commonly consist of several individual components that can interact with each other (as clearly demonstrated by ISFM, Fig. 2). Furthermore, such solutions require investments in agro-inputs and knowledge and skills, and are thus, per definition, limited to areas where the institutional environment is conducive for their uptake by smallholder farmers. Even then, not all farming households will be able or willing to invest in crop intensification practices, either by need (lack of resources) or willingly (no interest in intensifying agriculture).

Lastly, the full uptake of ISFM is a stepwise process whereby components are gradually added, often following logic (e.g., in the CIACLA region, fertilizer use was demonstrated to be higher in the presence of purchased maize seed). This makes the actual timing of impact studies quite important and supports the need for studies that look at changes over time, e.g., through panel studies. While not attempting to shy away from formal impact studies, the above observations demonstrate the many limitations such studies face when dealing with NRM-related topics.

Lastly and certainly not least, one major lesson learnt from the past 50 years is that a clearly impact-oriented and consistent approach to NRM R&D is required to ensure that the best practices get disseminated at scale. Changing the NRM R&D agenda too often, as was done regularly during the past 50 years, could have been another reason for delayed impact of these investments.

Clear responses to the application (crops on the left did not receive fertilizer while those on the right did) of appropriate fertilizer in a cassava-maize intercrop in South-East Nigeria. The trial was implemented in the context of the African Cassava Agronomy Initiative (ACAI). Photo by K. Fred, IITA.



Improving crops

First-ever Tanzanian *Mchare* banana hybrids produced

Allan Brown,
Hassan Mduma,
Rony Swennen,
IITA-Arusha

Young Mchare banana hybrid plants. Photo by IITA.

Producing seeds in banana for genetic improvement has always been a dauntless task, but some bananas are even more challenging to work with than others. The *Mchare* bananas, sometimes referred to as *Muraru, Mlali*, or *Mshare*, are diploid cooking bananas prized especially by the people of the Northern Tanzanian highlands but also in its neighboring countries including the east African islands. These bananas differ dramatically in texture and in genetic background from other, more familiar East African highland cooking bananas such as *Matoke*.

In the regions of Kilimanjaro, Arusha, and Mbeya these bananas can provide up to 30% of the caloric intake, bringing a premium price in the local markets. However, Mchare growers face serious obstacles as these bananas are susceptible to

Bunch of improved bananas developed by IITA. Photo by IITA.

almost every major disease and pest of banana in Africa, as well as being particularly vulnerable to a new strain of Fusarium that has been reported in Mozambique.

The reduced fertility and parthenocarpy (seedless fruit development) of these bananas make them especially challenging to work with. Most people who have spent their lives consuming them have never seen a banana seed. The varieties currently grown by farmers in the region have never been the target of systematic genetic improvement and in many ways, likely represent the same bananas that their ancestors have been growing for hundreds of years. The work of IITA researchers in Arusha has documented variability in pollen viability among Mchare varieties (manuscript in preparation) which has allowed us to focus our efforts on those varieties that are most likely to successfully produce seed. However, even the most fertile Mchare only produces about 20% of the pollen observed in wild type bananas and female fertility is also greatly reduced. As many as 30 daily pollinations can be required to produce a single seed. The challenges do not stop there. Only 17% of these seeds will germinate even using techniques such as embryo rescue. It is not an exaggeration to say that the production of these first Mchare hybrids is an extremely significant breakthrough.

In the past year, IITA along with our partners at the Nelson Mandela African Institution of Science and Technology (NM-AIST), has completed an expansion of facilities that include state-of-the-art facilities for tissue culture, pathology, and DNA analysis, with extensive pollination blocks established. The first fruit of this labor has resulted in the production of the first Tanzanian Mchare hybrids produced by hybridization with multiple disease resistant wild bananas.

Work will continue to evaluate the hybrids and determine if the resistance has been inherited and if the hybrids have retained the quality characteristics demanded by end users in the region. Unlike other bananas, Mchare is unique in that it is a diploid banana, and efforts will now focus on crossing these hybrids back to the original parents, recovering an optimal amount of the original quality while integrating multiple disease resistance. As the Mchare breeding program has only been operational at NM-AIST for the past 2 years, these first hybrids represent a significant step toward addressing serious food security issues in Tanzania.

Currently, we have established a collaboration with our host organization (NM-AIST) to develop a link to local farmers to facilitate the evaluation of texture and flavor characteristics of these bananas, which has never been accomplished before. The participation of the farmers will help ensure the quality characteristics of the bananas and soon ultimately lead to their successful adoption and dispersal.

Banana seeds. Photo by IITA.

Field of banana plants intercropped with legumes. *Photo by IITA.*

Mapping the white Guinea yam to speed up breeding

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Pollen collection of male flowers for use in controlled pollinations: The first step to create new yam varieties.
Photo by P. Agre, IITA.

Yam—most valuable crop

Yam, a starchy tuber produced underground by several *Dioscorea* species, is one of the most valuable crops in West Africa. The region produces 93% of global yam. In Nigeria, yam production is valued at $13.7 billion, exceeding that of cassava, maize, sorghum, millet, and rice combined.

However, despite its value and critical role in both food security and income generation for smallholder farmers, its cost of production is much higher than other crops in the region. It has high labor requirements—land preparation, planting, staking, weed control, and harvesting. In addition, farmers must save up to one-third of their harvested crop as seed for planting in the next season. Yam is also highly vulnerable to a plethora of pests and diseases as well as population pressure and climate change; and its growing demand has driven cultivation of this crop onto less fertile land.

IITA yam research has developed solutions to these challenges including developing improved varieties.

Modernizing yam breeding

Yam breeding is a complicated and lengthy process that starts with approximately 10,000 distinct seedlings that progress through 6–7 years of selection then to on-farm evaluation and variety release trials across many locations. In the end, only 2–3 varieties with desired traits are released.

Because of this lengthy process, yam breeders need tools and procedures that efficiently and effectively evaluate performance and selection of the best parents for hybridization and the progenies with the highest probability of replacing or adding to the currently grown varieties or landraces. They also need to fully understand market requirements to ensure that the new varieties they develop are acceptable to farmers, processors, exporters, or consumers.

The IITA breeding team and partners, largely through the AfricaYam project (www.africayam.org) has made progress in modernizing and improving breeding efficiency of this poorly understood but vitally important crop.

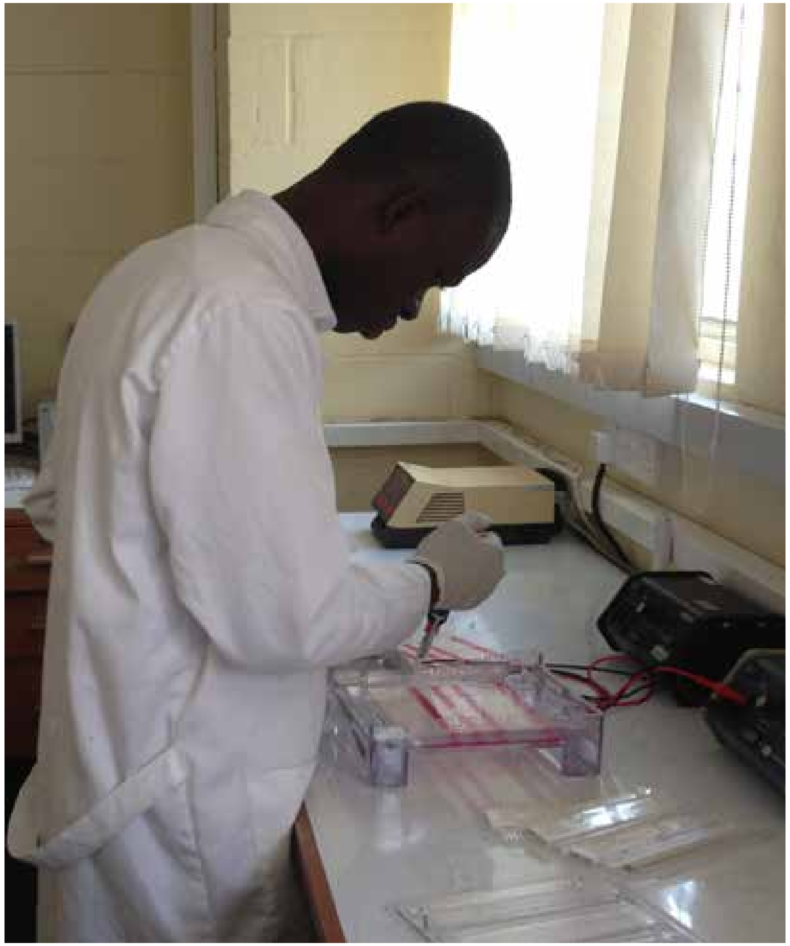
Breakthrough in genome sequencing

A recent major development in these efforts was the development of a reference genome sequence for white Guinea yam *(D. rotundata)* from IITA's breeding population. This was a result of innovative collaboration between IITA, the Japan International Research Center for Agricultural Sciences (JIRCAS), the Iwate Biotechnology Research Center (IBRC/Japan), and the Earlham Institute (UK).

Bioinformatics and sequencing of RNA (RNAseq) identified 26,198 genes in the yam genome. A subset of these genes was used for phylogenetic analysis (studying the evolution of the yam species) which showed that the yam genes didn't group with other representative monocots, including rice, palm, and banana.

Cultivation and weed control in yam field using two-wheel tractor.
Photo by A. Edemodu, IITA.

DNA quality assessment: Loading of DNA sample on agarose gel to assess quality of DNA.
Photo by P. Agre, IITA.



The yam genome was found to have a unique set of genes encoding proteins with lectin domains known to be associated with protection against pathogens, nematodes, and insects. To illustrate the value of the yam reference genome, sequencing of separate pools of DNA from female and male plants was conducted. The genome region controlling sex-determination was located on pseudomolecule 11 and DNA markers that are strongly linked to this trait were developed and evaluated.

Uses of reference genome

While the research team will continue to refine and improve the reference genome (*Raising the profile of yam: Whole genome reference sequencing of a neglected orphan crop revealed,* [http://www.iita.org/news-item/raising-profile-yam-whole-genome-sequencing-neglected-orphan-crop/)](http://www.iita.org/news-item/raising-profile-yam-whole-genome-sequencing-neglected-orphan-crop/) as improvements in sequencing technology and bioinformatics software develop, many studies have been initiated to use the reference genome for yam improvement. Using genotyping by sequencing, a diverse collection of 941 yam landraces, breeding clones, and related wild/semi-wild species were genotyped to study genetic relationships and develop single nucleotide polymorphism (SNP) markers for quality control. Distinct clusters of germplasm based on species were identified and this information was used to identify a subset of germplasm for trait characterization and association analysis.

In total, 318 clones were selected and resequenced with IBRC and trait collection has been completed for one year. Over 14 million SNPs were identified after alignment of the sequences to the reference genome and analysis using a bioinformatics pipeline. Similarly, biparental intraspecific mapping populations have been developed for both *D. rotundata* and for *D. alata*, genotyped and characterized under field conditions. Genotyping of these populations is ongoing in collaboration with Centre de coopération internationale en recherche agronomique pour le développement (CIRAD).

Collectively, this data will be used to identify marker-trait associations for important agronomic, disease and pest resistance, and tuber quality traits. Sequenced-based DNA markers have been converted to markers suitable for high-throughput, low-cost genotyping platforms. Genome-wide and trait-associated markers will be tested using new breeding methods (marker-assisted selection and genomic selection) to shorten the yam breeding cycle and quality-control protocols using DNA markers will be established to reduce errors in the breeding program.

In combination with other technology improvements, genomics-based breeding can dramatically improve yam breeding in the next few years. IITA and its national partners in West Africa will be better positioned to develop yam varieties needed in the markets and deliver these to farmers faster.

The results were published in the Biomedical Journal https://bmcbiol.biomedcentral.com/articles/10.1186/s12915-017-0419-x

Multiple stress tolerant soybean varieties on the horizon

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Researcher inspecting healthy soybean crop. Photo by IITA.

Despite positive trends in soybean production, average soybean yields in Africa of approximately 1.1 t/ha are much lower than the global average of nearly 2.5 t/ha. Most of the constraints to the crop's production are due to the impact of climate change, which tends to be greater in sub-Saharan Africa than in other regions. Impact includes erratic rainfall patterns and annual totals; shifts in the rainy season; an increase in dry spells and hot weather conditions, which lead to crops being exposed to drought conditions; and increased prevalence and sporadic occurrences of pests and diseases. These constraints pose new challenges for breeders to develop and disseminate new soybean varieties with improved yield potential as well as tolerance to multiple stresses to safeguard yield in the event of adverse climatic conditions.

Developing high-yielding, multiple stress tolerant soybean varieties through multidisciplinary partnerships is at the core of IITA's soybean breeding program. The specific objectives include: (i) developing well coordinated and characterized soybean trait pipelines that include drought tolerance, rust resistance, phosphorus use efficiency, and high biological nitrogen fixation (BNF); (ii)accelerating cultivar development pipelines by putting together the must-win traits; (iii) establishing an effective breeding management and bioinformatics database for soybean; and (v) capacity and capability building through training postgraduate students and mentorship of breeders in the national agricultural research systems (NARS).

During the 2017 season, germplasm acquisition, introgressions, and evaluation of preliminary and advanced soybean trials were done both in Nigeria and southern African countries in a well-defined and structured high-level process that delineates effective delivery of diverse varieties from IITA to the NARS and private seed companies.

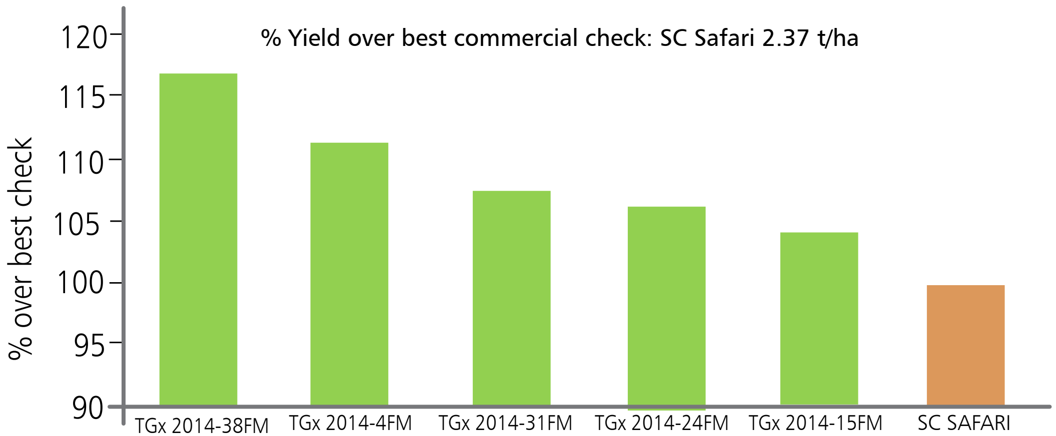
Germplasm acquisition and introgression

Evaluating rust resistance lines for yield and introgression of Rpp rust resistance genes into IITA elite lines

Acquisition of new germplasm during 2017 included evaluating some rust resistant lines from the USDA germplasm collection at Ibadan, Nigeria. Results from the evaluation indicated that only one known rust resistant accession PI635999 (Rpp 3&4) was moderately adapted to tropical conditions. The other known rust resistant accessions were not adapted. Crosses between the rust lines and IITA were developed and marker-assisted selection (MAS) will be used to select the resistant progenies from the crosses.

Preliminary and advanced variety trials

During the 2017 season, preliminary variety trials and advanced variety trials were planted in Malawi, Mozambique, Nigeria, and Zambia to determine the performance of varieties under different environmental conditions, which included drought and low soil phosphorus conditions. The trials consisted of 30–40 lines per set including checks. Genotypes exhibited significant differences for several agronomic and disease traits. On average, the best five experimental genotypes showed a significant yield advantage of between 5 and 16% better than the best commercial check (Fig. 2). As per product concept, experimental lines yielding greater than 5% compared to the best check will be advanced to the next stage of evaluation if other agronomic traits such as resistance to shattering, lodging, diseases, and having an acceptable seed size meet the criteria. For example, in Ghana, TGx 1844-22E distributed through Soybean International Trials (SIT) and having excelled in the advanced trials in Nigeria in 2015, is going through variety registration, https://mailchi.mp/illinois/have-a- look-at-sils-latestmonthly-digest?e=807cdd1b85, providing farmers with a wide range of choices to use multiple stress tolerant varieties to improve their production.



Yield advantage of best five experimental IITA lines over the commercial check SC Safari across 10 environments in Southern African countries—Malawi, Mozambique, and Zambia.

Increasing cowpea productivity in sub-Saharan Africa

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Measurements for plant height, stalk number and leaf color in Fashola village field (2015). Photo by IITA.

Cowpea (*Vigna unguiculata* [L.] Walp.) is a major source of dietary protein for people living in the savanna and Sahel regions of sub-Saharan Africa. It is also a source of income and livestock feed, and can improve soil fertility by fixing nitrogen (N) from the atmosphere in its root nodules. Constraints to cowpea production in West Africa include low and erratic patterns of rainfall, and severe attacks by insects and diseases, but the major constraint is poor soils. Even with sufficient rainfall, soils with low fertility cannot supply enough nutrients for the crops.

The use of chemical fertilizers is a simple and quick method to enhance plant nutrients in the soil. However, in rural areas of Africa, the prices of chemical fertilizers are usually twice the international prices making them unaffordable for most farmers. In addition, there are many places where farmers do not have access to chemical fertilizers due to the inadequate infrastructure and difficult economic conditions.

Legumes need P to fix N

Phosphorus (P) deficiency is a serious problem which limits the productivity of cowpea in the dry savanna and Sahel regions. Low levels of P in the soils have negative effects on the formation of root nodules and limit the growth and survival of rhizobia in the roots of legumes. This reduces their effectiveness in symbiotic N2 fixation.

On the other hand, sub-Saharan Africa has vast quantities of rock phosphate (RP) deposits of varying quality, some of which are of sedimentary origin and reactive. High- to medium-reactive (>15 g citrate-soluble P/kg) sedimentary rock P deposits are found in Burkina Faso, Mali, Niger, Senegal, and Togo in West Africa. Indigenous rock P is more readily available to farmers than chemical fertilizers.

Identifying effective rock P

The *Improving the water and nutrient use efficiency of crops under dry savanna and Sahel regions in Africa* project, supported by the Ministry of Foreign Affairs in Japan, conducted experiments in Nigeria to identify the effect of rock P application on cowpea. From the results, a minimum RP application of 57 mg P/kg is necessary to enhance cowpea yield. To verify the efficacy for indigenous rock P on cowpea cultivation and to identify the optimum method to apply RP in the field, the team conducted field tests from 2015 to 2016 in Fashola village, Oyo State, Nigeria. Fashola fields have extremely low soil P. The tested methods were broadcasting (BC) and micro-dosing (MD). To identify the effect of RP application with BC and MD on cowpea growth and yield, treatments using single super phosphate (SSP) were also established. Zero application treatment was used as the control.

From the study, the differences among the treatments compared to zero application were not significant except in two clones—IT97K-556-4 and IT90K-284-2. Although no significant differences were identified for the positive effects of the RP application on

Zero P

SSP-BC

SSP-MD

RP-BC

SSP-BC

Growth conditions of genotypes, IT97K-556-4 under (a) zero P application, (b) single super phosphate (SSP) application with broadcast (BC), (c) SSP application with micro-dosing (MD), (d) rock phosphate (RP) application with BC, and (e) RP application with MD at Fashola village field in 2016. Photo by K. Suzuki, IITA.

cowpea cultivation, the shoot dry weight (SDW) at 8 WAS in seven good responder genotypes except IT97K-499-35 tended to be higher under the RP application with BC and MD methods when compared to the control. Focusing on the application methods, MD and BC, the SDWs under MD application of 114 kg P/ha in 2015 and 60 kg P/ha in 2016 as RP tended to be higher than under BC application. The pictures show the positive effects of the MD method on cowpea growth. The same trends were identified under MD or BC application of 30 kg P/ha as SSP.

As the next step, our study focused on co-application of indigenous RP and arbuscular mycorrhizal fungi (AMF) to promote P nutrient uptake from rock P. In pot experiments, we inoculated cowpea with *Glomus intraradices* and established the treatments of no-inoculant and inoculant with AMF under no-P application and rock P application at a level of 60 mg P/kg. Using 15 cowpea genotypes, the pot experiment was conducted for verifying the effects of co-application of RP at 60 mg P/kg and AMF inoculation. One of 15 genotypes (Sanzi) showed significantly ($P < 0.05$) higher shoot dry weight (SDW) at 8 WAS with AMF co-application than in the treatment of only rock P application. The SDW of 14 other cowpea genotypes were slightly higher than when only rock P was applied. AMF inoculation appears to be ineffective under high soil P conditions. Therefore, these results indicated that rock P application at 60 mg P/kg is too high for AMF inoculation to work. The optimum application amount of rock P should be less than 60 mg P/kg.

In another pot test, four levels of rock P application: 0, 20, 40, and 60 mg P/kg were established with AMF inoculation using six cowpea genotypes selected from the nine genotypes. The SDW at 8 WAP showed that 20 mg P/kg was the optimum level for cowpea with AMF inoculation.

Additionally, AMF can contribute to increase water as well as P uptake. We observed that AMF inoculation has a positive effect on increasing drought tolerance of cowpea genotypes that are susceptible to drought. More detailed studies

Harvesting cowpea pods in Fashola village field. Photo by K. Suzuki, IITA.

Making crops healthy

Elite disease resistant germplasm successfully exchanged and evaluated in five African countries

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A technician multiplies hardened tissue culture plantlets of elite clones using node stem cutting technique at Kibaha, Tanzania. Photo by S. Tumwegamire, IITA.

They say two is better than one, but for this one-of-a-kind, four-year initiative, five was better than one. The project, that came to an end in June 2017, saw five countries (Kenya, Malawi, Mozambique, Tanzania, and Uganda) join forces to tackle one of the major challenges to cassava production—cassava brown streak disease (CBSD) and cassava mosaic disease (CMD). The two viral diseases are fast spreading across the continent affecting food security and incomes of smallholder farmers.

The project, New Cassava Varieties and Clean Seed to Combat CBSD and CMD, shortened to 5CP supported the countries to successfully share their five best cassava varieties in terms of yield and resistance to the two diseases. This was to speed up efforts to develop and supply farmers with improved varieties of cassava that are resistant to the two viral diseases, the greatest constraint to the crop's production.

CBSD damages tuberous roots, rendering them unfit for human consumption as well as depressing overall yield. The effects are insidious, since the plants often show no symptoms with farmers only seeing the damage at the time of harvest. CMD causes more obvious damage, as affected plants have yellow-green, twisted leaves, and plants can be severely stunted, producing either very small roots or none at all. Cassava varieties resistant to these two diseases are therefore urgently needed by rural farmers in eastern and southern Africa (ESA), to protect their food and income security.

5CP borrowed lessons from joint action against CMD in the 1990s, and brought together the national agriculture research systems (NARS) of the five countries most affected by the two deadly cassava diseases to share and test their elite germplasm to speed up the breeding process and develop varieties with strong resistance to CBSD and CMD. The other objective of the project was to pilot a commercially viable seed system in Tanzania to ensure farmers have access to a new pipeline of improved cassava varieties from research.

Hod did we tackle the problem?

Virus testing and indexing: The project started with each country selecting and submitting its five best cassava varieties in terms of yield and resistance to the two viral diseases, as well as four local checks. These were then cleaned of viruses at both the Kenya Plant Health Inspectorate Service (KEPHIS) and the Natural Resources Institute (NRI).

The 25 varieties were Sangoja, Sauti, Yizaso, Kalawe, and CH 05/203 (Malawi); Colicanana, N'ziva, Okhumelela, Orera, and Eyope (Mozambique); LM 08/363, F19-NL, Tajirika, Shibe, and F10-30-R2 (Kenya); Kipusa, Pwani, Mkumba, Mkuranga 1, and Kizimbani (Tanzania); NARO-CASS 1, NASE 14, NASE 1, NASE 3, and NASE 18 (Uganda). Two regional checks—Kibandameno (from Kenya, a susceptible check for both CMD and CBSD) and Albert (from Tanzania, a susceptible check for CBSD) were also included. All clean plantlets were dispatched to Genetic Technologies International Limited (GTIL), a private tissue culture (TC) laboratory in Nairobi, Kenya, for micropropagation.

Micropropagation: At GTIL, at least 300 TC plantlets of each variety were raised and

CBSD root necrotic damage among the susceptible clones Albert, Sagonja and CH05/203 compared to no necrotic damage among the tolerant clones F10-30R2, TZ-130, Orera and Mkuranga1 as observed at Bunda Tanzania in November 2016.
Photo by S. Tumwegamire.

sent back to the five countries, allowing the exchange of germplasm between them. Each country therefore received 25 resistant varieties including the best five, two local checks, and four own local checks. Genotype purity verification was done in collaboration with Biosciences eastern and central Africa (BecA) (Nairobi, Kenya) while both Mikocheni Agricultural Research Institute (MARI, Dar es Salaam, Tanzania) and IITA confirmed that plantlets were virus free.

To ensure the TC plantlets were well handled, two partners in each country were trained on post-flask management in collaboration with Uganda's cassava research program at the National Crops Resources Research Institute (NaCRRI). Screen houses in Malawi and Mozambique were repaired and new ones constructed in Kenya and Tanzania. The project also conducted a mock shipment to test the partners' readiness to receive the materials and identify possible challenges during the actual shipment.

Management of the exchanged elite varieties in target countries: Upon arrival in the countries, the TC plantlets were hardened, macropropagated using two-node stem cuttings, and field multiplied in sites with very low CBSD and CMD pressure that were isolated by at least 200 m from any cassava crop to minimize any virus spread. They were then distributed and planted in field trials at over 30 sites across the five countries. The sites had varying levels of CBSD and CMD pressure, and climatic and soil conditions.

What was achieved?

Three major achievements were accomplished Firstly, up to 31 varieties (25 elite, 2 standard checks and 4 national checks) were successfully virus-cleaned and indexed, and 27 varieties were exchanged among the target countries. The other four were returned to their respective mother countries as national checks. This germplasm presents a unique opportunity to identify varieties with high levels of resistance to both CBSD and CMD under the diverse range of virus/virus vector/environmental conditions in these five ESA countries.

Additionally, these varieties have great potential for use as parents to generate superior progeny. The clean stocks are also a great asset for initiating extension programs for multiplying and disseminating high-quality, pre-basic "seeds". Hitherto, most of the target countries have had no access to field-based stocks of high-quality, virus-tested planting material.

Secondly, a strong partnership was built between breeders and virologists in national and international institutions as they worked together to combat these diseases through elite resistant germplasm and clean seeds. The partnership also allowed cross-learning between partners at all levels of the process. It is envisaged that these partnerships will continue after the project.

Thirdly, the elite varieties were successfully tested in 33 different sites across the partner countries and comprehensive data collected, some of which has been uploaded to www.cassavabase.org. The remaining sets will soon be uploaded. Upon analysis, the collected data should elucidate the magnitude of genotype by environment interactions for CBSD/CMD, yield, and other performance characteristics.

Although combined data analysis is yet to be done, preliminary selected data analyses by graduate students on the project are already helping to guide stakeholders on which varieties are likely to be most appropriate in which agroecologies and CBSD/CMD disease pressure conditions within the eastern and southern African region.

Moreover, the preliminary data and the germplasm exchange described here have provided a foundation for the development and implementation of new CBSD mitigation programs in Tanzania (BEST Cassava Project), Burundi, Rwanda (CBSD Control Project), and eastern Democratic Republic of Congo (Action to control CBSD in DRC).

Acknowledgement

The initiative was implemented as part of a wider project "New Varieties and Clean Seed to Combat CBSD and CMD" led by IITA and funded by the Bill & Melinda Gates Foundation. The process and lessons of this success story have since been published as a journal article (http://link.springer.com/article/10.1007/s12571-018-0779-2) by the Food Security Journal in March 2018.

Managing natural resources

Taking good care of soils to increase land productivity

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Godfree Chigeza
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Violet Mwanza (right) showing soybean and maize crop grown in rotation to a fellow farmer.
Photo by T. Gondwe, IITA.

Violet Mwanza is a lead farmer from Nkunga agriculture camp in Chimusuku village, 35 km away from Katete District, Eastern Province, Zambia.

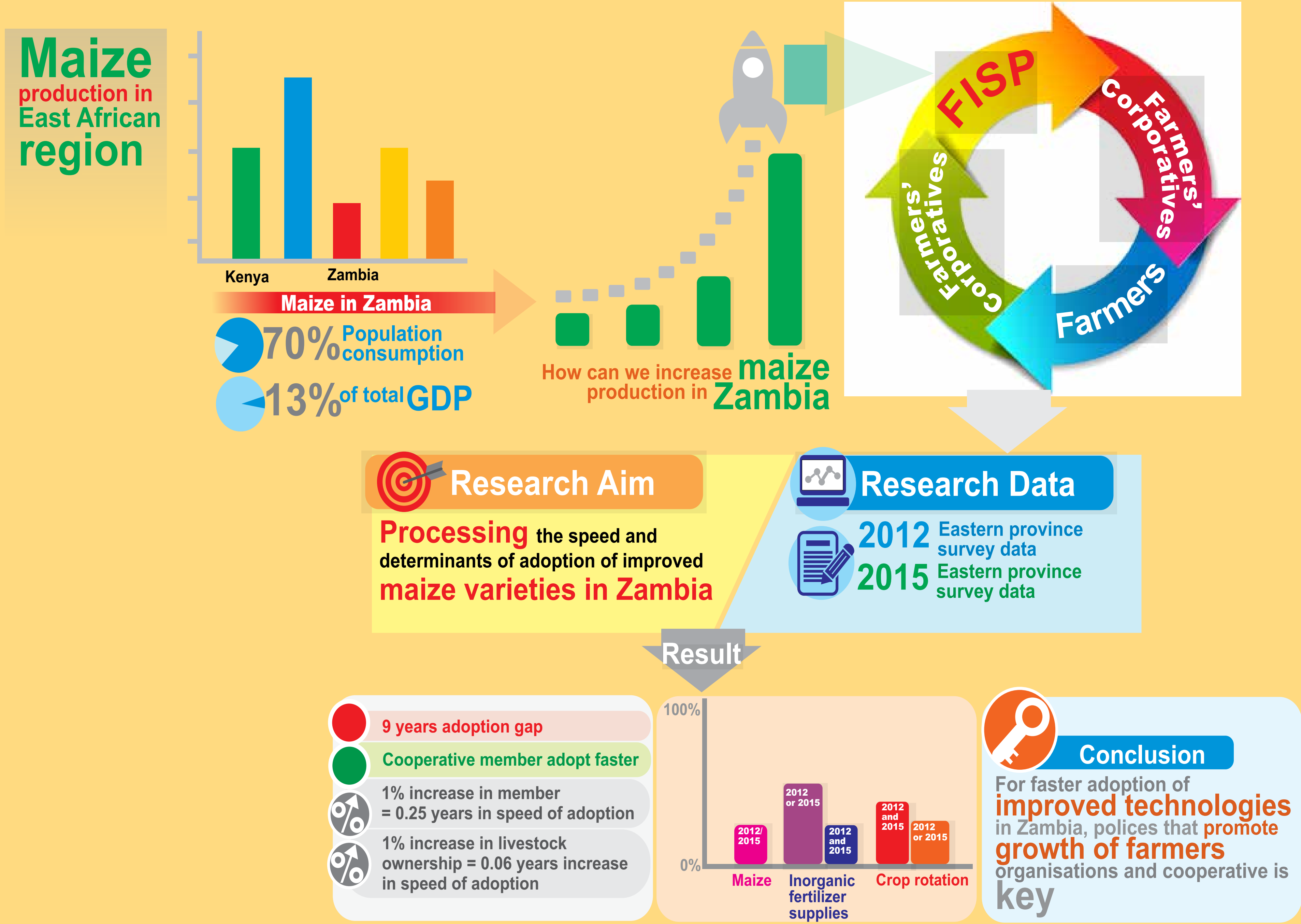
In July 2015, she enrolled in the Farmers' club and got trained as a lead farmer in the farmers' program under the project Scaling out Integrated Soil Fertility Manageent practices (ISFM) that IITA implemented in partnership with Development Aid from People to People (DAPP) with funding from the Alliance for Green Revolution in Africa (AGRA).

"I decided to join when I heard that the project focused on improving soybean production using ISFM practices to improve soil, income, and welfare of farmers," she says.

As a lead farmer she supported passing on the knowledge gained by setting up on-farm demonstrations for other farmers to learn. In 2015, she planted 2 ha of soybean and 2 ha of maize.

"I harvested 30 × 50 kg bags of soybean and 38 × 50 kg bags of maize. The harvest was poor due to poor rains. I used the money from maize and soybean sales to buy farm inputs for the 2016/17 season and I doubled the hectarage of soybean from 2 ha to 4 ha. I was motivated to increase the hectarage due to the good soybean market in 2015 season. The project also linked me to a seed company that provided me with seed and fertilizer on loan."

"I applied manure and half the recommended fertilizer rate for maize. I harvested 120 × 50 bags of soybean and 125 × 50-kg bags of maize. These results cannot go without appreciating the knowledge I have acquired from the project by joining the Farmers' club. These methods and practices of farming really helped me to have enough and a good crop yield with a good harvest. I consider myself to have succeeded and my harvest surpassed my expectations. My advice to fellow farmers is that if you take good care of your soils, land productivity will increase." Violet Mwanza



Maize
production in
East African
region
Kenya
Zambia
Maize in Zambia
70% Population consumption
13% of total GDP
How can we increase maize production in Zambia
FISP
Farmers' Corporatives
Farmers
Farmers' Corporatives
Research Aim
Processing the speed and determinants of adoption of improved maize varieties in Zambia
Research Data
2012 Eastern province survey data
2015 Eastern province survey data
Result
9 years adoption gap
Cooperative member adopt faster
1% increase in member = 0.25 years in speed of adoption
1% increase in livestock ownership = 0.06 years increase in speed of adoption
100%
0%
2012/ 2015
2012 or 2015
2012 and 2015
2012 and 2015
2012 or 2015
Maize
Inorganic fertilizer supplies
Crop rotation
Conclusion
For faster adoption of improved technologies in Zambia, polices that promote growth of farmers organisations and cooperative is key

Decision support tool for site-specific recommendations to improve cassava agronomy

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Pieter Pypers, and
Meklit Chernet
IITA-Nairobi

Mr Ritu Manzi displays a cassava root harvested from one of the ACAI trial plots on his farm in Butiama, near Bunda, Mwanza Tanzania. Preliminary results have indicated a good cassava response to fertilizer.
Photo by IITA.

Africa is the global leader in overall production of cassava, but the continent lags behind in yield averages. The average yield of just below 15 t/ha is dismal being below the global average of 20 t/ha, with some countries such as India reaching 30 t/ha.

The Africa Cassava Agronomy Initiative (ACAI) project seeks to address some of the most pressing agronomy problems within the cassava value chain in sub-Saharan Africa to increase the productivity of the crop and create a knowledge base necessary to sustain cassava agronomy research.

ACAI is led by IITA and partners with national agricultural research institutes (NARIs) and development partners in Nigeria and Tanzania. The National Root Crops Research Institute (NRCRI) and the Federal University of Agriculture, Abeokuta (FUNAAB) lead the implementation of the field research in Nigeria and the Agricultural Research Institute (ARI) in Tanzania. ACAI is funded by the Bill & Melinda Gates Foundation and is supported by several international research institutions for specialized research support and capacity building.

The project aims to conduct extensive research to understand cassava nutrient requirements and growth dynamics under different conditions within specific areas of interest. Crop growth models have been adapted and calibrated to simulate responses to nutrients and rainfall regimes and have been integrated into decision support tools to provide tailored recommendations. These tools, when deployed, will assist extension agents in advising farmers on the best practices to achieve higher yields and maximal revenue.

The decision support tools

In December 2017, ACAI marked its second year of activities since inception. In just under 21 months, the project had already moved through key milestones in generating a unique knowledge base on cassava agronomy, developing the initial versions of the decision support tools, and improving the capacity of partners and the NARIs to carry out agronomy research.

ACAI is developing decision support tools for six use cases targeted to improve fertilizer use for improved yield and cassava root quality, enable sufficient and sustainable supply of cassava roots to processing industries, and facilitate improved cassava agronomy advice.

1. Site-Specific Fertilizer recommendation tool, targeting extension agents supporting commercial cassava growers to maximize returns on investments in fertilizer.
2. Fertilizer Blending recommendation tool, targeting fertilizer companies to produce better blends suited for cassava.
3. Intercropping recommendation tool, targeting extension agents supporting smallholder cassava growers to maximize revenue generated in cassava intercropping systems by optimizing plant density and arrangement, and varietal choice.
4. Best Planting Practices recommendation tool, targeting commercial cassava growers investing in mechanized land preparation to recommend the most profitable tillage regime.
5. Scheduled Planting recommendation tool, targeting commercial cassava growers to ensure sustained year-round supply of cassava roots to the processing industry.
6. High Root Starch content recommendation tool, targeting outgrowers supplying roots to starch factories to maximize root starch content.

The project has finalized the prototype (V1) of the decision support tools deployed on desktop, Open Data Kit (ODK), and paper-based recommendations. In 2018, ACAI will be carrying out validation exercises to test the accuracy of the tools and the user experience and gather feedback from primary partners for further improvement.

IITA's Adebowale Adetunji and Rebecca Enesi reading a barcode to record data from a cassava trial plot at IITA, Ibadan, Nigeria. ACAI is using barcoding of plants and trial plots for identification and efficient data collection and data management.
Photo by IITA.

ACAI NOT trial results

Trials on cassava–maize (Nigeria) and cassava–sweet potato intercropping showed that substantial improvements compared with the local practice can be achieved through a combination of improved and compatible germplasm, optimized crop density and arrangement, and application of fertilizer. In Nigeria, average increases of 4 t/ha of cassava roots and 1.2 m^2 of maize cobs were achieved, and profitability of fertilizer use could be achieved by targeting fields based on local knowledge on the history of maize performance.

Trials on scheduled planting and harvesting, and starch measurements across the field trials for the various use cases showed wide variation in starch content and yield, with the month of harvest explaining 35–64% of the variation in starch content, and site-specific conditions (mainly weather) and crop age explaining another 21–36%. Small, negative fertilizer effects on starch content were found, but these only occurred when N and P applications were not balanced and did not outweigh the benefits of fertilizer effects on root yield.

The project has especially combined the use of the Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS) model and the Light Interception and Utilization (LINTUL) model. The QUEFTS model is applied for predicting the yield response to the combined application of nitrogen (N), phosphorus (P), and potassium (K) and identifying the most profitable nutrient regime given prices of available fertilizers, while the LINTUL model is used to predict water-limited yields by considering daily weather data, crop characteristics, and soil physical properties.

The two models are in a complimentary sequence to each other generating data on factors that influence cassava root yield. The data is analyzed to determine the kind and amount of fertilizer to be used so that farmers can get maximum return on investment.

Spatializing water-limited yield in Tanzania

These findings were integrated in the first versions of the decision support tools, in a format that allowed extension agents to provide site-specific and tailored recommendations to candidate farmers participating in a pilot exercise to validate the findings. The aim is to further improve both the content and the format of the recommendations before scaling up the tools planned in 2019.

ACAI has run more than 1400 trials across 940 trial locations in Nigeria and Tanzania with over 9000 yield assessments carried out from the trials. The partnership with the NARIs has linked the project with more than 10,000 cassava growers and extension agents within their system.

Numbers and figures

The decision support tools developed by ACAI will be deployed to extension agents operating within the dissemination networks of the development partners to support cassava growers to improve their yield, access the market, and apply best practices for optimal returns and efficient investment.

Although ACAI is currently validating the tools, the project is already training select individuals as trainers who will help transfer technical knowledge to extension agents, who will in turn disseminate and expand the use of the tool.

ACAI is aiming to create tools that will generate a value of $28 million within the project's five-year tenure. This value is expected to directly impact over 100,000 households in the countries where ACAI operates.

Evidence from first testing of the recommendations has confirmed that profitable yield increases of 20–100% can be obtained by applying the recommendations. The tools also successfully identify when not to invest in intensification options, which in itself is a substantial improvement over current, blanket recommendations.

After completion of the validation exercises, ex ante assessments of the potential impact of the tools will be conducted to aid in further targeting and tailoring.

Sylvia Okafor (right) supervising planting of a farmer-managed trial plot. She is an extension agent working with ACAI through NRCRI in Nando, Anambra East, Anambra State, Nigeria. Photo by IITA.

Ensuring impact & delivery

Science-based delivery to transform African agriculture

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IITA-Bukavu/WUR

Partners looking at experimental field. Photo by T. Gondwe, IITA.

In its golden jubilee year, IITA completed its strategic planning process and organizational restructuring to offer effective and efficient services for transforming agriculture in the continent. However, transformation of African agriculture has paramount challenges due to the social and physical diversity of the continent. This necessitates comprehensive approaches and customized strategies for increasing the use of technologies and achieving agricultural transformation. Such approaches and strategies cannot be achieved using existing innovation delivery approaches, which are based on high standardization and do not use real time data.

The objective of the "Scaling Readiness" program is to develop state-of-the-art decision support tools that can contribute to the extensive scaling of agricultural innovations. Scaling ready research is intended to enhance the IITA innovation science research initiated in the CGIAR Research Program on Humidtropics and use the experience of IITA scientists in Central Africa.

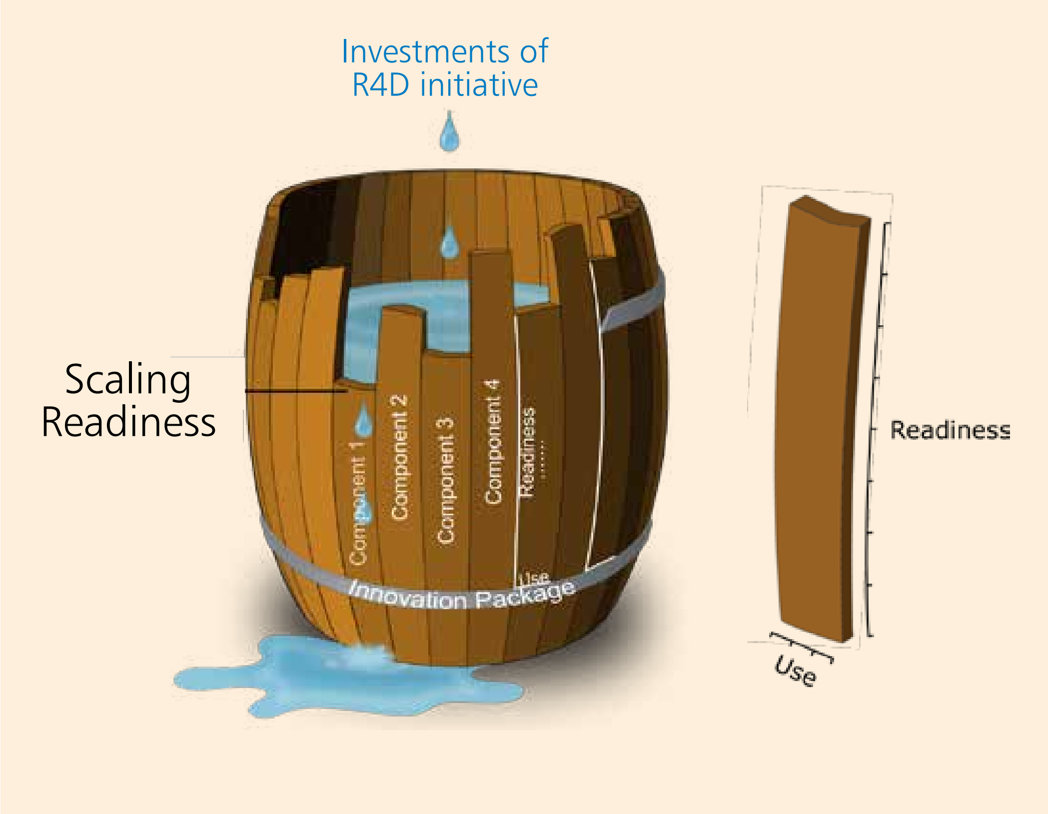
The research has since been taken up by many more initiatives at the Institute and beyond. In 2017, the team tested the approach and toolkit across all priority countries of the AfDB-funded Technologies for African Agricultural Transformation (TAAT) project. These are Nigeria, Tanzania, and DR Congo. Other countries include Burundi, Ethiopia, Ghana, Uganda as well as countries in other tropical regions such as Bangladesh, Cambodia, and Ecuador under the framework of the CGIAR Research Program on Roots, Tubers and Bananas (RTB).

Scaling readiness achievements

Scaling Readiness has contributed significantly to:

- A rapid analysis of the innovation system including profiling stakeholders, innovations, and projects based on their relevance to scalability.

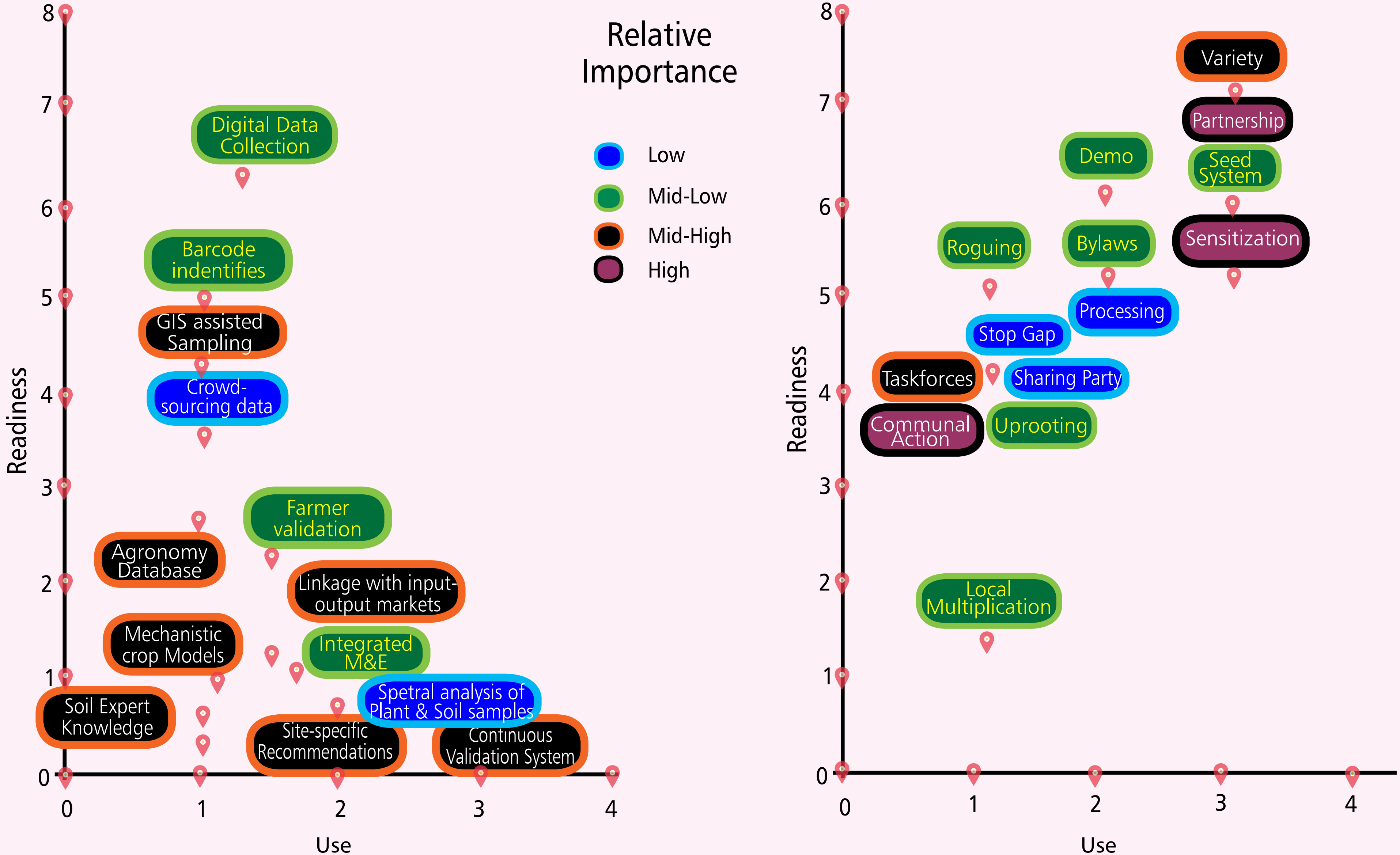
- Identifying the specific innovations that impede agricultural transformation in the targeted geographical areas.



Scaling Readiness Barrel. Innovations targeted by research-for-development projects (R4D) consist of multiple components. The component with the lowest scalability (measured against readiness and use indexes) determines the scalability of the innovation as a whole. To have a more effective scaling outcome and to use resources efficiently, R4D projects need to focus their activities on the component with the least scalability.

- Measuring current scalability of the innovations using evidence.

- Tracking the improvements in scalability of innovations.



Local: Nigeria, All Innovation Package: Cassava Agronomy at Scale; Date: 2017-04-24

Local: Tanzania, Chato, Innovation Package: Community Phytosanitation Date: 2017-02-09

Scaling readiness graphs of ACAI and Community Phytosanitation Projects.

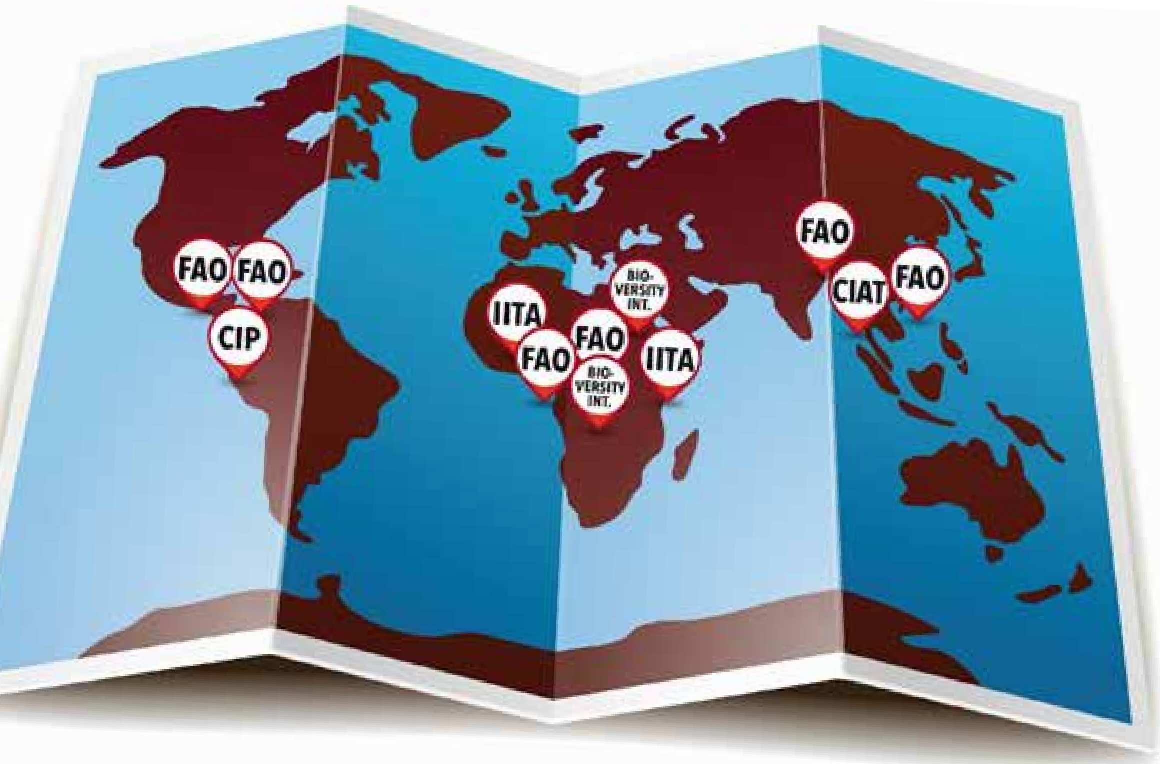
Scaling Readiness Team

The core team consists of IITA, Wageningen University, Bioversity International, CIP, and CIAT.

During 2017 Scaling Readiness supported the following projects:

- African Cassava Agronomy Initiative (ACAI) led by IITA
- Consortium for Improving Agriculture Based Livelihoods in Central Africa (CIALCA) led by IITA
- Community Phytosanitation for managing cassava brown streak disease (CBSD)
- Cambodia Cassava National Policy Consortium (CNP) led by UNDP
- Single Diseased Stem Removal (SDSR) led by Bioversity International
- Potato Late Blight Management (PLBM) led by CIP
- Capacity Development of Agricultural Innovation Systems (CDAIS) led by FAO and AGRINATURE.

Locations where the Scaling Readiness approach and tools were implemented in 2017.



Scaling Readiness research outputs in 2017

1. *Innovation and Scaling in Research for Development Interventions and Fundamentals of Scaling Readiness Approach*
2. *Scaling readiness indicators and tools for assessing technology, innovation and scaling readiness*
3. *The Scaling Readiness Case Studies*
4. *Scaling Readiness: An Approach to Assess and Accelerate Scaling of Innovations*
5. *Social network analysis approach for guiding and leveraging R4D investments*
6. *Social network analysis of multistakeholder platforms: Opportunities and constraints for innovation and scaling PLoS ONE 12(2): e0169634.*

In April 2017, the ACAI project conducted a baseline survey of the scalability of its components before it started scaling activities. Near the end of the project in February 2017, the Community Phytosanitation project made an endline assessment of the scalability of its components. It identified significant progress in the development of variety and partnership arrangement, but the local seed multiplication system was a critical component that hindered the application of the approach at scale.

Impact

Scaling Readiness generated evidence on the scalability of innovations in the CGIAR portfolio. It presented the scalability of each component of the ACAI and Community Phytosanitation projects and guided them to focus on the challenges that hinder the use of technologies and other innovations at scale.

Benefits

Scaling Readiness aims to provide support to IITA initiatives and provide them with evidence and decision support tools to develop and implement evidence-based scaling strategies. It also aims to use state-of-the-art social science methods, such as social network analysis and content analysis for publishing evidence about scaling the interventions IITA has been coordinating and its contribution to the transformation of African agriculture.

Multimedia campaign-based approach enhances scaling up adoption of legume innovations in Tanzania

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James Watiti, *Coordinator - Development, Communication and Extension (CABI), Nairobi, Kenya*

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A major challenge facing the research community is the uptake by the farming community of proven innovations to boost productivity. Scaling-up improved agricultural technologies is a complex and long-term activity, incorporating various issues such as market demand and supply, policy, extension, gender, and socioeconomics. The Scaling-up Improved Legume Technologies project (SILT) was designed to address some of these challenges while promoting scaling and increased uptake of integrated legume technologies developed through the N2Africa project.

Radio listening group is one of the methods used for information dissemination.
Photo by K. Hampson, IITA.

Farmers appreciating good performance of legume technologies at one of N2Africa sites in Gairo district, Tanzania. Photo by F. Baijukya, IITA.

The SILT research aimed to test and understand how a campaign approach, with different formats and media targeting different members of a typical small-scale farming family (i.e., with young/older or male/female and combinations), could best reach each individual, and then influence their knowledge, decision-making, and adoption as a household. The extension and communication information was presented as a campaign-based approach, and the technical campaign material was all drawn from a single, technical brief developed by the delivery consortium.

Specifically, the project sought to understand the contextualized insights into the merits of different combinations of media and approaches, to provide key learnings for future scaling-up programs, while at the same time increasing the profitable production of common bean and soybean in Tanzania.

The research challenge was to test how the different combinations of media and approaches work together:

The campaign approach focused on developing a variety of media, including print, demo plots, training days, and radio to support traditional extension approaches. This contrasts with most development communication projects, which are usually constrained to a single form of communication due to limited time, knowledge of alternative forms of media, or budget limitations. Many development communication projects involve intensive face-to-face efforts that are cost and labor intensive.

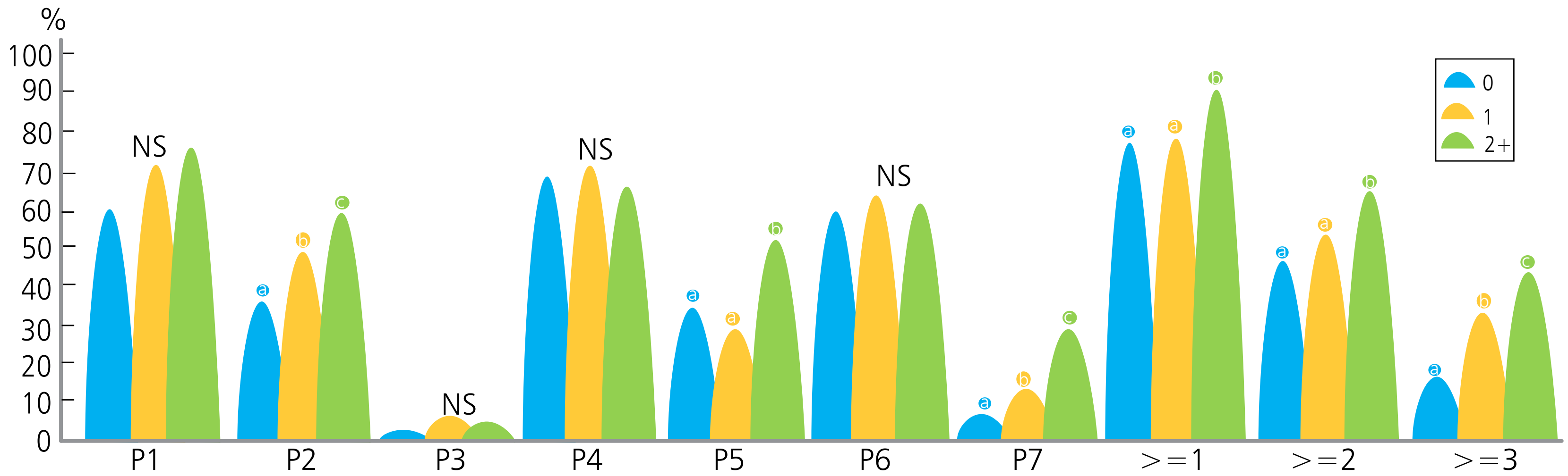
SILT hoped to show that there are alternatives and a range of options to suit different target groups, budgets, and objectives. The selection of media and the editing process refined in this project created nuanced information that targeted specific members of the households in an inclusive way and contributed to project success.

Farmers reached

A key target was to reach 500,000 farming family members through the multimedia campaigns. We directly contacted with 600,000 over 3 years. Another key target was to have 100,000 farmers starting to practice one of the promoted improved legume technologies. The evidence showed that this target had been exceeded, and many farmers have started to use more than one promoted practice, and shifted knowledge related to legume farming.

Overall, study results showed that combining multiple extension strategies enhances scaling-up processes with gender-disaggregated facts as follows:

- Women and youth easily accessed information when general agricultural advice is given using interactive approaches that encouraged



Percentage of respondents using each of the improved practices (promoted by SILT) and practicing more than 1, 2 or 3 practices for respondents exposed to 0, 1 or 2 or more project interventions. P1. Incorporate residues when preparing land, P2. Use of improved varieties, P3. Recommended spacing, P4. Recommended weeding, P5. Use of fertilizer with common beans, P6. Time of harvest, P7. Use of PICS bags. >=1. Using 1 or more improved practices, >=2. Using 2 or more improved practices, >=3. Using 3 or more improved practices.

them to participate, e.g., community-based demonstrations and field days.

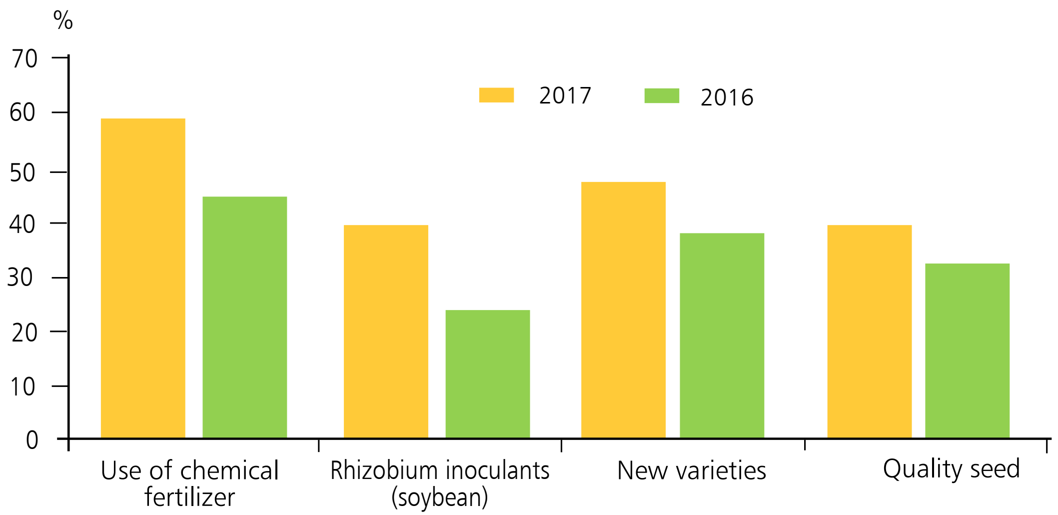
- Use of radio achieved wide coverage; however, integration with interactive radio listening groups at community level ensured more targeted reach of women and youth.
- Information sharing was observed at family level particularly by older and male family members. Though currently less structured, it provides an opportunity to promote family focused learning. Uptake of technologies requiring cash input was low.
- Despite variability in methods of obtaining information, there were no observed significant gender differences in uptake of technologies between men and women implying the need to focus on system-wide strategies to make inputs available such as improved seeds and input brokerage.

Researcher talking to farmers. Photo by IITA.

Key ingredients to successful scaling up

Key enabling factors included having a wide variety of partners covering the complexity of activities and issues involved: seed supply, research, policy, communication, and interactive radio. These partners realized early on the value that each organization brought to the consortium, and that synergies and close integration would be the key to achieving and sustaining our objectives.

Another key factor was the high level of consistency of the message across the campaigns at scale. Having one technical brief, signed off at national level, was vital. However, what really made the difference was the skill involved in, and therefore the effectiveness of, tailoring these messages to the targeted audience segment.



Shift of knowledge associated with SILT campaigns (based on intra-household and CATI Surveys in 2016 and 2017).

Illustration of multispectral partnerships coming together to develop consistent messages across campaigns. Example of common bean technologies. Illustration by D. Sones, CABI.

N2Africa's role in transforming African agriculture

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Edward Baars, *IITA-Abuja*
Fred Kanampiu, *IITA-Nairobi*
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Farmers on demonstration field at Bawku, Upper Eats Region of Ghana. Photo by T. Ampadu-Boakye, IITA.

The *Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa* (N2Africa) project, funded by the Bill & Melinda Gates Foundation, is working to expand the farm area planted to grain legumes (common bean, cowpea, groundnut, chickpea, faba bean, and soybean) and enhance their yields to improve smallholder farmers' incomes and food and nutrition security.

At the end of Phase 1 (2010-2013), the project had developed several products including certified seeds of improved varieties, inoculants, legume fertilizers, and labor-saving tools and services that benefited some 225,000 small-scale farmers in DR Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, and Zimbabwe.

The project went into a second phase (2014 to 2018), focused on scaling proven technologies and ensuring sustainable input and output supply chains for farmers to buy and use the products developed and tested under Phase 1. Three new countries--Ethiopia, Tanzania, and Uganda, were added to the project in the second phase as part of the project's core countries together with Ghana and Nigeria. The six other countries became Tier-1 countries that consolidated earlier achievements.

Evidence from agronomic research

Diagnostic, demonstration, and adaptation trials

Fifty-three diagnostic trials were established in 2017 responding to key research questions, mostly about nutrient management. A total of 1,454 demonstration trials were established focusing on disseminating a single technology or a combination of technologies. The demonstration trials showcased the best-bet technologies to many farmers and were used to collect data on their performance. Evaluation of these technologies was conducted with farmers to ascertain their preferred technologies and the information was used to reshape the technology packages they would use. Adaptation trials are small trials established and managed fully by farmers (with limited backstopping) to determine how they adapt technologies to their settings. Inputs that farmers received for these trials consisted of an improved legume variety with P-fertilizer and/or inoculants. In 2017, farmers established 25,071 adaptation trials. A selection of these adaptation trials was monitored to assess the performance of the technologies under heterogeneous farmers' conditions and management. Table 1 gives an overview of the number of trials established in the Core and Tier 1 countries in 2017.

In the adaptation trials, mean legume yields varied from 300 to 2,600 kg/ha on the N2Africa plots, and from 400 to 2300 kg/ha on own legume plots (10 × 10 m plots) (Table 2). Mean yields significantly increased on all N2Africa plots compared with the own legume plots, except for Uganda. Farmers generally saw an increase of 300 to 800 kg/ha on the N2Africa plot compared with their own legume plots. In relative terms, farmers growing cowpea or bush bean in Tanzania and soybean in Nigeria, on average more than doubled their yields. Generally, more than half of the farmers had

Table 1. Total number of diagnostic, demonstration, and adaptation trials established per country in 2017.

	Diagnostic trials (#)	Demonstration trials (#)	Adaptation trials (#)
Ghana	8	261	1,679
Nigeria	-	445	5,148
Borno State	–	80	320
Ethiopia	34	79	2654
Tanzania	25	146	4,418
Uganda	20	170	13,506
DR Congo	–	47	–
Kenya	–	15	–
Malawi	–	116	–
Mozambique	–	–	–
Rwanda	–	111	–
Zimbabwe	–	50	–
Total	87	1,520	27,725

a yield increase of >50% (except for Uganda). Note, however, that there is an experimental error associated with the use of measurements on sub-plots which may inflate the proportion of fields with more than 50% yield gain.

The lack of increase in legume yields on the N2Africa plots in Uganda may have been caused by dry spells in parts of the country, which limited the number of trials that could be harvested and depressed legume yields (cf. yields of bush bean and soybean). The positive effect of the use of P-fertilizer in adaptation trials of cowpea was larger in Eastern Tanzania than in other parts of the country, suggesting that P-fertilizer is especially recommended on cowpea in this area.

Table 2. Preliminary results from adaptation trials in 2017.

Country	Legume	Mean yield N2A	Mean yield own	Mean absolute increase	LSD*	Mean relative increase	Proportion of plots with gains > 50%	Sample size
		kg/ha	kg/ha	kg/ha		%	%	N2Africa vs. own plot comparisons (#)
Ghana	Cowpea	1045	647	407	83	86	63	41
Ghana	Soybean	1484	940	550	80	64	59	73
Nigeria	Soybean	1369	656	713	126	144	80	10
Ethiopia	Faba bean	2205	1470	735	215	58	50	10
Tanzania	Bush bean	1603	849	753	87	126	76	80
Tanzania	Cowpea	1216	407	806	66	514	90	143
Uganda	Bush bean	322	425	-103	220	–16	20	5
Uganda	Climbing bean	2617	2272	346	384	37	21	29
Uganda	Soybean	749	415	334	491	77	38	13

**Fishers Least Significant Difference test*

Recommendations for best-fit technologies

The combined results of yields and farmers' evaluations of diagnostic, demonstration, and adaptation trials over multiple seasons led to the development of best-fit recommendations for the different legumes in the core countries (Table 3).

In Ghana, the New Yara Legume (NYL) fertilizer (NPK, Ca, OMg_2, OB) was tested against TSP fertilizer. In all three legumes, NYL resulted in larger yields than TSP (see examples for soybean and groundnut in Fig. 1). Yields of cowpea were also significantly larger with 1250 kg/ha for TSP and 1380 kg/ha for NYL ($P < 0.05$). The difference in performance of cowpea and soybean varieties in different parts of the country in both diagnostic and demonstration trials led to tailored recommendations about the suitability of varieties for different parts of the country. The early maturing soybean variety TGX 1985-10E was outperformed by the other two improved varieties in terms of yield, but was still considered suitable for late planting.

Agronomic studies to develop recommendations for soils non-responsive to inoculation and P-fertilizer showed that an additional application of 30 kg/ha of S (sulfur) was recommended for chickpea production in Northern Ethiopia, while a combined application of K_2O (60 kg/ha) and lime (4.6 t/ha) was recommended for soybean production in acidic soils in Western Ethiopia.

Table 3. Best-fit recommendations for legume cultivation based on diagnostic, demonstration, and adaptation trials.

Country	Legume	Treatment
Ghana	Cowpea	Varieties Padi-tuya (Upper West Region) or Wang-Kae (Upper East and Northern Regions); New Yara Legume fertilizer
Ghana	Groundnut	Variety Samnut 22; New Yara Legume fertilizer
Ghana	Soybean	Varieties Afayak (farmer preferred) or Suongpungun in Upper East and Northern Regions, or TGX 1985-10E (early maturing) in Upper East and West Regions; New Yara Legume fertilizer; inoculants
Nigeria	Soybean	Varieties TGx 1951 - 3F; TGx 1955 - 4F; TGx 1904 - 6F or TGx 1835 - 10E; farm yard manure; SSP fertilizer; inoculants
Nigeria	Groundnut	P+K fertilizer
Ethiopia	Bush bean	P-fertilizer; inoculants
Ethiopia	Chickpea	P-fertilizer; inoculants; 30 kg/ha of S (northern Ethiopia)
Ethiopia	Soybean	P-fertilizer; inoculants; 60 kg/ha of K_2O and 4.6 t/ha of lime (acidic soils in western Ethiopia)
Tanzania	Bush bean	Variety Lyamungu 90; (N)PK fertilizer; inoculants
Tanzania	Cowpea	Variety Tumaini; P-fertilizer
Tanzania	Groundnut	Variety Pendo; farm yard manure; Minjingu Rock Phosphate (MRP); gypsum; Aflasafe
Uganda	Soybean	Variety Maksoy 3N; TSP; inoculants
Uganda	Climbing bean	NABE 12C; farmyard manure P-fertilizer

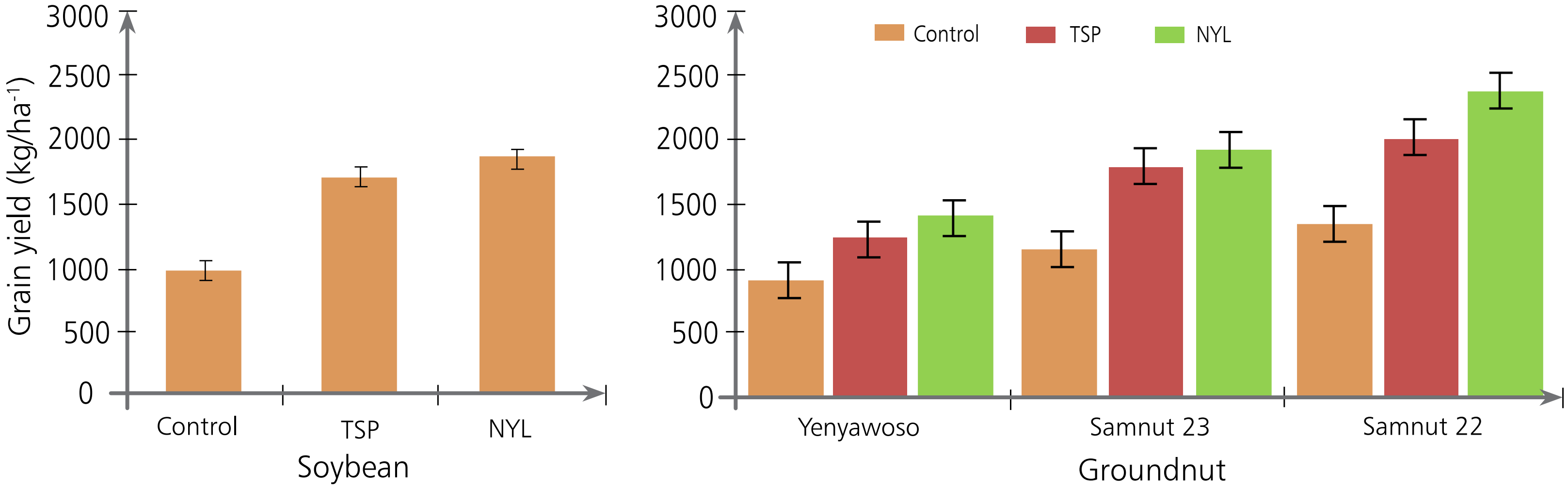


Figure 1. Grain yields of soybean (left) and groundnut (right) without and with TSP or New Yara Legume (NYL) in Ghana.

Bush bean in Northern Tanzania with a combination of (N)PK fertilizer and inoculants resulted in the highest yields. The highest yields of groundnut were attained with a combined application of farm yard manure, Minjingu Rock Phosphate (MRP), and a little gypsum. Farmers also ranked this treatment highly as these inputs are readily available and less costly to smallholder farmers. Aflasafe, a biocontrol agent for controlling fungi producing aflatoxin was added on top of fertilizer treatments to assess the impact of agronomic practices on its efficacy. There were higher levels of aflatoxin contamination on groundnut from plots that were not treated with Aflasafe and no difference between the two biocontrol methods as they both reduced aflatoxin levels by up to 95%.

In Uganda, diagnostic trials were conducted to identify the nutrients needed to close the yield gap related to soil fertility, as previous trials had shown that neither application of P + inoculation could close yield gaps of soybean nor manure + P close yield gaps of climbing bean. In soybean, inoculation and lime resulted in significant increases in yields compared to the control or lime alone; and yields of inoculation and liming with P were significantly better (1526 kg/ha) than without P (1,383 kg/ha). The addition of K, N, Mg, Ca, and micronutrients did not result in a significant change in yield until manure was added, resulting in a maximum yield of 1872 kg/ha. The economic viability of the nutrient combinations particularly inoculants alone, inoculants + P, and inoculants + P + manure—should be assessed and related to farmers' capacity to purchase. Climbing bean grain yields showed significant responses to lime application and combined application of lime + P.

This reiterates the need to manage soil acidity in the highland areas to improve climbing bean productivity. It could also explain the responses to manure and P application in some demonstration trials in previous years; manure probably plays a liming role. The liming contribution of manure needs to be evaluated, as manure could be an alternative option to agricultural lime in climbing bean production for those who have access to it.

In 2017, we also captured the "learning pathways" that have led to changes in demonstration trials from 2014 up to 2017; describing the main reasons behind moving from best-bets to best-fits[1]. Common reasons to discard varieties in demonstrations were poor yields (often the result of increasingly irregular rainfall patterns). Introduced varieties were therefore in most cases

[1] http://www.n2africa.org/content/tailoring-and-adaptation-n2africa-demonstration-trials

selected based on their drought tolerance and better yields. For groundnut, there was also a clear selection towards varieties with high oil content and with a good taste to accommodate market demand. Changes in inputs described specifically for 2017 were that Legumefix was added to bush bean in demonstration trials in Tanzania because results elsewhere (Ethiopia, Rwanda) indicated a response to inoculation in common bean. In Ghana, TSP was replaced by NYL for fertilizing cowpea and soybean. In Uganda, the herbicide Beans Clean was introduced in 2015 to produce bush bean, climbing bean, and soybean to reduce the labor intensity of weeding. Some weeds persisted after the application of Beans Clean, so a stronger, broad-spectrum glyphosate herbicide was introduced in 2017 to be used in combination with or instead of Beans Clean.

Feedback from farmers was very often the basis of changes. Evaluation with farmers is clearly necessary to steer practices towards best-fit within a regional context with its specific weather and market conditions. Other lessons learned from capturing these changes were the need for varieties that are more tolerant to changing and irregular weather conditions while still being high yielding and marketable. The availability and accessibility of legume-specific inputs such as certain rhizobium strains (Ethiopia), TSP (Tanzania, Uganda), or DAP (Ethiopia) were often a problem, stressing the importance of networking with partners and lobbying policymakers.

To transform agriculture in Africa, evidence on the effectiveness and impact of the dissemination approaches needs to be applied; this is an important research-for-development milestone of the N2Africa project since it is also a learning grant. Effectiveness of dissemination means smallholder farmers have the capacity to use and adapt the technologies. To create impact, this capacity needs to be complemented with a sustainable input (certified seeds, inoculants and fertilizers) and output supply.

Effectiveness of dissemination approaches

N2Africa and its partners continued in 2017 to reach smallholder farmers by raising awareness and conducting training on the use of technologies through various dissemination activities. These comprised field

Farmers' field visit, DR Congo. Photo by IITA.

demonstrations, adaptation trials, field day packages, and innovative multimedia including interactive radio campaigns, comics, videos, posters/leaflets, and SMS messages. By 2017, a total of 553,800 farmers had been reached (47% female), 33% more than the already ambitious target for 2017 (Fig. 2).

The project and its partners in 2017 established 1,454 demonstrations and 25,071 adaptation trials across the target countries. Most households (49%) were reached through demonstrations followed by field days and agricultural shows (27%). Through the end-of-season evaluation feedback sessions, about 90 farmer groups across Ghana, Kenya, and Uganda, evaluated the different approaches whereas 76 groups evaluated adaptations in Ghana and Uganda.

Farmers indicated their preference for demonstrations as they gave an opportunity for them to "see, learn, and do," when organized together. Demonstrations are also familiar platforms for farmers and make it easier to engage in and fit in with existing partner systems.

Field days also offer a platform to link with other value chain actors such as agrodealers and produce buyers, create linkages to access inputs and output markets, and offer broader learning as other farmers participate. Farmers indicated the unique opportunity given to individuals to practice the use of the technologies outside the group and to change it as desired.

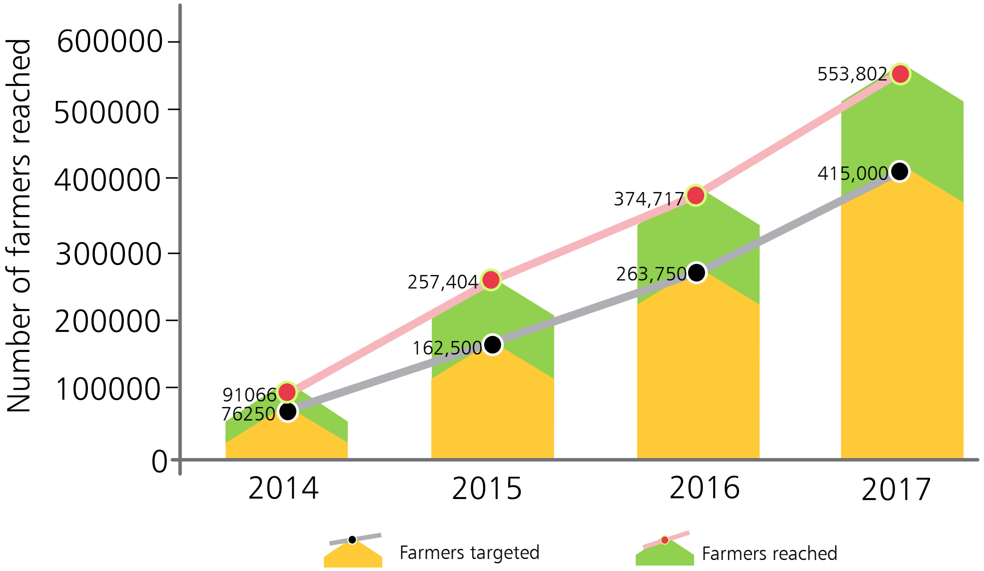


Figure 2. Total number of farmers reached from 2014 to 2017.

Although participation and preferences varied for each approach, awareness and knowledge levels about the technologies increased among farmers and resulted in the use of the technologies. A total of 182 farmers in Uganda participated in demonstrations only and 124 (68%) used the introduced varieties (Maksoy 3N); 54% of farmers who participated in the evaluations used at least a single technology with most using introduced varieties, spacing, fertilizers, and inoculants.

The data presented is from the project's Monitoring Evaluation and Learning (MEL) system. Other evaluations on the (cost)-effectiveness of the different dissemination approaches were conducted by an MSc student comparing radio to demonstration plots. The findings showed that farmers learn more from demonstrations compared to radio but net costs and learning increase favor radio campaigns in cost effectiveness. This led to N2Africa's sister project, Gender and the Legume Alliance: Integrating multimedia communication approaches and input brokerage (GALA) on farmer learning and change in behavior following radio and SMS campaigns. Seventy percent of farmers declared they had changed their behavior; radio with SMS was most effective followed by SMS, and radio alone.

Sustainable input supply

To address the challenge of limited access to and use of legume seeds, inoculants, and P-rich fertilizers, the countries continued to pursue the various strategies put in place in 2016. To sustain the production of certified seed, national seed systems were supported (e.g., ARI Uyole, Tanzania) to produce foundation seed for seed companies to produce certified seed. Others have linked seed companies and other partners directly to institutions that produce foundation seed, e.g., The Inventive Minds and EGALF Ventures in Nigeria have been linked to the University of Agriculture in Makurdi where they access foundation seed for their community seed producers. A total of 48 tons of foundation seed was produced and/or accessed across the selected countries.

To ensure legume seed is available at community level, the project continued to promote over 4,000 farmers to produce certified or quality declared seed across the countries. In aligning marketing seed with grassroot producer groups, 1,590 tons of seed were sold by seed companies, agrodealers, and community seed producers, increasing the cumulative volume of seeds used by farmers to 3,399 from 1,809 tons in 2016, achieving 74% of the target for 2017.

Table 2 shows that supported farmer groups had access to and used 67% of seed demanded across the various legumes. Some farmer groups indicated their interest and the volume required but did not purchase for various reasons including limited access to agrodealers and climatic changes. Some varieties are not resistant to drought and there was poor market access for those varieties.

Table 4. Seed quantities demanded and used by farmers in Ethiopia, Tanzania, Nigeria, Uganda, Ghana, Malawi, and Rwanda in 2017 (t/year).

Legume Type	Quantity Demanded[1] (t/year)	Quantity Used (t/year)
Soybean	642.7	498
Groundnut	207.4	140.5
Cowpea	162.8	93.2
Climbing Bean	111.3	60.4
Bush Bean	181.8	85.9
Total	1,306	878

n = 1,916 groups

[1] *Quantity demanded is defined as the total amount of seed aggregated centrally through farmer surveys done by local partners, i.e., business support services, extension agents, village-based advisors, CBOs, village-based agrodealers, and primary cooperatives.*

In 2017, the volume of inoculants and fertilizers used by farmers increased compared to 2016 (Figs. 3 and 4). About 79% of the volume of inoculant and 65% of the volume of fertilizer were achieved in relation to targets of 39 t/year and 7,700 t/year. Several strategies implemented together with partners contributed to this success. Agro-inputs Suppliers Ltd (AISL) in Malawi, for instance, invested in the distribution chain by procuring 15 solar-driven coolers for proper Nitrofix inoculant storage in 15 of its outlets and has constructed a permanent and fully equipped laboratory for inoculant production.

Although the overall targets for 2017 have not been met, the strategies implemented in 2017 will continue to yield results as the private sector continues to invest. For example, in Ghana, dissemination activities with YARA resulted in an increase in P-fertilizer used by farmers (e.g., from 150 t in 2016 to 194.6 t in 2017) excluding quantities distributed through the Government of Ghana's Planting for Food and Jobs program and this partnership is envisaged to continue in 2018. In Nigeria, the ABP program contributed to 78% sales of inoculants in 2017.

To sustain accessibility to improved seeds, countries have put in place various strategies including seed companies contracting trained seed producers as outgrowers. Other countries have also linked seed producers to seed companies for mopping up seeds produced. In addition, many more agrodealers (136) were engaged and linked to various farmer groups. About 32% stocked more than one legume input 68% stocked seeds, 32% stocked fertilizer, and 28% stocked inoculants. Most inoculants were distributed in Ethiopia through cooperative unions in addition to two agrodealers.

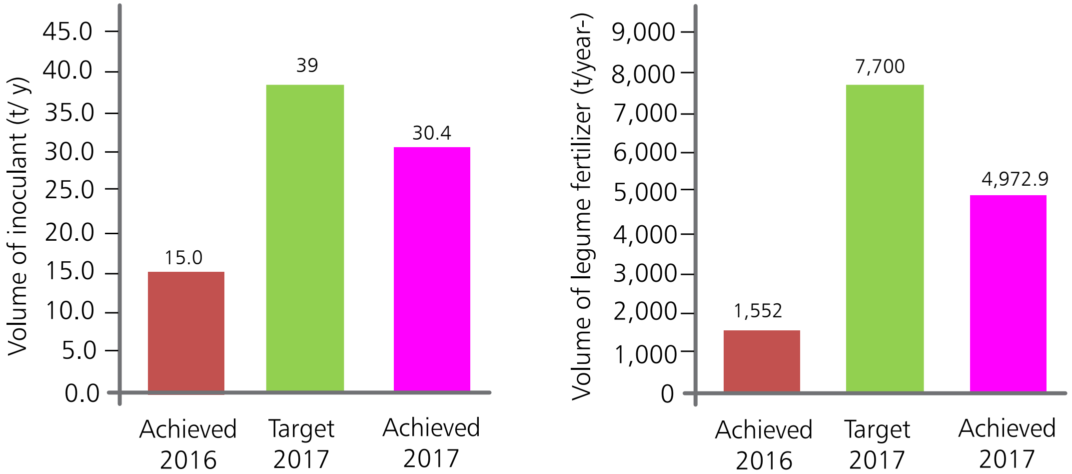


Figure 3. Volume of inoculants (left) and Legume Fertilizer (right) used by farmers in 2016 and 2017 (targeted and achieved) (t/year). Data based on available records from N2Africa Farmer groups.

Over 900 farmer groups were able to estimate inputs, especially seeds, needed for each season. However, this needs further support to ensure timely compilation and delivery to the input-dealers and access to input price information by farmers. Assessment of these systems has been made and an ICT-based demand quantification system is being piloted in Ethiopia, Ghana, Nigeria, and Uganda. Tanzania, however, has adopted the Village Based Agricultural Advisors (VBAA) and Community Volunteers (CV) models for input demand quantification for the upcoming year. The latter was based on limitations in the previous system where farmer groups quantified their demands but lacked price information.

Output market access and collective marketing

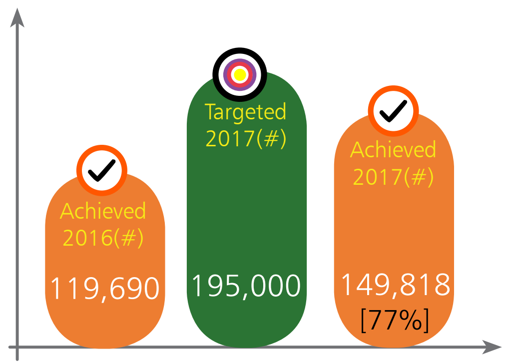
In total, 149,818 persons (46% female) were involved in collective marketing and value addition. The scales of operation were at both household and commercial levels. Table 3 is the aggregated data from countries and crops and indicates that 77% of the 2017 target has been achieved for participation in collective marketing.

Due to high demand for the produce, the price margin between collective marketing and individual selling is minimal in, for instance, Borno State. Most farmers among groups therefore sold individually without participating in the collective sales.

Farmers across the countries, at times, complained of delayed payments when they had collectively sold to major buyers, limited access to market information in comparing prevailing market prices to those being offered, and high storage costs for bulking.

In Tanzania, the introduction of VAT on animal feed increased prices and reduced demand. Animal feed processors could therefore not process soybean purchased in 2016. This decision has been reversed and hopefully the demand for soybean will revert in 2018.

Table 5. Number of farmers engaged in collective marketing[1] in 2016 and 2017 (targeted and achieved).



[1] *Collective marketing is where farmers come together to negotiate with buyers and sell their produce as a group allowing for better prices and lower transaction costs.*

SEMEAR project continues to improve livelihoods in Northern Mozambique

Ana Couvinhas
IITA-Zambia

Angonia Amos, field technician intern spraying FtF SEMEAR fields in Mozambique. Photo by A.F. Couvinhas, IITA.

The competitiveness and profitability of most smallholder legume and sesame farmers in Mozambique are constrained by low productivity resulting from many challenges including poor access to seeds of improved and high-yielding varieties and the use of poor agronomic practices. There is a complete lack of effective and well-coordinated mechanisms to produce and supply improved seed to farmers.

IITA, under the Improved Seeds for Better Agriculture (SEMEAR is the Portuguese acronym) project of the US Government Feed the Future (FTF) initiative, seeks to sustainably increase the adoption of improved technologies of cowpea, soybean, and sesame to increase incomes and food security of smallholder farmers, especially women. This is through increasing the production and supply of seeds

Gurue, Mozambique, Amélia Bitone, a model farmer and enthuisiastic community leader, is a FtF SEMEAR beneficiary, Photo by A.F. Couvinh*as*, IITA.

of improved varieties, strengthening the seed systems, enhancing the capacity of national partners to produce basic and certified seeds, and facilitating adoption.

SEMEAR aims to improve the availability of breeder, foundation, and certified seed of new improved varieties recently released in Mozambique and strengthen technology delivery in the HF project sites in Manica, Nampula, Tete, and Zambézia provinces. The project is led by IITA and is being implemented in collaboration with other research institutes (IIAM, ICRISAT, and CIAT) and is aligned with PEDSA, the country's national agricultural strategy. The overall goal of the project is to increase the adoption of improved technologies, income, and food security of smallholder farmers. It is targeting 100,000 households with 35% women in the project areas.

Achievements

In 2017, the second year of implementation, the project produced 136.44 t of early generation seeds of common bean, cowpea, groundnut, pigeon pea, sesame, and soybean representing 102% of the 133.76t target. This quantity of seed comprises 25.12t of breeder/pre-basic seed, which can plant 684 ha, and 111.32t of basic seeds expected to cover 2,287 ha of land during the upcoming season. The project also assisted its network of partners to produce 1,293.38 t of certified seed which is 87.2% of the annual target of 1,483.4 t. This shortfall is attributed to the low performance of common beans as well as delays with groundnut and cowpea seed production data from partners.

The project also facilitated the inspection of seed multiplication fields of partners and the subsequent certification of 14 community-based seed producers. The seed producers received certificates and batch numbers for their seeds to serve as evidence of quality assurance for seed buyers.

The project continued to create awareness through the establishment of demonstration plots to showcase the potentials of improved varieties and appropriate management practices, farmer training, field days, farmer exchange visits, and workshops. A total of 1,563 demonstration plots were established through the "Lead Farmer" approaches, with 38% of female lead farmers hosting demonstration plots on their farms. Furthermore, the proportion of female farmers hosting demo plots on cowpea, common bean, and groundnut ranged from 42 to46% due to the importance female farmers attach to food legumes for food security. In total 3,114 (1,856 males; 1,258 females) individuals were trained in many subject areas including variety selection, improved management practices, seed production techniques, seed storage, packaging, labeling, seed business management, and disease and pest control.

In addition, over 120 field days were organized in partnership with a number of organizations across project locations with the participation of 4,541 farmers and stakeholders, and almost 41% female farmers.

SEMEAR beneficiaries. Photos by A.F. Couvinhas, IITA.

Sectala Zendlana and Manuel Palusso are model farmers and FtF SEMEAR beneficiaries.

Amélia Bitone is a model farmer and enthuisiastic community leader. She is an FtF SEMEAR beneficiary.

“Farming is a serious profession”

Telma and Américo Sinsseque live in Namiro community in Northern Mozambique. The couple became partners with the SEMEAR Project in 2017 to support the production of certified seed.

Telma *Américo*

To start producing certified seed, the Sinsseque family purchased basic seed from the SEMEAR project. Telma allocated half a hectare of land to pilot production of the T-16 improved cowpea variety. She got 630 kg of certified seed, which she sold at 45 MZN/kg (US$0.75), while the local variety was going for 25 MZN/kg, and made approximately $475. Excited by these results, for the next season Telma aims to grow one hectare of certified seed of cowpea and one hectare of certified seed of sesame as they are more profitable, with the ultimate goal of expanding to 20 ha of improved varieties in the next 5 years.

“With improved cowpea seed I was able to make extra money to invest in my farming activities and meet my household needs,” she said.

Américo, Telma’s husband, accepted the challenge of experimenting with Lindi, an improved sesame variety, and obtained 119 kg of certified seed that he sold at 75 MZN/kg ($1.3). By applying good agricultural practices that he learned from SEMEAR, Américo realized that his agricultural business can become much more profitable and therefore, the following season, he will increase his farming land from the current 11 ha to 15 ha and he will mostly grow seed of improved varieties:

“I have made my decision; I will invest in production of improved crops like cowpea, groundnut, and maize.”

With the increased farm revenues, the Sinsseque family was able to invest in agricultural inputs like a spraying machine and mechanization services, improved their storage facility, and purchased a new motorbike. The impact of the SEMEAR project is much broader than this; in fact, the Sinsseque family hires up to 50 laborers from their community to help farming.

Instead of selling their entire crop to big commercial entities, Telma and Américo reserved 180 kg of improved cowpea seed and 25 kg of improved sesame seed to sell to local farmers struggling to access good-quality seed. This current season, up to 30 smallholder farmers will have access to certified seed.

Américo is also the president of the AFANE farmers’ association and in August 2017, the association’s seeds were certified by the National Seed Services Regional Laboratory of Nampula. SEMEAR facilitated seed inspections during the past cropping season. The certification was one step towards the formation of sustainable and profitable community-based seed production enterprises. Américo is very happy with the certification and says the group is committed to improving farming practices and producing good quality seed that comply with the national seed regulations.

“With the certified seeds AFANE farmers are motivated to farm because they are sure that those seeds will germinate and they will get good yields. They will also fetch better prices. When buyers refuse to pay fair prices, we can refuse that offer and we are sure that another client will appear!” said Américo.

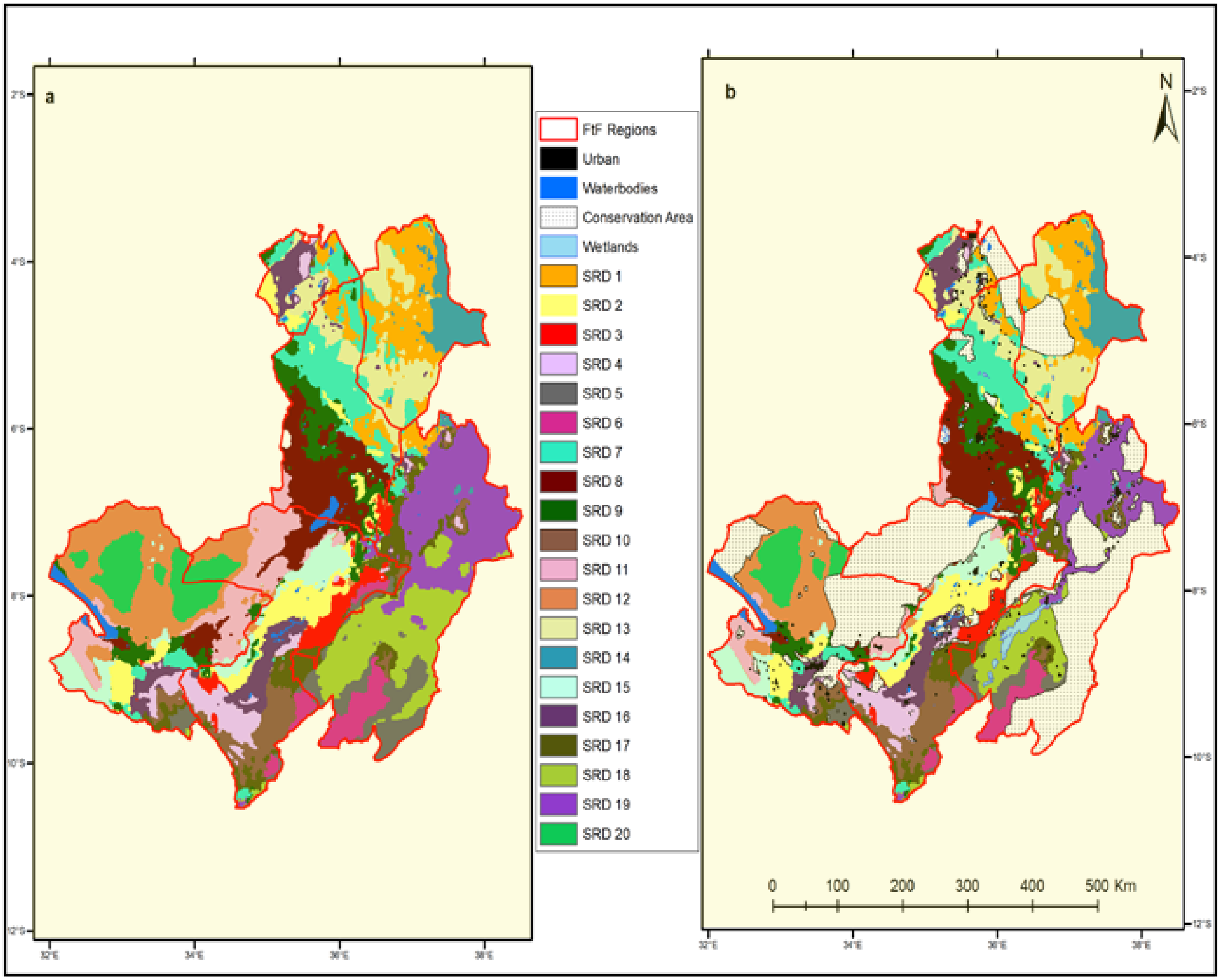
Using GIS tools to overcome the uncertainties of scaling technologies

Jonathan O'dhong
Africa RISING, IITA-Ibadan

Abeid Chonya and wife Sumaiya collaborate with the Africa RISING-NAFAKA project in bean seed multiplication in Mkungugu village, Iringa District of Tanzania. Photo by J. Odhong', IITA.

Traditional dissemination methodologies of improved agricultural technologies such as the use of the extension systems or the establishment of demonstration sites have shown potential at localized scales. However, there is a need for more cost-effective methods to disseminate technologies at much bigger scales through methodologies that complement and add value to these traditional dissemination styles. Welcome to the 21st century!

In the lush greenery of the southern highlands of Tanzania, one of IITA's leading research delivery projects, the *Africa RISING–NAFAKA project*, is blazing the way in applying GIS tools to add more precision to their scaling methodologies. The project, which is funded by the United States



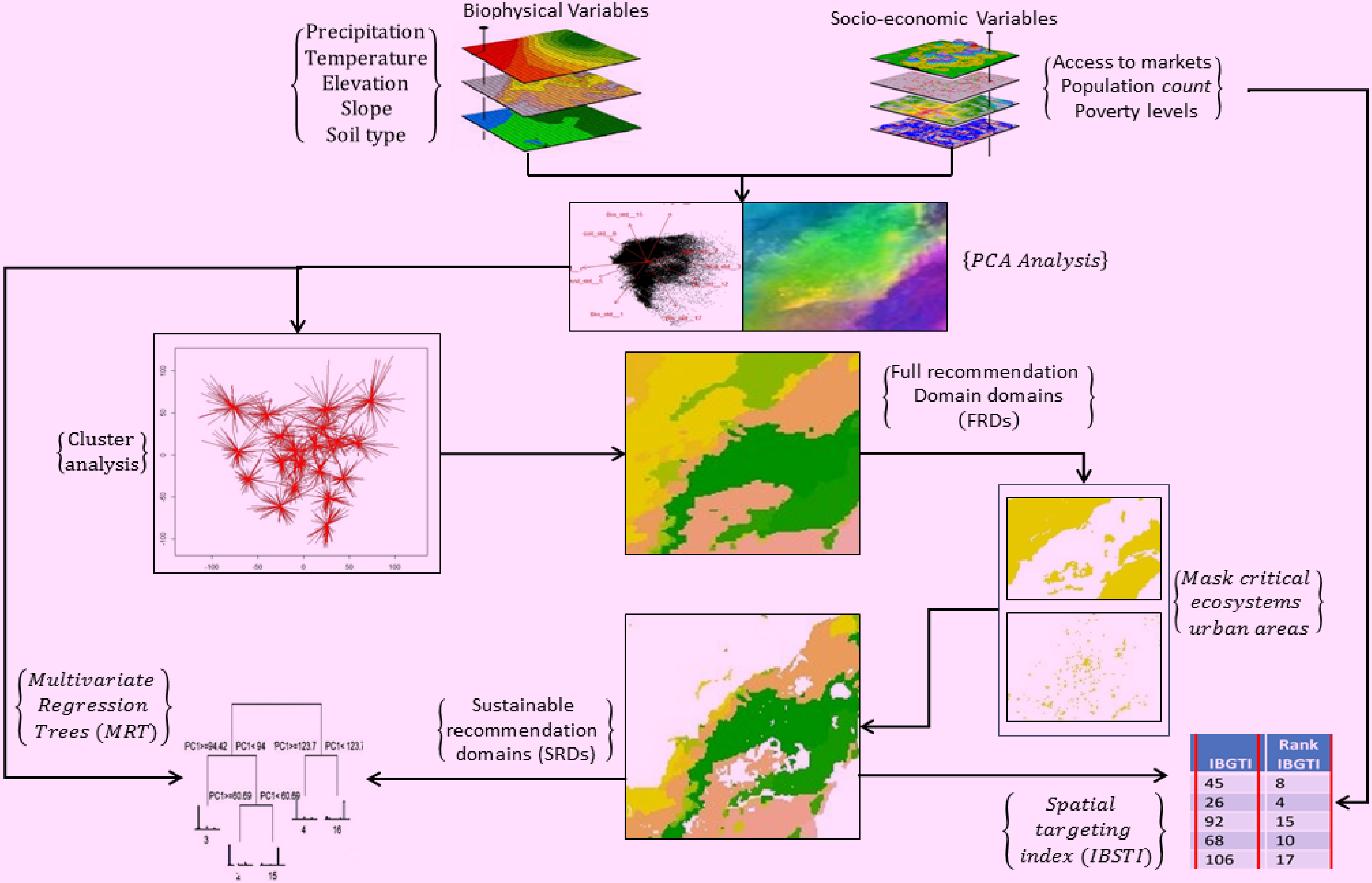
Map for Feed the Future zone of influence in Tanzania showing (a) clusters with relatively homogenous biophysical conditions and (b) the sustainable recommendation domains (SRDs) generated after masking critical ecosystems and urban areas from clusters (a).

Agency for International Development (USAID) Tanzania country mission, has successfully managed to identify 20 homogenous zones (with similar biophysical and socioeconomic characteristics) where the various technologies developed, validated, and promoted by the projects have the greatest possibility of gaining smallholder acceptance.

Francis Muthoni, the IITA GIS expert leading this effort, notes that: "With this bit of work we have reduced some of the uncertainties that exist when scaling out technologies. It also helps us to get rid of the traditional descriptions of agroecologies such as 'highlands', 'mid-latitudes', and 'lowlands' and use more location-specific descriptions. For instance, 'highlands' in Tanzania could be 'lowlands' in Nepal around Mt Everest. The next chapter in our work is what can be called evidence-based scaling," he adds.

A research paper highlighting this work, which was published by Muthoni and other collaborating authors from IFPRI and CIAT in the July 2017 edition of the *Land Use Policy Journal* has generated a considerable amount of interest, particularly in the USAID Tanzania country mission.

"This GIS information is very useful, particularly when doing site selection. I would like to actually see not only the scientists use this information, but also the development partners too," said the USAID Tanzania Country Mission's research and production advisor, Betty Maeda.



The analytical procedure for delineating sustainable recommendation domains (SRDs) and Impact Based Spatial Targeting Index (IBSTI).

Mzee Abdalla (center), a farmer in Ulaya village in Kilosa District in a discussion with Africa RISING GIS specialist Francis Muthoni (right). Photo by G. Ndibalema, IITA.

The findings of this research greatly improve the existing recommendation domains in many aspects. First, the newly generated domains are ecologically sustainable since critical ecosystems such as nature conservation parks and wetlands were masked out to ensure scaling-out of agricultural technologies has minimal negative impacts on biodiversity and ecosystem services. The masked areas included national parks in Mikumi, Ruaha, and Udzungwa mountains that are globally recognized biodiversity hotspots and water catchments with high vegetation biomass that store and sequester significant amounts of carbon. Secondly, the new domains are generated using an objective data-driven approach compared to existing domains that were generated using subjective expert judgements.

Thirdly, by using an Impact Based Spatial Targeting Index (IBSTI) as an objective tool for priority setting when scaling agricultural technologies, priority areas within each sustainable recommendation domain are identified and targeted. This, therefore, maximizes the potential impacts of scaling intervention and enhances rationalization of limited resources. It helps to pinpoint priority zones with a high overall population, high poverty index, and number of women and children less than five years that are essential for targeting specific agricultural technologies. This index enables development agencies to estimate potential impacts of their technologies thereby supporting evidence-based site selection. This enhances effective allocation of limited resources and promotes achievement of greater impact especially for projects with a limited time span.

SARD-SC influences sustainable agriculture to alleviate poverty for smallholder farmers

Chrys Akem
IITA-Ibadan

"The SARD-SC project has done many things for us. Before, we used to boil cassava to eat and sometimes make fufu, but the project has taught us a lot, especially processing cassava into various products. We now make custard, cakes, and bread from cassava flour and many other things," said Korma Koroma, leader of the Tangeai Women Association, Sierra Leone, during an impact assessment program carried out by the project in 2016.

IITA scientist working with farmers and partners on cassava value chains. Photo by IITA.

The intervention of the Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) project in 20 Regional Membership Countries (RMCs) in Africa has transformed the cultivation of cassava, maize, rice, and wheat. It has also added value to these crops through the introduction of high-yielding varieties, new processing methods, and other agricultural innovations and technologies.

SARD-SC, funded by the African Development Bank (AfDB) and executed by IITA, is an integrated research, science, and technology development project established in 2012 to improve the productivity and profitability of strategic crops in Africa identified by African Heads of States as rice, cassava, maize, and wheat. Improving the productivity of these crops would enhance food and nutrition security, reduce poverty, and improve the livelihoods of smallholder farmers and the people of the RMCs—Benin Republic, Côte d'Ivoire, DR Congo, Eritrea, Ghana, Ethiopia, Kenya, Lesotho, Madagascar, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Zambia, and Zimbabwe.

The project was implemented by several CGIAR centers, specifically IITA, ICARDA, AfricaRice, and IFPRI. ICARDA supervised the wheat value chain, AfricaRice carried out its activities on rice, and IITA supervised cassava and maize activities. IFPRI was tasked with supporting the other centers with policy initiatives and strengthening the technical and commercial capacities across the four value chains.

Farmer with herhuge cassava root.
Photo by IITA.

In its five years of implementation, the SARD-SC project recorded many achievements and milestones to ensure food security in the target RMCs. It employed a multi-pronged approach focusing on production, marketing, transformation, and consumption to drive agriculture as a profitable business for resource-poor, smallholder farmers. In Sierra Leone, the only way the people knew how to eat cassava was by boiling and traditional *fufu*. However, with the establishment of processing centers and training of women processors accompanied with technical backstopping, many new products have been introduced to the country. *Gari*, which is one of the major products of cassava in Nigeria, has now become a staple food in Sierra Leone after rice.

Employing the value chain approach to improve the profitability of the mandate crops and introducing technical innovations have opened new vistas for smallholder farmers in many communities. Value chain development has enabled the identification of gaps and interventions that can benefit marginalized groups such as women, youth, and the poor and has contributed to improving the livelihoods of farmers and women, especially those who have become financially self-reliant.

New varieties developed and released

Technology generation efforts through SARD-SC support have led to the release of six new, high yielding cassava varieties resistant to Cassava Brown Streak Disease (CBSD). In DR Congo, for example, these varieties have been handed over to the National Ministry of Agriculture for dissemination to farmers. They also served as sources for the regional breeding program, tackling CBSD challenges facing cassava growers in DRC and the Great Lakes.

In Sierra Leone, among the cassava varieties introduced into the country by the SARD-SC project was SLICASS 7. This has become the symbol of the women farmers and processor groups' success in the country. Agnes Mamigbane, chairperson of the Mamigbane Women's Processor group, in Bo District has this to say: *"SLICASS 7 can last up to seven days after harvesting the tuber without a stain."* She pointed out that the improved variety has enabled them to meet market demand in producing gari, high quality cassava flour (HQCF), and other cassava products; and reduce postharvest losses. Marie Yomeni, Cassava Commodity Specialist, said that because of the project's assistance, many of the women farmer groups had become invaluable partners of the project in supplying and disseminating improved varieties to other smallholder farmers.

The SARD-SC maize value chain particularly focused on creating and maintaining a seed system that would address low yields in the RMCs. Thus, the project developed and deployed tested and certified seed, and developed multi-stress-tolerant, nutrient-dense, and mycotoxin-resistant varieties and complementary crop management options. These were strategically deployed to create impact in different countries. To date, some 123 such varieties have been developed and tested on-station and on-farm.

Sam Ajala, Maize Commodity Specialist said, *"We are also concerned about maintaining sustainable production and multiplication of such certified seed varieties."* Some of the key milestones achieved included the introduction and intensification of maize farming in the southern part of Kaduna State and Nassarawa in Nigeria, establishing a maize innovation platform in Cameroon, and the economic transformation in the lives of maize smallholder farmers in rural Mali.

The SARD-SC wheat component has identified and released 21 new and best-fit improved wheat varieties along with their crop management packages, through successive multilocational field trials, and evaluation and validation of advanced breeding lines. Eight of these new varieties—four in Ethiopia, two in Nigeria, and two in Sudan—were officially released for wider cultivation in 2015. The introduction of heat-tolerant, high-yielding wheat varieties completely overcame the myth that wheat is not a tropical crop. Some countries such as Nigeria and Sudan readily incorporated this commodity into their agricultural transformation agendas.

New product development

Across the cassava and maize commodities, research and innovations have resulted in transforming traditional foods and agricultural produce into processed products. In all SARD-SC cassava countries, more than 50 culinary innovations have been developed using cassava flour for confectionery such as cakes, bread, doughnut, *chin-chin*, egg rolls, biscuits, meat pies, tofu and tofu kebabs, and tapioca. Odorless *fufu*, coconut gari, and vanilla-flavored ice cream are some other innovations derived from HQCF in Sierra Leone. Innovation has also brought about new products and diversification of maize cookies, chin-chin, To' (drink made from maize in Mali), and several other products. All these products are now commonly sold locally by women.

Activities were also undertaken to evaluate the economic use of cassava waste for commercial

Products developed from cassava starch on display. Photo by IITA.

production of edible mushrooms. The project had conducted ethnomycological surveys in each of the three regional Innovation Platforms established for cassava in Sierra Leone to assess indigenous knowledge on mushroom value to rural communities.

For the wheat value chain, many women beneficiaries have been trained on making both local and exotic recipes from wheat. The products included bread, cakes, doughnut, buns, meat pies, egg rolls, chin-chin, taliya (local spaghetti), *gereba, alkaki* (wheat sweet), and *funkaso*.

ACAI Project Manager Pieter Pypers explaining about ACAI's work.
Photo by IITA.

Introduction of good agronomic practices

SARD-SC aimed to enhance the productivity and profitability of the mandate crops for smallholder farmers in many RMCs because of low yield, poor farming methods, vagaries of weather, and lack of improved planting materials. The need to introduce good agronomic practices was imperative, hence, the maize value chain included the adoption of complementary crop management options in training farmers. Implemented through demonstration trials across the four value chains, the farmers witnessed the outcomes of modern farming methods applied on farms.

Adoption of agronomic practices by farmers was responsible for a higher percentage of uptake of improved technologies. Affirming the impact of the adoption, Hauwa Bio, leader of Muamia Women Association, Sierra Leone, said: *"IITA/SARD-SC has taught us how to plant cassava in rows, spacing, weed control, harvesting, and reduction of postharvest losses."*

Sani Hamza, from Guzou, Zamfara, recorded his first success with the application of the best agronomic practices in 2015. He harvested 4 t of maize in 1 ha. Previously, Hamza had attended the SARD-SC pre-season training organized in collaboration with the Maize Farmers' Association of Nigeria and the Ahmadu Bello University extension services. AfricaRice introduced a calibrated RiceAdvice android tool for providing farmers with guidelines on field-specific management practices to improve productivity and profitability.

Technology and mechanization

The project also introduced appropriate technology and mechanization to process the commodities.

In Sierra Leone, the project installed nine processing centers across the country in different cassava growing communities, equipped with milling machines, hydraulic pressers, graters, sealers, and many more to reduce drudgery and speed up processing .

The SARD-SC wheat sub-project introduced a raised bed mechanized planter towed by a tractor to all the wheat producing countries. The cost-effective machine was devised to make land preparing and sowing on raised beds convenient for resource-poor, smallholder farmers.

Teaming up with the private sector and research partners, AfricaRice developed technologies that rapidly transformed the rice business within project countries. AfricaRice introduced the Agricultural Transformation Agenda thresher-cleaner or ASI-Thresher into Nigeria and other rice producing countries. The machine was designed to remove particles from paddy rice. It also introduced a new technology named GEM (Grain quality, Energy efficient, and durable Material) rice parboiling technology and different types of weeders such as the ringhoe and the straight-spike.

Capacity development

SARD-SC considered training and capacity development as key to understanding and embracing technological innovations. For example, the rice component has enhanced the competence and skills of 451 NARES partners in crop management, marketing, integrated rice management, data analysis, and multi-stakeholder platforms.

In 2014, over 360 agricultural professional and stakeholders from various countries attended training and workshops on diverse topics under the wheat component. Under the cassava value chain, 167 NARES scientists and technical staff were trained, whereas 1025 people were trained in processing cassava into new products. In addition, nine PhD and 10 MSc students from four countries were offered scholarships to carry out research in agronomy, breeding, postharvest, and socioeconomics in collaboration with African universities. A good number of people have also been trained under the SARD-SC maize and wheat sub-projects.

Deploying Innovation Platforms

The SARD-SC project adopted the Innovation Platform (IP) as a strategy to gain maximum benefits across all the value chains. Bringing together a group of individuals with different backgrounds and interests to diagnose problems, identify opportunities, and find ways to achieve their goals concretized the concept of IPs.

More than 100 IPs were established and promoted dissemination and adoption of proven technologies, with more than 10,000 stakeholders trained across the four value chains on their operations for technology delivery and impact.

SARDC-SC Project Coordinator Chrys Akem. Photo by IITA.

The five-year SARD-SC project has indeed resulted in life changing impact on the beneficiaries and communities through the four commodity value chains.

In his assessment of the project success, Chrys Akem, SARD-SC Project Coordinator, said: *"We believe we have delivered; achieving more than the targeted 20% yield increase across the different commodities, engaging millions of households and laying pathways that will influence sustainable agriculture for smallholder farmers to alleviate poverty."*

Agricultural cooperatives in Zambia accelerate adoption of improved maize varieties

Julius Manda
Arega D. Alene, IITA-Malawi
Munyaradzi Mutenje
Adane H. Tufa
Peter Setimela
Victor Manyong, IITA-Tanzania

Maise is a major staple crop in Zambia.
Photo by IITA.

While maize is the number one staple crop in Zambia (for 70% of the population with 13% contribution to GDP), the average yields of around 2 t/ha, are very low compared to other countries in the region. Therefore, increasing its productivity is an important policy objective. Research has shown that the adoption of improved maize varieties is critical for increasing yields. Therefore, understanding the speed with which improved maize varieties are adopted and identifying the factors that enable faster adoption can greatly contribute to this policy objective.

Agricultural cooperatives in Zambia are one of the conduits through which the adoption of improved technologies such as improved maize and inorganic fertilizers can be accelerated or increased. The Zambian government is implementing the farmer input support program (FISP) that is supplying farmers with inputs such as improved seed and fertilizers at a subsidized price. To benefit from this program, farmers are expected to apply through their cooperatives, farmers' organizations, and associations. In addition to providing subsidized inputs, the program is encouraging farmers to adopt sustainable intensification practices such as crop rotation.

A study was conducted to assess the speed and determinants of adoption of improved maize varieties in Zambia using survey data collected in 2012 and 2015 in the eastern province of Zambia by IITA and the International Maize and Wheat Improvement Center (CIMMYT). The results from a duration analysis showed that the average time (adoption gap) it takes between the year a variety of improved maize is released and the year the farmer plants the variety was 9 years. Figure 1 shows that the waiting time or adoption gap was shorter for cooperative members (steeper slope) than that of non-members. This implies that cooperative members are more likely to adopt improved maize varieties faster than non-members.

The results further showed that cooperative membership, age of the household head, livestock ownership, and the number of contacts with agricultural extension officers are important determinants of the speed of adoption. A 1% increase in cooperative membership increases the speed of adoption of improved maize by 3 months. Similarly, livestock ownership increases the speed of adoption by 0.06 years. Livestock ownership plays an important role with regard to the provision of draught power that can be used for cultivation as well as transporting farm produce to the market. Contacts with extension agents indicated exposure to information on improved maize varieties, which in turn shortened the time between variety release and actual planting of the variety.

Results also showed that participation in cooperatives increased the probability of adoption of improved maize varieties, inorganic fertilizer application, and crop rotation in 2015. The probability of adoption of improved maize varieties increased by about 18 percentage points due to cooperative membership while that of inorganic fertilizer application increased by about 23 percentage points in 2015. The likelihood of adoption of crop rotation increased by nearly 19 percentage points with cooperative membership. The findings showed the same patterns for 2012. For 2012 and 2015 combined, cooperative membership increased the adoption of inorganic fertilizer application by 11 percentage points and crop rotation by 24 percentage points. Overall, the results point to the need for policies promoting farmer organizations such as cooperatives coupled with effective extension services for faster and greater adoption of improved technologies.

Women beneficiaries of SARD-SC.
Photo by IITA.

Famers using mobile phones to get information. Photo by IITA.

Microfinance at the margins: Understanding women's financial capabilities in South Kivu, DRC

Renee Bullock and Bonaventure Munzunghirwa
IITA-Bukavu

In the Democratic Republic of Congo (DRC), women's opportunities to gain skills in enterprise development and participate in formal savings opportunities are severely limited. The high rates of gender-based violence (GBV) further marginalize women from gaining access to microfinance.

Irongo Women's group following discussions on how to better manage household budgets and business activities. Photo by IITA.

that included training, group discussions, and personal counseling to improve entrepreneurial knowledge, skills, and attitude to support positive behavioral changes in household financial decisions. We worked with both women and men. Targeting women in skills training alone has proved to be an inadequate approach to supporting women's empowerment. Although women often engage in business and savings, commonly accepted norms and intra-household relations with spouses constrain women's decision-making about how to spend money and husbands may assume control over their spouse's income. Clearly, this undermines efforts to improve gender equality and development outcomes overall.

A woman reviews her personalized business plan with the project's economic coach.
Photo by IITA.

This project was jointly designed with Mamas for Africa, an NGO that supports women and girls in eastern DRC in their fight against violence, poverty, and inequality. Through this initiative, we facilitate access to microfinance services for women who have experienced GBV; increase women's ability in the household to support gender equitable household outcomes in managing finances; and support collective action mechanisms to increase solidarity and improve savings activities.

The project is currently in two rural locations in Walungu territory that have differing levels of market access. Irongo is a more rural location with weak market access, while Mushinga has better access to weekly markets. Thirty women who sought medical attention in the last 2 years were purposefully selected to participate. Qualitative and quantitative research methods were used. Focus group discussions and in-depth personal interviews were used to better understand the local context, including gender norms related to finances. Then a household baseline survey was conducted with husbands and wives, where applicable, to understand intra-household financial and business management and attitudes about gender-specific roles and better assess how women participants would manage income and savings in their households.

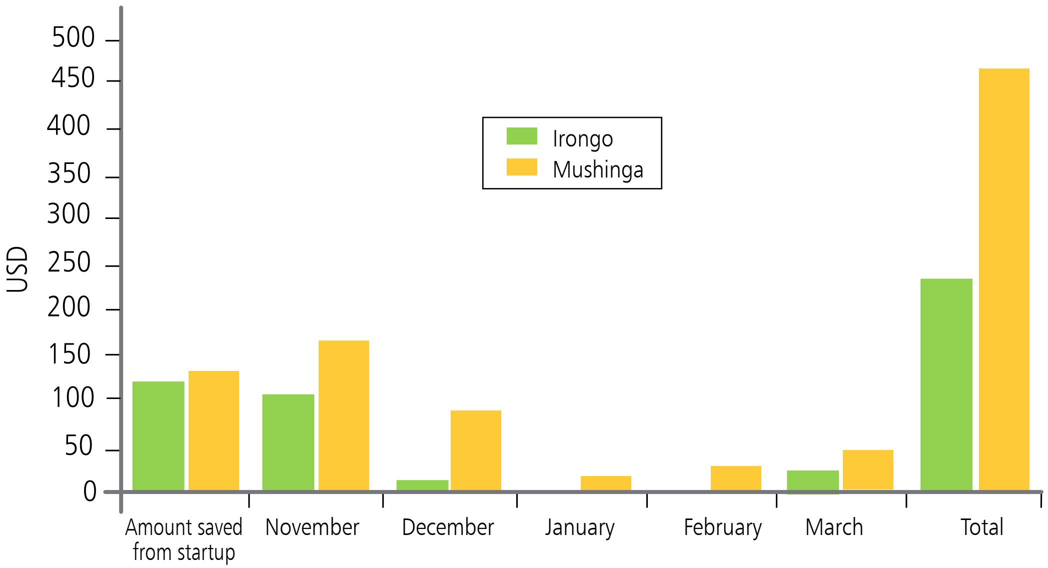
Twenty-six women from two villages opted to participate in the project; their ages ranged from 28 to 65; 67% of them are illiterate. Fourteen of the women are married, and seven are widows. The remaining women independently manage households while their husbands migrate in search of work, often in mines and potentially for years at a time. A 5-day intervention that included training and individual counseling was carried out with women and men to build women's financial capabilities.

Financial and negotiation skills were provided to build women and men's capacity and to change behaviors so women gain greater support from male household members in their enterprise and savings activities. Gender dialogue groups were used to discuss decision-making and planning of a household budget and sharing labor in household tasks, for example. Each woman then received US$30 as startup capital following training on allocating and developing a budget to meet household needs, invest in a microenterprise of their choice, and to save. Women then created a plan with support from an economic counselor on how to use this money.

Since the project began, women formed two groups and engage in diverse enterprises such as selling rice, beans, flour, and banana. They established a link to formal banking services and opened group accounts in the nearby banking cooperative. For half of the women, this is their first experience having their own savings account; only 27% of the beneficiary households received credit in the last 2 years. Each group in Irongo (12 members) and Mushinga (14 members) met once a week with a local facilitator, and saved and discussed their successes and challenges, recorded by the facilitator and shared to support a better understanding of microfinance challenges and opportunities.

The figure compares the savings performance of both groups: initial savings, savings from November through March, and the total savings. Both groups saved similarly in the initial round, $112 and $129, respectively. Savings amounts decreased from December through February. Explanations for the decreases were household shocks and emergencies, e.g., hospital fees. In Irongo, the group also faced challenges to secure a weekly meeting place, so did not manage to save in January and February. However, in March both groups were able to set aside savings. To date, Mushinga has saved a total of $468 and Irongo, $229.

A cause and concern for the discrepancy is Irongo's weak market access. Mushinga is close to two weekly markets and many members sell products in these markets. The Irongo group is currently developing plans to work more collectively with each other so that they may save more frequently. In general, married members often save higher amounts and save more frequently than widows and women whose husbands have migrated.



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In the baseline survey, we measured agreement with statements about autonomous and joint financial management, among others. Women often strongly agreed with statements that supported men's autonomy in managing money. They also said that women must share income with their spouse. In other words, men generally have authority on managing income, while women do not, reflecting unequal, gender-based differences in financial independence. The impact assessment showed significant decreased levels of agreement with such statements. Women were less supportive of men's autonomy and the necessity to share with their husbands, for instance. Such changes in attitudes are essential to change financial behaviors in the household. If women do not personally believe they have the right to manage finances independently, they will not.

Qualitative data also indicated changes in household management. Occasionally, women actively protested their husbands' requests to use money for alcohol. Rather, women put the money into savings as they had planned. In addition, women reported significant changes in their levels of satisfaction in managing expenses and increased skill in managing business. Women reported that they are also in a better position after the intervention to pay school and medical fees, and to purchase food. Such changes are critical to garnering sustainable change in the lives of these women and their familwies.

This project has provided key insights to guide future gender transformative research. Among these lessons is the need to use relational and intersectional approaches to understand the local social context. It is imperative to work with and engage men, especially in the household, to address and improve women's financial capabilities. Women's circumstances are diverse and dynamic; their experiences vary based on their household structure, affective networks, and life stage, for instance. This project showed that training of both men and women using financial capabilities approaches has supported significant changes and improvements in women's ability to exercise their ability to make choices or important finance-related decisions in the household. An integrated, gendered approach to microfinance will better support the potential to enhance women's entrepreneurship, savings, and gender equity in the agriculture sector.

Community women celebrating their successes on the processing center.
Photo by IITA.

Youth perception toward agriculture and drivers of youth engagement in agricultural value chains in eastern DR Congo

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Youth Agripeneurs in DRC. Photo by IITA.

Youth unemployment is a critical challenge in DR Congo where over 70% of young graduates are jobless. In the Eastern part of the country, the situation was exacerbated by decades of civil conflicts which have forced many youths to migrate from rural areas to the cities in search of good paid jobs. The region is endowed with huge agricultural potential, placing the sector in the best position to provide jobs and incomes for the youth.

Despite the global acknowledgement of the huge potential of the agricultural sector to provide jobs and incomes to young people in sub-Saharan Africa, youth engagement in agribusiness is still very limited. Understanding their perceptions and the factors that condition their engagement in agribusiness is indeed a critical step toward reducing unemployment among youths in Eastern DR Congo and particularly in South-Kivu province. This study aims to understand youth perception and factors that condition their engagement in agribusiness in Eastern DR Congo.

We randomly selected 375 youths (15-35 years) from 75 youth associations in South-Kivu province (Eastern DR Congo), precisely in Bukavu town and 25 km around. We analyzed perceptions and identified major drivers of youth engagement in different segments of the agricultural value chain.

A large portion (82%) of youth interviewed in South-Kivu perceive agriculture as a sector that can provide jobs and incomes for majority of unemployed youth in their area. This is because agriculture requires abundant labor in all segments of the value chain and does not require a high qualification. In addition, agribusiness offers good income generation opportunities for the youth given the high demand of agro-food commodities in the area where more than 80% of the food consumed is imported from neighboring countries (see figure). The positive perception observed is certainly explained by the fact that all the respondents are members of associations that are spaces for development thinking with special emphasis on the role of agriculture.

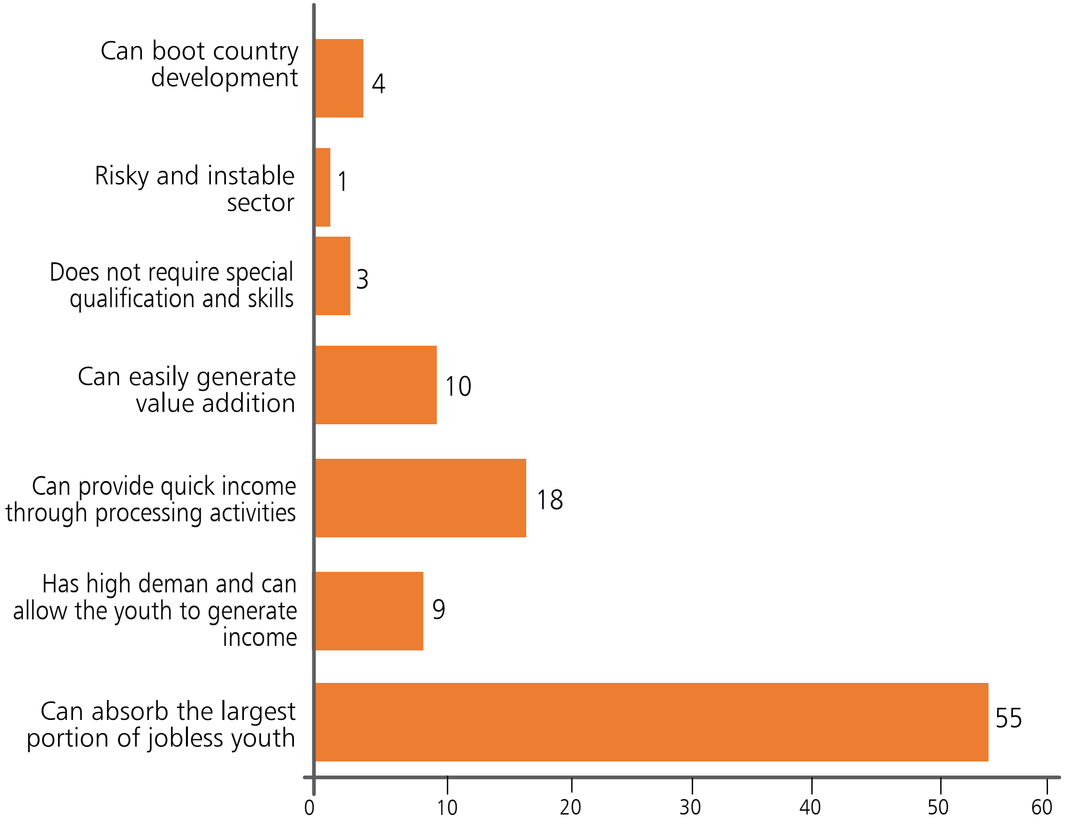
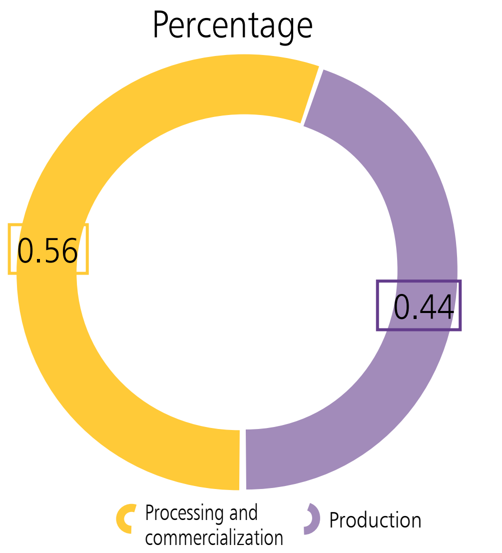


Figure 2. Youth perception towards agribusiness.



Youth engagement in different segments of the agricultural value chain

Analysis shows that youth are interested in all the segments of the value chain including production (44%) and specifically on processing and marketing (56%). Youth would engage differently in the various segments of the agricultural value chain. Majority of them (56%) preferred to engage in processing and commercialization segments for quicker and less risky income generation whereas 44% would like to engage in production.

Their engagement in agribusiness as well as in different segments is driven by their gender status. It was observed that young boys were more likely to be engaged than young girls. Their ability to easily have access to land increases their tendency to open farms and engage into agriculture. Large land sizes make farming much more economically viable for the farmers by enabling them to reap economies of scale and use better and cost-effective technologies. Land serves more than just a productive asset and is often used as a preferred collateral in the credit market. The level of the youths' experience in associations, which facilitate access to productive resources (e.g., land and finance), and to inputs and output market, experience in entrepreneurship, value of assets owned including the one owned by their family. On the contrary, asset value and number of years in off-farm entrepreneurship business discourage their engagement in the different segments of the agricultural value chain.

Despite their enthusiasm, several challenges prevent them from engaging in those agribusiness activities. Among these constraints is the very weak credit culture among youths as only 34% have ever asked for credit. However, 95% of people who asked for credit received it but the amounts received were small ($1,000 on average), at a high interest rate (6.8%) and short term for reimbursement (less than a year). However, the rate of reimbursement was high among credit beneficiaries (more than 95%), an indication that youths can pay back their loans. Other challenges identified were low level of skills in business ventures, overtaxation by government agencies, limited support from government and other development organizations, poor quality of physical and communication infrastructures as well as limited access to land.

Youth enthusiasm and engagement in agricultural value chains can be boosted by investing more in modernizing agriculture and reducing administrative and financial constraints to make it more profitable and more attractive to the youth. Efforts should be directed to enhancing youth skills in agribusiness while ensuring ease of access to land and other productive resources through youth-friendly systems with consideration to gender. Moreover, the development of effective government entrepreneurship programs aimed at supporting young people's enterprise could have a positive impact in engaging youth in agribusiness.

Youth Agripreneur making a pitch at a forum with partners during the board meeting. Photo by IITA.

Strategic initiatives

Innovative seed production technologies scaled up to boost yam production

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Norbert Maroya, YIIFSWA Project Manager, inspects yam plants in greenhouse. Photo by IITA.

While yam is an important food and income crop, one of the greatest constraints to its production is lack of high quality and clean seed especially of newly released improved varieties. There is competition between seed and food uses as the tuber can be used for both. Therefore, the aim of the second phase of the Yam Improvement for Income and Food Security in West Africa (YIIFSWA II) is to set up a robust commercial seed system to supply smallholder farmers with high-quality clean seeds of improved, released, and market-preferred yam varieties through private seed companies.

Yam plants grown in the screenhouse using aeroponics. Photo by IITA.

The initiative plans to reach approximately 320,000 smallholder farmers in six states in Nigeria (Benue, Enugu, Federal Capital Territory, Nasarawa, Niger, and Oyo) and two regions in Ghana (Brong Ahafo and Northern), the two project countries. In the process, other groups such as the certified seed yam producers and marketers will also benefit from selling the high-quality yam seed and developing seed business skills for long-term livelihood improvement. Similarly, technical and infrastructural capacities will be strengthened for the national research partners and for the private seed companies to profitably propagate enough high-quality pre-basic and basic seed yam.

Achievements

During the year 2017, three key interventions were successfully achieved toward the scaling up of high-quality seed yam propagation. technologies. These are:

Partnership with private sector on the aeroponics system

Four seed companies—Da-Allgreen Seeds Ltd., Biocrops Biotechnology Ltd., Nwabudo Agro Seeds Ltd., and PS Nutraceuticals International Ltd., were selected to establish an aeroponics system (AS) for basic seed yam production. Biocrops Biotechnology Ltd. had earlier benefited from one aeroponics system from YIIFSWA, and has agreed to build a second. All four seed companies committed to invest in AS technology and based on the development of each seed company's business plan, the updated LoA was signed.

The four seed companies had an aggregated land total of 50 hectares dedicated to producing basic seed yam annually. Business plans were developed together with each seed company that included information about the number of AS to be constructed, probable source of funding for investment, and their market strategy and development plan.

These new, high-ratio propagation technologies have generated a lot of attention mainly from new business actors such as the Federal

Ministry of Agriculture and Rural Development, the Nigerian Stock Exchange, Nigeria Agribusiness Group (NABG), and GTI Capital Limited. Concerns on the food safety aspects led to the visit of the National Agency for Food and Drug Administration and Control (NAFDAC).

A manual for clean foundation seed yam production http://yiifswa.iita.org/wp-content uploads/2017/10/Manual-for-Clean-Foundation-Seed-Yam-Final.pdf and a video on AS www.youtube.com/watch?v=lCwyPG1P9JY) was produced.

Bulking of breeder seed

The breeder seed production, initiated with a stock of 2,264 plantlets in January, was bulked to produce 36,550 breeder seeds at end-December using the Temporary Immersion Bioreactor system (TIBs). From the breeder seed produced, around 7200 TIBs plantlets were successfully hardened and partially used to plant two aeroponics systems that generated over 100,000 single-node vine seedlings transplanted in the field at a density of 40,000/ ha for basic seed yam tuber production. While the single-node vine cutting from aeroponics for basic seed yam production has the advantage of starting with virus-free planting materials, these can be reinfected with time in the field. The reinfection rate of virus-free seed yam in the fields was up to 7% of virus infection recorded between planting of the single vine in October 2016 and April 2017. The spatial variation in infection rates was typical for insect-transmitted viruses.

The average sizes of tubers harvested at 6 months are shown in Table 1. The tuber sizes vary from a minimum of 3 g (3 g to 49 g) to a maximum of 4,561 g (1002 g to 4,561 g).

The detailed procedures of breeder seed yam planting materials production using TIBs can be found at http://yiifswa.iita.org/wp-content/uploads/2018/02/Clean-Breeder-Seed-Yam-TuberONLINE.pdf -

Demonstration trials

The 80 performance demonstration trials spread across farmers' fields in six states [Benue (15), Enugu (6), FCT (10), Nasarawa (16), Niger (15), and Oyo (18)], were planted with three improved and released yam varieties (two *Dioscorea rotundata* [TDr 89/02665 and TDr 95/19177] and one *D. alata* [TDa 98/01176]). One location-specific farmers' best variety was used as a check to assess varietal performance and to quantify the superiority of the improved varieties over the locals.

At harvest, results revealed that TDa 98/01176 had the highest yield with a mean of 19.1 t/ha followed by TDr 95/19177 with 18.0 t/ha. TDr 89/02665 which had smaller seeds at planting recorded 14 t/ha while FB had the least yield with a mean 12.1 t/ha.

The maximum yield for each variety was recorded in Oyo (TDa 98/01176, 34.6 t/ha), Nasarawa (TDr 95/19177, 31.5 t/ha), Oyo (TDr 89/02665, 24.6 t/ha) and (FB, 22.7 t/ha). In areas where these improved varieties perform below the local best in terms of food quality or market preference, we promote the local best or market-preferred varieties by cleaning them against the major viruses affecting yam.

Table1. Range of sizes of tubers harvested from single-node vine 6 months after planting in the field.

TDr 95/19177 Year 2017	1000g	301g & 999g	150g & 300g	51g & 149g	50g
% of weight of tuber	22.5	55.7	13.0	6.9	1.9
Average weight per tuber (g)	1,316	548	218	95	22.0

Who earns, works more and covers the expenses?

Nicolas Patt, Centre for Rural Development, Berlin, Germany
Gundula Fischer, IITA-Tanzania

Vegetable farmer selling her produce in the field. Photo by J. Odhong, IITA.

The perception of men and women vegetable farmers in parts of Tanzania on the allocation of labor, income, and expenditure within households was found to vary in a study investigating gender dynamics in vegetable producers' households—a field that has not yet been sufficiently researched.

The study addressed the following questions:

- Who invests how much labor in the vegetable production process?
- Who gains how much income from vegetable sales?
- And finally, who covers which household expenses through the income gained?

Who spent more time on the farm?

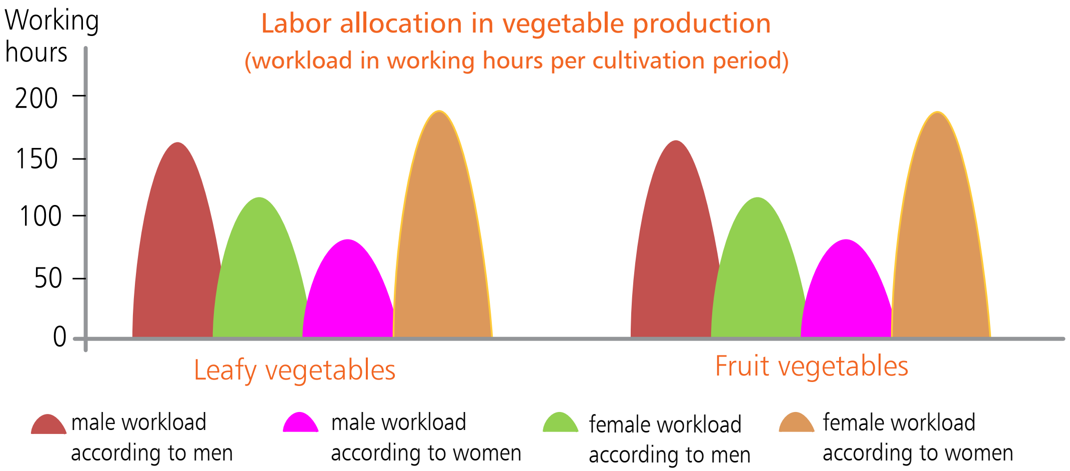
In male-headed households, both men and women perceived themselves as investing more time in farm-related ativities than their partners. This result was hugely contested during focus groups; both male and female respondents agreed that men often dedicate more time to fruit vegetable production, while women dedicate more time to leafy vegetable production (see figure). Nevertheless, women still emphasized that they perceive themselves as dedicating more time to farming than men.

However, there was a consensus on the distribution of responsibilities where both perceived men as "bread-winners" and women as being responsible for domestic chores. Consequently, both stated that domestic responsibilities prevent women from getting more involved in agricultural production, while men are free to dedicate most of their time to farm-related activities.

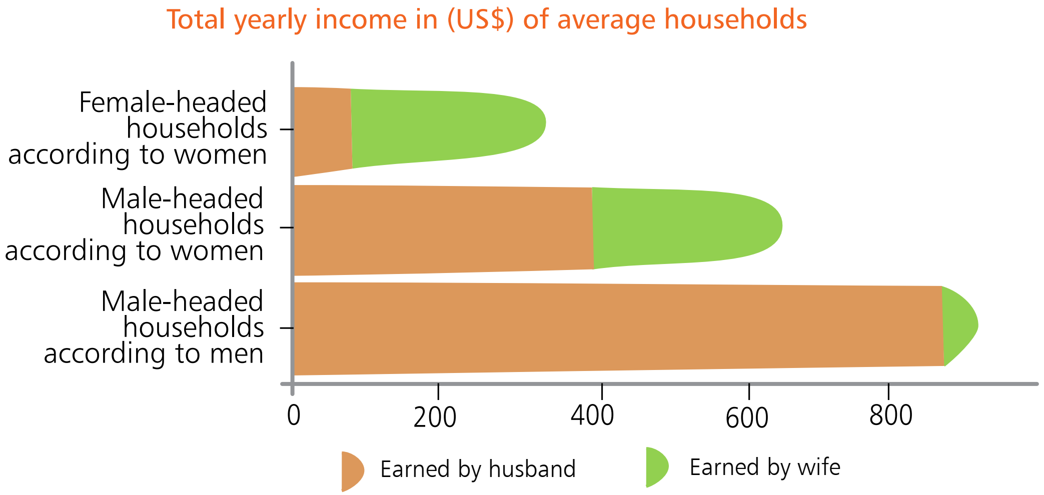
Who earns more and who contributes more to family expenses?

The difference in perceptions by men and women living in male-headed households concerning income and expenditure allocation, was again remarkable. Figure 2 shows the perceptions of men and women on the total amount of household income, as well as on how much is earned by husband and wife.

Investigating the different perceptions, focus groups revealed that both men and women keep their individual income confidential to strengthen their position in intra-household



Gender perceptions on labor allocation in the production of vegetable crops.



Gender perceptions on household economy.

negotiations on expenditure allocation. Both complained about their spouses' lack of contribution to the household economy. Patterns of cooperation and levels of trust among spouses varied considerably between households. Both male and female farmers understood low cooperation and male dominance as obstacles for development. Quantitative and qualitative data confirm that men tend to have higher incomes and dominate money-related decisions. This is astonishing since vegetable farming constitutes an upcoming business opportunity in the investigated communities and offers better access for women than other sectors (i.e., cereal crop production).

However, women still earn and control smaller amounts of money and, in most cases, remain economically dependent on their husband's contribution. Women explained that their lower income was due to men's control over access to land, financial capital, knowledge, and markets, while men perceived women as having physical limitations and poor money management skills, which restrict their opportunities to progress economically through vegetable farming.

Obstacles to achieving food security, poverty alleviation, and women empowerment

Vegetable production may constitute a beneficial livelihood strategy for women in rural Tanzania. Nevertheless, women still face numerous disadvantages compared to their male counterparts. These are mainly manifested in unequal access to key resources, such as land, financial capital, knowledge, and time, which results in unequal participation opportunities and unequal benefits from participation. The livelihood outcome of male and female farmers is essentially affected by intra-household benefit sharing. In this regard, distrust and low cooperation within the households may constitute serious obstacles for food security, poverty alleviation, and women empowerment.

Further research should investigate the correlation between participatory decision-making and household well-being. Lecoutere and Jassogne (2016) who analyzed this correlation for coffee farming households in Uganda concluded that participatory decisions on production and resource allocation have a positive effect on food and income security, as well as household well-being. Income control was more balanced between the spouses and men dedicated more time to reproductive activities. Consequently, we emphasize the necessity of including men in gender transformative interventions in agricultural research and development.

The study was conducted under the "Africa Research in Sustainable Intensification for the Next Generation" (Africa RISING) project funded by the United States Agency for International Development (USAID) and led by IITA.

The target farmers live in Babati, Kiteto, and Kongwa districts in northern and central Tanzania.

Women sell vegetables at a roadside market in Linthipe EPA Malawi. Photo by J. Odhong, IITA.

Vegetable farmers at a field day in Babati, Tanzania. Photo by I. Dominick, WorldVeg.

IITA Youth Agripreneurs in 2017: Improved approaches and widespread activities

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IYA, IITA-Ibadan

Trained Agripreneurs operating the fish smoking enterprise.
Photo by IYA.

The Youth-in-Agribusiness program has evolved, emphasizing the provision of training in agribusiness for youth, creation of jobs through the establishment of independent agribusinesses, expansion of the program to other locations in Africa, and recognition of the program through intense advocacy and impact.

Year 2017 witnessed the realization of these outcomes as many of the youth trained under the program became CEOs in the agricultural sector and created jobs for other unemployed youth.

The mechanism toward agribusiness development is through the development of detailed business plans for investment and commercial loans. Several mentors assisted in this effort, particularly EKIMIKS in Nigeria.

These plans were built upon six proven business models: seed production, cassava production and processing, fish production and processing, horticulture, advanced propagation systems, and value-added processing; but the youth were encouraged to explore other enterprise opportunities as well. This resulted in the establishment of some businesses outside the initial scope of the business plans.

Businesses launched in June 2017 are related to poultry raising, snack production, seed production, fish processing, and cowpea and yam packaging.

Frotchery Farms Limited: This business is located in Ibadan, Oyo State, Nigeria and owned by Babatunde Yusuf, Ngozi Chituru, and Hammed Oni, who were trained under the IITA Youth Agripreneurs incubation program. They specialize in the production of smoked fish using the smoking kiln technology. Developing a strong customer base, they have "grown" the product which is now available in supermarkets, restaurants, and hotels. The business has achieved a revenue of N3,707,560 (about $10,300) and processed over 4.5 tons of fresh catfish since start up while developing strategies to increase the existing market. Frotchery Farms projects that it will process 36.6 tons of fresh catfish resulting in average monthly sales of 2–4 million naira ($5555-11,500) and create direct employment for at least two additional youth in 2018.

Gracevine Foods: The business is owned and managed by Idowu Abosede, a young lady who studied Animal Breeding and Genetics at the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. Located in Ibadan, Nigeria, Gracevine adds value to agricultural produce by processing and marketing products such as clean stoneless cowpea, cowpea flour, yam flour, and plantain flour. The business has three young employees. This enterprise conducts business in Niger State and maintains another distribution office in Ibadan, Oyo State. Since existence, the business has produced 3.5 tons of its products with a generated revenue of N774,030 ($2,150) and a 23.4% profit. Furthermore, in 2018 the business is projecting a 25% increase in production totaling 12.25 tons of products and revenue of N2,400,000 ($6,667) with at least three additional distribution channels.

TopNotch Poultry: TopNotch Poultry is a small-scale, commercial feed-to-fork, broiler enterprise owned and managed by Yetunde Oginni and Ibukun Agbotoba. It aims to establish a reference-farm with feed milling, breeding, incubating/hatching, processing, and retail/food units for research, training, and demonstration in best-fit technologies and practices suitable for youth businesses. In addition to fresh broilers, TopNotch also provides smoked, grilled, and fried chicken. The business started with a loan of $14,000 and grew with a weekly processing of 500 birds, an annual revenue of $90,000, and $14,000 net profit. The demand for their product has grown and they are projecting a weekly processing of 1,000 birds, an annual revenue of $200,000, and a net profit of $40,000. A local investor invested some funds in the operation of the business.

TAC Farms: This is owned by Mustapha Quadri, a graduate of Botany from Ahmadu Bello University. TAC Farms produces improved maize and soybean grain for poultry farmers as raw material for feed formulation and oil processing industries that use soybean as a raw material. TAC Farms has 13 hectares of field in Zaria with an office located at Challenge, Ibadan, Oyo State. Since its establishment in 2017, TAC has harvested 28 tons of maize, but faced the challenge of floods, which destroyed

Bose, second from left, with her staff displaying her products.
Photo by IYA.

about 2 hectares of the field. The business has access to improved crop varieties developed by IITA.

Similar efforts are under way in Kenya where eight business plans involving 11 youth seeking $340,000 are under development.

Stakeholders at the official launching of the AgYouthlab Project.
Photo by IYA.

In DRC, eight agribusiness plans are being finalized requiring about $1.7 million in loans and a projected revenue of $7.8 million. Fish cages, poultry, and mushroom production were launched in April 2017 and additional business plan development is ongoing.

The young CEOs mentioned above were supported by IITA through the provision of start-up funds, improved planting materials, a series of entrepreneurial, business management, and leadership training, mentoring, and backstopping.

IITA's Business Incubation Platform (BIP) employed several Agripreneurs in 2011 as key account managers for IITA technologies like Aflasafe, Nodumax, and GoSeed while an additional five youth were employed as enterprise leads to run cassava, maize, plantain, vegetable, and fish businesses with the transfer of the enterprises to BIP.

Similarly, the five-year project funded by the MasterCard Foundation and awarded by Michigan State University was officially launched in 2017. The project, known as Agri-Food Youth Opportunity Laboratory (AgYouthlab), is targeted towards expanding youth employment opportunities in the agrifood systems of Nigeria and Tanzania. This program aims to train 16,250 out-of-school, disadvantaged youth within the age range of 18–24 in Nigeria and Tanzania along the value chains of cassava, poultry, oilseeds, horticulture, and aquaculture. This project provided full-time employment for six agripreneurs in Nigeria and Tanzania.

During early 2017, IYA moved to Imo State to establish an incubation center where young people in the southeastern part of Nigeria can be trained and equipped with agribusiness skills. The incubation center served as a model for gainfully employing young people in the state along the agricultural value chain. It provided an opportunity for IYA to extend its tentacles and fulfil its vision of ensuring that youth in all the geopolitical zones in Nigeria tap into the benefits available in agriculture to enhance food production. To show its support for the IYA program, the state government released some abandoned facilities—fish ponds, poultry, and greenhouse at the Imo State Polytechnic Umuagwo and at the Anambra-Imo River Basin Development Authority in Agbala to IITA for use in the incubation program. IITA deployed six experienced Agripreneurs from Ibadan and Abuja to renovate and resuscitate the facilities and display the viability of the horticulture, fish, and poultry enterprises.

The unit hosted the first-ever African Youth Agripreneurs Forum sponsored by the African Development Bank in IITA Ibadan. The conference, which was attended by over 300 young agripreneurs from all over Africa, gave them an opportunity to network and pitch their business ideas for funding.

Year 2017 also witnessed the commissioning of Africa's first Agripreneurs building at the IITA headquarters. The building is now called the A.A.A Agripreneurs building after the President of the African Development Bank, Dr Akinwumi Adesina. The building houses offices, seminar rooms, boardrooms, and other facilities. The commissioning was attended by the former Presidents of Nigeria, Chief Olusegun Obasanjo and General Yakubu Gowon.

The IKYA DRC team increased the production of cassava flour to an average of 16 tons per month. This activity is conducted in conjunction with Community-based Cassava Processing Centers (CCPC) established through other IITA projects where IKYA serves as a trainer and marketer of flour as well. Two factors limited the group's flour production: the supply of fresh cassava from outgrowers, and the rate of drying through an open-air system. To increase the supply of cassava, IKYA has linked with 14 youth groups engaged in cassava production and installed a locally made solar dryer at each CCPC. Drying will be accelerated through the purchase of a flash drier. Two large abandoned fish pond networks were discovered at Myakabere and Lwiro and are being modernized to produce catfish. To reduce costs the group produces its own feed from locally sourced ingredients. IKYA also operates a commercial bakery in Bukavu town where cassava- and protein-enriched breads are produced.

The unit also recorded progress with some of its projects. The Community Youth in Agribusiness Group (CYAG) project sponsored by Chevron Nigeria Limited engaged 147 beneficiaries in the host community with independent businesses spinning off after the first phase of the training. IYA's Building on the successes of the first phase of the training with negotiations ongoing for the flag-off of the second phase of the project.

After successfully training young adults on the business of owning and managing a fleet of smart tractors, The Hello Tractor Project sponsored by USAID in 2017 registered a cooperative society of smart tractor owners and operators to promote mechanization, improve farm efficiency, and bridge the gap between the booking and hiring services offered by the owners and operators to farmers especially in Oyo, Ondo, and the Epe axis of Lagos State.

The ENABLE Youth Program, one of the prominent projects under the unit, also commenced in Sudan and Madagascar in 2017. The ENABLE-Youth project in Sudan became fully operational with the appointment of a program coordinator and the establishment of nine incubation centers in five states. The project in Madagascar was also approved as a Project Preparation Facility (PPF). Other countries—Cameroon, DRC, Ghana, Kenya, Nigeria, and Senegal—will start soon.

For 2018, IYA has a focused vision for youth in agribusiness and sees its progress in terms of both short-term strategy and longer term targets. It is envisaged that IYA will provide leadership roles and services to Agripreneurs across Africa, developing collaborative programs that advance youth agribusiness skills, and improve both agribusiness opportunities and the creditworthiness of youth entrepreneurs. Services provided will include advocacy, fund raising, communication, and training. Agribusiness incubations will no longer be based within the IITA HQ in Ibadan. Pilot enterprises will be positioned in various locations with technical and logistical backstopping.

The AfDB ENABLE Youth Program has started slowly, but ultimately will provide loans to member countries towards developing national youth agribusiness programs in partnership with IITA. Many of the principles pioneered by the Agripreneurs will become incorporated into the curricula of universities and vocational schools. The positive examples set by young entrepreneurs will prompt commercial lenders to establish youth business programs and the public and private sectors to establish Youth Agribusiness Parks. Agribusinesses intended to provide self-employment for their founders will grow and provide decent jobs for other youth within a transforming agricultural sector.

Poultry enterprise at Imo Incubation Center.
Photo by IYA.

Training and seminars

Training

A total of 288 trainings were conducted by IITA for staff, partners, and other stakeholders. Table 1 shows the training activities and distributions.

Zoumana Bamba
IITA-Ibadan

Table 1a. Training distribution by research countries and gender.

S/N	Research Country	No. of Trainings Organized	No. of Male	No. of Female	Total
1	Benin	2	35	8	43
2	Burkina Faso	12	1450	708	2518
3	Burundi	3	23	6	29
4	Cameroon	4	182	246	428
5	Côte d'Ivoire	1	23	7	30
6	DR Congo	6	109	50	159
7	France	1	2	9	11
9	Ghana	17	10,384	9872	20,256
11	Kenya	4	74	23	97
12	Liberia	23	281	446	727
13	Malawi	18	1005	765	1770
14	Mali	2	37	8	45
15	Mozambique	3	54	18	72
16	Netherlands	1	13	7	20
17	Nigeria	118	4346	1501	5847
18	Rwanda	2	6	4	10
20	Tanzania	31	1193	865	2058
21	Thailand	1	8	3	11
22	Uganda	29	1412	698	2110
23	Zambia	7	78	50	128
	Total	285	20,715	15,294	36,369

Summary of Staff Development

S/N	Title	Location	Male	Female	Resource Person
1	Statistical Computing and Graphic Design in R environment	Bukavu, DR Congo	15	0	Dries Roobroeck, Pieter Pypers
2	Microsoft Excel Course for Data Management, Analysis and Presentation	Ibadan, Nigeria	15	14	Gerald Umeze, Solomon Ogunade
3	Leading and Managing people for results	Ibadan Nigeria	14	13	Mendoza Lilian, Lucy Omidiran, Lade Oke
4	Customer Services Seminar	Ibadan Nigeria	88	20	Andrew Middleton
5	Microsoft PowerPoint Advanced Training Course	Ibadan Nigeria	5	3	Gerald Umeze
6	Project Risk Management Workshop	Ibadan Nigeria	19	5	Martin Carter
7	Enhancing research through mechanization	Ibadan Nigeria	19	3	Peter Kolawole, Friday Ekeleme, Engr. Diallo, Eneh Uchenna
8	Effective driving skills and techniques	Kano Nigeria	23	0	David Oluwadare, Adedayo James, Onibiyo Gbenga, Mahuta John, Lawrence Betros
9	Effective driving skills and techniques	Abuja Nigeria	30	1	David Oluwadare, Adedayo James, Onibiyo Gbenga, Abubakar S. D, Okpeji Ese
10	Effective driving skills and techniques for IITA drivers	Ibadan Nigeria	47	0	Olugbemiga Onibiyo, David Oluwadare, James Adedayo
11	Statistical Computing and Graphic Design in R environment	Dar es Salam Tanzania	11	4	Dr. Pypers Pieter, Dries Roobroeck
12	Leading and managing people for results	Dar es salam, Tanzania	11	12	Temilade Oke
13	Statistical analysis using R	Ibadan Nigeria	29	6	Adebanji Temitayo Olagunju, Alabi Olumide Alaba, Yusuf Muideen
14	Business communication skills	Ibadan Nigeria	9	7	Zillion Impact Solutions
	External Trainings				
1	Hands-on Basic Molecular Biology Techniques	Ibadan Nigeria	9	2	Melaku Gedil, Ranjana
2	Statistics and Statistical Computing Methods Using SAS	Ibadan Nigeria	10	3	Sam Ofodile, Samuel Korie
3	Basic Bioinformatics	Ibadan Nigeria	6	1	Andreas Gisel
4	Cassava Production and Processing	Ibadan Nigeria	39	35	Okechukwu Richardson
5	Seed Banking	Ibadan Nigeria	6	0	Michael Abberton
	Total		405	129	

Summary of Staff Development

A total of 18 awards were given as shown bellow.

Units	No.	Hubs	No.	Type	No.	Sex	No.
FMS/Engineering	1	Western Africa	12	Individual	21	Male	15
HR/Admin	6	Central Africa	5	Group	3	Female	6
DMU/ICT	3	Eastern Africa	4			Group	3
Medical	1	Southern Africa	2				
Science/Research (R4D)	10	IITA UK	1				
Supply Chain/Procurement	2						
Gender	1						
Total	**24**		**24**		**24**		**24**

Internship

A total number of 501 interns were recruited: 96 graduate interns (47 male & 49 female) at 6 IITA locations (Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia), 314 IT/SIWES (145 male & 169 female) from 73 higher institutions across Nigeria, 2 batches of NYSC with a total number of 91 (31 male & 60 female). IT/SIWES and NYSC are interns applicable in Nigeria only.

Tables 1&2 Figures 1&2 show the distribution of graduate interns across IITA locations and IT/SIWES interns.

Table 1. Graduate Interns

Country	Male (no.)	Female (no.)	Total (no.)
Ghana	2	0	**2**
Kenya	2	1	**3**
Malawi	2	4	**6**
Nigeria	39	43	**82**
Tanzania	1	0	**1**
Zambia	1	1	**2**
Total	**47**	**49**	**96**

Table 2. IT/SIWES Interns

Category	Male (no.)	Female (no.)	Total (no.)
IT/SIWES	145	169	**314**
NYSC	31	60	**91**
Total	**176**	**229**	**405**

Other categories of trainees 2015–2017

Categories	2017		
	Male	Female	Total
Short-Term (Individual)	2	0	**26**
Visiting Scientist	3	5	**26**
Sabbatical	0	1	**1**
Use of Facilities	5	5	**40**
Total	**10**	**11**	**93**

Description of Capacity Development Database

The capacity Development Database was initiated to serve the broad spectrum of all CDO activities. The database received a boost within 2017.

The functional features within this period include: i) Uploading of training reports for scientists for their annual appraisal, ii) Documentation of graduate research students and monitoring of their progress reports, iii) Documentation of general staff training and development activities, iv) Online application for Talent grant and approval processes, v) Online submission of individual training reports, vi) Online registration and approvals for staff trainings and development activities. Other work done so far but not released for public access include online application for the following; i) graduate research students, ii) internship application, iii) Application for sabbatical/visiting scientists, iv) request for use of IITA facilities, v) request for external trainings for both groups and individuals.

Guidelines

Guidelines and standard operating procedures have been developed in the year under review. These include: i) Staff training and development policy and guidelines, ii) Internship procedure and guidelines, iii) Internship evaluation and feedback for interns, iv) Training needs assessment forms for individuals and Units, v) Development of the draft of the coaching and mentoring scheme.

E-learning system

CDO is developing the IITA e-learning system that will enable the institute to conduct training online using both text functions and an integrated virtual classroom system. Scientists and other staff can conduct trainings for their Units, the Institute, and public online using different time scheduling tools and cover as many locations as possible. There is also room for flexibility for self-paced learning. The e-learning is up to 60% completion and will be completed by the end of 2018.

Training Grants

CDO sourced and received training grants for capacity development in 2017. CDO also received a grant from IDRC for training 20 Postgraduate students (12 MSc and 8 PhD). Four training courses were also organized for them in Pedagogy, Data management, Research methodology, and Report writing. Another grant was secured in 2017 from IFAD for training 20 Postgraduate research students and is currently running.

Publications

Publications

In 2017 IITA scientists published 211 articles in peer-reviewed Thomson-indexed journals. Selected articles and manuals from the different hubs are presented here by research theme.

Articles

Natural resource management

Sosef, M.S., Dauby, G., Blach-Overgaard, A., van der Burgt, X., Catarino, L., Damen, T., Deblauwe, V., Dessein, S., Dransfield, J., Droissart, V., Duarte, M. C., Engledow, H., Fadeur, G., Figueira, R., Gereau, R. E., Hardy, O. J., Harris, D. J., de Heij, J., Janssens, S., Klomberg, Y., Ley, A. C., Mackinder, B. A., Meerts, P., van de Poel, J. L., Sonke, B., Stevart, T., Stoffelen, P., Svenning, J. C., Sepulchre, P., Zaiss, R., Wieringa, J. J. & Couvreur, L. 2017. Exploring the floristic diversity of tropical Africa. IN BMC Biology, 15:15.

Guilpart, N., Grassini, P., van Wart, J., Yang, H., van Ittersum, M. K., van Bussel, L. G., Wolf, J., Claessens, L., Leenaars, J. G. B. & Cassman, K. G. 2017. Rooting for food security in sub-Saharan Africa. IN Environmental Research Letters, 12(11):114036.

Hutton, M. O., Leach, A., Leip, A., Galloway, J. N., Bekunda, M., Sullivan, C. & Lesschen, J. P. 2017. Toward a nitrogen footprint calculator for Tanzania. IN Environmental Research Letters, 12(3):034016.

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Kihara, J., Sileshi, G. W., Nziguheba, G., Kinyua, M., Zingore, S. & Sommer, R. 2017. Application of secondary nutrients and micronutrients increases crop yields in sub-Saharan Africa. IN Agronomy for Sustainable Development, 37: 25.

Biotechnology & Plant breeding

Hickey, J. M., Chiurugwi, T., Mackay, I., Powell, W., Eggen, A., Kilian, A., Jones, C., Canales, C., Grattapaglia, D., Bassi, F., Atlin, G., Gorjanc, G., Dawson, I., Rabbi, I. Y., Ribaut, J., Rutkoski, J., Benzie, J., Lightner, J., Mwacharo, J., Parmentier, J., Robbins, K., Skot, L., Wolfe, M., Rouard, M., Clark, M., Amer, P., Gardiner, P., Hendre, P., Mrode, R., Sivasankar, S., Rasmussen, S., Groh, S., Jackson, V., Thomas, W. & Beyene, Y. 2017. Genomic prediction unifies animal and plant breeding programs to form platforms for biological discovery. IN Nature Genetics, 49. 1297-1303.

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Jamil, M., Kountche, B. A., Haider, I., Guo, X., Ntui, V. O., Jia, K. P., Ali, S., Hameed, U. S., Nakamura, H., Lyu, Y., Jiang, K., Hirabayashi, K., Tanokura, M., Arold, S. T., Asami, T. & Al-Babili, S. 2017. Methyl phenlactonoates are efficient strigolactone analogs with simple structure. IN Journal of Experimental Botany, 438.

Abdulmalik, R. O., Menkir, A., Meseka, S. K., Unachukwu, N., Ado, S. G., Olarewaju, J. D., Aba, D. A., Hearne, S., Crossa, J. & Gedil, M. 2017. Genetic gains in grain yield of a maize population improved through marker assisted recurrent selection under stress and non-stress conditions in West Africa. IN Frontiers in Plant Science, 8: 841.

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Muiruri, K. S., Britt, A. B., Amugune, N. O., Nguu, E., Chan, S. & Tripathi, L. 2017. Expressed Centromere Specific Histone 3 (CENH3) variants in cultivated triploid and wild diploid bananas (Musa spp.). IN Frontiers in Plant Science, 8: 1034.

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Samireddypalle, A., Boukar, O., Grings, E., Fatokun, C., Kodukula, P., Devulapalli, R., Okike, I. & Blummel, M. 2017. Cowpea and groundnut haulms fodder trading and its lessons for multidimensional cowpea improvement for mixed crop livestock systems in West Africa. IN Frontiers in Plant Science, 8: 30.

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Manda, J., Alene, A., Mukuma, C. & Chikoye, D. 2017. Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia. IN Agriculture, Ecosystems and Environment, 249. 22-30.

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Ramcharan, A., Baranowski, K., McCloskey, P., Ahmed, B., Legg, J. & Hughes, D. P. 2017. Deep learning for image-based cassava disease detection. IN Frontiers in Plant Science, 8: 1852.

Pidon, H., Ghesquiere, A., Cheron, S., Issaka, S., Hebrard, E., Sabot, F., Kolade, O., Silue, D.

& Albar, L. 2017. Fine mapping of RYMV3: a new resistance gene to Rice yellow mottle virus from Oryza glaberrima. IN Theoretical and Applied Genetics, 130(4). 807-818.

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Nutrition and Human health

Mutungi, C., Irungi, F. G., Nduko, J., Mutua, F., Affognon, H., Nakimbugwe, D., Ekesi, S. & Fiaboe, K. K. 2017. Postharvest processes of edible insects in Africa: a review of processing methods, and the implications for nutrition, safety and new products development. IN *Critical Reviews in Food Science and Nutrition*, 1-23.

Abass, A., Awoyale, W., Sulyok, M. & Alamu, E. O. 2017. Occurrence of regulated mycotoxins and other microbial metabolites in dried cassava products from Nigeria. IN *Toxins*, 9:207.

Riveron, J., Ibrahim, S. S., Mulamba, C., Djouaka, R., Irving, H., Wondji, M. J., Ishak, I. H. & Wondji, C. S. 2017. Genome-wide transcription and functional analyses reveal heterogeneous molecular mechanisms driving pyrethroids resistance in the major malaria vector Anopheles funestus across Africa. IN *G3-Genes Genomes Genetics*, 7(6). 1819-1832.

Manuals

Biotechnology and Plant breeding

Girma, G., Rabbi, I., Olanrewaju, A., Alaba, O.A., Kulakow, P., Alabi, T., Ayedun, B., Abdoulaye, T., Assfaw Wossen, T., Alene, A. & Manyong, V. 2017. A manual for large-scale sample collection, preservation, tracking, DNA extraction, and variety identification analysis. Ibadan, Nigeria: IITA. 44p. ISBN: 978-978-8444-83-1.

Plant production and Plant health

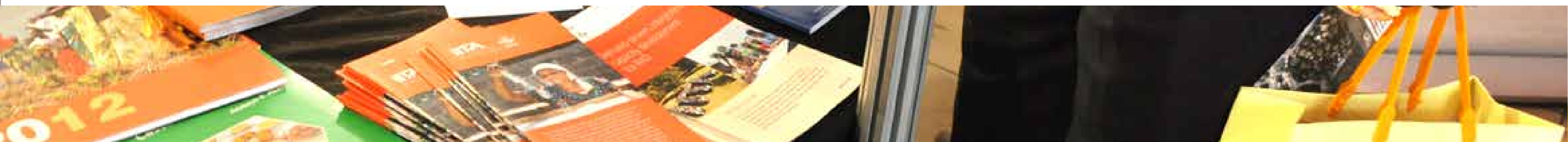
Atser, G., Dixon, A., Ekeleme, F., Chikoye, D., Dashiell, K., Ayankanmi, T., Hauser, S., Agada, M., Okwusi, M., Sokoya, G., Olorunmaiye, P., Olojede, A., Usman, H., Kulakow, P., Osunde, T., Adekoya, E. & Adekoya, E. 2017. The ABC of weed management in cassava production in Nigeria: a training manual. Ibadan, Nigeria: IITA. 30p. ISBN: 978-978-8444-87-9.

Makumbi, D., Craufurd, P.Q. & Kanampiu, F. 2017. Herbicide resistant maize seed production and handling. Nairobi, Kenya: CIMMYT. 20p.

Maroya, N., Balogun, M., Aighewi, B., Lasisi, J. & Asiedu, R. 2017. Manual for clean foundation seed yam production using aeroponics system. Ibadan, Nigeria: IITA. 68p. ISBN: 978-978-8444-88-6.

Viljoen, A., Mahuku, G., Massawe, C., Ssali, R. T., Kimunye, J., Mostert, G., Ndayihanzamaso, P. & Coyne, D.L. 2017. Banana diseases and pests: field guide for diagnostics and data collection. Ibadan, Nigeria: IITA. 73p. 978-978-8444-80-0.

Visitors looking at IITa publications in an exhibition. Photo by IITA.



Our Finances and supporters

Funding overview

Sholola Omoshalewa
IITA-Ibadan

Women entrepreneurs in a market. Photo by IITA.

Funding for 2017 was $98.713 million, of which 99.98% came from CRP and Non-CRP funding windows and 0.02% from other sources. Expenditures were $98.049 million (net of indirect costs recovery of $10.877 million) of which 88.9% was used for program expenses and 11.1% for management and general expenses.

The governments and agencies that provided the largest share of our funding in 2016 and 2017 are shown in Figure 1 (top 10 donors).

IITA`s 2017 total budget-cum-total expenditure are respectively depicted in Figures 2 and 3.

Table 1 shows investment by CRP and Non-CRP funding windows. Table 2 gives an indication of the financial health of IITA, while Table 3 lists the various investors.

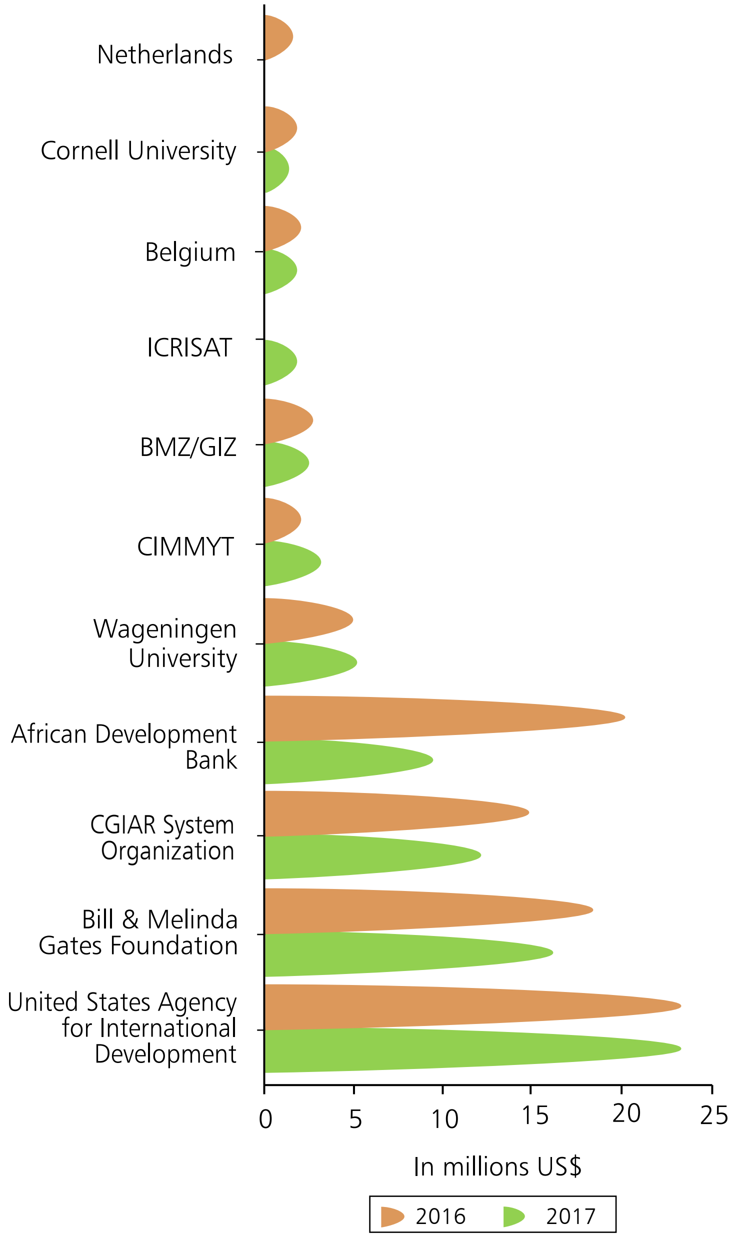


Figure 1. Funding: top 10 donors, 2016 and 2017.

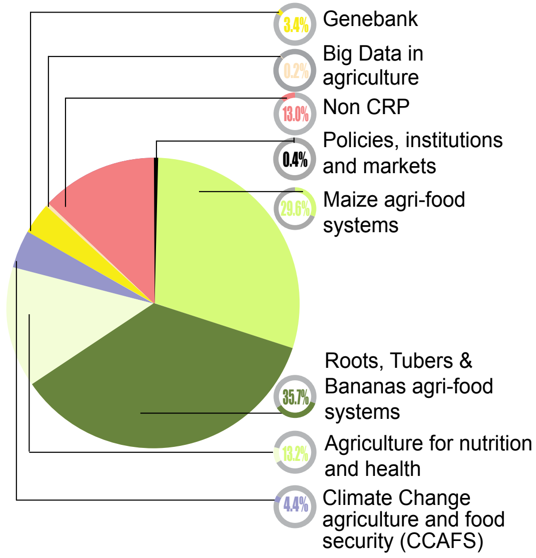


Figure 2. 2017 Investment by CRP and Non-CRP Funding Windows - Budget.

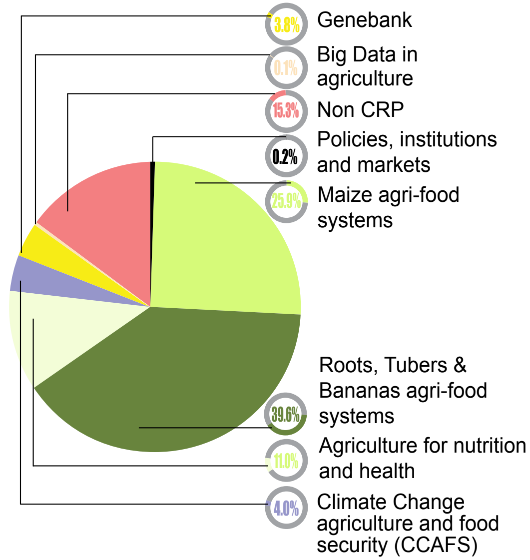


Figure 3. 2017 Investment by CRP and Non-CRP Funding Windows - Expenditure.

Table 1. 2017 Investment by CRP and Non-CRP Funding Windows.

CRP / Non-CRP	Budget ($`000) W1/W2	Budget ($`000) Window 3 / Bilateral Project	Budget ($`000) Total	Actual Expenses ($`000) W1/W2	Actual Expenses ($`000) Window 3 / Bilateral Project	Actual Expenses ($`000) Total
Policies, institutions and markets	125	288	413	125	72	197
Maize agri-food systems	2,089	30,440	32,529	2,089	23,309	25,398
Roots, tubers and bananas agri-food systems	5,189	34,125	39,314	4,917	33,940	38,857
Agriculture for nutrition and health	1,607	12,900	14,507	1,607	9,214	10,821
Climate change, agriculture and food security (CCAFS)	483	4,357	4,840	454	3,433	3,887
Genebank	2,793	989	3,782	2,781	970	3,751
Big Data in agriculture	245	–	245	113	–	113
CRP / Platform	**12,531**	**83,099**	**95,630**	**12,086**	**70,938**	**83,024**
Non-CRP	**–**	**14,350**	**14,350**	**–**	**15,025**	**15,025**
	12,531	**97,449**	**109,980**	**12,086**	**85,963**	**98,049**

Table 2. Performance indicators: Financial health.

	2017	2016
Short-term Solvency (or Liquidity)	33 days	30 days
Long-term Financial Stability (adequacy of Reserves)	33 days	30 days
Indirect Cost Rates	17.55%	11.90%
Cash Management on Restricted Operations	1.11	0.95
Audit Opinion	Unqualified / Clean Bill of Financial Health	

Table 3. List of IITA investors.

Investors	2017	2016
	(expressed in US$ thousands)	
African Development Bank	9,571	20,204
AGRA	285	587
Austria	574	205
Belgium	1,746	1,877
Bill & Melinda Gates Foundation	16,314	18,466
BMZ/GIZ	2,494	2,856
Burundi	274	–
Canada	643	–
CGIAR System Organization	12,086	14,901
Chemonics	144	–
Chevron Nigeria Limited	205	99
Commission of the European Communities	56	31
CORAF/WECARD	252	747
Cornell University	1,480	1,571
Delloite Consulting LLP	792	1,082
Democratic Republic of Congo	537	1,269
Development Aid from People to Peolple in Zambia	128	121
Donald Danforth Plant Science Centre	286	276
Food and Agriculture Organization	35	435
Food for the Hungry International	97	–
France	330	330
Friedrich-Alexander-University Erlangen-Nuremberg	323	263
Ghana	409	142
Global Crop Diversity Trust	778	365
International Crop Research Institute for the Semid-Arid Tropics	1,817	1,486
International Centre for Tropical Agriculture	1,330	1,724
International Food Policy Research Institute	777	726
International Fund for Agricultural Development	928	1,483
International Livestock Research Institute	800	641
International Maize and Wheat Improvement Centre	3,147	1,985
International Potato Centre	1,012	835
Ireland	143	–
Japan	745	505
Leventis Foundation	72	40
Liberia	1,164	445
Meridian Institute	45	–
Michigan State University	164	–
National Agricultural Research Organization	508	–
National Resource Institute	113	38
Netherlands	1,200	1,572
Nigeria	901	789
OCP S.A., Morocco	122	487
Programme Integre de Rehabilitation de l'agriculture dans la Province du Maniema	110	–
Purdue University	364	343
Queens University Belfast	278	–
Queensland University of Technology	591	272
Sweden	27	45
Swiss Agency for Development Cooperation	–	720
Tanzania	537	217
United States Agency for International Development	23,487	23,496
University of California	73	124
University of Illinois	251	241
University of Lausanne	203	138
Wageningen University	5,109	4,988
World Bank	777	–
Miscellaneous Projects	1,763	3,012
Grand Total	98,697	112,179

Caption here IITA.

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Headquarters and hubs

The new IITA-Bukavu Research Station in DRC Congo. Photo by IITA.

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