IITA
Research to Nourish Africa

CGIAR

annual report

2013

annual report 2013

IITA
Carolyn House, 26 Dingwall Road
Croydon, CR9 3EE, UK
www.iita.org

ISSN 0331 4340

Cover photo: Research scientist Charity Mutegi, the "daughter of Africa", is welcomed by fellow Africans during the World Food Day celebration and awarding in Des Moines, Iowa. Photo by K. Lopez, IITA

Contents

Message from the **Director General**

Dr Nteranya Sanginga
Director General

The year 2013 was another vibrant and fulfilling year for IITA. We continued to work towards meeting our objectives and commitments, overcoming many challenges along the way, and making gains in exciting new areas. We completed efforts to reposition IITA for the many ambitious tasks ahead, and made sure that our vision of success is aligned with that of the reformed CGIAR through mapping with the CGIAR Research Programs.

We continued to strengthen our research and our R4D partnerships through the decentralization of the hubs and integration of the CGIAR Research Programs and bilateral research initiatives. Our regional hubs have been transformed into strong, strategic, and independent R4D entities that are very responsive to the needs of the regions.

During the year, several new efforts were started: an E-Research task force was established to develop the backbone of IITA's research data management and knowledge delivery platform; and a monitoring and evaluation culture has been introduced as part of the R4D process.

In 2013 we gave priority to special initiatives, such as the West Africa Regional Genomics and Biotechnology Platform, the Pan African Platform for Soil Research, the Youth Agribusiness Development Initiative, a center linking climate changes to plant health, a business model for public-private partnerships, and the Business Incubation Platform (BIP). In support of the Agricultural Transformation Agenda and the Youth Employment Agricultural Program in Nigeria, IITA has started demonstrating how to achieve the objective of increased youth employment by creating the IITA Youth Agripreneurs (IYA) and satellite organizations in the hubs.

We have also established AgriServe which supports IITA's strategic objectives by providing advisory services and technical backstopping for planning, development, and implementation of start-up agribusiness opportunities, and linking these services to innovative investment.

The good news is that Humidtropics, the CGIAR Research Program that IITA leads, received very positive feedback from the Consortium on the program of work and budget. Humidtropics serves as the focal point for integrating IITA's research-for-development efforts.

On the R4D side, we continued to develop and promote improved and nutritious crop varieties of Africa's major staples and innovative practices on natural resource management for farmers, innovations on integrated farming systems and sustainable intensification of agriculture, commodity value chains for regional markets, and cost-efficient, natural solutions to pest and disease problems in the farms.

Our strong efforts at establishing new partnerships and reviving old ones have resulted in proactive and more strategic relationships and networks of partners from both the public and private sectors.

IITA is doing the best science and using results-based management for managing agricultural research interventions and to make sure that we have measurable impact. We have focused on ensuring more effective resource management of people, programs, money, facilities, and partners. We have given more attention to capacity building for national partners, and as a result, IITA's track record as a training provider of choice for agricultural research in the region is being revived. We have also emphasized working with the private sector and other nontraditional partners, which has allowed us to generate greater resources for research.

Resource mobilization efforts were intensified in 2013 and resulted in many new engagements with the private sector and governments in the sub-Saharan Africa region, and a 22% increase in funding from 2012 to 2013, and the number of international staff from 127 to 163.

Overall, IITA is on track with its refreshed strategy. The year 2013 was indeed IITA's year in many ways.

I thank the staff for their commitment to ensuring that IITA meets its goals. I am grateful to all our partners and our donors that have continued to support our efforts to become the leading partner in Africa that facilitates solutions to the challenges of hunger, malnutrition, poverty, and environmental degradation.

Message from the **Board Chair**

In 2013, IITA continued its rapid growth in research capacity. The Institute attracted many new projects and partners, increasing its research funding by more than 20% from 2012. To accommodate substantially increased numbers of both international and national staff, the Institute completed or initiated several major infrastructure development projects. The state-of-the-art science building in Dar es Salaam had its official opening in May 2013. A ground breaking ceremony was held in September for a new science building for the Southern African Hub in Lusaka to be completed in 2015. The science building in the Central African Hub in Bukavu, DR Congo, is being fully refurbished to be officially opened in June 2014. Infrastructure improvements on the IITA campus in Ibadan are also under way.

Considerable progress was made in the development of the Business Incubation Platform (BIP) on the Ibadan campus. The goal of the BIP is to facilitate the scale-up of technologies developed from IITA's research programs and advance public-private partnerships to deliver these technologies to African farmers. The aflasafe™ production facility is now operational, while the rhizobium inoculant pilot plant and the seed processing unit will be completed in 2014.

IITA's research programs are fully aligned with the CGIAR Research Programs. This was the first full year of operation of the CGIAR Research Program on the Integrated Systems for the Humid Tropics, led by IITA. Dr Kwesi Atta-Krah was hired to lead Humidtropics and an independent advisory committee for the program was established. IITA is a partner in eight other CGIAR Research Programs.

Four members of the IITA scientific staff received international awards in 2013. The Board of Trustees congratulates Drs Georg Goergen, Charity Mutegi, Tahirou Abdoulaye, and Piet Van Asten for their achievements. These awards indicate the excellence of IITA's scientists and the relevance of their research.

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. The refreshed strategy of the Institute established a goal of lifting 11 million people out of poverty and revitalizing 7.5 million hectares of degraded land by 2020. This is an ambitious target; however, the significant increase in research capacity and the quality and relevance of the Institute's programs will facilitate its achievement.

The Board of Trustees expresses its appreciation to DG Nteranya Sanginga and his senior management team for continuing to move the Institute forward, and for establishing the foundation for an even brighter 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

Mission and **Vision**

Farm families in the tropics are the intended beneficiaries of IITA's R4D efforts. Photo by IITA

Our Mission

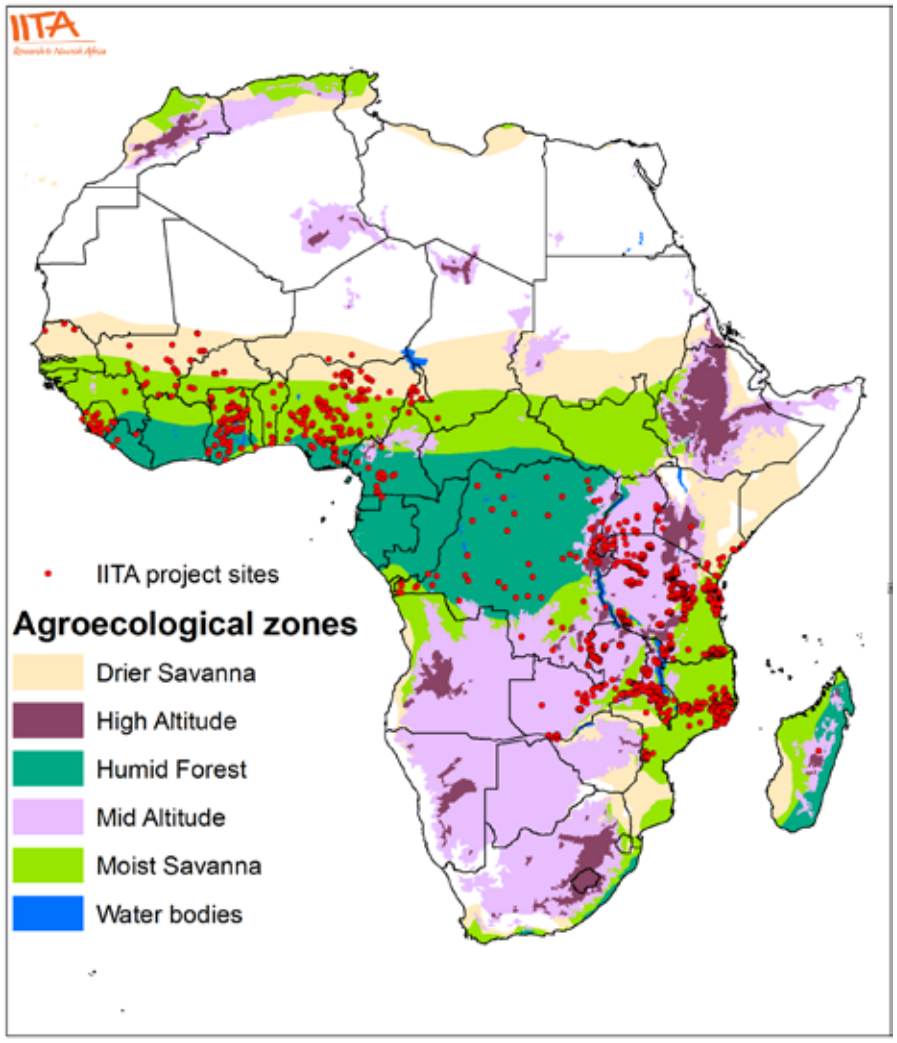
To offer a leading research partnership that facilitates agricultural solutions for hunger, poverty, and natural resource degradation throughout the tropics.

Our Vision

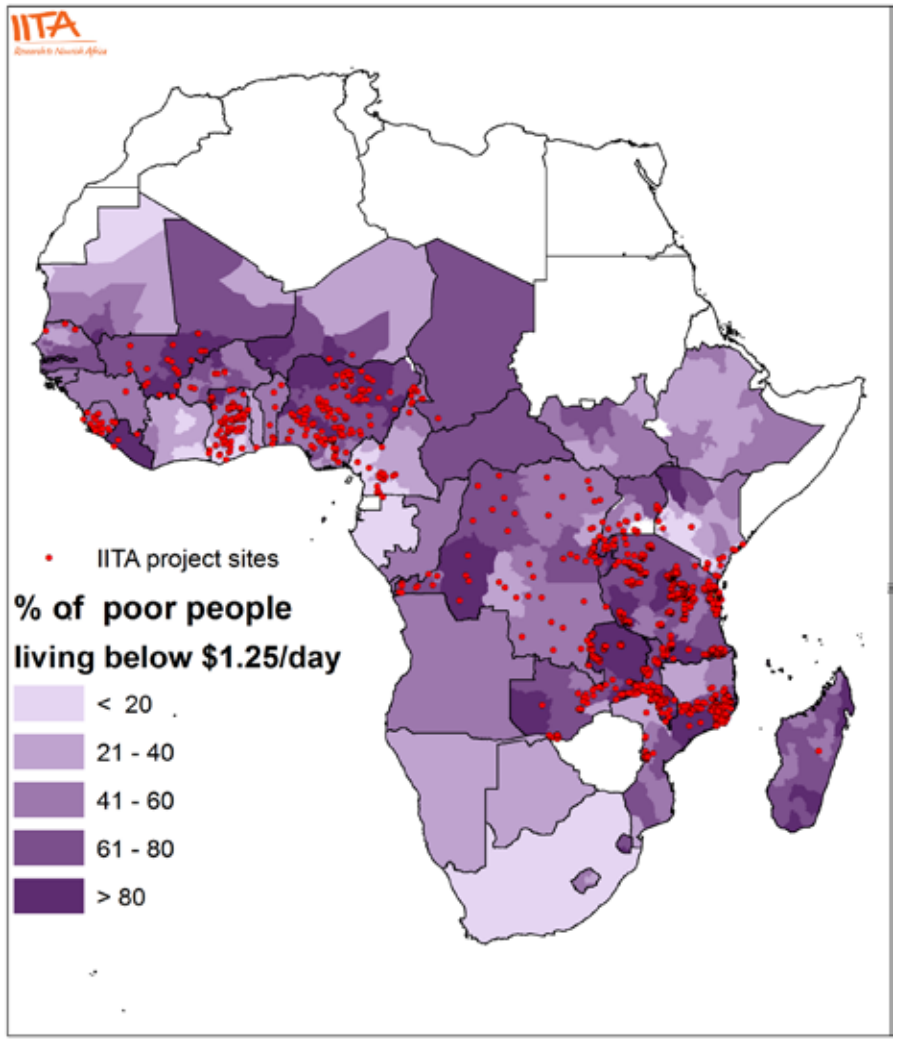
IITA's revised mission is in line with that of CGIAR and focuses on the four system level outcomes (SLO) described in CGIAR's Strategic Results Framework (SRF), namely, (1) increase in food security, (2) reduction of rural poverty, (3) reduction of undernutrition, and (4) more sustainable management of natural resources.

IITA will advance these SLOs by increasing the yields of major staple food crops, such as cassava, yam, maize, banana/plantain, soybean, and cowpea, by 60%; increasing average farm income by 50%; lifting 15% of poor households—over 11 million Africans—above the poverty line; reducing the number of malnourished children by 30%; and restoring and revitalizing 40% of degrading farmlands to sustainable resource management—equivalent to about 7.5 million hectares.

IITA will operate through decentralized but integrated regional research programs working on major agricultural constraints in Africa, specifically on crops, farming systems, and their natural resource base, and the CGIAR Research Programs that will also foster innovative partnerships and the outscaling of technologies developed in sub-Saharan Africa to the global tropics.



Agroecological zones across sub-Saharan Africa covered by IITA.



Percentage of people living below $1.25/day across sub-Saharan Africa.

Photo by IITA

IITA's R4D Strategy

IITA's R4D Strategy

In its strategy, refreshed in 2012, IITA aligned its mission to focus on the four system level outcomes of CGIAR, namely, reduction in rural poverty, increase in food security, improvement of nutrition and health, and sustainable management of natural resources in its impact zones in West-, Central-, East-, and Southern Africa. The coverage of four agroecological zones across sub-Saharan Africa—the Sahelian drylands (123 million ha), the humid forest zone (576 million ha), the mid-altitude savanna and forests (25 million ha), and the moist savanna and woodland zone (436 million ha) — has led to the development of a diverse range of research programs answering the needs of each specific zone.

Over the next several years, we will achieve our outcomes within these impact zones by increasing major staple food yields (cassava, yam, maize, banana/plantain, soybean, and cowpea) by 60%, raising average farm income by 50%, lifting 15% of the poor households above the poverty line, reducing malnourishment of children by 30%, and restoring 40% of degraded farms to sustainable resource management.

Consequently in 2013, IITA continued to operate through the decentralization of its programs by strengthening the regional hubs through well-integrated research approaches based on the different regional key farming systems. The IITA research programs are currently expanding to promote the gains for cassava in lowland areas in West and Central Africa and root and tuber cropping systems in East and Southern Africa. We also aim to enhance and diversify maize-legume farming systems and promote cereal, cowpea, and livestock integration in the dry savannas of West Africa, intensify banana- and cassava-based systems in the mid-altitudes of East and Central Africa, diversify the maize-based food

IITA works with farmers to introduce interventions that help make agriculture more productive in the different agroecological zones. Photo by IITA

Paul Ilona of HarvestPlus planting cassava with farmers in DR Congo. Photo by IITA

systems in Southern Africa, and develop high-value crops and crop-based value chains suited to the different market conditions in our impact zones.

In 2013, IITA also continued to expand and grow its research sites and operational facilities by decentralizing administrative services to the Regional Hubs. IITA operates from Ibadan (headquarters) that serves the Western Africa hub, Dar es Salaam for East Africa, and Lusaka for Southern Africa. Activities in Central Africa are administered jointly by the hubs in Nairobi and Kinshasa. The regional offices represent important strategic locations that help IITA engage in local and regional contexts, establish partnerships and mobilize resources, implement R4D programs, and manage and share risks as well as new knowledge.

In 2013 as well, IITA focused on developing a monitoring and evaluation (M&E) culture. CGIAR has adopted results-based management (RBM) as the approach for managing agricultural research interventions. To effectively demonstrate the achievement of our results and the use of evidence-based decision making as a management approach we are setting up a functional and gender-responsive M&E system. IITA is progressing well in its efforts to demonstrate its contribution to economic growth, poverty reduction, food security, and nutrition safety.

IITA continued to foster innovative partnerships and play catalytic roles in linking with advanced research institutes, national, regional, and international entities, the private scetor, policymakers, and farmers' organizations. Photo shows the President of the United Republic of Tanzania, His Excellency, Dr Mrisho Jakaya Kikwete, cutting the ribbon during the inauguration of the new science building in IITA, Dar es Salaam, Tanzania, May 2013. Photo by IITA

Photo by IITA

The IITA CGIAR Research Program **Portfolio**

Sub-Saharan Africa's population growth remains high compared to other regions of the world: 2.4% against 1.4% in non-African countries. Poverty, malnutrition, and hunger continue to plague the continent despite renewed and intensified efforts to overcome low productivity and food insecurity because production per unit area has not increased. Even modest gains in food production have come at the expense of the natural resource base.

Sustainable intensification of agriculture offers the potential to address several pressing development objectives by unlocking the potential of agriculture, adapting production systems to climate change, sustainably managing land and water resources, and reducing rural poverty. It provides opportunities to better conserve and recycle soil nutrients and reduce the need for clearing new lands for agricultural production.

IITA will continue to provide science-driven improvements in agriculture to overcome these development challenges through its R4D and innovation platforms. Its impact on farm and rural communities within the tropical zones, especially Africa, can be achieved with the active engagement in the CGIAR Research Programs, which are the main organizational structure of CGIAR research.

Of the 15 CGIAR Research Programs, IITA hosts and leads one, Humidtropics, and participates in eight others. Briefs on IITA's contributions during 2013 are provided in this section.

Golden harvest. Photo by IITA

Humidtropics is all about people

"When I first came to IITA about 30 years ago, I was part of the team developing the early farming systems concept and that was when much work was done in the villages outside IITA. This development-oriented on-farm research was a context in which we were doing our work in the fields because we found it necessary to have a direct link between the farmers and us, between development and research." Kwesi Atta-Krah rejoined IITA as director for the CGIAR Research Program, 'Integrated Agricultural Systems for the Humid Tropics' (Humidtropics) in late 2012.

A former deputy director general of Bioversity International, he is responsible for providing overall management and leadership for Humidtropics.

"Humidtropics is all about people. It is about seeing how farming communities lead their lives and understanding what they see as priorities, and building our research on that type of perspective with an eye on development outcomes. It is about integrated systems—looking at the entire system where the farmers operate, including both on-farm and off-farm components, the issue of gender, results-based management and knowledge sharing. It is about partnerships—how the various stakeholders work together to achieve the program's goals. The key instrument that we use is R4D platforms, where we bring together different actors within the system: farmers, development partners, extension people, policymakers, processors, and investors. It basically calls for a different type of partnerships, a different attitude and mindset to research to solve real problems faced by farmers in their communities."

Humidtropics

As the lead center of Humidtropics, the CGIAR Research Program on Integrated Systems for the Humid Tropics, IITA has embraced the challenge and the opportunity to broaden its contribution to the global strategy towards poverty alleviation, food security and nutrition enhancement, and environmental integrity management. Through the Humidtropics' Executive Office, the Institute oversees the conduct of integrated systems research that is relevant to the regions of the humid tropics of the world, and promotes learning and sharing of lessons learned through the entire program with the global community.

The world's humid tropics are home to 2.9 billion of the world's poorest people, most of whom are poor farmers living on about 3 billion hectares of land. These regions are critical to local, regional, and global food supplies, and central to the maintenance of global biodiversity. Humidtropics is working with the goal of improving total agricultural productivity and transforming the lives of the rural poor in target regions of the humid tropics. This is being achieved through integrated systems approaches in R4D, with a focus on sustainable intensification and the capacity to innovate through partnerships and broad stakeholder participation.

Partnerships are fundamental for the conduct of systems research and are therefore a key aspect of Humidtropics' research function. The founding partners of Humidtropics are IITA, ILRI, ICRAF, IWMI, Bioversity, CIP, CIAT, FARA, AVRDC, *icipe*, and Wageningen University. Research in Humidtropics, however, is done with a much broader pool of partners, which is centered on the R4D and innovation platforms and spans the research-to-development continuum, as well as covering the value chain and impact pathways. During 2013, workshops were organized as instruments to initiate R4D

platforms involving multidisciplinary and multisectoral partners but also to engage in local, national, regional, and global functional partnerships related to the R4D agenda of Humidtropics.

Humidtropics also underwent significant changes in 2013. First, the operational structure of the program was consolidated and the research organization was realigned to reflect the adoption of Intermediate Development Outcomes (IDOs) as development targets shaping the orientation of our research and enabling the program to contribute to the CGIAR System Level Outcomes. A second major development during 2013 was the adoption and initiation of Flagship projects, previously called action areas, as the essential blocks for structuring, organizing, and implementing R4D. There are five Flagship projects, the first of which is developed on a thematic cross-cutting basis to ensure strategic coherence, e.g., in methods development, across the entire program, and with a strong emphasis on integrating gender and capacity development. The remaining four Flagship projects are developed on an area basis, covering the East and Central African Highlands, the West African Humid Lowlands, Central Mekong, and Central America and the Caribbean. Activities in these Flagship areas take place at selected action sites.

In 2013, the generation of research has been largely through the Strategic Research Themes (SRTs), working in an integrated fashion within action areas. Research outputs in 2013 have come from two sources—from the SRT research development and also from the existing research of partners, now mainstreamed into Humidtropics. A major achievement in 2013 relates to building the concept of integrated systems research within partner organizations and establishing the structures and teams for its execution. Progress towards outputs has involved the initiation of systems analysis in action sites. Baselines and entry points for innovation and systems

Crop and livestock integration in the farm. Photo by IITA

intensification in some action sites have been identified; activities are being initiated through the establishment of partnerships and R4D and innovation platforms in key locations across all Flagship project areas.

A key milestone in operationalizing the Humidtropics agenda in 2013 was the formal agreement between Roots, Tubers, and Bananas (RTB) and Humidtropics. This is a most significant partnership. In 2013, a number of engagements culminated in a workshop for planning joint projects for implementation between Humidtropics and RTB, with the participation of the MAIZE CGIAR Research Program. Furthermore, Humidtropics and Livestock and Fish joined RTB in an initiative led by the Global Cassava Partnership for the 21st Century that organized a high-level consultation in October on

Cassava, maize, and legumes growing well on healthy soil. Photo by IITA

Cassava-Based Feed Systems for Africa in Ibadan, Nigeria, opening another potential avenue for cross-CGIAR Research Program collaboration. Other CGIAR Research Programs with which there are ongoing discussions for coordination, co-location, and collaboration with Humidtropics include A4NH, WLE, FTA, and CCAFS. Some of the Humidtropics Flagships and action sites are co-located with the focal areas of other CGIAR Research Programs, creating an opportunity for sharing baseline data and partnerships and so making impact more quickly and at a larger scale.

Operationalizing the Humidtropics research agenda in Africa

In addition to leading the program's global operations, IITA also coordinates the activities in the two African Flagships. In East and Central Africa, several ongoing multi-partner projects and initiatives with systems research components are mainstreamed into the Humidtropics program, whereas activities in West Africa mostly start afresh. This presents different opportunities and challenges with respect to establishing and operationalizing the program.

East and Central African Highlands

The Humidtropics' East and Central Africa Flagship was launched in May 2013 in Bukavu, DR Congo, by the Governor of the South Kivu Province. The event was attended by the program's founding partners, regional and national organizations, and farmers' organizations. The Flagship area covers Rwanda, Burundi, eastern DR Congo (Kivu), southern Uganda, western Kenya, and western Ethiopia.

Following the launching, start-up activities including consultations and the mobilization of key stakeholders were carried out in DR Congo, Burundi, and Rwanda. These inception workshops provided a forum to develop a shared understanding of the program, agree on the process of mobilizing national and local support for the

program, and identify core stakeholders and facilitators to assist the program in each country. The following program action sites were identified at the country level: DR Congo – Walungu Groupement and Kamanyola Plain; Burundi – Kirimiro, Buyenzi, Buyogoma, Bweru, Mugamba, and Mumirwa; Rwanda – Rubengera, Kidaho, Ntarabana, Gatore, Nyagatare and Mayange Sectors, and Mayaga-Marangara-Gisagara-Nyamagabe axis; Kenya – Western Kenya; Uganda – Lake Victoria Basin; Ethiopia – Western part.

In addition to action sites, potential field sites and entry points were identified. The common entry points included the following: soil fertility management, the integration of legume trees into production systems, crop diversification, *Striga* management, strengthening of seed systems, crop livestock integration, agroforestry-livestock mixed enterprises, value chain development of priority crops, sustainable land-use systems, and water management. Measures to enhance coordination and the next steps, such as field site visits, situation analysis, and R4D platform inception meetings, were discussed.

The situation analysis is a primary component of Humidtropics activities that will guide the validation of field sites, entry points, and the establishment of R4D platforms. The situation analysis in Uganda and Kenya was led by ILRI. Supervisory committees were established in each country to oversee data collection, focus group discussions, data analysis, and reporting. Key partners who will participate and implement the R4D platforms were identified. More partners should join in 2014, leading to the complete establishment of R4D platforms as critical instruments to manage collaboration, ensure synergy, and attain adoption. Field site visits were organized in five countries to complement the situation analysis. These visits enabled participants to connect the Humidtropics agenda to farming realities and further review the entry points identified at the inception workshops.

Get up, stand up - Africa RISING

"Having grown up on a farm in a very rural part of Colorado, I naturally had a lot of interest in agriculture. Living in an area where we had problems with soil erosion and water management, I was keen on learning more about the solutions to agricultural problems". Today Jerry Glover is the Senior Sustainable Agricultural Systems Advisor with USAID, Washington, D.C. He has been involved with the Africa RISING project since its inception in 2011. IITA leads and coordinates the Africa RISING projects in West, and East and Central Africa.

"When Africa RISING started, I wanted it to focus on farming systems as a whole, to complement the very commodity and value chain-focused investments in our other USAID programs. The concept of sustainable intensification was a good organizing principle around which we built the program. I think the Africa RISING research team has done a tremendous job in integrating social and economic concerns with diverse mixed crop-livestock systems and being open to many issues that more specialized and commodity focused research projects are not addressing.

"For me, the most important outcome so far has been developing the highly skilled research networks of partners and platforms. We have come together as a complex and diverse set of people to address a wide range of agricultural research issues in some fairly remote, poorly supported communities. We are developing an infrastructure, a network of expertise that involves national partners who can help support these communities do what they want to do. Building together this partnership has been perhaps the most rewarding component of Africa RISING."

Farmers participating in a climbing beans trial. Photo by IITA

West African Humid Lowlands

The West African Humid Lowland Flagship comprises Cameroon, Nigeria, Ghana, and Côte d'Ivoire. Activities started with the launching workshop held in June at IITA in Ibadan, Nigeria. The workshop gathered representatives from Humidtropics' founding partners, international research and development institutes (CIRAD, CIFOR, FAO), and national research and development institutes of the action area countries. As such, it created an opportunity to forge partnerships with regional and national organizations.

The participants identified potential action sites for the program, as follows: Nigeria – Oyo, Osun, and Ondo States; Cameroon – transect from center to western regions; Ghana – Ashanti region; Côte d'Ivoire – southern region. Diversification and/or intensification of cocoa-based production systems, intensification and increased profitability of root and tuber cropping systems, soil fertility management systems, and livestock integration were identified as common entry points for innovations and interventions at the action sites.

Directly following the launching, an inception workshop was held at the Osun State action site. A wide range of stakeholders including research institutes, universities, farmers' organizations, NGOs, inputs dealers, and traders discussed how they could collaborate with Humidtropics on sustainable intensification. The Governor of Osun State also participated in the workshop.

More detailed information on entry points for interventions and innovations were identified, e.g., the diversification and integration of crops and livestock, pest management, sustainable natural resource management, and improved support from institutions to farmers. There was a consensus that partners expect Humidtropics to create a suitable environment and interactions between partners/stakeholders, enhance the livelihoods of poor crop and livestock farmers, address key sustainability issues for poor farmers, develop innovations meeting the needs of people in the region, and provide assistance to farmers to ensure agricultural development.

The situation analysis is ready to take off and the next step is to establish the R4D platform, defining its mode of operation, and developing monitoring and evaluation tools.

Policies, Institutions, and Markets

The CGIAR Research Program on Policies, Institutions, and Markets (PIM) is a program of research designed to bring about improvements in policies, institutions, and markets for achieving impact in the four areas that constitute the system-level outcomes of CGIAR—improved food security, reduced rural poverty, improved nutrition and health, and more sustainable management of natural resources. PIM's work was reorganized in 2013 into seven Flagship projects: Foresight Modeling, Science Policy and Incentives for Innovation, Adoption of Technology and Sustainable Intensification, Sectoral Policy and Public Expenditure, Value Chains, Social Protection, and Natural Resource Property Regimes.

In 2013, IITA primarily participated in two Flagship projects: foresight modeling and value chains, but contributed also to technology adoption and sustainable intensification, cross-cutting strategic gender research, and capacity strengthening. The foresight modeling work involved the ex-ante evaluation of promising technologies for IITA's mandate crops under alternative drivers of change and R&D investments. IITA's work on value chains involves the impact evaluation of upgrading cassava value chains in sub-Saharan African countries through postharvest engineering and processing research. Through a systematic evaluation of existing and potential interventions along the cassava value chains, this work aims to identify best practices and upgrading options to strengthen the value chains. The following highlights some of IITA's research and capacity strengthening efforts in 2013.

Foresight modeling

A major output of the strategic foresight modeling work in 2013 has been a list of 38 promising technologies developed for IITA's

A market in Nigeria. Photo by IITA

mandate crops. The list is part of a major effort to undertake ex-ante technology evaluation for priority setting and adds to the 150 technologies identified by other CGIAR centers involved in the Global Futures project since its inception in 2010.

Adoption of technology and sustainable intensification

Role of farming experience

Farming experience plays a key role in influencing farmers' decisions to adopt, abandon, or sustain adopted agricultural technologies. This study investigated the relationship between the adoption of and experience with new agricultural technologies using data from smallholders, and also measured the adoption of agricultural technologies by farmers who had received training and crop improvement technologies through farmers' organizations. The analysis was based on data from projects supported by the Danish International Development Agency (DANIDA) in Uganda from 1994 to the late 2000s.

Women preparing food products for sale. Photo by IITA

The results show that farming experience is largely useful in the early stages of adoption of a given technology when farmers are testing its potential benefits. Farmers may then abandon the technology if the benefits are smaller than the amount of efforts used, especially if it is labor and area demanding. This implies that, in addition to gradual advances in technology improvements, continuous retraining is essential for farmers to keep updating their experiences and to increase the adoption of improved agricultural technologies. This is particularly important in the framework of designing effective policies for promoting the uptake of new agricultural technologies.

Adoption of improved maize varieties

A study was conducted in eastern Zambia to identify the determinants and correlates of long-term nutritional status of children and to assess the impact of improved maize varieties on child malnutrition. Results showed that the probability of stunting increases with the age of the child, implying that younger children are less likely to be malnourished than older children. As children grow older, less breast milk and the weaning process may make them more vulnerable to malnutrition.

The results further showed that the probability of stunting decreases with the education level of the adult female household members. This implies that educated females play an important role in sharing knowledge related to children's health, such as good child-care practices and the ability to recognize illness. Ownership of a radio facilitates the acquisition of nutritional information, allowing a more effective allocation of resources to promote child health.

Furthermore, results showed that the adoption of hybrid maize reduces the probability of stunting. The adoption of new varieties leads to higher yields, and this enables households to have adequate food for consumption and income from the sale of surplus food.

Finally, the results showed that improved sanitation reduces the probability of stunting among children.

On average, children from non-adopting households were relatively more stunted (61%) than those from adopting households (40%). This means that the probability of stunting among children from adopting households is 21% lower than that among those from non-adopting households. The results point to the need for policies that promote the adoption of improved crop varieties as these have the potential of addressing widespread malnutrition through increased production and productivity for increased home consumption and incomes.

Impact of agricultural research investments

A study was conducted to examine the impact of investment in cassava and yam research on food production and incomes among smallholder farmers in Nigeria over a 10-year period since the establishment of the Root and Tuber Expansion Program in 2001. The study used data from a nationally representative survey of 5000 households; 15% were headed by women. Despite significant research investments, the results revealed gaps between current and potential impacts, as exemplified by the actual adoption rate of improved varieties of yam (24%) and cassava (43%) although the potential adoption rate with the exposure of all farmers to the new varieties was 44% (yam) and 57% (cassava). The gaps between actual and potential impacts of improved varieties point to the need for unlocking the potential of agricultural research through efficient input supply systems for clean planting materials and increased mechanization of production and processing.

The results also showed that the proportion of female farmers (8%) that adopted improved yam varieties has increased more than that of their male counterparts (5%). Female farmers recorded higher output, higher yield, and higher income from yam production than male farmers.

Research is for people and communities. Photo by IITA

To tap the unexploited potentials of agricultural R4D, investments need to be targeted to favorable regions and complementary investments made to improving the supply of clean disease-free planting materials and fertilizers, mechanization of production and cassava processing, capacity building of farmers, farmers' organizations, marketing arrangements, and agricultural innovation systems.

Value chains

Industrial firm credit redistribution and value chain financing

A study was conducted to assess the applicability of value chain financing among agro-industrial companies in sub-Saharan Africa. The results showed that agro-industrial firms in competitive markets redistribute credit to suppliers as their holdings of bank credit in investment capital increase, releasing cash flows for value chain lending. The results indicate the need for policies that facilitate increased participation by banks in agricultural value chains in the region.

Capacity building

At the request of CORAF/WECARD, IITA organized a training course on innovation platforms in value chains. The goal was to strengthen the capacity of national partners involved in agricultural research and technology dissemination to significantly increase agricultural productivity in the West and Central African region. Participants came from national programs and other actors included policymakers. The focus of the training was on the principles and implementation of innovation platforms, gender/equity, and value chain analysis. Such capacity strengthening activities were conducted in Sierra Leone, Burkina Faso, and Bénin. In total, five training courses were organized and a total of 144 participants (36 women), took part in the program.

Strategic research on gender

The Integrated Seed Sector Development in Uganda commissioned a gender study that was undertaken by IITA and partners to assess the differences between men and women regarding seed production and marketing needs, interests, and roles, as well as access to and control over seed production resources.

The results indicated differences in seed preferences among men and women: women preferred seeds that catered to food security, were less demanding in terms of labor, and had less competition with men's crops (e.g., beans, groundnut, and sesame). On the other hand, men preferred highly priced seeds that had less competition with food (e.g., rice and cassava). However, compared with women, men were more able to purchase seeds while women were limited by inadequate funds, limited access to productive resources, and inability to make independent decisions at the household level. In marketing, men produced and sold more seeds than women. Women were limited by their lack of land, labor, access to improved technologies, and the fact that part of the seeds they produced was eaten as food by the household. In contrast, depending on the crop, much of the seeds produced by men were sold for income.

Regarding access to and control over productive resources and decision making, men owned, controlled, and made all decisions regarding land and other inputs such as seeds, fertilizers, and chemicals. Generally, the results suggest that local seed businesses benefited men more than women. Efforts aimed at establishing gender-equitable businesses thus require strategies that stimulate women's participation in leadership and capacity enhancement training and participatory varietal selection for increased access to improved technologies.

MAIZE

The CGIAR Research Program on Maize (MAIZE) has been designed to generate and provide new technologies, know-how, methodologies, and novel tools. The program has been organized around nine strategic initiatives that house sets of activities. IITA has been implementing activities clustered around the various strategic initiatives in West and Central Africa for the last 2 years. The highlights for 2013 are presented here.

Germplasm development, testing, validation, and release

Monitoring genetic gain in breeding for drought tolerance

One of the major goals of the joint IITA/CIMMYT project *Drought Tolerant Maize for Africa* (DTMA), funded by the Bill & Melinda Gates Foundation, has been the development of maize open-pollinated varieties (OPVs) and hybrids that produce under drought at least 1 t/ha more than the hybrids and OPVs commonly grown in 2006. A comparative trial showed that the varieties developed between 2007 and 2010 had 22% and 13% higher yields, respectively, compared with earlier varieties. In a second trial, comparing late-maturing, three-way cross hybrids developed in 2011/2012 with commercial hybrids, the best three-way crosses produced 54% more grain yield under drought and 23% more under irrigation compared with the commercial hybrids. The best three-way cross hybrids were also shown to significantly outyield commercial hybrids in follow-up trials in Benin Republic, Ghana, Mali, and Nigeria. The increases in grain yields were not associated with significant changes in other major agronomic traits.

Preparing maize for seed production. Photo by IITA

Molecular markers for identifying homozygous and homogeneous maize inbred lines

More than 400 early and extra-early maturing and intermediate and late-maturing maize inbred lines were genotyped by genotype-by-sequencing at Cornell University. The intermediate and late maturity group included 125 *Striga* resistant and 190 drought tolerant maize inbred lines. Single-nucleotide polymorphism (SNPs) analysis showed that the majority of the lines of the intermediate and late maturity group had less than 10% heterozygosity. Some parental lines of hybrids have been selected for further inbreeding to develop fixed lines. Phylogenetic trees constructed using SNPs will be used to identify the heterotic affinities of the lines for use in developing hybrids and breeding populations.

A maize experiment in IITA, Ibadan, Nigeria. Photo by IITA

Channeling drought tolerant products to partners

In 2013, almost 400 sets of regional trials were dispatched to partners in West and Central Africa for testing. Maize varieties and hybrids were selected from these trials for validation tests in 2013 in Benin Republic, Ghana, Mali, and Nigeria. The results were used to recommend the best drought tolerant varieties and hybrids for registration and release in the countries. In collaboration with partners in Nigeria, two extra-early maturing hybrids and one later maturing drought tolerant yellow OPV were released in 2013. Also, two early maturing hybrids resistant to *Striga* and tolerant of drought and low soil nitrogen were released in Mali as *Sanu* and *Mata*.

Identifying maize hybrids with enhanced pro-vitamin A levels

A regional trial composed of hybrids formed from inbred lines with intermediate to high levels of pro-vitamin A was dispatched to partners for evaluation. Results of carotenoid analysis showed that almost all hybrids included in this trial had significantly higher levels of pro-vitamin A compared with a commonly grown orange commercial hybrid (Oba Super II) in Nigeria. The best 10 hybrids were comparable to Oba Super II in mean grain yield and six hybrids had pro-vitamin A concentrations which were 55 to 146% higher than those of Oba Super II. The most promising pro-vitamin A hybrids will be further tested in national performance and on-farm trials to generate data for variety registration and release.

Seed supply to accelerate deployment

Access to productive and new stress-tolerant varieties and hybrids by the national agricultural research systems (NARS) and the private seed companies is important for the production and marketing of good quality seeds to farmers. In 2013, NARS, community based seed producers, and private seed companies were supplied with seeds of extra-early (>12 t), early (>2 t), and intermediate/late-maturing (<8 tons) drought tolerant maize varieties that in turn generated at least 2500 t of foundation seeds. In addition, 1.3 tons of three registered *Striga* resistant maize varieties were supplied to partners for demonstrations in northern Nigeria and for further multiplication by the community based seed producers and emerging seed companies.

One objective of the agricultural transformation initiative of the Federal Government of Nigeria is to increase the use of improved seeds by supporting research institutes to supply breeder and foundation seeds to registered seed companies for the production of certified seeds. IITA is fully committed to the initiative and also in assisting the national research partners to produce and supply seeds to seed companies. In 2013, more than 40 tons of foundation seeds of several recently released maize varieties were produced by IITA for further multiplication and dissemination to farmers.

Incorporating legumes in maize-based farming system

A trial involving the rotation of maize with soybean and cowpea was evaluated at two sites in Mozambique for 2 years. At both sites, the soybean-maize and cowpea-maize rotations significantly increased maize grain yield and produced more maize residue, compared with maize after maize rotation. The benefits of previous soybean and cowpea crops to succeeding maize may be likely to be attributable to the legumes providing residual nitrogen, organic carbon, and other benefits including a reduction in pest and disease pressure.

Pest management

Maize stem borer

On-farm trials were conducted in Benin Republic to assess the efficiency of an egg delivery system of the parasitoid *Trichogrammatoidea eldanae* to plants for controlling stem borers. The pest population pressure from stem borers was quite high in 2013 but the parasitoids were still able to significantly reduce populations, particularly of *Eldana saccharina*, leading to a higher average grain yield in the trichogramma-treated plots.

Maize streak virus disease

Maize inbred lines were artificially inoculated with the maize streak virus disease and disease severity was scored for 6 weeks. Among the 157 lines, 41% showed resistant reactions whereas 30% were susceptible to the virus. Resistant lines are currently being used to develop hybrids and synthetic varieties.

Aflatoxins

The identification of fungal strains for biocontrol to reduce aflatoxin contamination in maize starts with field collections of *Aspergillus flavus* strains from major maize production zones. In 2013, maize samples were collected in Ghana, Mozambique, and Tanzania. Atoxigenic (non-toxin producing) strains identified from each country were purified and sent to the USDA-ARS laboratory in Arizona to determine their genetic diversity. Country-specific atoxigenic strains were selected as candidates for efficacy testing to identify the most competitive strains capable of displacing the aflatoxin-producing strains. The final biocontrol product contains a mixture of strains effective in reducing aflatoxins in maize across a broad range of environments in the country. Strains isolated from each country will be pooled to create regional biocontrol products.

Forging the 'chains' of development

"Cassava, maize, rice, and wheat! Voilà!" Chrys Akem is referring to the crops the African Development Bank-funded Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) project ideals with. Chrys is the SARD-SC-project coordinator with many years of experience in breeding and disease control of many crops, fruits, and legumes.

"In a nutshell, SARD-SC aims to improve food and nutrition security and contribute to poverty reduction in 20 African countries by working on the value chain of important commodity crops. You might ask, 'What is a value chain?' Simply put, a value chain refers to the linked processes and market activities by which value is added to a product—in this case a particular commodity crop—from the point of production to processing, marketing, and consumption. The project introduces innovations ranging from generating new crop varieties and novel production and processing technologies to enhancing capacities of farmers and other stakeholders, development of related infrastructure, and efficient project management.

"After 18 months, the project has already seen some major achievements. In 2013, we developed, identified, and nominated for release several high-yielding wheat varieties in Sudan and Nigeria. We have also initiated the construction of a number of postharvest handling facilities for the cassava value chain in most of the project countries.

"What makes SARD-SC special is its use of Innovation Platforms within each commodity value chain. This approach brings together all concerned stakeholders to collectively see what the problems are and, together, come up with suitable and relevant solutions."

Striga - biocontrol

As part of *Integrated Striga Management in Africa* (ISMA), funded by the Gates Foundation, the efficacy of a *Striga* biocontrol product, *Fusarium oxysporum* f. sp. *strigae* (Fos), was evaluated under natural and artificial infestation in northern Nigeria. Seeds of resistant and susceptible maize varieties were coated with Fos inoculum prior to planting and the emergence and number of flowering *Striga* were scored during the growing season. Biocontrol in combination with *Striga* resistant maize reduced emergence by 73% compared with the susceptible control, and by 39% compared with the resistant variety without the biocontrol agent. Biocontrol in combination with the susceptible variety significantly reduced emergence by 53%, resulting in 42% reduction in the number of flowering plants and in an increase of 21% in grain yield compared with the susceptible control (i.e., without biocontrol). The observed reduction in *Striga* emergence across maize varieties and the increase in grain yield are indicators of the effectiveness of the biocontrol product.

Striga - nitrogen

The response to nitrogen fertilizer of early maturing, drought resistant and *Striga* resistant maize varieties was evaluated in northern Nigeria. Two nitrogen-use efficient varieties, identified from these trials, are now being tested on-farm to confirm their performance for release in Nigeria.

Gender mainstreaming

Gender-based participatory evaluation of varieties

Studies of preferences for drought tolerant maize varieties and hybrids among men and women farmers in Benin Republic, Ghana, Mali, and Nigeria showed that preferences differ among countries and groups. In Benin Republic, for example, yield is the most important criterion for both men and women farmers, but men

tended to also emphasize color as it relates to market demand while women tended to emphasize characteristics for nutrition and processing. The results of these studies will be used to modify the selection criteria for breeding and for better targeting of varieties for male and female farmers. Studies were also conducted to assist seed companies with training on developing strategies for assessing the market potential of gender focused, innovative, cost-effective, and timely seed supply.

Gender-based adoption pattern studies

A gender-based adoption pattern study found that women prefer early maturing and nutritionally enhanced varieties whereas men prefer high-yielding varieties. The socioeconomic heterogeneity of men and women and the diverse and complementary choices of both gender groups should be taken into consideration in planning a study to obtain comprehensive adoption patterns.

A maize field in the shadow of a nearby mountain. Photo by IITA

Roots, Tubers, and Bananas

The CIP-lead CGIAR Research Program on Roots, Tubers, and Bananas (RTB) is one of the programs that engage the most scientists at IITA. RTB is organized around a number of delivery, discovery and learning, and support Flagships; IITA is actively involved in several of those, contributing broad expertise on cassava, banana, and yam, ranging from molecular plant breeding and pathology over field agronomy to social science. A brief update on selected projects is given here.

IITA scientists breed for high-yielding and disease and pest-resistant cassava varieties. Photo by IITA

Cassava

Cassavabase—a globally accessible database for breeding and genomic information

Cassavabase.org, a globally accessible database for cassava breeding and genomics information, was launched for public access in April 2013 in collaboration with Cornell University, IITA, the National Root Crops Research Institute (NRCRI), Nigeria, and the National Crop Resources Research Institute (NaCRRI), Uganda. Cassavabase will curate field research data and genomics information for the Nextgen Cassava project and will be available as a global cassava data management resource. In 2013, the use of tablet computers for field data collection was fully implemented to facilitate the rapid availability of cassava harvest data for use in making selections. Cassavabase is serving as a learning tool for the development of accessible databases for other RTB crops including banana, sweet potato, potato, and yam.

Next Generation Sequencing to improve use of cassava genetic diversity in Africa

IITA and national cassava breeding programs hold the largest collections of cassava germplasm in Africa. In an effort to establish the genetic structure and relationships within and among the breeding collections, DNA from cassava clones from IITA, regional breeding programs, and CIAT has been submitted for genotyping-by-sequencing to Cornell University. The emerging picture of the African germplasm shows that the origin is the primary source of genetic structure, suggesting the need for germplasm exchange. The data are also being used to identify and eliminate genetic duplicates in the germplasm collections for cost-effective and efficient conservation and utilization. Furthermore, genotyping and QTL analysis were done for two populations segregated for plant

Tiny deadly insects

"Whiteflies are one of the top 10 most serious pests that threaten agriculture", says James Legg, a plant virologist at IITA with more than 20 years experience of working on plant viruses and their insect vectors. James has developed a passion for developing knowledge products in various new media formats, including video and mobile phones.

"I like to communicate with farmers because we can exchange our understanding on the problem of plant diseases. Today, my focus lies entirely on whiteflies. These tiny delicate insects transmit hundreds of virus species including those that cause cassava mosaic disease and cassava brown streak disease, two of the most destructive diseases of cassava.

"The whitefly problem in Africa has reached epidemic proportions developing over the last two decades. To solve the problem, IITA has done work to identify resistance to these insects, and to characterize the natural enemy fauna, with a view to identifying opportunities for biological control. Researchers and development investors are finally beginning to recognize that there will be no long-term solution to the cassava virus problem without addressing the whitefly component. Both RTB and CCAFS are supporting whitefly research.

"We are working with many partners on whitefly studies, including African NARS and universities. Other partners have included sister CGIAR centers such as CIP and CIAT, Tel Aviv University, the University of Arizona, and the Natural Resources Institute in the UK. I believe these partnerships are essential to the effective implementation of research on whiteflies, a problem that has a global scale."

Huge cassava roots harvested from the IITA farm. Photo by IITA

health, morphology, and nutritional value. Traits that were mapped with SNP markers include resistance to cassava mosaic disease, carotenoid accumulation, and anthocyanin coloration. These markers are currently being converted for marker-assisted selection. Finally, the application of genotyping technologies resulted in genomic selection on a one-year cycle in Nigeria. Annual selection cycles should lead to increased genetic gains in cassava and the faster release of improved varieties for farmers.

Delivery of biofortified cassava in Nigeria

IITA and CIAT have been collaborating to address vitamin A deficiency in Africa by producing biofortified cassava genotypes with enhanced content of beta-carotenoids. In 2013, the first widespread dissemination of vitamin A cassava varieties occurred in Nigeria with the release of three varieties—IITA-TMS-IBA011368, -371, and -412—disseminated to over 100,000 smallholder farmers by HarvestPlus. Over 30,000 farmers were trained on best agronomic practices for vitamin A cassava and a database was created to document all distributions and to track further dissemination. Differentiated experiences with the vitamin A cassava varieties among women and men will be assessed to provide information for the next phases of breeding.

Gender-responsive innovation platforms: Cassava-based communities in Zambia

Making Agricultural Innovations Work for Smallholder Farmers Affected by HIV/AIDS or MIRACLE, funded by the Swedish International Development Agency, introduced four small-scale cassava processing centers in Luapula Province, northern Zambia. MIRACLE highlights opportunities for crop diversification for women via village decision making bodies (lead farmers) and innovation platforms in the areas of food security, diets, health, nutrition, and income generation for HIV-infected and affected beneficiaries. The processing centers will be operated by MIRACLE-supported entrepreneurs, with technical and business backstopping for at least one year.

Awareness and adoption of improved cassava varieties and processing technologies

The awareness and spread of improved cassava varieties and the adoption of processing technologies were studied in a survey of 952 households in Nigeria. In general, farmers grow a mixture of improved and local varieties. However, adopters of new varieties showed increased yields compared with non-adopters. Use of improved varieties was closely related to access to the improved processing technologies that improve the efficiency of cassava processing. The adoption rate of improved planting materials was 68% of the 75% who were aware of the varieties.

Impact assessment of the cassava enterprise development

The economic impact of the Cassava Enterprise Development Project (CEDP), funded by multiple donors and operating in 11 States in southern Nigeria during 2004-2010, was evaluated in 2013. The main points of interest for the study were the reduction in cassava mosaic disease, the increase in average yields, and expansion of marketing and processing activities. As a result of the project, more than 19,000 hectares were planted with resistant varieties and production increased from 12.5 million tons in 2004 to over 24 million tons in 2010, an increase of over 11% per year. Yields also showed an annual increase of 1.4% over the project period. The estimated total number of job opportunities created in the cassava processing sector was over 14,000, out of which 25% were permanent positions (12% for men, 13% for women) and 75% part-time positions (20% for men, 55% for women). CEDP also involved

agro-dealers, weed control groups, credit institutions, machine fabricators, marketing agents, industrial cassave users, extension agents, NGOs, State and local governments, regulatory agencies, consumers, and researchers. Capacity development and research efforts resulted in 1730 BSc, 227 MSc, and 70 PhD degrees.

Economic impact of cassava research and extension

The economic impact of cassava research and extension in Malawi and Zambia, 1990-2008, showed that investments in cassava improvement have led to the release of high-yielding and CMD tolerant varieties. Multiplication and distribution of virus-free cassava planting materials had an estimated return on investment of 24%. If these improvements are combined with the development and dissemination of varieties with preferred consumer quality characteristics and improved industrial traits, the return on investment is estimated to be 40%.

Banana

Developing transgenic banana with resistance to Xanthomonas Wilt

Banana Xanthomonas Wilt (BXW) disease caused by the bacterium *Xanthomonas campestris* pv. *musacearum* (Xcm) has endangered the livelihoods of millions of farmers who rely on banana for staple food and cash, resulting in annual losses of over US$500 million across East and Central Africa. We have tested constitutive expression in banana of both a Hypersensitive Response-Assisting Protein gene (*Hrap*) and a Plant Ferredoxin-Like Protein gene (*Pflp)* from sweet pepper for resistance to BXW. Transgenic lines developed with either *Pflp* or *Hrap* and stacked gene constructs were maintained and multiplied *in vitro*. Further work to evaluate the *Hrap* and *Pflp* genes stacked together generated several lines for testing in a glasshouse. Promising lines are under multiplication for

Going bananas

"Eve did not give an apple to Adam but a banana" — says Rony Swennen, a world-leading banana breeder, although he considers himself simply a banana lover. "Banana was one of the first crops domesticated by people, and improved drastically over time thanks to farmers all over the world. I started getting interested in banana in 1979 by working at IITA in Nigeria.

We addressed challenges facing plantain in West Africa—low yield and attack by a fungus called black Sigatoka. And through working with bananas I started learning about life in Africa as well, because banana is not simply a crop, but a way of living. At that time most scientists were not interested in banana and research was very poor. The former IITA DG Ermond Hartmans said: 'Rony, go full speed and do your PhD!', so I did. The research I was involved in resulted in a breakthrough with the development of the technology to obtain seeds from the sterile plantain crop, seed germination, and selection of plantain hybrids with yield increases of up to 225%. During that period IITA started its plantain and banana program.

"Today I can capitalize on the work of three generations of banana breeders. We are looking at setting up a more integrated breeding program through collaboration not only with IITA scientists but other banana experts coming from partner organizations. There is a lot of good banana research and expertise now in IITA, but a massive amount of information available on banana and plantain improvement work has been forgotten and is not being used by farmers or even policymakers. There is still so much to be done on perennial crops like banana and plantain. Thanks to new technology and networking, research can go faster, and we can make a lot of difference if we achieve impact through capacity development."

Banana bunch. Photo by IITA

Yam market in Ghana. Photo by IITA

confined field trials. The promising lines showing BXW resistance in confined field trials were also evaluated against *Fusarium* wilt under screenhouse conditions. All the transgenic plants showed lower disease severity and leaf symptom index.

Platform to protect smallholder farmers from Banana Bunchy Top Disease

Banana Bunchy Top Disease (BBTD) is the most devastating viral disease known in banana and plantain, and its spread in Africa has a negative impact on the economy, livelihoods, and quality of life of millions of farmers. The disease is already established in 14 countries and will continue to spill rapidly into more regions unless immediate action is taken. Currently, IITA, Bioversity International, and CIRAD (French Agricultural Research Center for International Development) are partnering on an RTB-funded Project, *BBTD containment and recovery by building capacity and piloting field recovery approaches through a learning alliance*. The platform is a framework for a participatory approach to eradicate infected plants and resuscitate banana production in nine pilot sites in Bénin, Nigeria, Cameroon, Gabon, Congo Brazzaville, DR Congo, Burundi, and Malawi.

Yam

Fast and cheap seed yam health test

Yam in West Africa is affected by several viruses resulting in mosaic disease and significant losses in production and quality. Infected tubers serve as vehicles for the viruses and the only effective method of controlling virus diseases is through the use of virus-free planting material. Production of clean seed yam, however, depends on the ability to detect key viruses, and this currently requires four separate tests. IITA established a single-tube multiplex RT-PCR assay for the detection of three viruses in seed yam planting materials,

simplifying plant health assessment and thus the production of clean planting material. A training course was organized to disseminate the technology to researchers from the national programs of Nigeria and Ghana. Using this technology, clones of clean seed yam for popular landraces in Nigeria have been established and are being used as seed stock for rapid multiplication.

Ghana launches national yam strategy

In 2013 Ghana launched a strategy for the development of the yam industry. The strategy aims to make Ghana the leading source of premium quality yam products with global penetration that contributes to an improved Ghanaian economy and livelihoods. The initiative is also looking at developing commercially-driven research and development and capacity building in yam value chains. The International Trade Centre and IITA provided technical support and process facilitation for developing the strategy, based on a platform that includes stakeholders from the private sector, support institutions, commercial and development banks, key ministries, farmers, processors, research institutes, universities, and NGOs.

Improving tissue culture technologies for plant survival

''The potential of temporary immersion bioreactors (TIB) in meeting crop production demands is high and we just stand and its beginning," says Morufat Balogun, a Tissue Culture Specialist at IITA, working in the Yam Improvement for Income and Food Security in West Africa (YIIFSWA) project.

"My role in the project is to optimize TIBs for production of yam seed, which are practically grown in the air. We call them aeroponics. In the aeroponics system, plants are grown without the use of soil or aggregate medium by spraying plant roots with a nutrient solution. The next step is to ensure the quality of the plants. And this is where TIB technology plays a crucial role. Conventional tissue culture has been used to produce disease-free plantlets, but TIB technology provides a more precise control of the conditions for plant survival and development. TIBs also provide a rapid and efficient plant propagation system for many plants, not only yam, using liquid media to avoid intensive manual handling. In addition to diminishing production costs TIB saves energy and augments micropropagation productivity and efficiency. We can produce twice as many plants a year than with conventional tissue cultures. This will increase the availability of high quality seed by farmers and will raise yield and profit margin, and enhance livelihoods. More yam will be available and can be used throughout the value chain to produce more food. TIB technology at IITA will be rolled out for production of yam seed in about a year.''

Cowpea experimental field. Photo by IITA

Grain Legumes

As a partner in the ICRISAT-led CGIAR Research Program on Grain Legumes, IITA participated in three Product Lines in 2013: PL1. Drought and low-phosphorus tolerant common bean, cowpea, and soybean; PL4. High nitrogen-fixing chickpea, common bean, faba bean, and soybean; and PL5. Insect-smart chickpea, cowpea, and pigeonpea production systems. IITA's work was focused on cowpea and soybean and carried out in Burkina Faso, Cameroon, Ghana, Malawi, Mozambique, Niger, Nigeria, Senegal, and Tanzania.

Cowpea breeding

Most cowpea grown in sub-Saharan Africa is grown in the dry savannas, characterized by low soil fertility [mainly phosphorus (P) deficiency] and drought. Cowpea is attacked by several insect pests throughout the growth period, with devastating effects on yield. Hence, developing improved cowpea varieties with stable yields, better adaptation to drought and low soil-P conditions, and requiring minimum insecticide application will enable farmers to grow cowpea more profitably while also ensuring environmental safety.

Two IITA cowpea breeding lines were registered and officially released in 2012 in Tanzania: IT99K-7-21-2-2-1 (local name: Vuli-AR1) tolerant of drought and resistant to the parasitic weed *Alectra*, and *Alectra* resistant IT99K-573-1-1 (Vuli-AR2). Their medium maturity and seed types were preferred by producer and consumer groups. Two other drought tolerant and *Striga* resistant lines, IT99K-573-2-1 and IT98K-205-8, were released in Burkina Faso.

Two wild cowpea relatives with higher levels of resistance to aphids than the cultivated lines have been crossed to improved cowpea lines for generating populations segregating for aphid resistance. With the recent progress in cowpea genomics we anticipate using marker-assisted backcrossing for developing new varieties with traits, preferred by farmers and consumers, such as large seeds, from the segregating populations.

Cowpea entomology

Cowpea is plagued by four major insect pests: cowpea aphids, flower thrips, legume pod borers, and pod-sucking bugs. In addition to host plant resistance, the development of insect-smart cowpea systems includes the use of biological control and biopesticides, i.e., integrated pest management (IPM).

An experiment set up to compare conventional, botanical, viral, and fungal pesticides against the pod borer *Maruca vitrata* confirmed results obtained from farmers' fields in Burkina Faso and Niger. Combinations of botanical (neem oil) and viral (MaviMNPV) pesticides yielded the highest larval mortality in *M. vitrata* populations (46% and 41%, respectively) compared with all other treatments, confirming that biopesticides can be as effective as the standard synthetic pesticide.

Two Asian braconid parasitoids, *Therophilus javanus* and *Phanerotoma syleptae* attacking the pod borer, were collected from The World Vegetable Center (AVRDC) in Taiwan, and imported into the containment rearing facilities at IITA-Bénin in Cotonou. Studies on host range, suitability, location, and competition are being carried out at IITA-Bénin to evaluate the ecological potential of both parasitoids as candidates for biological control in West Africa.

Cowpea pest. Photo by IITA

Cowpea virology

Cowpea is susceptible to natural infection with more than 20 different viruses worldwide, nine of which have been recorded in sub-Saharan Africa. *Bean common mosaic virus*-black-eyed cowpea mosaic (BCMV-BICM), *Cowpea aphid-borne mosaic virus* (CABMV), *Cowpea yellow mosaic virus* (CYMV), *Cowpea mottle virus* (CMeV), *Cowpea golden mosaic virus* (CPGMV), *Cucumber mosaic virus* (CMV), *Cowpea mild mottle virus* (CPMMV), and *Southern bean mosaic virus* (SBMV) are the most frequently occurring viruses. These viruses, either in single or mixed infection, can reduce yields by between 10 and 80%. The use of resistant varieties is the most economical and effective method of controlling viral diseases; genetic studies on the mode of inheritance of virus resistance is essential for choosing appropriate breeding procedures. This study focuses on determining the inheritance of resistance to BCMV-BlCM, SBMV, and CMV. The two best lines, IT98K-1092-1 and IT97K-1042-3, were used to determine the inheritance of multiple virus resistance in cowpea. They were crossed with two highly susceptible cowpea lines and F_1, F_2, BC_1, and BC_2 populations were generated and phenotyped during 2011 and 2012. The F_2 generation of these crosses is being advanced to establish recombinant inbred lines (RILs) for use in developing DNA markers linked to multiple virus resistance.

Farmers and their legume field. Photo by IITA

Cowpea and soybean agronomy

During the 2012/2013 growing season, 30 soybean and 25 cowpea genotypes were evaluated across four agroecologies in Mozambique to identify the best performing genotypes for the production zones. The selection criteria include high grain yield, yield stability across locations and years, tolerance to soybean rust and drought, and promiscuous nodulation in soybean. Yields for the top 10 performing soybean genotypes within two major production regions ranged from 2.8 to 4.5 t/ha. The genotypes produced adequate nodules with existing indigenous rhizobium. Most of the best cowpea were early to medium maturity lines with significantly larger seed size than the most popular improved cowpea variety (IT-18). Yields of up to 2.8 t/ha were obtained during the 2012/2013 growing season.

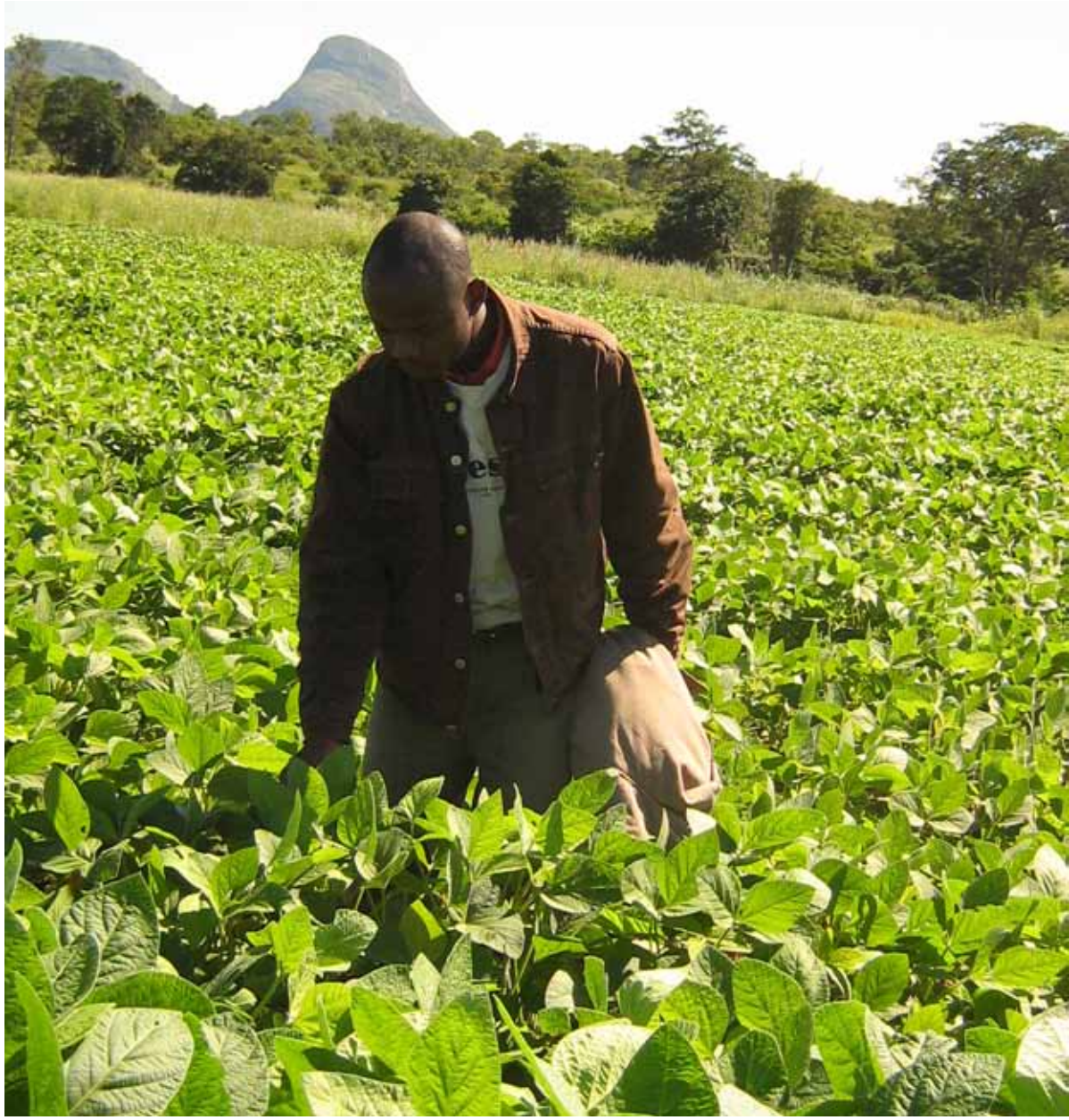
Also in Mozambique, five imported peat-based inoculant products and the liquid formulations of two of the peat-based products were tested in soybean across four sites. The products performed consistently across sites with no interaction effect between site and inoculant. All the products except the liquid formulations significantly improved nodulation. The products Biagro and Biofix consistently produced the highest grain yield. The yield increases resulting from inoculation suggest that it is profitable to use inoculants in the agroecologies, in particular for first-time soybean fields.

Soybean yield was enhanced by 63% (to 1.1 t/ha) by *Rhizobium* inoculation and phosphorus (P) application in Samaru-Kataf in northern Nigeria. In Zaria, *Rhizobium* inoculation alone did not significantly affect grain yield. The results were confirmed in 30 on-farm trials established in both Zaria and Samaru-Kataf but response to inoculation was observed only in Samaru-Kataf. Application of P generally increased grain yield with or without inoculation across all the varieties. In this area, application of P is the key to enhancing grain yield.

About 250,000 farmers (about 40% women) were targeted to benefit from the field evaluation and demonstration activities through field days. Demonstrations included the cultivation of soybean, and use of inoculants. They were also linked to the market to sell soybean to agro-processors.

Soybean rust

Asian soybean rust caused by the fungus *Phakopsora pachyrhizi* is an important disease causing yield losses of between 10 and 90%. Resistance breeding is the best management option but this has been made difficult by the high pathogenic variability of the fungus. Our studies have indicated that rust is widely distributed in all agroecologies in the east and southern African region. In



A field of healthy soybean. Photo by IITA

Legume-maize intercropping in a farmer's field in Malawi. Photo by IITA

a capacity development effort, 19 field officers were trained on soybean integrated pest management, especially disease and pest diagnostics. In West Africa, we compared 40 soybean lines with the rust-resistant check TGx 1987-62F in experimental fields at IITA-Ibadan. The results suggest that some susceptible soybean germplasm can produce higher yields than the currently released soybean lines in the absence of soybean rust. Advanced early and medium maturing soybean lines with different degrees of rust resistance will be screened under high soybean rust pressure in on-station trials.

Cowpea cropping systems

In northern Nigeria, experiments were conducted with different row spacings of cowpea—single, double, and triple rows/ridge. Grain yields generally increased significantly with an increasing number of rows/ridge; in one site, double row planting yielded 87% more and triple row planting 74% more than single row planting. Consequently, farmers were trained to use two rows/ridge. Field demonstrations were also established, exposing farmers to improved *Striga* resistant cowpea and two rows/ridge spacing, comparing them with farmers' existing varieties planted using their own practices. Improved varieties planted in double rows/ridge produced more than double the yield of local varieties planted using local practices.

Agriculture for Nutrition and Health

The CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), led by IFPRI, pursues two strategies: to influence agricultural research to focus its contributions on improving health and nutrition outputs and outcomes, and to enhance collaborative research among the agriculture, nutrition, and health research communities. The program is organized around five components: (1) Nutrition-sensitive value chain, (2) Biofortification, (3) Control of agriculture-associated diseases, (4) Integrated agriculture, health, and nutrition programs, and (5) Policy and decision-making across agriculture, health, and nutrition. A4NH activities are implemented in southeast Asia and sub-Saharan Africa. IITA is engaged in the nutrition-sensitive value chain, biofortification, control of agriculture-associated diseases, and integrated agriculture, health, and nutrition programs components.

Nutrition-sensitive value chains

Good nutrition, especially in the first years of a child's life, provides lifelong benefits in health, education, and productivity. However, one in four children under 5 years in the developing world—approximately 148 million children—suffers from undernutrition. Limited information is available on the current nutrition status, type, and amounts of foods consumed, and the nutrient intakes of children under 5 and women of childbearing age in the countries of sub-Saharan Africa.

Adaptation and expansion of a Food and Nutrient Database for Dietary Studies

In collaboration with the School of Public Health, University of Texas-Houston, USA, IITA has developed a Nigerian food, recipe,

A scientist explains about aflatoxins to farmers in Mozambique. Photo by IITA

Safety first

"I have seen the devastating effects of aflatoxins on many Kenyan households. Seeing how many lives have been lost, tons of staple food destroyed, millions of shillings wasted, and livelihoods destroyed, I have thus committed my professional career to addressing food safety issues." As a reward to this commitment, Charity Mutegi, Country Coordinator of IITA's aflasafe project in Kenya, received the 2013 Norman Borlaug Award for Field Research and Application, endowed by the Rockefeller Foundation. Charity was recognized for her work as a member of the IITA research team that had achieved major breakthroughs by applying locally adapted and easy to use biological tools to combat contamination with the deadly aflatoxin mold—one of the worst food safety concerns in the continent—that occurs in staple crops such as maize grain or groundnut.

"Food safety is a very important element of food security, but it is ignored, with costly consequences. In the past a lot of effort has gone into increasing yields, which is good, but we are cognizant of the fact that such efforts can go to waste when food safety concerns are not considered. The biological control product aflasafe was produced using safe, non-toxic strains of the Aspergillus flavus *fungus. These are introduced to the field, where they compete with their toxic cousins, the aflatoxins, pushing them away and thus protecting the crop. My wish would be to see more engagement like this at research and policy levels, so we can deal better with food safety matters and ensure that Africans get safe and healthy food."*

and nutrient database modeled after the United States Department of Agriculture (USDA) Food and Nutrient Database for Dietary Studies (FNDDS). This is a database of foods, their nutrient values, and weights for typical food portions; it is used to code food intake data and to calculate nutrient intakes based on the foods and amounts reported. It is created using the nutrient retention factor methodology and nutrient values from chemically analyzed portions.

Zambia, Swaziland, and Sierra Leone currently have limited and incomplete nutrient and portion information on raw and processed foods. Through adapting and expanding the Nigerian food, recipe, and nutrient database, using the Food Intake Analysis System (FIAS), we have created FNDDS databases for these countries. The latest food consumption and nutrition population survey in the countries was used to identify commonly consumed foods, preparation methods, and portions, and for kitchen testing recipes and chemically analyzing new recipes and foods for nutrients. Fifteen thousand food records reported in the country surveys were reviewed to identify foods not in the current Nigerian database. Dishes not matching existing recipes had new recipes created in FIAS and were kitchen tested for nutrients. The rigorous methodology to create the Nigerian database was replicated using intake data from the three countries. As other African country-specific data are added, the Nigerian database will become the sub-Saharan African Food, Recipe and Nutrient Database (SAFRND). It will aid policymakers and public health workers to estimate the nutritional and nutrient intake status of children under 5 and women of childbearing age.

Nutrition interventions

To promote household use of soybean to improve the nutrition status of children under 5 and women of childbearing age, 12 × 2-day training workshops on soybean processing and utilization

were conducted in 14 communities in Chipata, Katete, and Lundazi districts in eastern Zambia. The objective of the seminars was to show how soybean can be incorporated into traditional food products and to introduce novel soybean-based products, such as soy flour, soy milk, tofu, and soy egg. Among the different products, communities preferred the soy egg, milk, cheese/tofu, and flour. The training workshops were held at the rural community health centers in the villages. A total of 203 women and 32 men participated in the training. Similar workshops were conducted in Mozambique and Swaziland with a total of 5,410 people trained in soybean processing and utilization.

Biofortification of sub-Saharan staple food crops

Food insecurity and malnutrition affects millions in sub-Saharan Africa, especially women and children. This is addressed through research that focuses on increasing the nutrient content of staples and by developing varieties with enhanced nutrient content and reduced compounds that interfere with the absorption and utilization of nutrients (antinutritional factors) to improve the utilization of nutrients.

Development and testing of seeds and roots for improving nutrition

The National Food Consumption and Nutrition Survey in Nigeria shows that nearly 30% of children under 5 suffer from vitamin A deficiency, and 19% of pregnant women and 13% of nursing mothers live with a high risk of vitamin A deficiency. In a project funded by the HarvestPlus Challenge Program of CGIAR as part of strategies to address the prevalence of vitamin A deficiency, IITA in partnership with the Institute for Agricultural Research (Nigeria), has developed pro-vitamin A-rich maize using conventional breeding. After more than 8 years of development and testing, open-pollinated, pro-vitamin A-rich, orange maize varieties have now been released in Nigeria. Other collaborating partners involved in testing include the Institute of Agricultural Research & Training, University of Maiduguri, and the National Centre for Genetic Resources and Biotechnology. The project continues to work with the private sector and community based seed producers to speed up the process of production of good quality seeds of the pro-vitamin A-rich varieties for smallholder farmers. The varieties can supply increased vitamin A levels in the diets of millions of children, pregnant women, and nursing mothers who consume maize every day in Nigeria. The varieties are easy to multiply and disseminate and will provide not only increased levels of pro-vitamin A but also higher yields to farming communities.

Control of agriculture-associated diseases

Aflatoxins are extremely toxic substances produced by the highly prevalent and common *Aspergillus* fungi. Aflatoxins reduce food

Women and children are among the vulnerable groups. Photo by IITA

quality, are barriers to trade, pose serious risks to health, and have caused deaths in Africa and Asia. Recurrence of drought, further induced by climate change, has accentuated the aflatoxin problem. Aflatoxin contamination is pervasive in the food production system in Africa, leading to unknown but significant social and economic costs with respect to impaired health and productivity of people, increased food spoilage, and inability to market agricultural products internationally. A4NH supports the management of aflatoxin through a combination of technical, policy, and institutional measures to significantly reduce the impact of aflatoxin. This is being done through a project that increases awareness of aflatoxin in Nigeria and the biological control of aflatoxins in maize for enhanced food safety and income in Burkina Faso.

In diet diversity we trust

"The price of meat, milk, and eggs—this is what most farmers complain about. They are just too expensive for poor farmers," says Isabel Madzorera, Food Nutritionist based at IITA-Zambia and working with the Making Agricultural Innovations Work for Smallholder Farmers Affected by HIV/AIDS in Southern Africa (MIRACLE) project. MIRACLE covers Zambia, Malawi, Mozambique, and Swaziland.

"Farmers do know that they need animal-based food products to be healthy, but they just can't afford them. And therein lies the problem: these are what people need—children especially—if they are to avoid malnutrition.

"With MIRACLE, this is one of the big issues that we address: improving the nutrition of women and children by introducing affordable crop-based sources of protein. We strive to understand what exactly farmers eat, when, and how—and then encourage them to diversify their diets to include nutrient-dense legumes and vegetables. One of our strategies in MIRACLE has been to promote the processing and use of nutrient-rich crops. We also train farmers to process soybean into flour that can then be used in making breads and other dishes as a protein-dense supplementary meal for people affected by HIV. However, changing people's eating habits is not easy. To this end, we continue to educate households on processing, using, and consuming nutrient-dense crops so that they may have a healthier future."

AgResults initiative implemented

Nigeria is the largest producer and consumer of maize in sub-Saharan Africa and, as smallholder farmers produce 80–90% of all maize in the country, any attempt to control aflatoxin must be focused on that group. The AgResult Aflasafe Project started in 2013 and is funded by the World Bank. This works with Nigerian maize-producing organizations or cooperatives as implementing partners to provide incentives to smallholder farmers to adopt a biological control technology, aflasafe™, which reduces aflatoxin contamination of maize by up to 99%. The project is focused on demonstrating a new model for increasing the adoption of this new technology.

More than a thousand farmers/households in Kaduna, Kano, and Zamfara in Nigeria are currently involved in the program. Four implementing partners received 25 tons of aflasafe™ that was applied by the farmers to more than 2000 hectares of land. The aflasafe-treated maize has been harvested and is undergoing verification test of aflasafe™ and aflatoxin prevalence. Current aflatoxin results show an average of 3.6 parts/billion of aflatoxin from the grain samples tested. Sale of the aflatoxin-reduced maize at a premium price is already being stimulated by the outcome of the test. The household consumption rate of the aflasafe™-treated maize will also be determined.

In addition, innovation platform workshops are conducted to create awareness on aflatoxin management, give information about aflasafe™, and facilitate market linkages between buyers and the implementers. This has led to further contractual agreements between the implementers and members from the feed and food industries in buying the aflasafe™-treated maize.

A partnership between the Ministry of Health (NAFDAC) and Ministry of Agriculture (CADP) in the development of modular Aflatoxin Quality Control centers for maize in different regions in Nigeria is in progress. This developed as a result of the recommendation from the National Flag-off on Aflatoxin Awareness organized by NAFDAC in collaboration with IITA in November 2013.

Demonstration-scale manufacturing factory of aflasafe™

A demonstration-scale plant for aflasafe™ has been developed at IITA in Ibadan, Nigeria, to serve as a blueprint and guide to designing and constructing low-cost manufacturing facilities for a developing country context. Contacts developed and relationships built with equipment manufacturers will help in creating turn-key facilities that can be replicated in other countries. The plant produced a total of more than 80 tons of aflasafe™ for Nigeria, Burkina Faso, Senegal, Zambia, and Kenya in 2013. It was established that aflasafe™ produced in this facility meets rigorous standards at low cost and with the use of commercially available equipment. The results are encouraging for future scaling out and impact of the product. aflasafe™ is provisionally registered in Nigeria with donors and governments supporting its replication and adaptation in several African countries. Final registration of the product is ongoing with NAFDAC, the local regulator in Nigeria.

Demonstration-scale factory for aflasafe in IITA, Ibadan, Nigeria. Photo by IITA

Young boy tending to livestock in an area with poor soil. Photo by IITA

Water, Land, and Ecosystems

IITA's contribution to the CGIAR Research Program on Water, Land, and Ecosystems (WLE) is focused on identifying integrated soil fertility management (ISFM) interventions for the sustainable intensification of farming landscapes, and the development of site-specific recommendations for moving such interventions to scale. Heterogeneous farming landscapes provide the context for site selection and are also the domain within which recommendations are developed. Specific attention is given to the occurrence and rehabilitation of non-responsive soils and quantification of the sustainability aspects of ISFM interventions. Our activities focus on the Volta-Niger basin in West Africa and the Nile basin in East and Central Africa.

With the farming landscape as basis, the key areas for IITA's WLE activities in 2013 were (1) recommendations and measures for increasing crop productivity and soil health, (2) ISFM recommendations for the sustainable intensification of maize-based systems with specific focus on *Striga* management, and (3) diagnostics and rehabilitation of non-responsive soils.

Recommendations and measures for increasing crop productivity and soil health

Identification of effective Rhizobium strains from local soils in Ghana and Nigeria

Research activities were undertaken to identify and disseminate site- and crop-specific recommendations for the use of rhizobial inoculants and accompanying measures to increase grain legume productivity within heterogeneous farming landscapes. Rhizobial strains were isolated in two agroecological zones of northern Ghana.

The strains are being tested to assess their efficacy compared with similar strains in commercial products. Similar work has been conducted in Nigeria where more than 600 isolates were collected from various legume crops, mainly soybean, groundnut, and cowpea, in the Sudan and northern Guinea savannas. The authentication and evaluation of this collection are still ongoing.

Assessment of ISFM components affecting crop responses to inoculation

Activities were undertaken to identify and disseminate recommendations for the use of effective biofertilizers within the context of ISFM. So far, the focus has been on the use of biofertilizers together with phosphorus (P) fertilizers. In Nigeria, where most soils are deficient in P, it was confirmed that the performance of Legumefix (a rhizobium inoculant) is improved when there are sufficiently available levels of P in the soil, and the application of Legumefix together with P is thus recommended. In most cases, 30 kg P/ha has shown good results, but the application rate has to be optimized. Similarly, P application improved soybean responses to Legumefix in Upper West, Tamale, and Upper East regions of Ghana, mbut a lower rate (20 kg/ha) was sufficient.

During the 2012/2013 growing season, data were also collected on inoculum/fertilizer interactions under different soil conditions in Mozambique, in agroecologies similar to those in the Volta-Niger basin. Field trials were conducted at five sites to evaluate the effect of inoculation on six soybean varieties. Inoculation responses varied across agroecologies and among varieties. At two of the sites, inoculation increased grain yields by 500–1200 kg/ha. Follow-up field studies were conducted at four sites and in farmers' fields across the landscape to evaluate the responses to inoculation and the interactive effects of P and starter N application on nodulation and grain yield. Inoculation plus P application produced the highest grain yields, suggesting that inadequate levels of P limited the yields of inoculated plants. This was confirmed by results from the on-farm demonstration trials managed by farmers. Inoculation increased grain yield and was further increased by application of P.

Co-assessment of biofertilizer and/or biopesticide products

Various microbiological products (i.e., biofertilizers or biopesticides) have different modes of action. It was hypothesized that co-inoculation would show synergistic effects. Preliminary results show that co-inoculation of trichoderma (i.e., a biopesticide) and ECO-Rhiz-Soy (a biofertilizer) increased the grain yield of soybean, cowpea, and groundnut. Similarly, co-inoculation of trichoderma and *Bacillus subtilis* (a dual property product that has both biofertilizer and biopesticide properties) produced higher maize yields compared with the single effect of both products. Further studies would be necessary to assess the compatibility of common biofertilizers and biopesticides available in the market.

Scaling up the promising biofertilizer/biopesticide technologies in the context of ISFM

Technologies found efficacious in our research activities are scaled up in farmers' communities. In 2013, dissemination of legume technologies such as Legumefix was sustained in northern Nigeria in collaboration with partners from national institutions. In total, the COMPRO-II and N2Africa project reached approximately 44,000 farmers across Benue, Kano, Kaduna, and Niger States with the purpose of creating awareness about these cost-effective and environmentally friendly technologies. The adoption of the technologies will allow resource-disadvantaged smallholder farmers to redirect agricultural lands into sustainable use by minimizing the nutrient depletion of the soil. In addition, several legume technologies, consisting of packages of promiscuous soybean

IITA scientists looking at Striga infestation in a maize field. Photo by IITA

varieties, inoculants, and P fertilizer, were found to be well adapted to the agroecologies of northern Nigeria. The projects will continue to reach out to more farmers to improve the productivity of more agricultural land, resulting in better natural resource management.

Sustainable intensification of maize-based systems

The damaging impact of *Striga hermonthica*, a soil-borne parasitic weed affecting the productivity of maize-based systems in the Volta-Niger basin, varies substantially within farming landscapes and appears to be related to general soil fertility conditions. The weed thrives in dry areas particularly on soils low in nitrogen and organic matter. To plan and implement interventions for the successful management of the weed in the Nigerian savannas, a series of surveys were carried out in 2011 and 2012. The objective was to assess the level and extent of infestation of cereal and cowpea fields and the severity of the attack on crops, and to determine the soil factors associated with infestation of crop fields. There was a high level of infestation in cowpea, maize, millet, and sorghum. The severity of attack ranged from high to very high for all the crops. Detailed soil analysis showed that poor soil fertility in these communities may, in part, be contributing to the high level of *Striga* infestation that was observed.

Assessing, understanding, and targeting non-responsive soils

Evidence has been accumulating that many smallholder croplands in sub-Saharan Africa show a very low agronomic efficiency of agro-inputs, e.g., fertilizer and/or improved varieties. This so-called "non-responsiveness" can arise from physical, chemical, and biological conditions in the soils that are inherent or induced by the removal of crop residues, i.e., with minimal return or addition of nutrients. Knowledge on the specific causes of non-responsiveness in African smallholder croplands, and diagnostic tools to identify them is not

well developed. In 2013 this project assessed the rate of economic non-responsiveness to inorganic fertilizer, i.e., when the value of yield increase in response to fertilizer input is less than twice the cost of the fertilizer, field trials were performed in 94 smallholder farms in Tanzania (Tabora Region), Kenya (Siaya County), and Nigeria (Kaduna State). Across the agroecological zones and various soil types, 30–50% of the croplands were considered economically non-responsive. Management practices such as time of fallowing and use of inorganic fertilizers and manure were shown to increase agronomic fertilizer efficiency. Conversely, the further fields were located from farmers' homesteads the less profitable was the use of inorganic inputs for maize and soybean crops. These and other findings show that fertilizer usage needs to be integrated in a larger diagnostic and management framework. In the next two years the NSF-BREAD project will explore more deeply the soil-specific constraints on the agronomic efficiency of inorganic inputs and take part in the development of low-cost and field-portable diagnostic tools for screening soil-plant health status. In the end such research will help in customizing management recommendations for improved crop productivity on degraded or marginal soils.

Sustainable soil inputs

"On-farm trails performed in 2013 show that between 30 and 50% of the crop lands are non-responsive to inorganic fertilizer inputs," says Dries Roobroeck (above, right), a postdoctoral fellow on soil fertility management based in IITA, Nairobi, Kenya. "I work on a project concerning the 'non-responsiveness' of maize and soybean cropping systems to inorganic fertilizer inputs, which aligns with the development of low-cost and field-portable diagnostic tools for plant-soil health assessments. Besides this I assist in studies on the use of biochar for the control of soil-borne diseases and improvement of fertilizer use efficiency. I am excited to work in the IITA research on natural resource management and to be able to actively contribute to the institution's new strategy on sustainable intensification of farming systems. My project aims to assess the extent of non-responsiveness of crops, understanding the biogeochemical causes, and targeting different options to improve agronomic efficiency of fertilizer inputs in smallholder maize and soybean cropping systems in DR Congo, Kenya, Tanzania, and Nigeria. Differences in crop responsiveness to inorganic inputs according to soil type and management history demonstrate the need for customizing fertilizer recommendations to optimize agronomic efficiency and come up with a viable intensification pathway."

Climate Change, Food Security and Agriculture (CCAFS)

CCAFS was among the first CGIAR Research Programs to start. CIAT is leading this global, collaborative effort involving all 15 CGIAR centers. IITA is involved in activities in Africa where the main collaborators are NARS partners in the west and east African humid zones and CGIAR centers CIAT, ILRI, ICRAF, Bioversity, and IFPRI. CCAFS' vision is to reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high quality international agricultural research, partnership, and leadership. The program is organized into four closely interlinked themes: (1) Adaptation to Progressive Climate Change, (2) Adaptation through Managing Climate Risk, (3) Pro-poor Climate Change Mitigation, and (4) Integration for Decision-Making. In 2013, IITA concentrated its efforts on themes 1 (adaptation) and 3 (mitigation), but also increased its contributions to theme 4 (integration for decision-making).

Banana and coffee intercropping is one climate-smart system that contributes to adaptation and mitigation of climate change. Photo by IITA

The IITA CCAFS team is working on three linked themes:

Adaptation through improved germplasm and IPM

The impact of climate change on staple crops in Africa will be very important. Cereal crops, in particular, may experience yield losses amounting to tens of percentage in the coming decades because of increasing temperatures and changes in rainfall quantities and distribution. To prevent severe losses in income and food security, scientists are developing more resistant germplasm that can cope better with drought, pest, and disease stresses. Alternatively, farmers can also shift crops that are less sensitive to the predicted climate changes, such as cassava, banana, and cowpea. IITA is conducting research on understanding the impact of climate variables on IITA's mandate crops, particularly those that look promising for climate change adaptation.

A joint review and planning workshop between CCAFS and RTB was organized in February 2013 by CIP, IITA, Bioversity, and CIAT on *Management of critical pests and diseases through enhanced risk assessment and surveillance and understanding of climate impacts through enhanced modeling* (workshop report available at: http://www.rtb.cgiar.org/publication/rtb-and-ccafs-scientific-and-planning-workshop-report/wppa_open/). The knowledge on plant

health issues for root, tuber, and banana crops was also taken into account in a priority setting exercise for research that involved both a large expert survey and an ex-ante assessment of yield constraints and potential technical solutions.

The IITA team also investigated interactions among cowpea, endophytic organisms such as the fungus *Beauveria bassiana* and mycorrhizal fungi, and the pod borer *Maruca vitrata*, an important cowpea pest, under adverse climatic conditions with regard to rainfall (simulated through varying watering regimes). The study was carried out both as a screenhouse experiment using potted plants and artificial pod borer infestation, and as a set of field experiments under different climatic conditions with natural infestation. Plants inoculated with beneficial endophytes seemed to cope better with the climate-induced stresses.

Besides the work by plant health specialists, progress was made on better understanding the interaction between plant genotypes (G) and the environment (E) for more targeted breeding of IITA mandate crops. A germplasm catalog for cowpea was initiated, with 75 new entries being uploaded, to strengthen cowpea diversity to tackle climate change. In addition, sets of historical cowpea breeding trial data were organized and converted into Agtrial format—the CCAFS database on agricultural trials across the globe. This activity is conducted in close collaboration with the IITA Biometrics Unit.

Adaptation and mitigation challenges in perennial-based cropping systems

From its Uganda office, IITA is an active member of the Sustainable Agricultural Initiative (SAI) platform, a food industry initiative (including Nestlé, Unilever, and Danone) for sustainable agriculture worldwide. IITA contributed actively to the development of the industry's rules (PCR) for quantifying the carbon footprint of global

Changing climate change with farmers

''We cannot work with farmers on the causes of climate change but we can work with them on changing some of its impact," says Laurence Jassogne, Systems Agronomist based at IITA-Uganda and coordinator of a project that is looking at synergies in climate change adaptation and mitigation in coffee and cocoa systems. "There are not many farmers in the areas that we work in who are not concerned with climate change. However, the meaning that they give to it is quite diverse. For many, unpredictable or unfavorable weather conditions are already associated with climate change. In our coffee work, we train farmers on climate change adaptation by introducing maps that indicate where coffee could be suitably grown now and where in the future when the climate is actually changing. Basically, we develop together ways to adapt in the short and long term. This is one way of how we implement our project in which we are developing all kinds of 'climate-smart' practices with farmers that will help to adapt to the effects of climate change.

"In 2013, we completed the yield gap analysis of the different coffee areas in Uganda – a key output in our climate change research. We are now able to rank the major constraints in the coffee-growing regions. We also developed a map showing the major soil nutrient deficiencies of specific areas. Our recommendations can help coffee and cocoa producers to become more cost-efficient as they can target the most deficient soil nutrients first, consequently increasing their productivity and income.''

coffee production. The IITA contribution focused on defining the boundaries of the production systems (e.g., how to attribute greenhouse gas [GHG] emissions in intercropped vs monocropped coffee fields) and participation in SAI platform meetings with the coffee industry partners. The industry adopted the Cool Farm Tool (www.coolfarmtool.org) as their primary tool to quantify carbon footprints. IITA has engaged with the developers of the tool to further discuss how to quantify better the GHG emissions released during the "wet processing" of coffee; i.e., a process where the fruit flesh is separated from the beans through fermentation.

Besides direct emissions of GHG, about half of the emissions originating from agriculture are due to land use changes, most notably the conversion of carbon-rich forests and wetlands into agricultural land. Within the realm of the use of perennial systems as a tool both for the mitigation of and adaptation to climate change, a study was conducted on cocoa as a driver for deforestation in DR Congo. The results showed that deforestation is still largely driven by population movements and the expansion of staple food crops, as opposed to the trend in West Africa, where cocoa has been identified as a major driver for deforestation, causing significant emissions of the GHG responsible for climate change. The impact of crop and land use changes on deforestation was further studied in the joint ICRAF-IITA project called *Reducing Emissions from All Land Use* (REALU) towards a landscape approach for reducing emissions in Cameroon. This is part of the *Alternatives to the Slash and Burn* (ASB) project (www.asb.cgiar.org/PDFwebdocs/CAMEROON_REALU.pdf). REALU uses a whole landscape approach to managing carbon and supporting livelihoods. Through action research, REALU develops a set of approaches, methodologies, and national capacities to implement effective landscape-based strategies for *Reducing Emissions from Deforestation and Degradation* (REDD+) within a context of rural sustainable development, national sovereignty, respect for community and indigenous rights, and the integrity of a global GHG accounting system.

A major joint BMZ-funded project, titled *Trade-offs and synergies in climate change adaptation and mitigation in coffee and cocoa systems,* started in 2013 and includes IITA, CIAT, and other national partners in Ghana (CRIG, Agro-Eco), Uganda (NaCORI, HRNS), and Tanzania (TaCRI). The project aims to develop climate-smart cocoa and coffee technologies that will help both the smallholders and the industry to create a steady income and supply. This included launching workshops with NARS partners and the recruitment of 6 PhD students with university partners in Germany (2 Gottingen and 1 Hanover), Netherlands (1 WUR), Switzerland (1 ETH), and South Africa (1 WITS). In addition, a new project, Cocoa-Eco, focused on developing climate-smart cocoa systems in Ghana, was funded by SNV in partnership with Ghana's largest cocoa cooperative, Kuapa Kokoo. The project already delivered updated coffee and cocoa suitability maps and initiated the characterization of potential for adaptation and mitigation of various coffee and cocoa systems.

Integration for decision-making

IITA was the lead organizer for a CGIAR-wide workshop on analyzing trade-offs and synergies in agricultural systems that was organized in February 2013 in Wageningen, the Netherlands. Understanding system dynamics, identifying tipping points, and understanding trade-offs across temporal/spatial scales and actors require the identification of key parameters in the systems and an understanding of their sensitivity to climate change. It is important to note that research on these systems not only requires insights into the biophysical dynamics but also into human behavior (i.e., socio-political and economic drivers). The workshop received strong technical and funding support from CCAFS. It attracted around 30 participants representing five CGIAR Research Programs and several

CGIAR centers and universities. The workshop focused on both technical approaches to trade-off analysis, and the theory of change and underlying assumptions that need to be addressed to reach impact at scale. The main objectives were to (i) share experiences on available methods and tools to identify and analyze trade-offs in agricultural systems, (ii) discuss and explore how lessons learned can be applied within CGIAR Research Programs, and (iii) explore the potential for synergies and collaboration between scientists and programs. The workshop resulted in a report and a paper on trade-off analysis in agricultural systems in the journal Current Opinion in Environmental Sustainability (http://dx.doi.org/10.1016/j.cosust.2013.11.012).

In Rakai, Uganda, the IITA team pursues participatory identification and the development of adaptation options to overcome climate change. To enable and begin fruitful discussion with extension partners and farmers, a series of communication materials were developed with the help of partners. The discussions revealed that smallholders' vulnerability to climate change had increased over the past decades with their decreasing access to wetlands and grazing lands that were considered communal in the past. Nowadays, these lands are owned by large property owners. They often fence off or guard the area while transforming them into eucalyptus woodlots. Consequently, farmers can no longer have access to these lands that would buffer feed and food needs during periods of drought. National and local policies are not enforced—policy-implementing agents are often absent or poorly linked, according to a climate change policy study in Uganda conducted by IITA for CCAFS.

Performance and outlook

IITA was rated consistently among the top centers for 2012 and 2013 performance within CCAFS for work on the climate-smart coffee systems based on banana intercropping. Furthermore, an IITA-led concept note for a new CCAFS call, aimed at creating impact at the national policy level as of 2014, was selected for funding. As a consequence, IITA will almost double its CCAFS funding for 2014 and will further strengthen its plant and farm-level research with a PhD research on policy and gender. In collaboration with national climate change units, ministries, and NARS partners, a CGIAR group led by IITA and consisting of CIAT, ILRI, ICRAF, and Bioversity will be engaging with policymakers in Uganda and Tanzania.

PhD students working on climate change research in Uganda. Photo by IITA

Genebanks

The collection, conservation, documentation, and facilitation of the effective use of plant genetic resources are central components of efforts to enhance food security. IITA's Genetic Resources Center (GRC) houses key germplasm collections of the major staple crops of sub-Saharan Africa, cassava, cowpea, maize, yam, soybean, banana and plantain, also of African yam bean, bambara groundnut, winged bean, and other legumes.

The CGIAR Research Program for Managing and Sustaining Crop Collections (Genebanks) has the following four major objectives:

Morphological characterization of wild Vigna. Photo by IITA

1. Crop diversity in International Collections under Article 15 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is secured in perpetuity
2. Conserved crop germplasm is clean, available, and disseminated
3. Use of conserved crop diversity is informed and facilitated
4. Crop diversity is conserved within a rationalized, cost-effective, and globalized system

During 2013 progress has been made in all these areas.

In the regeneration and characterization of our collections we have developed the use of field sites away from Ibadan (Ikenne and Ubiaja for cassava and yam, Mokwa for legumes with an additional experimental site at Kano). This allows us to optimize the regeneration of accessions that may not perform well at Ibadan. For the field phenotyping of our collections, we are working more closely with the breeders at IITA to incorporate aspects of agronomic evaluation into our work. At the same time, we are developing approaches to integrate data collected on accessions in the field by GRC with that from breeders' trials to add value to both datasets. Together with the banana/plantain breeding group we are taking part in a global exercise for the characterization of key accessions in these species.

In 2013 the CGIAR genebanks developed and adopted new guidelines for the conservation of genetic stocks (e.g., mapping populations). The value of the GRC collections means that keeping a secure "copy" of the accessions we hold (i.e., safety duplication) is a vital aspect of the work we do. During 2013, 2338 accessions of our seed crops were duplicated at the Svalbard Global Seed Vault in Norway and 2,365 accessions of the clonal crops (cassava and yam) in AfricaRice, Cotonou, Benin Republic. For the future, we have agreed that maize will also be duplicated at CIMMYT and legume crops at CIAT.

Neglected and underutilized species

The main thrust of our work, and the great majority of accessions in our collections concern the major staple crops of sub-Saharan Africa. However, several species are important in the diet of millions of people but receive little attention in terms of research and breeding and, as a result, they have not yet fulfilled their potential as food crops. One example is taro (*Colocasia esculenta*). With funding from RTB, we have employed a consultant to report on the current status of this crop in Nigeria, Ghana, and Cameroon and the threat posed by Taro Leaf Blight, with a view to reinvigorating research on this crop.

Characterizing cowpea germplasm. Photo by IITA

Safety duplication

It is critically important to duplicate our collections elsewhere to ensure their safety in case of any natural or man-made threats to the genebank at Ibadan.

Yam and cassava in the Genetic Resources Center's in-trust collection are duplicated for safety at the Africa Rice Center facility in Cotonou, Republic of Benin. The total accessions of these two crops at IITA are 4413 out of which 3643 accessions have been duplicated since 2004.

Safe duplicates of seeds from IITA's seedbank collections are stored at the Svalbard Global Seed Vault (established in the permafrost in the mountains of Svalbard and designed to store duplicates of seeds from seed collections around the globe) as well as in the Saskatoon genebank in Canada and also at CIMMYT. In the last four years we have duplicated a total of 16,472 (65%) accessions of our collections.

The table below summarizes the safety duplication so far. The aim is to duplicate the entire collection by 2016.

Crop	Total accessions in collection	Accessions safely duplicated	
	no.	no.	%
Cowpea	15,379	11,761	76%
Soybean	4,841	1,522	31%
Bambara groundnut	1,752	932	53%
Maize	1,565	713	46%
Wild *Vigna* spp.	1,543	1,517	98%
African yam bean	456	27	6%
Yam	1,619	1,386	86%
Cassava	2,794	2,257	81%
Grand total	**29,949**	**20,115**	**67%**

With the same rationale, we have undertaken field experiments to characterize accessions of winged bean and we are complementing this with molecular analysis of genetic diversity. Similar diversity studies on African yam bean have given interesting results. Both these species are tuber-forming legumes which have the potential to play a more significant part in the diets of West Africans.

Outreach and impact

The year 2013 saw a significant increase in the distribution of breeders' lines (BL), particularly of cassava and banana. Distribution for these species, in line with phytosanitary requirements, is carried out in the form of tissue culture plantlets and is additional to the distribution of our collection for research and breeding elsewhere.

Laboratory viability testing of genetic resources for viable seed distribution.
Photo by IITA

A key aspect of our future work will be a stronger focus on the impact of the distribution of accessions in terms of new varieties and how they affect farmers' livelihoods. To this end, a PhD student, jointly supervised by GRC and the socioeconomics unit of IITA, has been carrying out a survey in northern Nigeria, analyzing the adoption of new cowpea varieties but (more importantly) how they have enhanced food security either through direct consumption or as a source of cash.

We have also taken steps to increase the level of feedback from those in receipt of our germplasm concerning its use and this will be followed up in 2014 with a survey of customer satisfaction. GRC had a strong presence at the International Symposium on Tropical Root Crops–Africa Branch (ISTRC-AB) held in Accra in September 2013 and was involved in organizing the First Global Yam Conference which immediately followed ISTRC-AB at the same venue. A number of presentations from GRC staff were made and these meetings were important opportunities for networking, information exchange, and the initiation of new collaborations.

Capacity building and collaboration

During 2013 GRC received a very large number of visitors and undertook longer periods of training for 19 individuals, and four ongoing MSc students and two PhD students. Three of the MSc students are working on different aspects of tissue culture and one on molecular genetic diversity. Following exchange visits, we have also strengthened collaboration with the National Root Crops Research Institute at Umudike, Nigeria, in the areas of conservation and use of clonal crops, including tissue culture and pre-breeding. Several specific steps have been identified that will be implemented in 2014.

Cowpea collection for our children

"In the IITA Genetic Resource Center (GRC) we hold the world's largest collection of cowpea, the most important food legume in West and Central Africa," says Badara Gueye, a cell biologist and physiologist. He manages the in vitro genebank and lab of GRC. "Our genebank maintains this collection in trust for the world, our children, and the children of our children with almost 17,000 accessions from about 90 countries across the globe. Cowpea is an important source of vegetable protein and a crucial food security crop especially in arid regions of Africa. In many parts it is the only major food source available by the end of the dry season when the markets are empty.

"Cowpea will become increasingly important due to its potential as a climate-resilient crop which could tackle the risk of hunger in the face of climate change. The crop's potential will be further enhanced by its role as a cash crop for farmers. Therefore we expect the demand for cowpea to grow faster than the supply. At GRC, we conserve, characterize, document, and make available the genetic resources of this important crop to everybody throughout West Africa and beyond. An important part of realizing the practical benefits and use of IITA's cowpea collection will come from our cooperation with cowpea breeders and farmers in the form of joint evaluation. We believe that participatory evaluation of our collection will speed up the use of germplasm by farmers and enhance the cowpea production significantly."

In the future, the CGIAR genebanks are likely to take on a central role in the generation and analysis of sequencing data. Within GRC, we have started the processes of building the necessary skills and expertise to allow us to play our part in this.

Legume seeds maintained in the IITA genebank. Photo by IITA

Photo by IITA

Financial Information

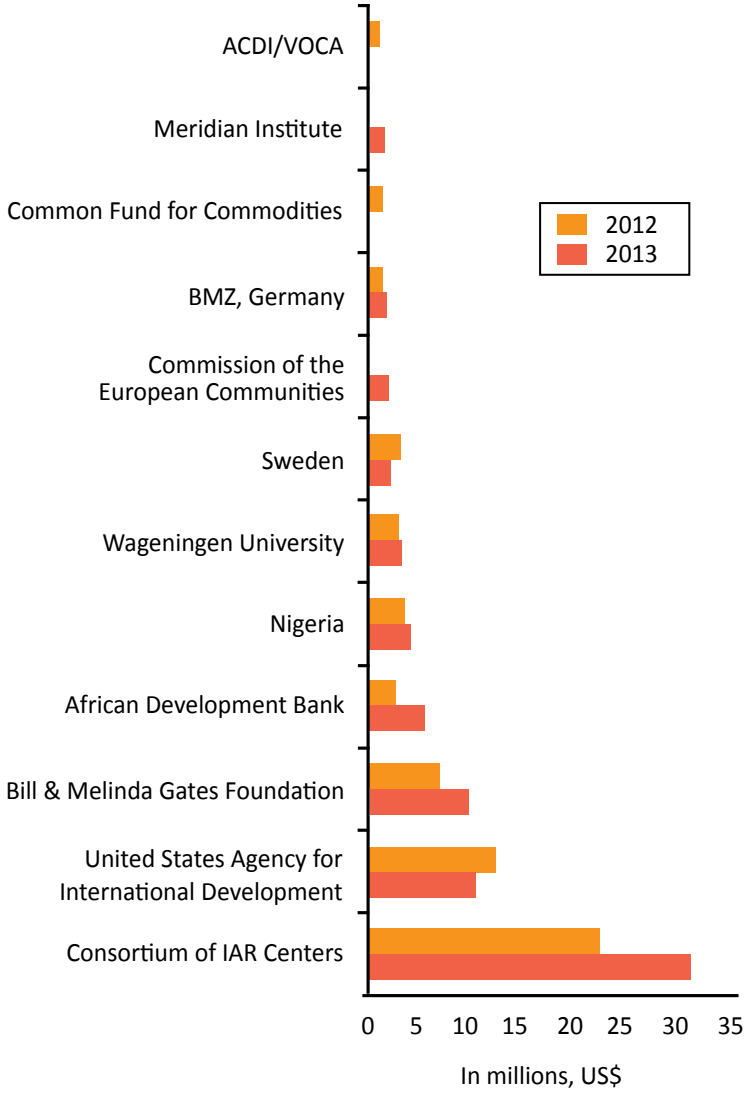
Funding for 2013 was US$87.140 million (2012: US$71.629 million), of which 99% came from CGIAR investors and 1% from other sources. Expenditures were $85.092 million (2012: US$69.097 million, net of indirect cost recovery of US$8.574 million, of which 90.5% was used for program expenses and 9.5% for management and general expenses.

Figure 1 shows the governments and agencies that provided the largest share of IITA's funding in 2012 and 2013 (top 10 donors) while Figures 2 and 3 reflect the distribution IITA`s 2013 budjet and expenditures, by CGIAR Research Program.

Table 1 shows IITA's 2012 and 2013 investment by CGIAR Research Program; Table 2 reflects 2012 and 2013 financial health indicators; and Table 3 lists the 2012 and 2013 IITA investors.

IITA's innovative partnership has resulted in generating more resources for research. Photo by IITA

Figure 1. Funding: Top 10 donors, 2012 and 2013



A farm couple showing off a good maize crop.

Figure 2. 2013 Investment by CGIAR Research Programs Budget

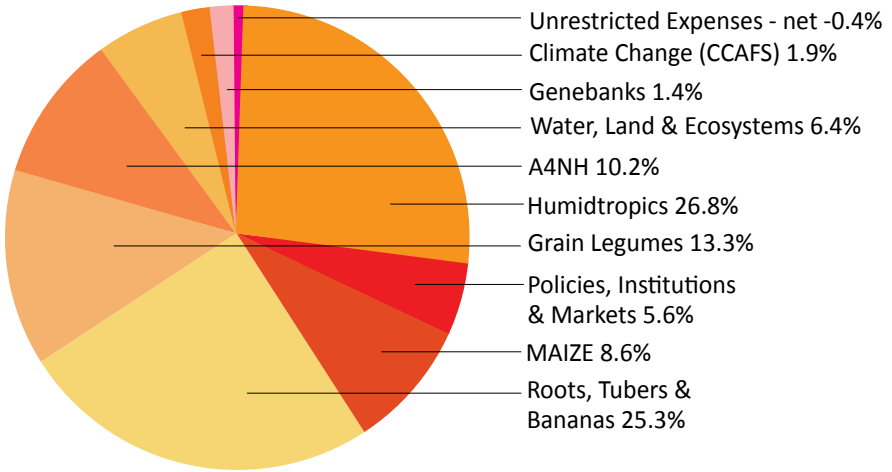


Figure 3. 2013 Investment by CGIAR Research Programs Expenditure

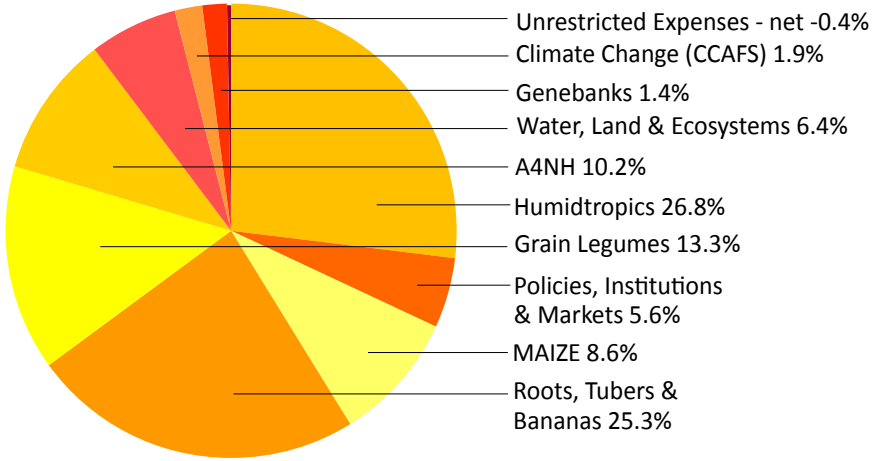


Table 1. 2013 Investment by CGIAR Research Program.

CGIAR Research Programs	Budget ($'000)			Actual Expenses ($'000)		
	Unrestricted / Windows 1&2	Window 3 / Bilateral Projects	Total	Unrestricted / Windows 1&2	Window 3 / Bilateral Projects	Total
Humidtropics*	13,672	12,799	26,471	11,819	11,104	22,923
Policies, Institutions & Markets	666	4,871	5,537	665	3,614	4,279
MAIZE	1,679	6,859	8,538	1,527	6,343	7,870
Roots, Tubers & Bananas	6,892	18,109	25,001	6,536	13,601	20,137
Grain Legumes	6,476	6,687	13,163	6,477	6,056	12,533
Nutrition and Health	2,450	7,634	10,084	2,430	6,178	8,608
Water, Land & Ecosystems	262	6,099	6,361	262	5,090	5,352
Climate Change (CCAFS)	668	1,202	1,870	668	982	1,650
Genebanks	956	436	1,392	957	542	1,499
Windows 1&2 and Restricted CGIAR Research Programs	33,721	64,696	98,417	31,341	53,510	84,851
Unrestricted (net)	-365	-	-365	241	-	241
	33,356	**64,696**	**98,052**	**31,582**	**53,510**	**85,092**

* Includes Humidtropics Windows 1&2 partners' expenditures (2013: $7.967 M and 2012: $4.626 M) per CGIAR Advisory Note.

Table 2. Performance indicators: financial health

	2012	2013
Short-term Solvency (or Liquidity)	31 days	35 days
Long-term Financial Stability (adequacy of reserves)	31 days	35 days
Indirect Cost Rates	14.84%	15.51%
Cash Management on Restricted Operations	0.11	0.51
Audit Opinion	Unqualified / Clean bill of financial health	

Table 3. List of IITA investors.

IITA investors	2012 (in US$ thousands)	2013 (in US$ thousands)
ACDI/VOCA	1,055	40
African Agricultural Technology Foundation (AATF)	142	66
African Development Bank	2,573	5,365
AGRA	173	553
Austria	50	247
Belgium	385	554
Bill & Melinda Gates Foundation	6,884	9,661
GIZ, Germany	1,210	1,708
Canada	68	28
Catholic Relief Service	30	91
Chemonics International	-	24
CIMMYT	1,874	1,755
CORAF/WECARD	74	288
Cornell University	92	742
Commission of the European Communities	141	1,860
Common Fund for Commodities	1,196	1,122
Consortium of IAR Centres	22,478	31,341
Denmark	62	111
DDPSC	100	-
Food and Agriculture Organization	227	93
France	330	330
Global Crop Diversity Trust (GCDT)	189	393
icipe	-	58

ITA investors	2012 (in US$ thousands)	2013 (in US$ thousands)
ICRISAT	1,564	1,237
International Fund for Agricultural Development	-	354
IFPRI	427	548
Ireland	166	101
Japan	796	1,244
Leventis Foundation	68	115
L`Union Economique et Monetaire Quest Africaine	520	-
Meridian Institute	743	1,436
Nestle	268	-
Netherlands	448	427
Nigeria	3,453	3,994
Norway	-	-
Purdue University	497	37
Rockefeller Foundation	-	500
Sierra Leone	213	468
Sweden	3,108	2,097
Switzerland	115	505
United States Agency for International Development	12,301	10,389
Wageningen University	2,910	3,116
WASCO	437	-
World Bank	62	42
Miscellaneous projects	1,831	2,478
Challenge Programs	1,385	785
Grand total	**70,645**	**86,303**

Commercial mass propagation of banana plants. Photo by IITA

Photo by IITA

Publications

In 2013, IITA scientists published articles in peer-reviewed Thompson-indexed journals, book chapters, review articles, chapters in conference proceedings, and various other publications. A selection of some of these articles from the different hubs is presented below by research theme:

Natural resource management

Dewitte O, Jones A, Spaargaren O, Breuning-Madsen H, Brossard M, Dampha A, Deckers J, Gallali T, Halletti S, Jones R, Kilasara M, Le Roux P, Michéli E, Montanarella L, Thiombiano L, Van Ranst E, Yemefack M, and Zougmore R. 2013. Harmonisation of the soil map of Africa at the continental scale. Geoderma 211-212.

Gentile RM, Vanlauwe B, and Six J. 2013. Integrated soil fertility management: Aggregate carbon and nitrogen stabilization in differently textured tropical soils. Soil Biology and Biochemistry 67: 124-132.

Ndabamenye T, Van Asten PJA, Blomme G, Vanlauwe B, Uzayisenga B, Annandale JG, and Barnard RO. 2013. Nutrient imbalance and yield limiting factors of low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. Field Crops Research 147: 68-78.

Ndabamenye T, Van Asten PJA, Blomme G, Vanlauwe B, Swennen R, Annandale JG, and Barnard RO. 2013. Nutrient imbalance and yield limiting factors of low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. Field Crops Research 135: 126-136.

Ndabamenye T, Vanlauwe B, Van Asten PJA, Blomme G, Swennen R, Uzayisenga B, Annandale JG, and Barnard RO. 2013. Influence of plant density on variability of soil fertility and nutrient budgets in low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. Nutrient Cycling in Agroecosystems (DOI 10.1007/s10705-013-9557-x).

Otinga AN, Okalebo JR, Njoroge R, Emong'ole M, Six L, Vanlauwe B, Pypers P, and Merckx R. 2013. Partial substitution of phosphorus fertilizer by farmyard manure and its localized application increases agronomic efficiency and profitability of maize production. Field Crops Research 140: 32-43.

Paul BK, Vanlauwe B, Ayuke F, Gassner A, Hoogmoed M, Hurisso TT, Koala S, Lelei D, Ndabamenye T, Six J, and Pulleman MM. 2013. Medium-term impact of tillage and residue management on soil aggregate stability, soil carbon, and crop productivity. Agriculture, Ecosystems and Environment 164: 14-22.

Tueche J, Norgrove L, Hauser S, and Cadisch G. 2013. Tillage and varietal impacts on tomato (*Solanum lycopersicum* l.) production on an ultisol in central Cameroon. Soil and Tillage Research 128: 1-8.

Vandamme E, Renkens M, Pypers P, Vanlauwe B, Smolders E, and Merckx R. 2013. Root hairs explain P uptake efficiency of soybean genotypes grown in a P-deficient Ferralsol. Plant and Soil. In Press.

Vanlauwe B, Wendt J, Giller KE, Corbeels M, Gerard B, and Nolte C. 2013. A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: the appropriate use of fertilizer to enhance crop productivity. Field Crop Research. In Press.

Wendt J and Hauser S. 2013. An equivalent soil mass procedure for monitoring soil organic carbon in multiple soil layers. European Journal of Soil Science 64: 58-65.

Plant production and health

Adegbola RO, Ayodeji O, Awosusi O, Atiri G, and Kumar PL. 2013. First report of banana bunchy top virus in banana and plantain (*Musa* spp.) in Nigeria. Plant Disease 97: 290-292.

Adikini S, Beed F, Tusiime G, Tripathi L, Kyamanywa S, Lewis Ivey ML, and Miller SA. 2013. Spread of *Xanthomonas campestris* pv. *musacearum* in banana plants: implications for management of banana *Xanthomonas* wilt disease. Canadian Journal of Plant Pathology. DOI:10.1080/07060661.2013.845856.

Agboton BV, Hanna R, Onzo A, Vidal S, and von Tiedemann A. 2013. Interactions between the predatory mite *Typhlodromalus aripo* and the entomopathogenic fungus *Neozygites tanajoae* and consequences for the suppression of their shared prey/host *Mononychellus tanajoa*. Experimental and Applied Acarology 60: 205-217.

Agunbiade TA, Sun W, Coates BS, Djouaka RF, Tamo M, Ba MN, Binso-Dabire L, Baoua I, Olds BP, and Pittendrigh BR. 2013. Development of reference transcriptomes for the major field insect pests of cowpea: a toolbox for insect pest management approaches in West Africa. PLOS ONE 8: 1-14.

Bothon FTD, Gnanvossou D, Noudogbessi JP, Hanna R, and Sohounhloue D. 2013. *Bactrocera cucurbitae* response to four *Cymbopogon* species essential oils. Journal of Natural Products 6: 147-155.

Nakato V, Beed F, Ramathani I, Kubiriba J, Rwomushana I, and Opio F. 2013. Risk of banana *Xanthomonas* wilt spread through trade routes and practices. Journal of Crop Protection 2: 151-161.

Onzo A, Bello IA, and Hanna R. 2013. Effects of the entomopathogenic fungus *Neozygites tanajoae* on the predatory mite *Typhlodromalus aripo* on cassava green mite: screenhouse experiments. BioControl 58: 397-405.

Paparua P, Dubois T, Coyne D, and Viljoenc A. 2013. Differential gene expression in East African highland bananas (*Musa* spp.): Interactions between non-pathogenic *Fusarium oxysporum* V5w2 and *Radopholus similis*. Physiological and Molecular Plant Pathology 82: 52-63.

Wagacha JM, Mutegi C, Karanja L, Kimani J, and Christie ME. 2013. Fungal species isolated from peanuts in major Kenyan markets: Emphasis on *Aspergillus* section *Flavi.* Crop Protection 52: 1-9.

Zandjanakou-Tachin M, Ojiambo P, Vroh Bi I, Tenkouano A, Gumedzoe YM, and Bandyopadhyay R. 2013. Pathogenic variation of *Mycosphaerella* species infecting banana and plantain in Nigeria. Plant Pathology 62(2): 298-308.

Biotechnology and plant breeding

Badu-Apraku B, Yallou C, and Oyekunle M. 2013. Genetic gains from selection for high grain yield and *Striga* resistance in early maturing maize cultivars of three breeding periods under *Striga*-infested and *Striga*-free environments. Field Crops Research 147: 54-67.

Huynh B-L, Close TJ, Roberts PA, Hu Z, Wanamaker S, Lucas MR, Chiulele R, Cisse N, David A, Hearne S, Fatokun C, Diop NN, and Ehlers JD. 2013. Genepools and the genetic architecture of domesticated cowpea. The Plant Genome 6: 1-8.

Kawuki RS, Herselman L, Labuschagne MT, Nzuki I, Ralimanana I, Bidiaka M, Kanyange MC, Gashaka G, Masumba E, Mkamilo G, Gethi J, Wanjala B, Zacarias A, Madabula F, and Ferguson ME. 2013. Genetic diversity of cassava (*Manihot esculenta* Crantz) landraces and cultivars from Southern, Eastern and Central Africa. Plant Genetic Resources available on CJO2013. Doi:10.1017/S1479262113000014.

Muchero W, Roberts PA, Diop NN, Drabo I, Cisse N, Close TJ, Muranaka S, Boukar O, and Ehlers JD. 2013. Genetic architecture of delayed senescence, biomass, and grain yield under drought stress in cowpea. PLOS ONE 8: 1-10.

Ndabamenye T, van Asten PJA, Blomme G, Vanlauwe B, Swennen R, Annandale JG, and Barnard RO. 2013. Ecological characteristics and cultivar influence optimal plant density of East African highland bananas (*Musa* spp. AAA-EA) in low input cropping systems. Scientia Horticulturae 150: 299-311. http://dx.doi.org/10.1016/j.scienta.2012.11.037

Social science and agribusiness

Adejumo O, Atanda O, Raiola A, Somorin Y, Bandyopadhyay R, and Ritieni A. 2013. Correlation between aflatoxin M1 content of breast milk, dietary exposure to aflatoxin B1 and socioeconomic status of lactating mothers in Ogun State, Nigeria. Food and Chemical Toxicology 56: 171-177.

Ainembabazi JH, Shively G, and Angelsen A. 2013. Charcoal production and household welfare in Uganda: a quantile regression approach. Environment and Development Economics 18(5): 537-558.

Romijn E, Ainembabazi HJ, Wijaya A, Herold M, Angelsen A, Verchot L, and Murdiyarso D. 2013. Exploring different forest definitions and their impact on developing REDD+ reference emission levels: a case study for Indonesia. Environmental Science and Policy 33: 246-259.

Tambo JA and Abdoulaye T. 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Regional Environmental Change 13(2): 375-388.

As a knowledge resource center, IITA provides an avenue for young students visiting IITA to learn more about science and agriculture. Photo by IITA

Photo by IITA

Capacity Building

In keeping with IITA's strategic objectives, capacity building activities continue to expand through increased partnership activities with regional economic commissions, the private sector, NARS, advanced research institutes, government ministries, and universities. IITA's 2013 annual report reflects the institute's focus on developing capacity to contribute to the reduction of hunger and poverty in the tropics.

IITA's capacity development program focuses on developing the skills of staff and scientists in the region. It also facilitates IITA's organizational and institutional development, and strengthening of information systems. To this end, several activities that will raise the capacity for agricultural R4D have been implemented. These include the engagement of graduate and undergraduate students, development of collaboration with NARS and academic scientists in the region, and skills development of Institute staff. They also include training workshops on relevant topics, both in-house, and regional, for scientists from around sub-Saharan Africa.

The IITA Capacity Development Strategy for 2014-2018 has been approved by the BoT in November 2013. The goals of this strategy are to (1) strengthen IITA in R4D, knowledge sharing, and technology dissemination, (2) strengthen the capacity of individuals and organizations to undertake R4D for CGIAR Research Programs, (3) increase the potential for IITA innovations to be further developed, adapted, and adopted widely, and (4) support the capacity development of end-users, farmers, and women's organizations, and private and public organizations for research uptake, innovation, and knowledge sharing.

The Capacity Development program is leading the implementation of IITA's E-Research. The vision of the E-Research project is "To develop an infrastructure for managing agricultural research data to improve R4D and service delivery by supporting the entire chain from the laboratories to smallholder farms, leading to rural poverty reduction, food security. and economic growth."

The Capacity Development program supported several students and young scientists from countries within Africa to the ISTRC and the Global Yam Conference in Ghana. About $30,000 was committed to the sponsorship of 33 students, of which 14 were female. This

Graduate Trainee Program in 2013

Category	PhD		MSc		BSc		Total		Grand total
	M	F	M	F	M	F	M	F	
Graduate students recruited in 2012	17	8	28	18	19	9	64	35	99
Graduate students carried over from 2012 into 2013	37	18	37	22	0	0	74	40	114
Graduate students recruited in 2013	21	16	31	29	18	15	70	60	130
Graduate students completed in 2013	18	5	38	18	0	0	56	23	79

Other types of training	RTAs		Interns/ volunteers		NYSC		SIWES/IT		Total		Grand total
	M	F	M	F	M	F	M	F	M	F	
Intakes	8	4	1	8	15	22	132	139	156	173	329
Ongoing	0	3	0	3	0	0	44	57	44	63	107
Completed	8	6	0	8	21	26	80	82	109	122	231
Total	16	13	1	19	36	48	256	278	309	358	667

enabled the new generation of scientists to meet with the old to gain more knowledge and experience in agricultural research during the ISTRC Africa Branch Symposium Students were mostly from South Africa, Ghana, Central Africa, Cote d'Ivoire, and Nigeria.

Training is an essential component of any capacity development effort. Below are highlights of some key activities in 2013.

Short-term training

A total of 124 Group Training Courses, including training of trainers (ToTs), were conducted at different locations in 17 countries on agricultural enabling environments, productivity, food security, technology transfer, and best management practices. For these training courses, 3,436 females (31%) and 7,603 males (69%) participated.

Capitalizing on results

''Research results are our capital," says Thomas Wobill, who is the IITA Expert in Monitoring and Evaluation. He joined IITA in 2013 and has vast experience in monitoring and evaluation of development programs.

"CGIAR has adopted results-based management as the approach for managing agricultural research interventions. To effectively demonstrate achievement of results and use evidence-based decision making as a management approach are challenging tasks and require the setting up of a functional and gender-responsive monitoring and evaluation (M&E) system.

"IITA is progressing well in its efforts to demonstrate its contribution to economic growth, poverty reduction, and food and nutrition security. I am happy to note that the initial perception of my role as the IITA policeman has changed. M&E does not mean control, but joint learning. Scientists and other program managers are now engaging the M&E unit in setting up their data systems to capture relevant information for their programs. This is exciting!

"In 2013, my focus was to create awareness about M&E and to obtain the commitment to M&E among staff via interactive training. We also conducted a comprehensive M&E system assessment to determine the status of M&E practices, and to ascertain the readiness of IITA to embrace M&E. Next steps would include the development of a system in R4D interventions where we would be able to share the lessons we have learned, create understanding on best practices, and propagate success stories so we would develop a culture of learning and communication among us and with our partners.''

Staff development

Ten staff development group/in-house training were conducted with 245 participants broken down into 156 males and 89 females in the areas of financial management, biometrics, drivers' training, and using Microsoft Excel.

A sum of $40,000 grant was made available for staff training through a competitive grant scheme organized by the Capacity Development Office. The Talent Development Competitive Grant, launched in 2013, aims to support job/professional development within IITA. A total of 67 applications were received with a total training cost of $203,261. The applications cut across all hubs and almost all topics. Sixteen staff (14 males and 2 females) benefited from this grant.

Knowledge sharing

The Knowledge Center (KC) ensures that IITA scientists and other clients have access to the information they need for research at the time needed and in the right format regardless of location. KC also identifies, organizes, preserves, and disseminates IITA knowledge or research output for worldwide accessibility to increase IITA's visibility and uptake of knowledge for development. Main activities include improved access of R4D researchers to online information resources such as CAB Direct, TEEAL, JSTOR, Scopus, Elsevier, others; increased KC service efficiency and effectiveness; KC space rearrangement, with 16 computer workstations and 16 PCs.

IITA collaborated with 25 countries on capacity development and knowledge sharing. These include Uganda, Ethiopia, Sierra Leone, Cameroon, Kenya, Nigeria, Burkina Faso, Ghana, Tanzania, USA, Zambia, Togo, Mali, Mozambique, Belgium, DRC, Central Africa Republic, Costa Rica, India, Japan, Netherlands, Norway, Bénin, Senegal, and Spain.

Training bakers in using cassava flour to make bread. Photo by IITA

Photo by IITA

Staff

In 2013, IITA had a total of 1,052 staff broken down into 889 nationally recruited and 163 internationally recruited staff spread in 15 countries. Of this, 243 (23%) are women and 809 (77%) are men. Majority of the staff (68%) are based in headquarters in Ibadan, Nigeria.

Breakdown of staff by location.

	IRS			NRS		
Duty station	Male	Female	Total	Male	Female	Total
Abuja, Nigeria	2	0	2	6	0	6
Benin Republic	7	0	7	19	3	22
Burundi	1	0	1	0	0	0
Cameroon	4	0	4	17	7	24
DR Congo	6	1	7	29	10	39
Ghana	5	0	5	6	1	7
Ibadan, Nigeria	55	24	79	457	125	582
Kano, Nigeria	3	0	3	33	4	37
Kenya	7	4	11	9	8	17
Liberia	2	0	2	10	2	12
Malawi	3	0	3	18	5	23
Mozambique	2	1	3	19	7	26
Sierra Leone	2	0	2	4	1	5
Tanzania	12	5	17	26	14	40
Uganda	2	2	4	17	7	24
USA	1	1	2	0	0	0
Zambia	5	6	11	20	5	25
Total	**119**	**44**	**163**	**690**	**199**	**889**

Shaping the future of agriculture

"Most people our age are not attracted to agriculture, probably because it is not very glamorous or the money isn't very good. A few are interested but are stymied by lack of training, resources, and capital support," say Bankole Akinyele and Evelyn Ohanwusi, both in their mid-20s, and co-leaders of IITA's Youth Agripreneurs Program or IYA. "Our vision is to reorient young people in rural areas in Africa toward more productive engagement in agriculture through undertaking activities in agribusiness, service provision, and market-oriented agriculture that also offer benefits to the larger community.

"Our program is based at IITA. Here we get our technical, logistical, and training support as well as a lot of moral support directly from the Director General Dr Nteranya Sanginga and its staff. The farming activities, however, such as planting, harvesting, and marketing are done entirely by us. We produce cassava, banana/plantain, soybean, maize, vegetables, and fish. We also engage with the public and private sectors for our ventures. In 2013, we kicked off an extensive training program and established farms within and outside of IITA. We are happy to see that the IYA concept is already being replicated in other IITA hubs. It is our dream that one day African youths go back to the land that has sustained us, the generations before us, and the generations still to come."

Photo by IITA

Board of Trustees

Bruce Coulman, Chair
Professor and Head of the Plant Sciences Department
College of Agriculture and Bioresources, University of Saskatchewan
Saskatoon, Saskatchewan, Canada

Amos NamangaNgongi
Chair, African Fertilizer and Agribusiness Partnership and Chairman of Kose Estates
P.O. Box 43
Limbe, Cameroon

Ibukun Odusote
Permanent Secretary
Federal Ministry of Agriculture and Rural Development
Area Eleven, Garki, PMB 135, Abuja, Nigeria

Hilary Odo Edeoga
Vice Chancellor and Professor of Plant Taxonomy and Cytogenetics
Michael Okpara University of Agriculture, Umudike, Nigeria

Jill Findeis
Director, Division of Applied Social Sciences and Professor of Agricultural & Applied Economics
University of Missouri-Columbia
Columbia, Missouri, USA

W John Griffith
4931 East Chalk Point Road
West River, MD 20778, USA

Anne Kathrine Hvoslef-Eide
Professor of Applied Biotechnology
Norwegian University of Life Sciences
Ås, Norway

Hans Jöhr
Corporate Head of Agriculture
Nestlé, Vevey, Switzerland

Xikombiso Mbhenyane
Deputy Vice Chancellor—Academic
University of Venda
Thohoyandou, South Africa

Tom Medlycott
Director of Internal Audit
Department of Agriculture, Fisheries and Food
Dublin 2, Ireland

Roel Merckx
Professor, Soil Fertility
Faculty of Bio-Science Engineering and Head Department of Earth and Environmental Sciences
Katholieke Universiteit
Leuven, Belgium

John Pickett
Professor, CBE, DSc, FRS
Michael Elliott Distinguished Research Fellow
Rothamstead Research
Harpenden, United Kingdom

Nteranya Sanginga
Director General
IITA, Oyo Road, Ibadan, Nigeria

Photo by IITA

Headquarters and Hubs

Headquarters and Western Africa Hub

PMB 5320, Oyo Road, Ibadan 200001, Oyo State, Nigeria
Tel: +234 2 7517472 | USA Tel: +1 201 6336094 | Fax: +44 208 7113786

Central Africa Hub

ume4163, avenue Haut-Congo
Commune de la Gombe
Kinshasa, République Démocratique du Congo
Tel: +243 990 212 603, +243 814 765 596

Eastern Africa Hub

Plot 25, Mikocheni Light Industrial Area
Mwenge Coca-Cola Road, Mikocheni B, PO Box 34441,
Dar es Salaam, Tanzania
Tel: +255 22 2700092 | Fax: +255 22 2775021

Southern Africa Hub

Plot 32 Poplar Avenue, Avondale, Lusaka, Zambia | PO Box 310142,
Chelston, Lusaka, Zambia
Tel: +260 211 840365

International Mailing Address

IITA, Carolyn House, 26 Dingwall Road, Croydon, CR9 3EE, UK

Excellent facilities for excellent research

"I am happy to be within the first generation of researchers who can use the state-of-the-art lab facilities in the IITA Science Building in Tanzania," says Harun Muruthi, an associate professional officer (APO) in plant pathology and recipient of the Wageningen University-administered Lukas Brader scholarship program for outstanding students from sub-Saharan Africa. "I am currently working on soybean rust disease, a fungus. What is the further risk of the already widespread disease for soybean production in Africa and how can we develop rapid diagnostic tools? We need these tools urgently to map the disease and characterize pathogen populations. This will inform soybean breeders to deploy, screen or develop resistance germplasm, which ultimately translates to better soybean production."

"The Science Building provides me with unique facilities to conduct my research. The architects have created an environmentally friendly building that blends with the surroundings and provides a stimulating environment for research and learning. The building has four labs: pathology, food quality, nematology, and molecular. They are spacious and have modern scientific equipment. Each lab can accommodate more than 15 researchers across disciplines at any given time. This creates synergy through sharing of ideas among scientists. Excellent research can only be achieved in excellent facilities and environment which would attract excellent researchers. We are 37 researchers now, women and men, and we still have space for some more."

Partners and students use the new lab facilities in Dar es Salaam. Photo by IITA

CGIAR Research Program **Coordinators**

Stefan Hauser, s.hauser@cgiar.org
Root and Tuber Agronomist
CGIAR Research Program on Integrated Systems for the Humid Tropics
Nigeria (Ibadan)

Victor Manyong, v.manyong@cgiar.org
R4D Director
CGIAR Research Program on Policies, Institutions and Markets
Tanzania (Dar es Salaam)

Abebe Menkir, a.menkir@cgiar.org
Maize Breeder
CGIAR Research Program on Maize
Nigeria (Ibadan)

Peter Kulakow, p.kulakow@cgiar.org
Cassava Breeder
CGIAR Research Program on Roots, Tubers and Bananas
Nigeria (Ibadan)

Manuele Tamo, m.tamo@cgiar.org
Legume Entomologist
CGIAR Research Program on Grain Legumes
Bénin

Bussie Maziya-Dixon, b.maziya-dixon@cgiar.org
Crop Utilization Specialist
CGIAR Research Program on Agriculture for Nutrition and Health
Nigeria (Ibadan)

Alpha Kamara, a.kamara@cgiar.org
Systems Agronomist
CGIAR Research Program on Water, Land and Ecosystems
Nigeria (Kano)

Piet van Asten, p.vanasten@cgiar.org
Systems Agronomist
CGIAR Research Program on Climate Change, Agriculture and Food Security
Uganda

Michael Abberton, m.abberton@cgiar.org
Head, Genetic Resources Center
CGIAR Research Program for Managing and Sustaining Crop Collections (Genebanks)
Nigeria (Ibadan)

annual report 2013

Development and Production

Coordination: Katherine Lopez
Contributors: Stefan Hauser, Victor Manyong, Abebe Menkir, Peter Kulakow, Manuele Tamo, Bussie Maziya-Dixon, Alpha Kamara, Piet van Asten, and Michael Abberton
Design and Layout: Jeffrey Oliver, Katherine Lopez, Clement Ono-Raphael, and Godson Bright
Editors: Ylva Hillbur, Andrea Gros, Katherine Lopez, and Rose Umelo
Online version: Katherine Lopez, Kwasi Asiedu, Tunde Ajayi
With support from: Olusegun Adebayo, Ezekiel Bolarinwa, Adejare Adetunji, and Adegboyega Juba
Acknowledgment: Catherine Njuguna

Electronic version: www.iita.org/annual-reports