ANNUAL REPORT • BUILDING A SUSTAINABLE FOOD FUTURE

CIAT IN REVIEW 2016/2017

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CIATforward ▶▶

17 visions of a sustainable future

THE FUTURE OF FOOD: TAKE A WALK ON THE WILD SIDE

WHY BIG DATA WILL SHAKE UP FARMING

SEEDS, CLIMATE, AND DIETS IN THE 21ST CENTURY

SPECIAL CIAT 50 1967-2017

CIATrewind ◀◀

FIFTY YEARS AND 50 wins

+ EXCLUSIVE TIMELINE

This happened in 2016

HIGH-IRON BEANS REDUCE IRON DEFICIENCY IN JUST A FEW MONTHS

THE CASSAVA GENOME HUB: TERABYTES OF DATA SET TO REVOLUTIONIZE BREEDING

SILVOPASTORAL SYSTEMS AN OPTION FOR SUSTAINABLE LIVESTOCK IN POST-CONFLICT COLOMBIA

DISCOVER

A GENETIC RESOURCES CENTER TO "CLIMATE PROOF" FOOD SUPPLY IN THE 21ST CENTURY

FUTURE SEEDS A global hub for crop diversity

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SUSTAINABLE DEVELOPMENT GOALS

Forever pioneers

By Ruben Echeverría
CIAT Director General

I saw the huge impact of the Green Revolution as it unfolded, the lives it saved, the millions of people it spared from hunger, and those it helped rise out of poverty.

But I also witnessed the new challenges as they began to emerge. Today, 40% of land is severely degraded, hundreds of millions of people have an abundance of calories but suffer from poor nutrition, vital ecosystem services are undervalued and at risk and, of course, climate change threatens to destabilize many of the world's most vulnerable people.

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Forever pioneers

By **Ruben Echeverría** CIAT Director General

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But I also witnessed the new challenges as they began to emerge. Today, 40% of land is severely degraded, hundreds of millions of people have an abundance of calories but suffer from poor nutrition, vital ecosystem services are undervalued and at risk and, of course, climate change threatens to destabilize many of the world's most vulnerable people.

These are complex issues that cut across scientific disciplines. But I believe CIAT has never been in a stronger position to help the global community address them.

That's because in the 50 years since CIAT was established, science has been revolutionized by new tools, techniques, and technologies. Some of these were developed by CIAT itself. They are helping science keep pace with the challenges.

It means that, as an institution, we can now aspire to impacts that previously we could only dream of. Until recently it was inconceivable to undertake research to improve entire landscapes, or quickly bundle multiple traits into crops through gene editing. Soon the data revolution will enable us to breed crops *in silico* – using computers and DNA information alone. This will help us quickly develop new varieties of beans, rice, cassava, and tropical forages that are

> "After all, we now have 50 years of experience behind us, showing us clearly the way forward

targeted to specific environments, markets, and nutritional requirements. Big data approaches will help us refine and deliver site-specific advice to farmers about what to plant, when to plant, and how to best manage their crops.

Many of these advances were once the realm of science fiction; now they're tools at our disposal. And that's the power of pioneering science: it pushes the limits of knowledge; it makes the inconceivable achievable.

Our donors, investors, and staff have made this possible. Their visions of a better world have helped improve the lives of millions of people over the last 50 years. The same goes for the many governments, universities, research organizations around the world, who have shared our passion, belief, and optimism. Our successes are their successes; our impact their impacts.

Now, new partnerships are emerging that will help us build on what we've achieved. Governments and development banks are increasingly coming to CIAT to help them devise strategies for climate-smart crop and livestock production, healthier diets and more sustainable food systems. We're also working even more closely with the private sector to ensure smallholder farmers play active roles in profitable international value chains for high-value crops such as coffee and cocoa, as well as livestock products. These developments promise more long-term impacts, and even better value for money for those whose investments continue to drive our research.

But as we look to the future, there are some things that definitely won't change. Agriculture will continue to be one of the most important drivers of economic and social development on the planet. And that means CIAT will remain committed to producing high-quality scientific research that policymakers can use to improve the productivity, competitiveness, and profitability of farming. It means we will remain committed to innovation and impacts that are targeted, inclusive, and long-lasting. It means we'll continue to strengthen our global network of partners across Africa, Asia, and Latin America and the Caribbean, to accelerate progress and improve lives – particularly with our national research partners, to proactively respond to the emerging threats and opportunities. And of course, it means we'll continue to demonstrate the enormous potential of our research in helping achieve a sustainable food future for all.

This is why I'm immensely proud to look back at five decades of CIAT in this landmark Annual Report, and equally keen to share my excitement about the huge opportunities ahead. After all, we now have 50 years of experience behind us, showing us clearly the way forward.

At a glance

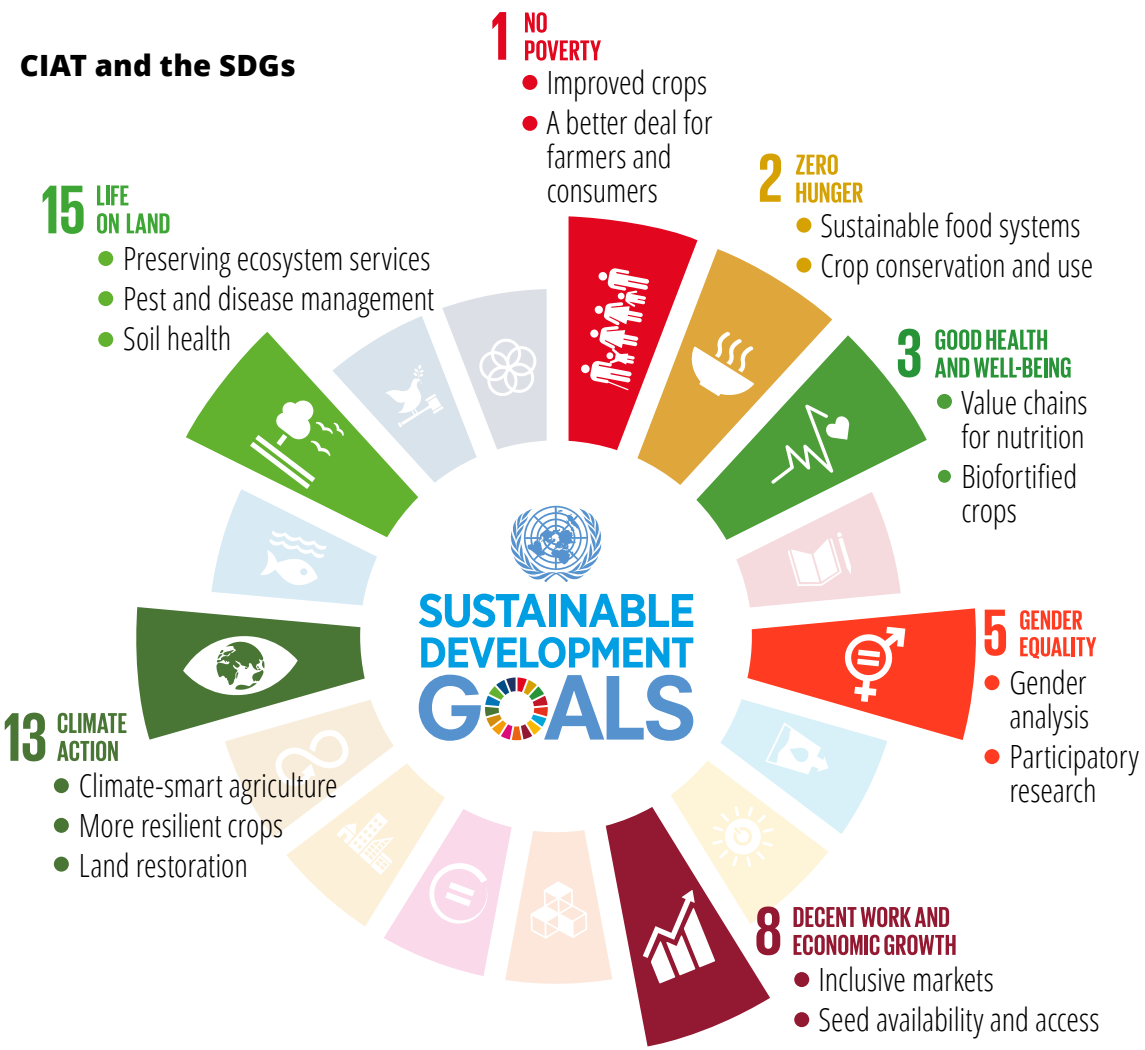
Our vision
Building a sustainable food future

Our mission
Reduce hunger and poverty, and improve human nutrition in the tropics through research aimed at increasing the eco-efficiency of agriculture

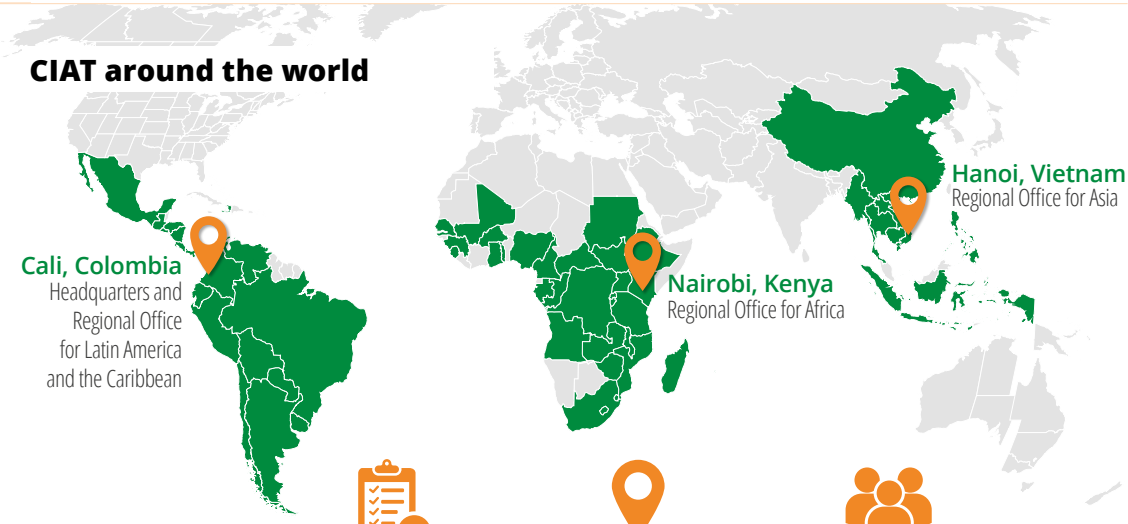
HOW?

1. Food security and nutrition
2. A better deal for farmers and consumers
3. Building resilience
4. Global partnerships for impact

CIAT and the SDGs



CIAT around the world



+300 Active projects in **+50** countries

1,000 Staff

Conserving crop diversity

CIAT's genebank takes care of the world's largest collections of key crops underpinning the supply of carbohydrates and plant/animal proteins in tropical food systems, namely beans, cassava, and tropical forages.

Since its inception, CIAT's genebank has distributed more than half a million samples from 141 countries to requesters in more than 160 countries.

37,987 BEAN ACCESSIONS

6,643 CASSAVA ACCESSIONS

23,140 FORAGE ACCESSIONS

Sharing our research in 2016:

178 Refereed journal articles **72%** ARE OPEN ACCESS

CIAT is a CGIAR Research Center:

4 Global Integrating Programs

- Agriculture for Nutrition and Health
- Policies, Institutions and Markets
- Water, Land and Ecosystems
- Climate Change, Agriculture and Food Security

8 Agri-food System Programs

- Grain Legumes and Dryland Cereals
- Fish
- Forests, Trees and Agroforestry
- Livestock
- Maize
- Rice
- Roots, Tubers and Bananas
- Wheat

3 Platforms

- Genebanks
- Excellence in Breeding
- Big Data in Agriculture

CIAT leads the Global Integrating Program on Climate Change, Agriculture and Food Security (CCAFS) and, jointly with IFPRI, co-leads the Platform for Big Data in Agriculture.

CIATForward

Our visions of a sustainable food future

Is a sustainable food future possible? Can we help put the world on track to achieving the Sustainable Development Goals?

These CIAT fellows tell us how we can make it happen.

13 CLIMATE ACTION

MAKING CLIMATE-SMART AGRICULTURE THE *norm*

By **Ana María Loboguerrero** Latin America Regional Program Leader (CCAFS)
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It might have taken years, but agriculture is firmly on the global climate change agenda. The next step is to make change happen on the ground too. I think that in the coming years we're going to see the rapid expansion of climate-smart agriculture (CSA) into regions we never thought possible.

From Africa and Asia, to the work I've been involved in Latin America, we've already seen how climate-smart villages (CSVs) can reduce emissions from farming and help farmers adapt to extreme weather, while also sustainably increasing production of crops and livestock. The results have been outstanding; we've seen farmers not just adapt to climate change, but thrive under it.

CSA requires a carefully tailored package of interventions, developed in unison with farmers. These include rainwater harvesting – so that they can grow crops all year round – even during the dry season. Farmers in our CSVs in Colombia are becoming scientists themselves: they're taking part in trials to breed bean varieties that are more resistant to water stresses. They're also monitoring the climate, through a local network of weather stations, helping them make the right decisions about what and when to plant. They're also producing their own organic fertilizers using crop residues, reducing greenhouse gas emissions by a factor of ten.

> "CSA requires a carefully tailored package of interventions, developed in unison with farmers

But despite these bright spots, agriculture still lags behind the progress being made in other sectors in responding to the climate change challenge. For example, the explosion in clean energy has resulted in new ways of generating electricity to the point where green energy now can compete with fossil fuels. In transport, hybrid and electric cars are now a reality. This is happening because investors saw that the long-term payoffs were huge. They plowed money into research and development (R&D); they saw the challenge as an opportunity.

So why does agriculture only receive a tenth of the R&D funding enjoyed by the energy and transport sectors? After all, it contributes a quarter of global greenhouse gas emissions and is one of the sectors most exposed to extreme weather. The bottom line is that we all need to eat; surely there can be no bigger payoff.

But agriculture is different; it requires more than a technological fix. It's a way of life. In many parts of the world, it's associated with poverty rather than profit. And while over two-thirds of the cars we drive come from 10 major carmakers, the food we eat comes from hundreds of millions of small-scale producers, and hundreds of thousands of larger ones. It means large-scale transformation is more elusive – and therefore less appealing to investors.

But I think we're on the cusp of a major transformation. In the coming years, we'll see a big shift in the ways we produce, distribute, and access our food, towards ones that are much more climate smart, profitable, and sustainable. The huge opportunities will drive innovation and investment. We'll see the rapid rise of things such as crop insurance, which – almost overnight – has created a multibillion-dollar industry in India, and the use of communication technologies to make seasonal forecasts more accessible – these have already reached more than 7 million rural people in Senegal. We'll also see more impact investors, such as Root Capital, partnering with research centers to promote and scale-up CSA in Latin America and Africa. This is just the beginning. As the interests of research organizations, the private sector, farmers, and consumers begin to align, I believe we'll see big, positive disruptions to our food systems, with climate-smart agriculture becoming the norm, rather than the exception.

3 GOOD HEALTH AND WELL-BEING

Seeds, climate AND diets IN THE 21ST CENTURY

By **Peter Wenzl** Program Leader, Genetic Resources
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We are what we eat, but what we eat may need to change. That's because of what's happening to our planet and what we're learning about the microbes in our gut. How can genebanks help?

Climate change predictions vary, but they don't seem to be getting any more optimistic. Severe yield losses are plausible around the world, and severe climate change may transform the agricultural map in regions like sub-Saharan Africa and Central America. The risk of a shock to the global food system is increasing. At the same time, the global population keeps growing, urbanizing, and shifting to "Westernized" diets relying on cereal grains, sugar, vegetal oils, and livestock products.

> "Genebanks are the raw material with which to reshape agriculture and improve diets for the 21st century

While undernourishment around the world has dropped by almost half in the last century, obesity and diabetes are spreading as "Westernized" diets are becoming more popular. Yet, there are native people whose traditional diets contain either more carbohydrates or more animal proteins than Western diets, and they're perfectly healthy. Scientists still don't understand exactly why. But it appears people on "ancestral" diets have a more diverse microbiome (mixture of gut bacteria) than people consuming "Westernized" diets characterized by an unprecedented density of "acellular" carbohydrates (cereal flour, sugar). "Westernized" microbiomes seem to be skewed towards fewer microbial species that appear to cause systemic inflammation leading to obesity and other diseases.

Why does all this matter for genebanks? Well, they offer solutions to both problems of climate change and diet-related chronic illnesses. The hundreds of thousands of plant varieties conserved in the world's genebanks are the raw material with which to reshape agriculture and improve diets for the 21st century. This will happen in two ways. First, genetic improvement will help make our crops more resilient to drought, heat, and pests and diseases. Second, they will help us shift towards more "evolutionarily appropriate" diets based on a more diverse range of nutrient-dense food crops.

Already, CIAT's genebank has a lot to offer. It holds the world's largest collections of key crops underpinning the supply of healthy carbohydrates (cassava) and plant/animal proteins (beans, forages) in tropical food systems. But because of the scale and confluence of these challenges, we have decided to expand and improve it.

Future Seeds (see p. 68) will be much more than just a genebank. It will be a global hub for plant genetic resources and a driver for bio-innovation in tropical food systems. As well as conserving vital crop collections as a "genetic insurance policy," it will also help leverage innovations in genomics and other technologies to home in on useful traits. It will also be a platform to connect to regional genebanks with whom we'll deploy cutting-edge technologies across a broad range of food crops, while also spreading awareness about the evolving policy frameworks regulating genetic resources.

The mainstreaming of DNA sequencing and genomic prediction methods in genebanks, image-based phenotyping, genome editing and other exciting approaches enable us to harness genetic resources in a more comprehensive and targeted manner than was possible in the past. I'm convinced that, if used wisely, crop diversity will help us catch up and keep pace with the profound transformations taking place across tropical food systems, perhaps re-aligning people, plants, and the planet in new, unsuspected ways!

AFRICAN AGRICULTURE: *paving the way to prosperity*

By **Debisi Araba** Regional Director, Africa
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My grandfather remains an inspiration to me. He made his fortune trading in Lagos with merchants from around the world in the early 1900s. Then, when his business became a success, he and a few friends volunteered to build a road, linking his hometown to Lagos, to help others literally make the journey to prosperity.

The result was the 24-kilometer, four-lane Ikorodu road, which today cuts the time it takes to get to Lagos from Ikorodu town, helping transform the fortunes of the millions who use it daily – from farmers bringing their goods to market, to blue- and white-collar professionals heading to work.

People like my grandfather understood the value of going the extra mile – of turning today's challenges into tomorrow's solutions. I believe that as Africa invests in vital infrastructure, from roads and high-speed internet, to sustainable power, we will see the continent's fortunes transform.

This will usher in unprecedented opportunities for farmers. They will have lower transaction costs and better access to agricultural inputs, markets, and market intelligence. Food production will continue to shift from subsistence to commercial farming and profitable agribusiness, with entrepreneurship coming to the fore.

As Africa transforms, we want to ensure that farmers' investments in agriculture become a conduit for better financial, social, and health outcomes, despite the pressing challenges posed by extreme weather and increasing land degradation. Over the last 50 years, CIAT has been a partner in this transformation. Improved beans, developed by CIAT and our partners, are now grown and consumed by millions of people, contributing to healthier diets and improved nutrition. Our work to restore and improve soil fertility has helped breathe new life and productivity into degraded lands. We want to continue to empower farmers to grow and feed their families with more nutritious food, while also reaching lucrative new markets.

For African agriculture to really thrive, I believe that we will need to complement the investments and efforts of small-, medium- and large-scale enterprises with our scientific expertise, to help them identify new opportunities, technologies, and solutions, to ensure the biggest possible impact.

Together with seed companies and government partners, we are already investigating commercial production of improved forage seeds on the continent, using digital mapping to identify areas with the right conditions. This has never been done before and holds enormous promise: a forage seed industry in Africa could enable more farmers to grow crops such as improved *Brachiaria* grasses, which can help make farms more resilient to climate change, while enabling farmers to benefit from the growing demand for meat and milk.

Today we don't just need to build one road – there are no silver bullets. We need a whole network of solutions to ever more complex problems. If we are to meet the targets laid out in the Sustainable Development Goals, we need to create multiple pathways for the millions of farmers and agro-entrepreneurs on their route to prosperity, so that together we can cover the last mile, like my grandfather did a century ago.

> "As Africa transforms, we want to ensure that farmers' investments in agriculture become a conduit for better financial, social, and health outcomes"

2 ZERO HUNGER

BEANS *without borders*

By **Claire Mukankusi** Plant Breeder
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My dream has always been to reach the poorest in Africa through science. And now, as a "doctor of plants," as my children call me, I help regulate the flow of beans between the world's largest bean genebank in Colombia and many countries in Africa.

Beans are essential in sub-Saharan Africa. In East Africa alone, they are the second most-traded commodity, and a meal is often considered incomplete without them. In many African countries, every woman, with only a very small piece of land, can grow and sell beans, to put a nutritious meal on the table.

Thanks to decades of research, we have already made huge progress in improving beans. They are now more nutritious and affordable, and the plants are more productive and hardy in the face of heat and drought.

But if we're going to meet the Sustainable Development Goal "end hunger, achieve food security and improved nutrition," we're going to need to raise the bar even higher.

As a breeder, I rely on genetic diversity to make progress. If one bean variety is lost forever, we might never know how its unique attributes could have helped us – and future generations – tackle specific challenges. That's why the 37,000 accessions at CIAT's global bean collection in Colombia, and the 3,000 at our genebank in Uganda are at the heart of the work of the Pan-Africa Bean Research Alliance (PABRA) to improve beans for the continent.

> "The Common Market for Eastern and Southern Africa (COMESA) is a free trade area for 20 countries, which has allowed us to significantly speed up the release of new beans

Safely conserving these beans is key to breeding new varieties, to empower farmers to increase their production, resilience, and incomes.

We also need to increase the range and availability of beans with improved qualities – like high iron, tolerance to pests and diseases, and resilience to heat, drought, and low soil fertility.

But to do that, sharing data and bean samples is vital. For the last 20 years, PABRA – the largest network of bean researchers in Africa – has brought together partners from across Africa to share data, expertise, and bean samples. Yet in too many cases, policy is not keeping up – sometimes this means there are long delays in developing improved beans and getting them to farmers.

There are some exceptions. The Common Market for Eastern and Southern Africa (COMESA) is a free trade area for 20 countries, which has allowed us to significantly speed up the release of new beans. It means that, for the first time, we can use data from high-iron varieties released in Uganda, Burundi, and Rwanda, to launch the same varieties in Tanzania and Kenya, where ecological conditions are similar, instead of duplicating lengthy testing procedures in each country.

Such policy developments enable us to have a greater impact, for example, to mainstream better beans in school feeding programs to address malnutrition, or to help farmers beat drought in their fields.

Our strong network of national research programs must galvanize to take advantage of such opportunities, to ensure improved beans can move faster across boundaries, available to more people at affordable rates.

But further progress across Africa requires us, as a scientific community, to also traverse country boundaries and share everything we've got: from knowledge, data, and breeding lines or germplasm for better beans ready for the table. Our farmers depend on it.

1 NO POVERTY

LIVESTOCK: The *untold story*

By **Birthe Paul** Environmental Scientist
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For me, there are two sides to every story. And that's definitely the case when it comes to livestock.

In North America and Europe, we hear much about the negative health impacts of eating too much meat; of cows producing too much methane; of deforestation driven by our hunger for beef. In industrialized and emerging economies, these concerns are valid.

But in developing countries, there's a different side to the story. For millions of people in sub-Saharan Africa, livestock are indispensable. They're not mass-produced on factory farms, but raised by family farmers in rural areas.

As a vital source of meat and milk, livestock provide dietary diversity for those who need it most, and a dispensary of fresh milk. Plus, through sustainable intensification, they could be a source of far fewer greenhouse gas emissions.

That's an exciting prospect, because livestock – particularly cattle – have enormous potential to lift people out of poverty across Africa.

Some – such as *Brachiaria* grass – are easy to digest, cutting methane emissions per liter of milk or kilo of meat. They can also restore soil fertility, prevent erosion, and sequester carbon dioxide, while better tolerating drought and providing food during lean times.

So why haven't more farmers planted improved grasses?

First, many farmers don't prioritize crops for their animals to eat; they focus on crops for their families. So most mixed crop-livestock farmers spend a lot of time collecting low-quality, wild grasses to feed their cattle, locking them into a vicious cycle of low productivity and financial returns. Changing this will require changing the farm system.

Second, farmers currently struggle to get improved forage grass seeds of *Brachiaria*, for example, which are yet to be mass-produced in Africa. That's why we're using big data approaches to work out where a homegrown commercial seed industry for *Brachiaria* seed production might be viable in Africa, to boost the supply of better, more affordable forage seeds.

> "For millions of people in sub-Saharan Africa, livestock are indispensable. They're not mass-produced on factory farms, but raised by family farmers in rural areas

I've seen how, by switching what animals eat and improving management practices, farmers can transform their meat and milk production, boosting their incomes.

This study from the Tanzanian highlands shows that by feeding livestock improved grasses with local supplements, milk yields could go up 29 percent for local breeds, boosting income by up to 39 percent – which can help farmers pay for healthcare, or send their children to school.

Central to improving cattle productivity will be improving their diets. Nutritious grasses bred for local conditions already exist.

Improved forages are no single solution, but they are a powerful weapon in our armory. We can literally sow the seeds to feed the engine of sustainable growth for Africa, guiding the international community towards the first Sustainable Development Goal of wiping out poverty.

That's a side to the livestock story the world needs to know.

Photo by Giuseppe Carotenuto (FAO)

8 DECENT WORK AND ECONOMIC GROWTH

WHY BIG DATA WILL *shake up farming*

By **Andy Jarvis** Director
Decision and Policy Analysis (DAPA) Research Area
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In rural Nepal recently, lots of the smallholders I visited took selfies with me on their smartphones, sharing them on social media. Until recently, it was the other way around.

It was an epiphany moment: if the tech revolution has now reached smallholders, the data revolution will surely follow.

And it couldn't come sooner. A maize farmer in Iowa today uses data on weather, fertilizer, planting dates, and irrigation to make precise decisions about how to produce food. These help maximize production and minimize risk.

A smallholder in Africa, Asia, or Latin America, meanwhile, has just 40 chances in his or her lifetime to perfect farming. Each year they tweak the system to see what works, hoping next season will be better.

But with up to 1 billion smallholders suddenly coming online, that's all going to change. It's going to fuel the biggest shake-up of farming in a generation and help democratize precision agriculture.

It's also going to smash stereotypes. The notion of the smallholder farmer – hoe in hand, tilling the land – is living on borrowed time. Very soon they will have a smartphone in one hand and the controls to a drone in the other.

Rain dances will be out of fashion too. Text messages will tell farmers when rain is coming, how much, and which crop variety is going to perform the best in the coming season.

Farmers will also be empowered in the marketplace. Information will flow both ways along the value chain, with smartphone apps connecting buyers directly with sellers.

In addition to crops, one of the most important things smallholders will produce is data. They'll continue to enjoy a special connection with the land; but by sharing and receiving data, they'll also enjoy a special connection to a global network of modelers, analysts, and number crunchers who will beam personalized recommendations straight back to their phones. Personalization is the buzzword in Silicon Valley; why not in the Rift or Kathmandu Valleys too?

At the heart of all this will be the new CGIAR Platform for Big Data in Agriculture. It's a virtual space for some of the biggest names and brightest minds in the tech world and agricultural science to come together and mine datasets for patterns, trends, and anomalies. It will help transform farm data into intelligence, providing new insights for boosting food production, responding to climate change, tackling malnutrition, and protecting ecosystems.

Right now, the only limit is our imagination.

"The notion of the smallholder farmer – hoe in hand, tilling the land – is living on borrowed time. Very soon they will have a smartphone in one hand and the controls to a drone in the other"

3 GOOD HEALTH AND WELL-BEING

NUTRITION IN AFRICA: TIME FOR "unusual" business

By **Mercy Lung'aho** Nutritionist
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I'm passionate about working in nutrition. I do what I do because I know how it feels when everybody looks the other way. I was a "preemie" – a premature baby. Weighing a mere 1.08 kg and anemic, the doctors gave me 72 hours to live. But I'm still here; against all the odds I survived, and now I want to be part of the solution.

As a nutritionist, I cannot look the other way while women and children are dying of anemia and malnutrition on our watch.

Worldwide, malnutrition is responsible for almost half of the deaths of children under the age of five. Some 90 percent of those occur in 34 countries; 22 of which are in Africa. Although malnutrition has multiple causes, I strongly believe the root of the problem in Africa is dysfunctional food systems that fail to provide the right nutrients in the right quantities for people of all ages to thrive.

This has to change.

Fortunately, nutrition has become accepted as a global priority – it even has its own Sustainable Development Goal (SDG). But if we're going to meet SDG3 – for good health and wellbeing – we're going to need less business-as-usual, and more unusual business.

First, we need to radically rethink the concept of food security, and focus on nutrition security as well. Having enough calories is not enough – we need better food production and distribution systems that ensure everyone has equal access to safe, diverse, and nutrient-dense foods, produced with minimal damage to our environment. Yes, it's a tall order.

But I've already seen how small changes in eating habits can be life-changing. For example, daily consumption of specially bred, high-iron beans can prevent and even reverse anemia in women and children. That's a quick, effective response to a condition that can blight their entire lives – entire nations.

> "As a nutritionist, I cannot look the other way while women and children are dying of anemia and malnutrition on our watch

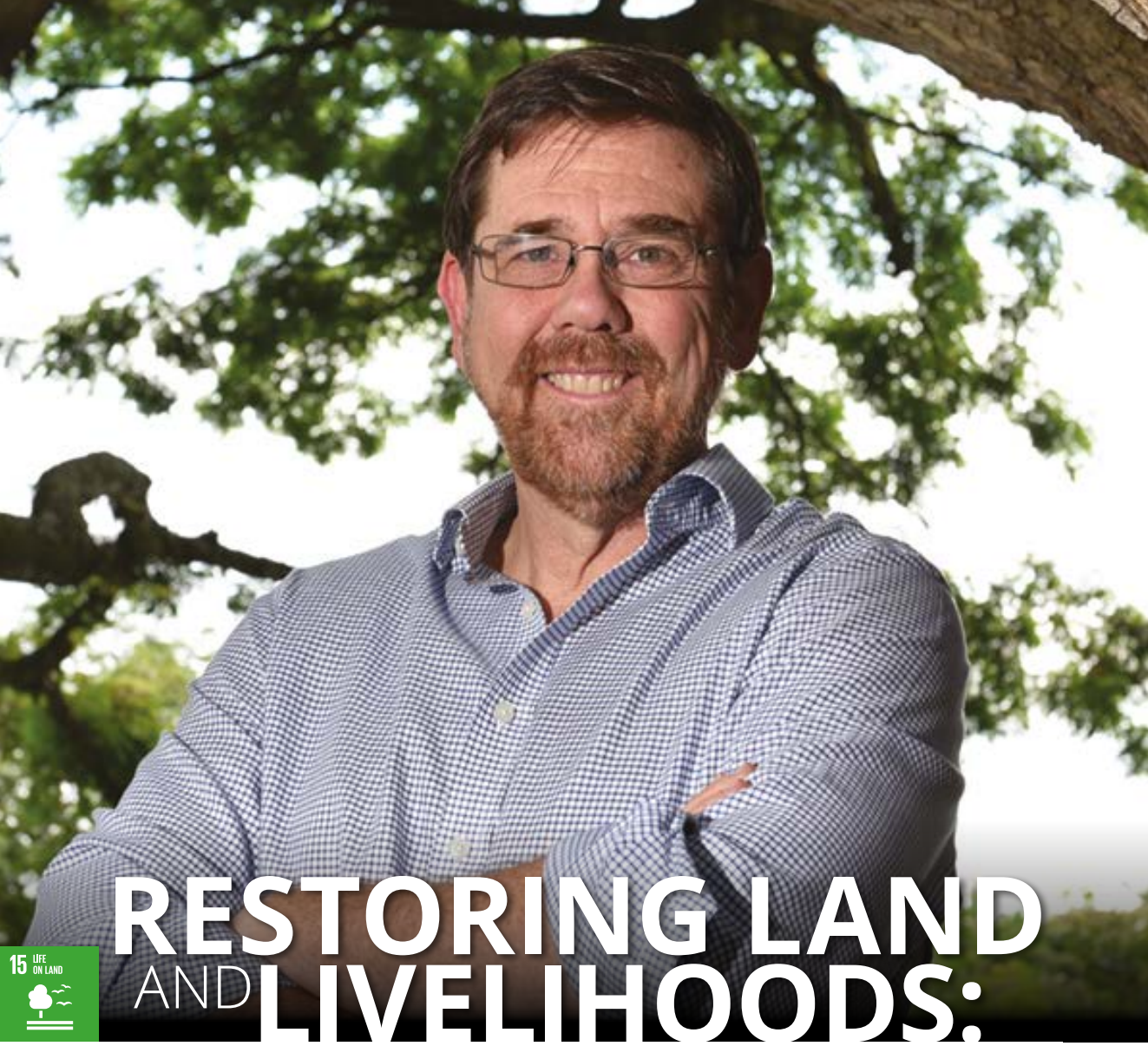
Those beans were bred for more than two decades – they were improved, adapted to local conditions and preferences for flavor, color, and seed size. They were released, made accessible, successfully grown, harvested, stored, prepared, and consumed. It required researchers to think broadly across a mini-food system – one just for beans. But it worked.

The scientists at HarvestPlus and the International Potato Center (CIP) who won the 2016 World Food Prize – and the teams that facilitated this innovation – have shown that biofortified crops, and the way they are produced and distributed, can play a critical role in tackling malnutrition.

But to have the greatest impact, to tackle malnutrition on every front – from under-nutrition to over-nutrition – we need to better understand what vulnerable populations eat and how. We need to understand what constitutes a healthy diet in the African context; to work with the public and private sectors to promote safe, diverse, and nutritious foods.

These things are achievable – I believe we live in exciting times. We've never been in a stronger position to tackle malnutrition, and we need to work with every sector of society to do it.

We can't look the other way.



15 LIFE ON LAND

RESTORING LAND AND LIVELIHOODS:

A CALL FOR *public* AND *private* SECTORS

By **Louis Verchot** Director
Soils and Landscapes for Sustainability (SoiLS) Research Area
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Traveling across the tropics, I've seen a vast array of situations where poverty and the failure to value ecosystems have left landscapes in deplorable conditions. Fortunately, land restoration is now a priority in the global development agenda.

Peatland fires in Southeast Asia in 2015 brought the topic to the fore, through the headline-grabbing haze events and health catastrophes that ensued. However, most landscape degradation is insidious: soils erode over decades; several hectares of natural vegetation are lost at a time; nutrients are depleted with each harvest.

Land degradation is, therefore, a bit like the problem of climate change, provoking rare crises and mostly characterized by slow, incremental change that belies its seriousness. Today, roughly 50% of the world's crop and grazing lands are moderately to severely degraded. If this had happened overnight, there would have been outcry, but it crept up on us. If the current trend continues, land degradation alone could reduce agricultural production by 12% and increase food prices by 30% in the next 25 years.

The issue has broader implications. Recent estimates suggest that ecosystem services are worth US$145 trillion annually, but that land degradation over the past 25 years has shaved 17% off of this value. This is bad news for all of us, but particularly those living in rural and highland areas of the tropics, who often directly depend on these services for their food and livelihoods.

CIAT has been working to solve problems in degraded landscapes for decades, through its work on improved forage and livestock systems and focus on cassava – a crop of last resort in many degraded landscapes. But now, in response to the scale of the challenge, we're taking it up a level. Our Soils and Landscapes for Sustainability (SoiLS) group is working on improving nutrient management and increasing soil organic matter on farms, and a range of other activities aimed at restoring fertility and enhancing productivity.

Encouragingly, we've been able to show that restoration can be profitable in humid and semi-arid areas with moderate degradation in Latin America. This opens the door to private financing – an innovative feature of Initiative 20x20, which aims to restore 20 million hectares of land in the region by 2020. CIAT is providing technical and scientific backstopping with partners at the World Resources Institute (WRI) and the Tropical Agricultural Research and Higher Education Center (CATIE).

But restoration of severely degraded lands in semi-arid areas will continue to require public financing. The good news is that public and private pledges in Initiative 20x20 already exceed $1.1 billion. We're also contributing to the African Forest Landscape Restoration Initiative (AFR100), which aims to restore 100 million hectares in 21 countries by 2030, by engaging political, technical, and financial partners.

> "If the current trend continues, land degradation alone could reduce agricultural production by 12% and increase food prices by 30% in the next 25 years

These efforts should help us demonstrate that land degradation can be halted and reversed in ways that are productive, profitable, and sustainable. Taking these to scale will require innovation and new knowledge. We'll also need better policy implementation and cost-effective monitoring systems. CIAT is bringing its different teams together to support the engagement of countries and non-state entities in this effort.

Ultimately, fixing a problem is always more expensive than keeping it from happening. So we also need better incentives to prevent land degradation, and technical solutions that meet the needs of farmers. With the importance of soils, landscapes, and ecosystems now firmly on the global agenda, I believe we're probably in the strongest position ever to achieve that.

15 LIFE ON LAND

WHAT PERU TEACHES US ABOUT *paying nature its due*

By **Marcela Quintero** Leader, Ecosystem Services
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Peru's Cañete River Basin is a great example of the benefits and challenges of payments for ecosystem services (PES).

Downstream, farmers depend on the river for irrigation; further upstream rafting operators, shrimp farmers, and a hydropower company all use the river to make money. But those living far uphill, where the water comes from, had few options for earning a living. They were custodians of the whole watershed, but had no incentive to protect it. The high-altitude grasslands and wetlands were being used to graze cattle; trees were being cleared to open up new agricultural land. That affected the flow of water in the river, putting the watershed – and those who depend on it – at risk.

It's exactly the kind of situation where a PES scheme can help: water users downhill could pay a charge to compensate those uphill – to help conserve the "service" of water flowing in the river.

But PES schemes are renowned for their complexity: exactly who should pay and how much? How should the money be collected? How should it be spent? I've seen how failure to answer questions like these can halt PES schemes in their tracks, despite the best intentions. Given that we urgently need to incentivize more sustainable and equitable land-use, this needs to change.

In Latin America, Peru is showing what the future could look like. In 2014, following a pilot project in Cañete and several other areas, the country passed a law concerning Compensation Mechanisms for Ecosystem Services (MRSE). No other country in the region had gone so far in setting out the role of the public and private sectors in investing in ecosystem services, and the minimum requirements for establishing PES schemes that are robust and transparent.

Peru also recognized that sustainable water management benefits all sectors – from agriculture to manufacturing and beyond. That made it a shared goal that unites the country around healthy ecosystems and the role they play in many aspects of daily life. It was literally a watershed moment.

But to ensure success, we need to go further. We need much more scientific evidence of the environmental and socioeconomic impacts of ecosystem services, to help policymakers, scientists, and academics raise awareness. That means documenting the role of PES schemes, but also showing how environmental management can help achieve broader objectives, from contributing to food security and increasing resilience to climate change, to bringing opportunities for tourism, recreation and more.

We also need an international vision: as developing countries exploit their natural resources, the benefits often leave the country – timber is exported; water "embedded" in agricultural products leaves too. Recipient countries often don't reinvest to ensure the long-term viability of those supply chains. We need to find ways to close this loop so that different sectors see environmental investment as essential to their own future.

It's enormously encouraging to know that we are already starting to move along this path: Colombia is currently considering a similar law to help unlock public and private investment in ecosystem services. But we need more people to join us, from more governments, countries, and industries. It would mean that instead of being fearful of a future of environmental degradation, we can edge closer to a sustainable future that we feel proud to be a part of.

"No other country in the region had gone so far in setting out the role of the public and private sectors in investing in ecosystem services"

Photo by Rowell Dikitanan (CIAT)

THE CHANGING FACE OF *agri-entrepreneurs* IN ASIA

By **Dindo Campilan** Regional Director, Asia
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We often hear and read about the stereotype of an Asian smallholder farmer: weathered face, wicker hat, and probably standing in a rice field. It might paint a pretty picture for travel guides, but it's not an image that appeals to the next generation of agri-food producers in the region.

But there are forces converging to make agriculture in Asia attractive again – that is, profitable, and appealing to a better educated and technologically connected young population.

Let's take climate change. Extreme weather and climatic variations have provided the jolt many farmers needed to stop putting all of their eggs in one basket. They are starting to realize that diversification, among others, is key to resilience. With the impacts of climate change reduced, young people will be better assured of the promise of agriculture as a profession.

We're also witnessing a clamor for more sustainably produced food and healthier diets, especially in the region's rapidly growing cities. From Bangkok to Bangalore, the public increasingly want to know where their food comes from, how it is produced, and if it's safe to eat.

These are just two of the numerous movements gaining momentum in Asia, and CIAT anticipates being a part of both. In Bhutan and Myanmar, for example, we're laying the foundation to help plan for future climates. Our longstanding partners, such as in Vietnam, China, and the Philippines, are using CIAT tools to guide large-scale public and private sector investments in the agri-food sector. And our research into eco-efficient agriculture is already helping support more resilient, sustainable, and integrated farming systems in the region.

We'll continue to support high-value commodities, given the importance of cassava in Thailand, coffee in Indonesia, and livestock in Cambodia. We also expect to launch new national partnerships to ensure that agricultural progress is not made at the expense of the lands, forests, and river basins that provide vital ecosystem services.

But ultimately, Asia's agriculture rests in the hands of the next generation of farmers, especially smallholders. They will be key to driving the changes the region needs. Yet for a long time, they have had limited power to change – they'd wait for the rains to come without knowing when, while often disconnected from critical support services. The rural youth, uncertain of the prospects for agriculture, have been seeking more exciting lives elsewhere.

But that's all going to be shaken up. Equipped with a growing number of science-driven tools and services, tomorrow's farmers will be able to make smart, informed, and independent decisions. A new breed of agri-entrepreneurs will be checking Facebook for the latest weather advisories, using smartphone apps for crowdsourcing data, and making investment presentations in agri-business forums.

In the not-too-distant future, agriculture will become synonymous with innovation, tech-savviness, profitability, and "green" credentials. Smallholder farmer-entrepreneurs – both men and women – will be recognized and rewarded for their role in feeding the region with safe, nutritious food. And armed with cutting-edge tools and technologies, they won't be totally defenseless against nature's whims.

As someone who grew up surrounded by farms on Asia's Pacific edge, I'd say that the region's agriculture sector has already come a long way. And it will continue to progress, with the stereotype of the smallholder farmer already on the cusp of transformation.

"In the not-too-distant future, agriculture will become synonymous with innovation, tech-savviness, profitability, and 'green' credentials

15 LIFE ON LAND

THE FUTURE OF FOOD: take a walk ON THE wild side

By **Colin Khoury** Crop Diversity Specialist
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I think the future is going to be a lot wilder and weedier. That's a good thing.

That's because the majority of our food is grown by converting the enormous complexities of wild landscapes into more simplified, controllable, agricultural ones. Farmers do this when they cultivate the soil, remove weeds, apply pesticides, and plant crops that their families eat or that they can sell in the market. This "culture" of agriculture is how we grow more food than ever before.

But the costs are many: soil erosion and losses of soil fertility, declines in pollinators, pesticide toxicity, fertilizer pollution, and greater vulnerability of crops to pests and diseases. On top of this is climate change, which makes growing food increasingly unreliable.

The future of food is, therefore, all about how we can continue to grow lots of it, while preventing, eliminating, or even reversing the environmental and social costs of cultivation. It's about keeping the gains we've made through our agricultural practices, machines, chemicals, and seeds, while halting the destruction of biodiversity and soils. It's about finding a better balance between the domesticated and the wild.

How are we going to do this? By improving our farming practices so that we disturb the soil as little as possible, so that the complexities of life underground can creep back in. By becoming much more judicious in the use of chemicals, so that crops can be productive on farms full of worms, bees, moths, and birds. By breeding crops to be resistant to pests and diseases, and productive under more stressful conditions. And by expanding our palettes to include more nutritious foods that grow easily where they are produced.

Wildness and weediness will be key to our success. Crop wild relatives and ancient, barely domesticated crop varieties hold the secrets to breeding crops of the future.

As farmers struggle with climate change and land degradation, scientists will increasingly look to these plants for help. Some might be resilient to heat or drought; others might tolerate saline soils. Weeds and wild plants are a genetic safety net for the world's food supply.

Many of them still exist in small garden plots and in the forests, shrublands, and deserts of the world, particularly in the tropics. But they are facing a host of threats, from urbanization, pollution, the expansion of agriculture, and even war.

The good news is that we're coming to appreciate wildness, perhaps just in time. Fully conserving it – both in natural habitats and genebanks, where it's accessible to plant breeders – is the next step. Making sure this wildness is truly accessible to the global community, through agreements such at the Plant Treaty, is also vital. Finally, reinvesting in research, not only to safeguard these resources, but also to better understand them, share this knowledge, and work with it so that it is useful to farmers around the world, is crucial to our "re-wilding."

"Crop wild relatives and ancient, barely domesticated crop varieties hold the secrets to breeding crops of the future"

8 DECENT WORK AND ECONOMIC GROWTH

LATIN AMERICA AND THE CARIBBEAN: *lessons in sustainability*

By **Carolina Navarrete** Coordinator, Latin America and the Caribbean
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A lot of people probably don't realize it, but in some respects Latin America and the Caribbean (LAC) is already in the future. It's one of the most urbanized regions in the world and by 2050 the United Nations predicts that more than 90% of its population will live in cities.

This rural-urban shift has already reshaped markets for food and other agricultural products, providing new opportunities for economic growth. But it also means LAC is dealing with many challenges that other regions of the world have more time to plan for.

Fortunately, LAC is ahead of the curve in other respects. Some countries in the region have made huge advances in the way they produce food; are proud and proven early adopters of new agricultural technologies and have developed groundbreaking policies on issues from ecosystem services to climate-smart agriculture. These have been driven by a large, well-qualified pool of scientists, practitioners, and academics, and supported by government institutions, civil society groups and a robust private sector that encourages entrepreneurship.

> "LAC really can become the precedent for inclusive, agricultural development and sustainable food systems that can both inform and inspire the rest of the world"

As a result, I believe LAC is poised to be recognized as one of the great food baskets of the world.

But arriving at this point has brought all kinds of challenges. From the destruction of vast areas of rainforest, loss of invaluable fauna and flora, and depletion of freshwater sources, to the millions of hectares of land degraded by unsustainable practices, economic growth in the region has provided many cautionary tales.

Progress has been unequal too. Many people – including smallholder farmers and rural dwellers – have been left behind economically, as cities and industrialized agriculture exploded. With the entire region highly exposed to climate change, there's a danger that its position as a major food producer could become increasingly precarious – and so too the plight of its most vulnerable people.

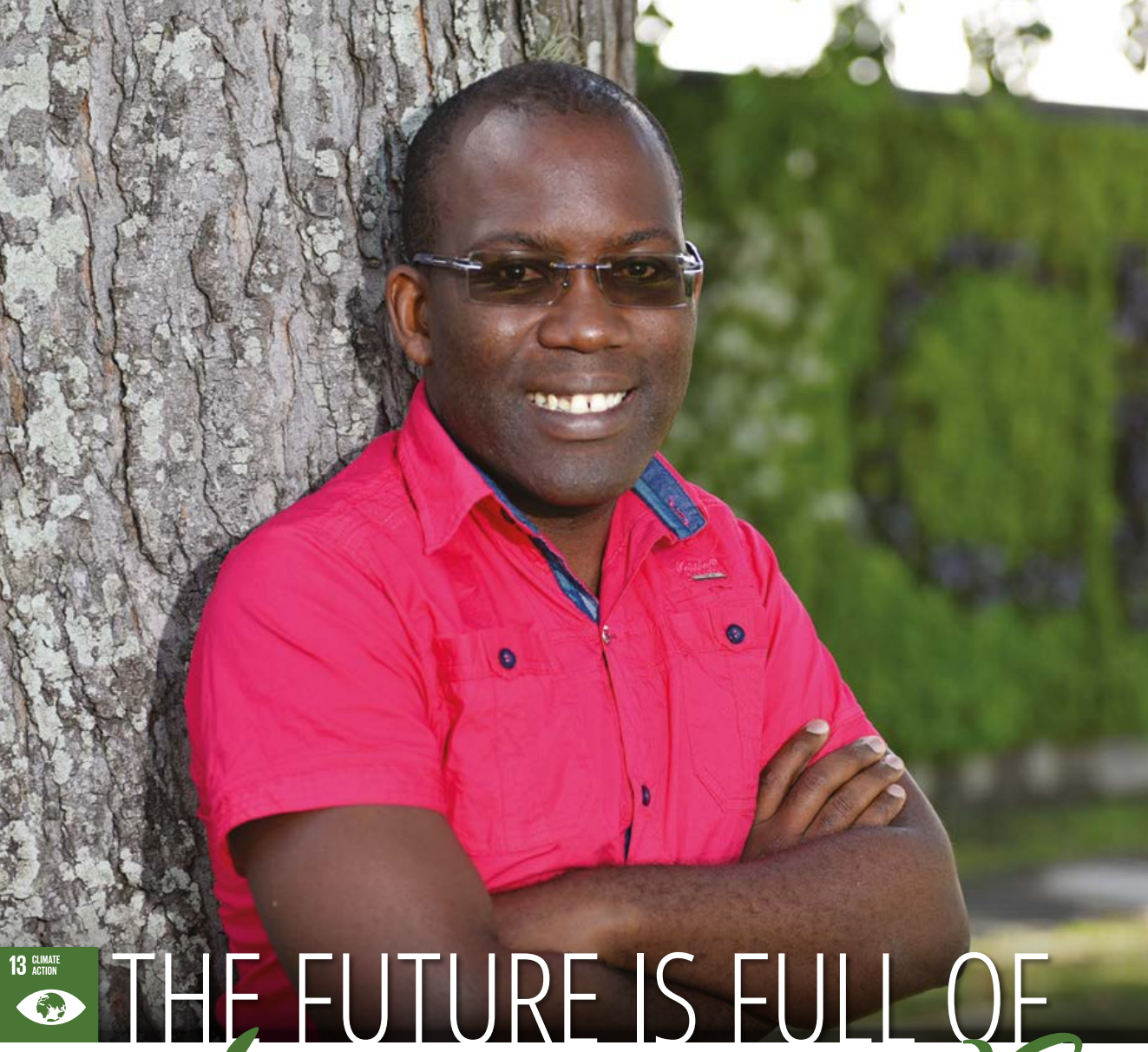
Building resilience across the agricultural sector must, therefore, continue to be a high priority for LAC, combined with increased efforts to protect and sustainably manage its natural resource base.

With agriculture continuing to provide the economic foundation for much of the region, rural populations, particularly women and youth, must be included in development plans. Policies and institutions will need to advance to meet the challenge.

While some of these challenges are daunting, they are also enormous opportunities. What I know for sure is that there will be no one-size-fits-all solution; the region is far too large and too diverse. Instead, responses will need to reflect the range of cultures, landscapes, ecosystems, and social conditions. Caribbean nations will require sets of policies for sustainable development different from those in Central America's vitally important Dry Corridor; upland areas will require site-specific interventions different from those in the lowlands; the vast and diverse Amazon Basin alone will require multiple approaches.

With diversity often comes complexity, and that's certainly the case in LAC. But in tackling these issues, I think the region will continue to innovate. While international donors increasingly focus on development challenges, particularly in Africa, it will be down to governments, regional development banks, the private sector, and civil society groups in LAC to team up directly with research organizations to co-develop, test, and scale-up solutions that generate lasting impacts for livelihoods and the environment.

That way, I believe LAC really can become the precedent for inclusive agricultural development and sustainable food systems that can both inform and inspire the rest of the world.



13 CLIMATE ACTION

THE FUTURE IS FULL OF *green cows*

By **Ngonidzashe Chirinda** Farming System Specialist
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For me it's a travesty that livestock have such a bad name.

All we hear is how animals produce greenhouse gases, drive deforestation, and destroy the land. I can see why so many look down on livestock.

I think that's going to change, radically. For me, the future is full of green cows.

That's because I've seen first-hand how animals can be raised sustainably and profitably. We don't have to dream about it – it's happening right now.

I've also seen how different pastures can nourish animals, rehabilitate soils, prevent erosion and capture carbon.

And I've seen how better feeding regimes can cut methane emissions while maximizing productivity, incomes, and the quality of meat and milk. This is simply by fine-tuning the combination of grasses and legumes fed to animals.

Some of this we already know; we just need to find better ways of spreading the word. Instead of reinventing the wheel, maybe we just need to attach the wheels we have to the right wagon.

But exciting new advances are coming too.

I think we're going to hear a lot more about one particular tongue-twister: biological nitrification inhibition (BNI). This describes the ability of certain plants – such as CIAT's *Brachiaria* forages – to trap nitrogen in the soil, preventing it from turning into nitrous oxide – a greenhouse gas 300 times more potent than CO_2. BNI helps keep nitrogen in the ground. That's good for soil health and mitigating climate change, and for saving farmers money on fertilizer. I think research in this area is going to pay huge dividends across whole landscapes. Tomorrow we'll be as familiar with the idea of BNI as we are today with the concept of water footprints.

You often hear that change will be slow, because agriculture is a culture, and cultures take a long time to evolve. But I think that's a cop-out; we just need to rethink the way we take these ideas to the farmers, to the private sector, to governments. Just think how many changes we've seen in popular culture in the last 50 years: from hippies, to punks, emos, and hipsters and everything in between. In an interconnected, globalized society, change can happen in a season or even overnight. This will help new and existing innovations take hold quickly.

With so many green cows on the horizon, it won't be long before we stop talking about livestock's "long shadow" and start talking about its long reach. We'll need to invent new expressions because "triple-" or "quadruple-win" won't be broad enough to capture the full range of benefits animals bring to smallholders, consumers, and the environment.

> "I've seen first-hand how animals can be raised sustainably and profitably. We don't have to dream about it – it's happening right now

5 GENDER EQUALITY

CREATING MORE OPPORTUNITIES *for women* AND MEN

By **Jennifer Twyman** Gender Research Leader
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On my first trip to Western Kenya in 2005, I visited a small orphanage where I was struck by how limited the children's opportunities were. It taught me that opportunities are not equally distributed: some people have options, others don't. I wanted to learn more about the processes creating these unequal outcomes, to find ways to reduce inequalities, and create opportunities for those facing limited options.

As a gender researcher, I often wonder what it is we really want to achieve when we talk about concepts like "gender equity," "gender equality," and "women's empowerment." What would success look like? I believe all people should have opportunities and options to earn a living; to receive an education; and to have access to health care, nutritious food, clean air, and unpolluted soils and water.

CIAT has been working to address these kinds of social issues for years. Today, gender research at CIAT includes identifying women's contributions to agriculture and the rural economy. Agricultural systems – like all economic systems – rely not only on productive activities such as growing food, but also on care activities within the household. Looking after children, the elderly or sick, cooking, cleaning and washing are all activities that often go unnoticed – perhaps because they usually don't have a tangible economic value. But food production can't happen without this vital work going on behind the scenes.

Ongoing work to establish "gender inclusive" programs and policies that reflect the needs and preferences of men and women is also important. These efforts can contribute to more effective crop varieties and agricultural management practices for responding to climate change, for example.

This type of research is vital to creating more equal opportunities and improving rural development. Moving forward, we also need to better understand the social norms that influence what men and women of different social groups (ethnicity, race, age, class, etc.) should do. Sometimes these norms are so ingrained that we believe they limit what women and men are actually capable of doing. Recognizing how these norms affect our actions, and the impact of our research, is a crucial first step to having real impact on people's lives. We can only begin to change gender norms if we are aware of them.

That's why gender research isn't just about, or for, women. It's about men, too. And, perhaps most importantly, it's about recognizing the needs, preferences, and challenges of different groups of women and men.

So how can we achieve this? First, we should continue to work directly with rural communities, listening to what different groups of men and women need and want; understanding their own visions of the future. We can then provide information and research better aligned with their thinking.

Specifically, as agricultural researchers, we can provide women and men of all ages, ethnicities, and races with information, technologies, innovations, and opportunities that give them the chance of a better life.

If we can do more work like this, we might then find that current and future generations have many more options for living the lives they want to lead.

> "We can only begin to change gender norms if we are aware of them

3 GOOD HEALTH AND WELL-BEING

WHY HEALTHY CITIES DEPEND ON *vibrant countrysides*

By **Stefan de Haan** Program Management Officer
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"A new food paradigm is emerging in Vietnam that is focused on quality rather than quantity, diversity rather than uniformity, and the importance of smallholder inclusion"

When I arrived in Vietnam in early 2015, my first conversations with the local shop owner, the lady at the bank, and the taxi driver were about the country's food. What did I think of it? Did I like it? What was my favorite dish?

When they found out I worked in agriculture, these exchanges quickly turned to the topic of food safety. How do we know if the food is healthy? How do we know if it's okay to eat? They had heard about farmers using too many pesticides; could they trust what they were eating to nourish them, rather than make them sick?

As I settled into my new life in Hanoi, I soon realized that other issues relating to the food system were also a concern: food waste, environmental damage, and unsustainable farming were national talking points.

What Vietnam is witnessing is happening on a regional and global scale: food systems are transforming quickly, becoming increasingly industrialized and globalized. At the same time, Vietnam's agriculture has been intensifying, in many cases surpassing the land's natural carrying capacity. Taken together, these changes have resulted in a range of health and environmental challenges that we now have to respond to.

These food systems are also increasingly "anonymous" – in many countries, the family farm has become invisible, and the consumer influenced by powerful marketing that doesn't always have their best interests at heart. The displacement of traditional diets with processed, uniform, energy-dense foods has been linked to the rise in obesity and other lifestyle-related diseases around the world. Vietnam and other Southeast Asian countries are no exception.

It's both fascinating and troubling just how quickly and how much these new food systems have disrupted food cultures that are sometimes centuries long.

But I believe the situation can be turned around. A new food paradigm is emerging in Vietnam that is focused on quality rather than quantity, diversity rather than uniformity, and the importance of smallholder inclusion. It's a paradigm that recognizes that healthy cities depend on vibrant countrysides producing a wide range of food in a sustainable way. It's a paradigm in which the relationship between urban and rural areas is symbiotic, with farmers, city dwellers, and the environment all benefiting.

But to get there we'll need to overcome a series of obstacles. For example, we'll need to raise awareness with some sectors of society about what constitutes a healthy diet. This includes women in particular, who are normally household decision makers when it comes to what their families eat. And we'll need to involve the youth too – they're the ones who will be the driving force that helps transform the country's food systems, not least because they will be the farmers of the future.

Another is that diverse and healthy food is often more expensive than industrially produced, processed food, meaning only wealthier consumers can afford it.

But I think that it will soon be accessible to consumers from all socioeconomic backgrounds in Vietnam, not only the fortunate few. Its production and marketing will be traceable and environmentally friendly; the work of research organizations, such as CIAT, will help policymakers promote key innovations, from ecologically sound farming practices, to low-carbon food retail networks, improved storage to reduce food losses, and improved "wet markets" offering fresh, healthy food in the country's rapidly growing cities.

If we can do this, it could mean that Vietnam's food systems will not only be more diverse and increasingly healthy, but they will also become a space where consumers set the agenda. They will revalue all the unique elements of Vietnamese diets, including the use of fresh and sustainably produced food. It will create an environment that incentivizes producers to grow food that rural and urban dwellers alike are happy to consume and happy to share with their families.

It means the concerns of people like my local shop owner, the lady at the bank, and the taxi driver will have a direct, positive influence on the countryside, and the nation's health.

WHY DIVERSITY, DISRUPTION, AND INNOVATION IN *science* MATTER

By **André Zandstra**
Head of Partnerships and Communications
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> We've heard many times that 'business-as-usual' is over. But we hear less about what will take its place. I think the world urgently needs disruptors

CIAT's impacts over the last 50 years stem from a broad multidisciplinary approach, the thoughtful involvement of partners, and a keen focus on impact. But what does this really mean for the incomes of producers, the budgets of consumers, and the environment at large?

Firstly, with our headquarters in Latin America, we have a test bed for the rapid assessment of new crops, practices, and approaches to tackling huge challenges, such as malnutrition and climate change. This work spans numerous countries and agro-ecological zones. Combine that with our long-established presence in Africa and Asia, and we can evaluate and disseminate new interventions quickly – perhaps saving years in time and research costs. This is "south-south development" at lightning speed; it makes our global presence an enormous asset, and one, I believe, will reinforce CIAT's position as a key and trusted partner in innovative research for years to come.

If that sounds compelling, here comes the multiplier effect: the breadth and depth of CIAT's expertise means we're uniquely positioned to develop new innovations, and respond to new challenges. A quick stroll to the coffee shop at headquarters will bear witness: each morning you'll find CIAT staff not just looking for a caffeine fix, but an intellectual fix too. You might find a seasoned bean breeder sharing ideas, data and contacts with a social media specialist, or a geospatial analyst, gender expert, and soil scientist, all developing ideas for their own work.

This cross-fertilization of ideas doesn't stop after coffee; it's a microcosm of the many research synergies you find across CIAT. These enable us to understand complex problems from multiple perspectives. It's one of the reasons millions of people in Africa now grow high-iron beans; why our livestock systems are greener and more profitable than others; why governments around the world trust us to help them develop far-reaching strategies to cope with climate change, land degradation, and pest and disease outbreaks. And it's the reason we can play a part in helping achieve many of the United Nations' Sustainable Development Goals.

We've heard many times that "business-as-usual" is over. But we hear less about what will take its place. I think the world urgently needs disruptors; it needs scientists to develop pioneering approaches that challenge the status quo; that provide truly innovative ways of tackling a growing list of social, environmental, and agricultural concerns. Fortunately, disruption is hard-wired at CIAT; it's part of our institutional culture. After all, we saw the value of data before data got big; we were working on climate change while it was still part of the lunatic fringe; we saw that nutritious diets would become as important – if not more important – than those simply rich in calories.

Our foresight on these and other issues comes from being dynamic, responsive, inclusive, and diverse. It comes from the fact we work in over 50 countries, with over 900 staff whom we encourage to think big, think broad, and think new. It comes from the vital, continued support of our partners and donors in both the public and private sectors all over the world. And, of course, it also comes from 50 years of dedication and hard work behind us, pointing us towards a more prosperous, sustainable future.

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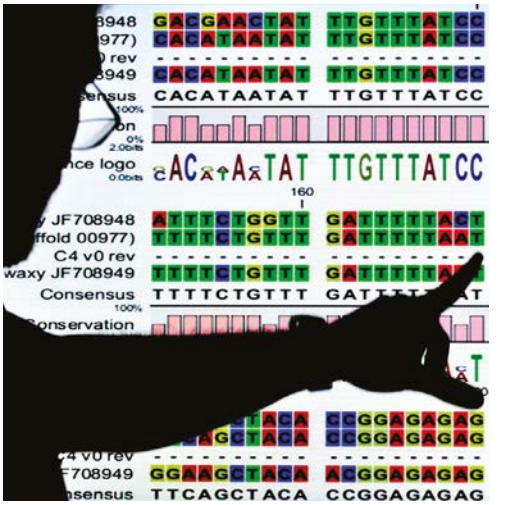
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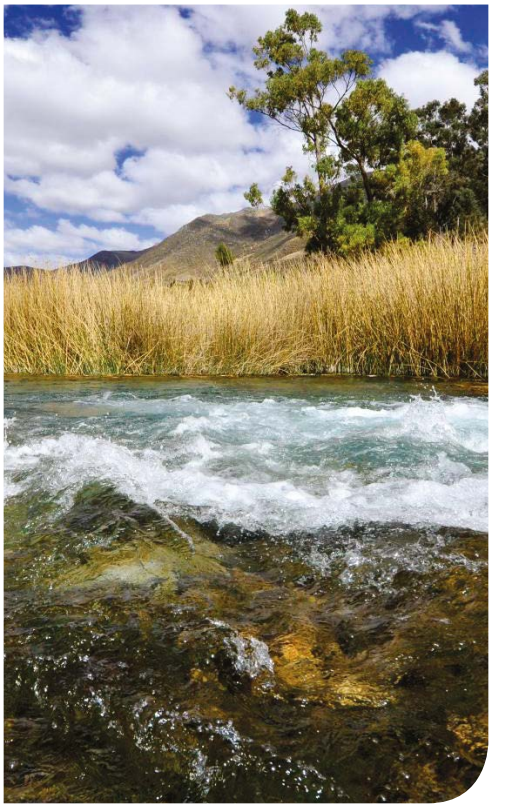


HIGH-IRON BEANS *reduce iron deficiency* IN JUST A FEW MONTHS

Eating specially bred high-iron beans twice a day for just four-and-a-half months reduced iron deficiency and anemia in young women in Rwanda, according to research published in 2016.

Iron deficiency is the world's leading nutritional ailment, particularly in developing countries. It can impair cognitive and physical development in children, while anemia, often caused by iron deficiency, increases risks to women during childbirth.

Yet, despite efforts to curb iron deficiency through supplements and fortified foods, the condition continues to affect an estimated 2 billion people worldwide.

Iron deficiency is the world's leading nutritional ailment and affects an estimated 2 billion people worldwide

The study, published in *The Journal of Nutrition* and the result of an 18-week research project involving iron-deficient women in Rwanda, is the first of its kind to show that eating "biofortified" beans bred to contain more iron has a significant, positive impact on iron levels in the blood.

"It really breaks my heart as a woman, as a mother, and as a daughter of this continent, to see women and children suffering from malnutrition," said **Mercy Lung'aho, CIAT nutritionist**, and co-author of the study. "These results are tremendously exciting because they show for the first time that these beans are an excellent vehicle for delivering long-term, low-cost solutions to a major health problem."

The beans were developed through HarvestPlus, a joint initiative of the International Food Policy Research Institute (IFPRI) and CIAT. Scientists took native American beans conserved in the CIAT genebank that are naturally high in iron, and crossbred them to adapt them to tropical conditions. As well as producing good yields

and a grain color preferred by farmers, the beans also tolerate intermittent drought. Iron-biofortified beans have already been released in Colombia and Nicaragua and were released for the first time in Uganda last year.

CIAT's Director General, Dr. Ruben Echeverría, said:

"This is a remarkable and exciting finding that shows biofortified beans can help tackle serious nutritional challenges. It's excellent news for everyone who has supported research into biorfortification, and should be a cause for celebration during the International Year of Pulses."

What's **next?**

- Efforts are required to further improve the yields of biofortified beans beyond those of standard beans. Biofortified beans and the farmers that grown them would benefit from a range of additional traits such as resistance to disease, and adaptation to poor soils.
- Biofortified beans need to reach those farmers in the form of seed for planting, and creative mechanisms are needed to achieve this on a broad scale in different regions of the world.

Biofortification. What is it?

Biofortification, a term coined by CIAT scientist Steve Beebe in 2001, is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology.

Biofortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops. Biofortification may, therefore, present a way to reach populations where supplementation and conventional fortification activities may be difficult to implement and/or limited (WHO).

CIAT scientists focus on raising the content of critical micronutrients in three staple crops: beans, cassava, and rice. This work contributes to HarvestPlus http://harvestplus.org/

THE CASSAVA GENOME HUB: TERABYTES OF DATA SET TO REVOLUTIONIZE BREEDING

The Cassava Genome Hub, an online platform that produces and stores more than 15 terabytes of genetic data on cassava, is pioneering a big data approach to crop improvement.

"When it comes to cassava, we are in the midst of a genomic revolution that is producing enormous amounts of information," said Luis Augusto Becerra, Cassava Program leader at CIAT.

"Our goal is to develop the tools and skills needed to analyze all this data, and in turn accelerate and enhance the impact of international agricultural research on cassava."

The Hub allows researchers to manage and mine huge amounts of data independently, using graphical and analytical tools to conduct complex analysis in a user-friendly way. The process involves taking cassava samples, genetically sequencing them, and uploading that data to the site.

Scientists around the world can then compare wild with domesticated cassava plants, or land races with elite lines, to identify differences, and pinpoint desirable traits and genes.

Taking a 'byte' out of blight

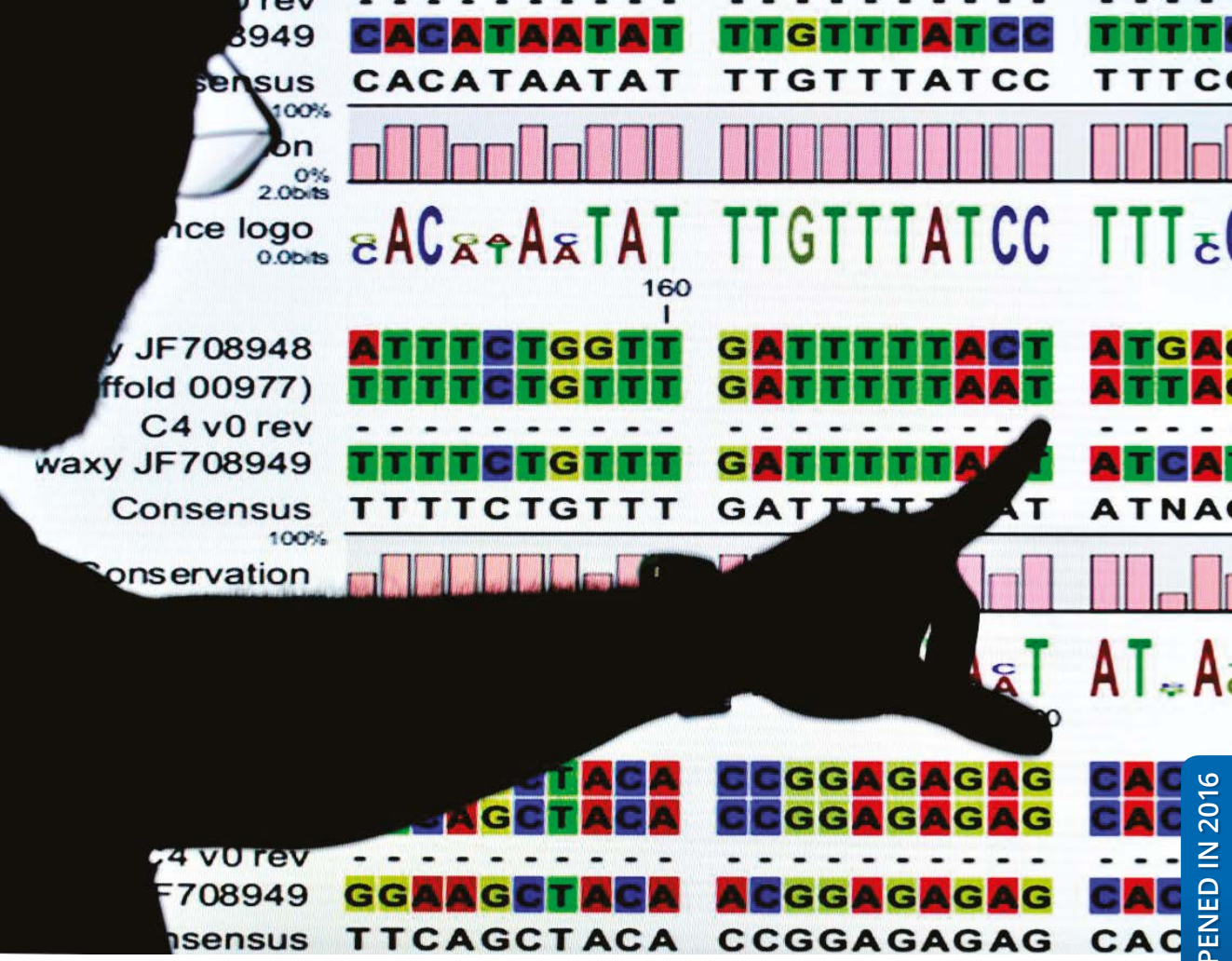
Data from the Hub is already being put to good use. Researchers have found that different genetic variations in a single DNA building block may help predict the susceptibility of cassava varieties to heat, drought, pests, and diseases.

For example, data from the platform has been used to screen for and identify genetic resistance to Cassava Bacterial Blight (CBB), a destructive disease that causes yield losses of up to 75% in some African countries. That data can now be used in efforts to develop blight-resistant commercial cassava varieties.

According to Dr. Becerra, the Cassava Genome Hub "can contribute far beyond the scope of what we thought possible when we began. There's huge and unknown potential that we haven't tapped into yet."

He foresees the sequencing of all 6,000+ cassava accessions in the CIAT genebank in the next couple of years. The Hub's technologies are already expanding to other tropical crops, including cocoa, coffee, banana, and sugarcane.

The Cassava Genome Hub is just one way in which CIAT is working to transform rural livelihoods through the power of information. CIAT will also jointly lead the CGIAR Platform for Big Data in Agriculture, launched in



January 2017, which aims to help organize, convene, and inspire partners to use open data in innovative ways.

The Cassava Genome Hub is jointly managed by CIAT, the French Agricultural Research Center for International Development (CIRAD), and Research Institute for Development (IRD), with participation from the CGIAR Research Program on Roots, Tubers, and Bananas; South Green; Agropolis Foundation; BGI; National University of Colombia, University of London, and a network of collaborators worldwide.

The Cassava Genome Hub is supported by the CGIAR Fund Donors through the CGIAR Research Program on Roots, Tubers and Bananas, and by the Agropolis Foundation.

CGIAR Platform for **Big Data in Agriculture**

Data has become a valuable global commodity. But it is much more than simply information: in expert hands, it is intelligence.

Join a platform that will help provide data-driven solutions to ongoing research for development impact.

http://ciat.cgiar.org/global-partnerships/big-data-platform/

"Magic beans"

BEAT MALAWI'S WORST **DROUGHT** IN 30 YEARS

In 2016, Malawi suffered the worst drought in 30 years, attributed to a particularly severe El Niño weather cycle. It left the country's central and southern maize-growing areas in ruin.

But while the maize withered, some beans developed by CIAT and its partners were bucking the trend. Weathering the drought, the pods were plump and ready for harvest. As a result, local farmers started calling them "magic beans."

The beans had been bred to mature early – in around 60 days instead of the usual 90 or so. It's an escape mechanism against the crippling effects of drought. The beans also have longer roots, helping them reach water deeper in the soil.

Mesoamerica, the area from Central Mexico down to northern Central America, is the ancestral home to the magic beans. Their ancestors were collected and conserved in the CIAT genebank in Colombia, and screened for interesting traits. That's where they were found to have the potential to withstand drought. They were crossed and selected for drought tolerance by bean scientists at CIAT headquarters and then sent to Malawi.

Next followed research station trials, then field tests with farmers, via the CIAT-led Pan-Africa Bean Research Alliance (PABRA), together with the Malawi's Department of Agricultural Research Services. These helped researchers pinpoint the two most promising varieties.

More recently, the team in Malawi has been testing the beans with different combinations of chemical fertilizer and manure, as well as intercropping them with maize. Seeing the success of these trials from the roadside, other farmers have started asking where they can get the seeds. CIAT scientists hope the beans will be commercially released soon, offering farmers a safety net when the rains fail.

Initial trials of the "magic beans" in Malawi were supported by Germany's Federal Ministry of Economic Cooperation and Development (BMZ). Subsequent work was part of Africa RISING project, a multi-donor, multi-partner effort led by Michigan State University and funded by USAID.

PABRA 20 YEARS
Pan-Africa Bean Research Alliance
Transforming agriculture since 1996

Through the Pan-Africa Bean Research Alliance (PABRA), over 550 new bean varieties have been released across sub-Saharan Africa, and millions of farming households have accessed quality seed of improved and preferred bean varieties. PABRA is coordinated by CIAT and currently works to improve bean production in 30 countries.

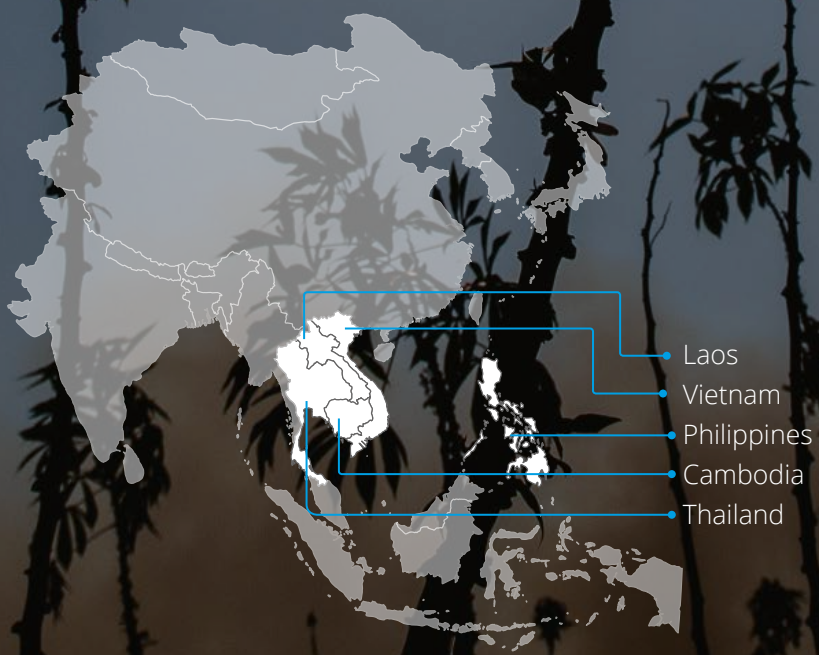
http://www.pabra-africa.org

What's **next?**

The performance of the "magic beans" could be further enhanced through research to:

1. Incorporate other desirable attributes in drought-resilient bean materials, such as larger seed size and shorter cooking times.
2. Determine optimum plant density in a maize-bean cropping system to maximize yields.
3. Combine traits for drought resilience with heat resilience as well, since drought-affected areas in Southern Africa are also associated with higher temperatures.

THREATS ON MULTIPLE FRONTS: PESTS AND DISEASES SPREAD IN SOUTHEAST ASIA'S CASSAVA FIELDS



More intense dry spells and rain are favoring the spread of pests and diseases that could threaten the multi-billion dollar cassava industry and food security in Southeast Asia, according to a CIAT-led study in *Pest Management Science.*

Symptoms of Cassava Witches' Broom disease were found in two-thirds of the 430 fields studied; the cassava mealybug pest was found in 70 percent of fields

It contained the most up-to-date assessment of pest and disease threats in the region's cassava fields, with scientists gathering data from 430 sites.

In particular, they found that Cassava Witches' Broom disease has reached the Philippines, Vietnam, Cambodia, Laos, and Thailand. Presumed to be spread by an as-yet-unknown insect, it can reduce yields by up to 60%, and symptoms of the disease were found in two-thirds of fields studied. The cassava mealybug, a pest that followed cassava from its center of origin in South America and that can also cripple yields, was found in 70 percent of fields.

Cassava is the third largest source of calories in Southeast Asia after rice and maize, and supports the livelihoods of around 40 million people in the region

"A number of factors have triggered the explosion in pests and diseases in Southeast Asia's cassava fields, including climate variability and the changing frequency of droughts," said CIAT entomologist Kris Wyckhuys, one of the report's authors. "We also found that some pests and diseases are far bigger problems than we previously thought, and alarmingly, they've already spread further than we thought. It's, therefore, vital that we act now to safeguard food security, farmer welfare, and the long-term sustainability of rural industries."

Cassava is the third largest source of calories in Southeast Asia after rice and maize, and supports the livelihoods of around 40 million people in the region. The crop – grown predominantly by smallholders – underpins a US$5-billion regional market in starch, which is used to produce products from paper to biofuel. In Indonesia, cassava is also a staple food.

"Right now urgent action is needed to address Cassava Witches' Broom particularly in Cambodia and central Vietnam, and to halt the spread of cassava mealybug in Indonesia, where it's moving into areas where cassava is a prime food security crop," continued Wyckhuys.

The study called for comprehensive pest management, including stronger controls on the movement of cassava stakes, which can harbor pests and diseases. Biological control, which includes the use of insects that are natural enemies of mealybugs to try and contain outbreaks was also recommended, along with more research into ways to boost the natural health of agro-ecosystems in general.

Biological control is already a reality in Southeast Asia, with releases of the killer wasp, *Anagyrus lopezi* in Thailand, Vietnam, and Indonesia in recent years to target mealybug infestations. The wasps have drastically lowered mealybug populations in Thailand and southern Vietnam, but researchers have noticed that, in areas with prolonged drought and low soil fertility, the wasps are less effective. Also, some growers have continued to use insecticides, which kill beneficial insects.

SILVOPASTORAL SYSTEMS AN OPTION FOR *sustainable livestock* IN POST-CONFLICT COLOMBIA

Long plagued by challenges, from sputtering armed conflict to frequent drought, Patía is a microcosm of Colombia's livestock conundrum. With around 23 million cattle and an average of one animal to 1.4 hectares, it's a lot of land for not much cow.

It's also the recipe for environmental calamity. Land degradation due to livestock production is widespread, forests have been cut down to make way for grazing areas, and livestock are responsible for a large part of the country's agricultural greenhouse gas emissions. But somewhere like Patía, there are few other options. Pretty much everyone depends on cattle – all 35,000 head of them.

Up until 2007, Noelí Angulo let his cattle graze the naturalized grasses that spring up each year. But these weren't particularly nutritious or resilient when the rains failed; productivity and earnings were low. Then everything changed. Active in his local farmers association, scientists from the University of Cauca (Unicauca) and CIAT asked if he would be willing to try silvopastoralism – a rotational grazing system that combines nutritious forage grasses, herbs, shrubs, and trees.

As well as the promise of increasing the productivity of both cattle and land, improved forages used in silvopastoral systems can also weather drought, help restore degraded soils, and reduce greenhouse gas emissions associated with cattle farming. Noelí agreed.

To establish the system, he divided his land into six plots. In one he planted *Brachiaria*, a broad-leaved grass native to Africa that grows in knee-high clumps. It's more nutritious and drought-tolerant than the wispy wild grasses. Its deep root system also helps accumulate soil carbon and stabilizes the soil, protecting against erosion. Easier to digest and more

CIAT's forages team has been trialing a climate-smart livestock system in Patía, in Colombia's restive Cauca department.

nutritious than the naturalized grasses, cattle fed with *Brachiaria* are more productive, resulting in lower methane emissions per kilo of meat or liter of milk.

In an adjacent plot, he planted Canavalia, a drought-hardy legume conserved at the CIAT genebank, associated with improved grasses. As well as a palatable source of protein for cattle, it fixes atmospheric nitrogen, adding to soil fertility and reducing the need for fertilizer. In additional plots, he planted other nutritious forages, along with naturalized and introduced leguminous shrubs and trees for feed or shade or both.

Noelí moves the cattle from plot to plot roughly every five days. The rest period allows the grazed plots to recover in a cycle that – with good management – can continue productively for years.

The results go some way to explaining Noelí's big smile: currently, his 20 cows graze five hectares – more than five times the average stocking density in Colombia. He gets an additional 50% amount of milk from each cow, and his animals reach slaughter weight in three years instead of five. The extra income has helped him send his son to university; he hopes to become a vet. When a severe drought struck Patía in 2012, many farmers lost cattle to dehydration or starvation; Noelí's – fortified by a good diet based on drought-resilient grasses – all survived.

CIAT and Unicauca are testing a range of improved forages and silvopastoral systems like Noelí's and already around 200 farmers in Patía are either trialing silvopastoralism, or the improved forages that are the foundation of the system. They're also investigating bottlenecks that could prevent widespread adoption, such as access to forage seeds, and ways to introduce the ongoing management practices that silvopastoralism requires. These and other issues will need serious work.

But there's probably never been a better time to try. Fifty years of armed conflict in Colombia has brought enormous rural instability. The prospect of peace means many farmers – and loan providers – can start thinking seriously about investing long term for the first time in generations. If those investments can help make livestock systems more productive, resilient and sustainable, the environmental returns could be huge.

Drought-resilient grass

COULD BRING **MILLIONS OF DOLLARS** TO EAST AFRICAN DAIRY FARMERS

For millions of people in sub-Saharan Africa, livestock are indispensable. Yet, they are often blamed for damaging the environment and contributing to global greenhouse gas emissions.

By switching what animals eat and improving management practices, farmers can transform their meat and milk production, boosting their incomes – and reducing the environmental footprint of the animals they keep.

Our research gives an idea of the potential impact of improved varieties of high-quality, drought-resilient forage grasses called *Brachiaria*. They could help boost milk production by up to 40 percent and bring millions of dollars to struggling East African dairy farmers, if widely adopted.

Dr. Steven Prager, a senior scientist at CIAT and co-author of the study, said the study assessed benefits that could accrue to East African dairy producers from adopting new varieties of *Brachiaria* pasture grass.

The grasses were developed and have been improved through decades of research by CIAT plant breeders to survive harsh growing conditions, while providing considerable nutritional benefits for livestock.

> "Farmers could benefit more from surging consumer demand for livestock products in East Africa," he said. "Our research shows that *Brachiaria* grasses could be the cornerstone of productive and resilient livestock systems that quickly provide more milk and money for small-scale dairy farmers."

The CIAT analysis focused on the additional milk and money smallholder farmers could deliver for an estimated two million small-scale dairy farmers across Kenya, Tanzania, Ethiopia, Uganda, Rwanda, and Burundi.

It found that investing in forage quality – and in getting new forages to farmers – can be a low-risk investment, yet likely to generate benefits in the order of tens of millions of dollars.

What's **next?**

- Research is needed to investigate ways to produce commercial-quality forage seed in Africa. This would result in cheaper seeds for farmers, and help kick-start a homegrown industry for commercial seed production, spreading the benefits to more farmers there.
- *Ex ante* impact studies can help show the potential impact of improved forages and management practices on livestock systems in specific areas. These can help guide investments and the development of incentives to achieve a range of impacts, from boosting livestock production to lower greenhouse gas emissions.
- Additional participatory research can reveal which forages grow best under different management regimes, how to integrate them into farming systems, and how to encourage adoption by farmers.

Central America's **BEAN** and **COFFEE** production **threatened** by **climate change**

Climate change could transform the agricultural landscape in Central America, with key crops such as beans and export-quality coffee losing suitability, and potentially dire impacts on farmers and rural livelihoods, according to a CIAT study.

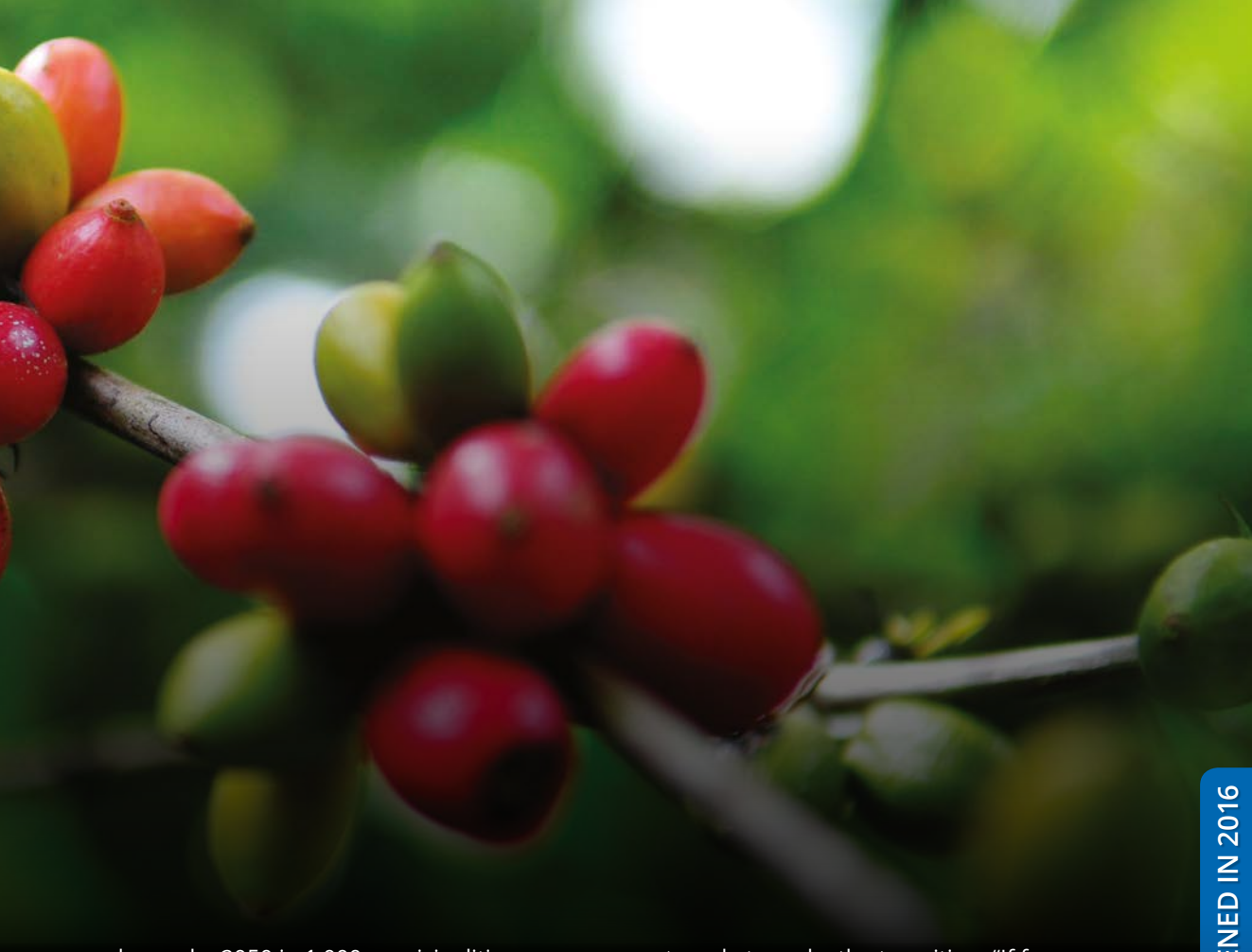
The findings add to the mounting evidence that rising temperatures and longer, more intense dry seasons will severely affect agriculture in one of Latin America's poorest regions, unless measures are taken to prepare and adapt.

"Climate change could redraw the agricultural map of Central America," said CIAT climate scientist Peter Läderach, one of the authors of the study published in *Climatic Change.*

Beans, coffee – the region's most valuable export crop – and banana will suffer the greatest decreases in suitability, especially in municipalities in the Dry Corridor, a drought-prone area spanning Guatemala, Honduras, Nicaragua, and El Salvador, and home to approximately 10 million people.

"What will be key is how well prepared the farmers across the region are for the changes to come, their ability to adapt, and how soon they can act. Our study is the most thorough assessment yet of the likely impacts in Central America and the vulnerability of local populations."

The researchers used crop and climate models to assess the likely impact of climate



change by 2050 in 1,000 municipalities across Guatemala, Honduras, Nicaragua, and El Salvador. They found that the effects will vary widely, requiring nuanced responses from policymakers.

But on average, the results showed that beans, coffee – the region's most valuable export crop – and banana will suffer the greatest decreases in suitability. The most severe changes are expected in municipalities in the Dry Corridor, a drought-prone area spanning the four countries, and home to approximately 10 million people.

Meanwhile, maize, cassava, upland rice, and sorghum are expected to respond positively to climate change in all the countries studied. But the authors warned that, while some areas may become more suitable for these crops, some are protected areas such as forests or important water catchment areas.

They also stressed that even though some crops will gain in suitability, farmers might still struggle to make the transition. "If farmers have to switch crops, that's a major decision that can require significant financial outlay and risk," said study leader Claudia Bouroncle, of Costa Rica's Tropical Agricultural Research and Higher Education Center (CATIE). "Many won't have the means to make the change."

To address this, the scientists also assessed the vulnerability of farming communities in each municipality and their "adaptive capacity," or ability to respond to the situation. They hope the findings will help policymakers prioritize their investments in climate change adaptation. The team also hopes their approach can be refined and applied in other climate change-prone parts of the world.

Even though some crops, including maize, cassava, upland rice, and sorghum, will gain in suitability, farmers might still struggle to make the transition.

TREES ON AGRICULTURAL LAND sink four times THAN PREVIOUSLY

A 2016 study in the *Nature* journal showed that carbon sequestered by trees on agricultural land could be more than four times higher than previously thought. The research was carried out by a team of scientists from several organizations, including CIAT.

Between 2000 and 2010, tree cover on agricultural land increased by 3 percent globally, resulting in a 4.6 percent increase in biomass carbon. Yet while the importance of carbon stored and sequestered by forests is widely recognized and land cover changes well monitored – see for example Terra-i – carbon stored by trees on agricultural land needs to be better measured.

The benefits of increasing tree cover on agricultural land go far beyond carbon sequestration. Trees increase soil organic matter and improve soil health, making farms more resilient to climate extremes. They also help protect soils from erosion, and tree products such as fruits and nuts contribute to food security, incomes, and more diverse diets.

Since trees stay in the soil for many years, their biomass contributes to a build-up of carbon over the long term. Growing more trees on farmland could be a significant route to increasing carbon sequestration, above and below ground.

more carbon THOUGHT

terra-i
An eye on habitat change

Terra-i detects land-cover changes resulting from human activities in near-real time, producing updates every 16 days. It currently runs for the whole of Latin America and is being expanded over the next year to cover the entire tropics.

http://www.terra-i.org/terra-i/about.html

What's **next?**

- Increasing carbon in the landscape will entail landscape mapping and using site-specific data to guide decision makers about where to invest in certain management practices over others, including where agricultural land can support more trees.
- Further research is needed to identify drivers of land-use change at regional, national, and sub-national scales, to develop policies that enhance carbon sequestration on agricultural land, which benefit farmers and society as a whole.

FARMERS IN UGANDA team up with scientists to find better beans

Sunny Mbeeta Abwooli knows how to whip up a delicious meal, especially when it involves one of her favorite ingredients: beans.

"We have many varieties of beans in Uganda," says Sunny, pointing to a basket of different kinds of beans. "They are different in color, taste, and how they grow."

Beans can help in the fight to combat malnutrition. For women in particular, they are a good way to earn money, since traditionally they often control the income from beans.

But the severe impact of drought and changing weather conditions on Sunny's bean yields has been a blow. And so – together with 300 other farmers in western Uganda – she has partnered with scientists to find better, more resilient beans for her community. Together with the Pan-Africa Bean Research Alliance (PABRA) researchers and partners from HarvestPlus, the National Crops Resources Research Institute (NaCRRI) in Uganda and CIAT, she and other farmers tracked height, yield, number of pods per plant, and disease resilience among new bean varieties.

Their input is vital to improve current bean varieties and ensure new beans – like those bred to contain extra iron, released in 2016 – will be accepted by local communities. Dr. Stanley Nkalubo, the breeder and leader of the Legumes Research Program at NaCRRI, who evaluated and recently released new high-iron varieties in 2016, said:

"Instead of buying expensive supplements, communities can now buy and grow these beans as a way of boosting nutrition and reducing anemia – a major health concern in Uganda – also knowing they will get yield despite drought."

The first high-iron, drought-resilient beans have already been released in Uganda and distributed to Tanzania, Malawi, Kenya, Madagascar, Ethiopia, and South Sudan.

Each country still has to evaluate these varieties for local conditions and preferences – through participatory research with farmers.

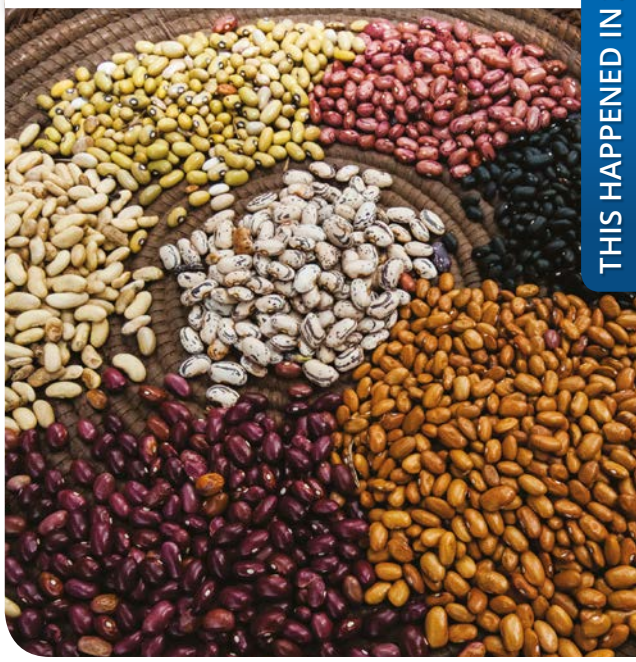
CIAT continues to work with local partner organizations across Africa and with farmers like Sunny to improve beans with characteristics such as high iron, based on locally preferred taste, color, cooking time, climatic conditions, soil suitability, and tolerance to pests and diseases.

A spokesperson for Global Affairs Canada, a critical supporter of bean research in Africa through CIAT and PABRA – since its establishment in 1996 to promote collaborative research – said:

"Beans are an important source of nutrition and income for smallholder farmers, many of whom are women and the rural poor involved in the bean trade. Investment in scientific bean research will lead to the development of new varieties of beans that are climate resilient, higher in nutrition, and more marketable. PABRA, through its network of experts from around the continent and its bean innovation platforms, plays a key role to ensure the increased impact of research."

What's **next?**

- Support ongoing research to develop bean varieties able to withstand changing climatic conditions, meet other farmers' preferences, and that have the characteristics demanded by bean buyers.
- We also need to fast-track the release of varieties regionally, to promote regional trade.
- Biofortified beans must be part of public health policies to address malnutrition. To support this, nutritional education for farming communities and extension workers is needed to show the importance of biofortified beans and other nutritious crops that can constitute a healthy, balanced "food basket."



A new "superfood" for Colombia

New high-iron beans were officially released in Colombia in June 2016.

They contain as much as 60% more iron than normal beans, and are intended to address the problem of iron deficiency in diets. Affecting up to 2 billion people globally, iron deficiency can lead to impaired cognitive and physical development in children, while anemia – often caused by iron deficiency – increases risks to women during childbirth.

In Colombia, iron deficiency affects up to 35 per cent of children under 12, with hotspots in the country's Atlantic coast and Amazon regions. "This is the number one public health concern in the world in terms of the sheer number of people who suffer from it," said Steve Beebe, leader of CIAT's Bean Program, which was closely involved in the development of the two high-iron varieties released in the country in June. "These new beans should enable farmers to grow their own nutrition more effectively, and help efforts to tackle the problem of micronutrient deficiency at its core."

How were the beans biofortified?

Screening more than 1,000 beans conserved in the CIAT genebank, Beebe and his team of bean breeders found several to contain high levels of iron. These beans were then crossbred with varieties popular in Colombia to ensure they were adapted to local conditions, and were of acceptable size, color, and taste for farmers and consumers. They are also as high yielding as local varieties, and able to tolerate major fungal and viral diseases. Their release in Santander follows extensive testing to ensure good yields and to confirm their nutrient concentration.

Beans, a popular staple in Colombia, typically contain around 50 parts per million (ppm) of iron; the new varieties contain 82 ppm – about 60% more. They have also been bred to contain 50% more zinc – a micronutrient vital for a strong immune system. As well as being more nutritious, the new beans also produce good yields and are of the shape, size, and color preferred by farmers.

Beebe added that since beans are already a good source of protein and carbohydrates, the new varieties could be considered "superfoods." The new beans were developed using a method called biofortification, which uses traditional breeding practices to increase the levels of important nutrients in staple crops.

New high-iron beans were officially released in Colombia in June 2016

It is the first time biofortified beans have been released in the Andean zone of Colombia, with the departmental governments of Santander, Tolima, and Valle del Cauca also expressing interest in including high-iron beans in school feeding programs. Releases of high-zinc maize and high-zinc rice are scheduled to take place in the next year. Vitamin A cassava is also in the pipeline.

"It's extremely encouraging to see so many governments around the world recognizing that biofortification is a tremendous tool to help improve the health of their people," continued Beebe. "It's a great moment for Colombia, for farmers, all of our research partners and, of course, the United Nations' International Year of Pulses, which is helping raise awareness of the nutritional importance of these foods."

The work was undertaken by Colombia's National Federation of Cereal and Legume Growers (FENALCE), Foundation for Agricultural Research and Development (FIDAR), and CIAT, under the auspices of HarvestPlus, a global biofortification initiative jointly led by CIAT and the International Food Policy Research Institute (IFPRI). HarvestPlus has already released a range of biofortified crops containing higher levels of key nutrients such as Vitamin A, iron, and zinc across the developing world. Its scientists won the World Food Prize 2016 for their work to improve the vitamin A content of orange-fleshed sweet potato.

Ma village in Northern Vietnam: A living lab to test

Climate-Smart Agriculture

Confronted with dwindling yields as a result of prolonged droughts, bursts of heavy rain, and frequent cold snaps, farmers in Ma, a village in northern Vietnam, have been learning to use their precious resources so that nothing goes to waste.

Find out more on Climate-Smart Villages (CSV) at **https://ccafs.cgiar.org**

Hoāng Quōc Viet no longer disposes of buffalo dung by burning it; instead he treats it with effective microorganisms (EM) – chemical processing agents that increase a compost's macro- and micronutrient content. Then he raises earthworms in the dung and feeds them to his chickens. He also uses the treated dung as fertilizer for his rice and cassava. He saves money on fertilizer and chicken feed, and the chickens, as well as the rice and cassava, grow very well.

Tran Trung Kien stopped using chemical fertilizer on his home garden and over 200 fruit trees over a year ago. He mixes the same EM with cow dung and uses that instead. He has also started penning in his cattle to keep them from catching diseases when grazing, as well as to keep them from causing damage to crops. He plants grass to feed the cattle and to reduce erosion on sloping land.

Nguyen Thi Thu has stopped burning rice stalks after harvest. She now sprays them with EM for use as fertilizer for next season's rice. As well as saving money on fertilizer, she says her rice tastes sweeter, better.

These are some of the technologies and practices selected by Ma farmers, through CIAT's work with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The objective is to test a range of complementary approaches that can help farmers become more resilient to climate risks, and make their farms more sustainable. They realized that something needed to be done: extreme and unpredictable weather had

disrupted cropping patterns; fewer but more intense rains caused severe landslides, soil erosion and degradation; increased cold stress was killing more and more cattle each year; and new crop diseases were emerging. All of these have affected yields and incomes.

From a "basket" of ten climate-smart agricultural (CSA) technologies and practices, farmers chose and prioritized those they felt were best suited to their needs. CIAT further refined the list through cost-benefit analysis and scenario testing, together with participatory land mapping exercises, to determine which ones would go to field trials, and how these should be implemented.

The final list of technologies and practices to be tested in Ma includes:

- intercropping cassava with legumes
- bordering the cassava plots with grass strips to protect soil fertility and prevent erosion
- climate-smart rice production
- acacia livelihood development to restore soil fertility
- integrated water management for improved water access for rice production
- cut-and-carry livestock systems

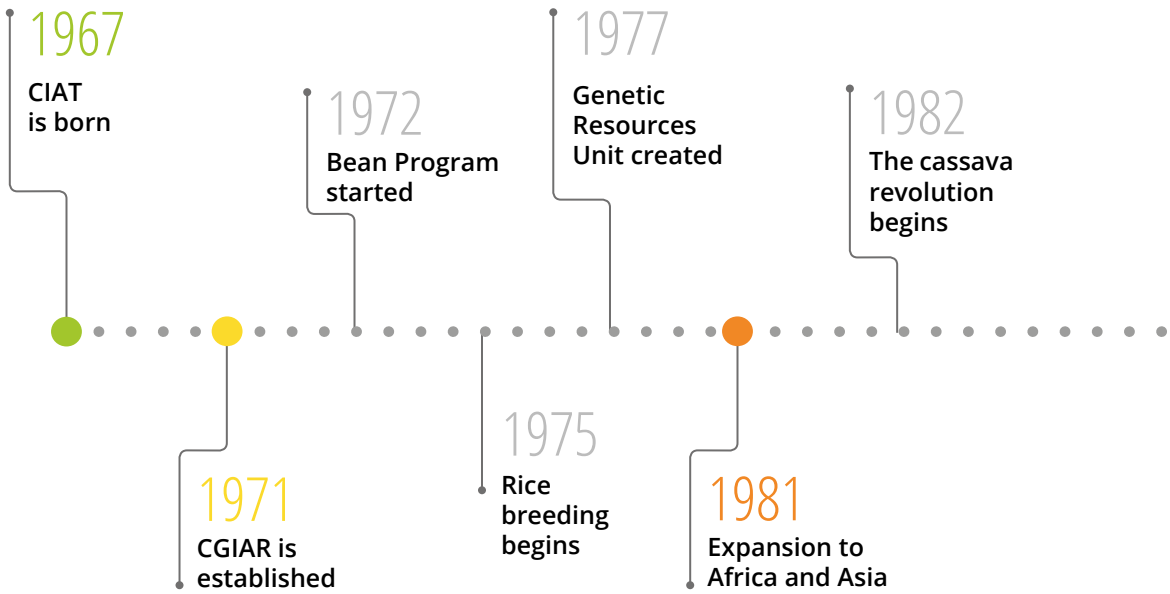
A few more approaches have been found to be suitable and are now prioritized for testing. These include integrated home gardens, vermicomposting, raising poultry on a "living bed" of sawdust treated with EM to improve poultry health, and rice straw processing to make bio-fertilizer. Testing for several of these began in 2016; the rest will be tested in 2017.

"Climate change is moving too quickly for the sequential testing of individual CSA practices. By bundling several together in climate-smart villages like Ma, we can help farmers move much more quickly towards sustainable farming systems that are more resilient and productive," said CIAT's Vinh Bui, a scientist and coordinator for the CCAFS climate-smart village project in Vietnam.

In 2016, CIAT launched a climate-smart agriculture (CSA) sourcebook, "Towards climate resilience in agriculture for Southeast Asia: an overview for decision-makers", referencing a wide range of CSA practices and demonstrated technologies from over 700 sources. The Ma CSV action is performed within the frame of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

50 YEARS OF *growth* AT CIAT

MOMENTS AND



MILESTONES

1967
CIAT is born
CIAT is formally established on 17 October 1967. Though formed in cooperation with the Colombian government, CIAT would function autonomously, governed by an international board of trustees. Dr. Ulysses J. Grant, a plant breeder and the Regional Director of the Agricultural Program of the Rockefeller Foundation in Colombia, is designated Interim Director. Grant, a man of both vision and action, is lauded as being the chief negotiator, promoter, and executer behind the establishment of CIAT.

1971
CGIAR is born
In May 1971, 18 countries and four organizations, convinced that agricultural science is a powerful tool to combat hunger, unite as the Consultative Group on International Agricultural Research (now CGIAR). Originally headquartered in Washington, DC, CGIAR starts as an informal association of countries, international and regional organizations, and private foundations in support of agricultural research. CIAT, IRRI, CIMMYT, and IITA are supported as the original CGIAR centers. Over four decades, the number of CGIAR centers grows from four to fifteen.

1981
Expansion to Africa and Asia
Efforts are made to post staff in Africa and Asia, particularly for work on cassava in Indonesia and Thailand, and on beans in Burundi, Rwanda, and Zaire (now the Democratic Republic of the Congo). At this time, CIAT's long-range plan calls for significant increases in outposted staff and for an emphasis on decentralization through global networking and collaboration.

1992
Emphasis on sustainability
In conjunction with the 1992 UN Earth Summit in Rio de Janeiro, and responding to the growing realization that research aimed to increase food production must also contribute to the conservation of natural resources, poverty reduction, and the promotion of equity, CIAT launches its Resource Management Research Division. It makes a clear investment toward both sustainable development and gender equity.

1996
CIAT launches PABRA
The Pan-Africa Bean Research Alliance (PABRA) includes government research institutions, universities, and international research centers. It works with farmers, rural communities, NGOs, and other private sector organizations to increase smallholders' access to improved and marketable bean varieties, new crop management techniques, and market chain information. Since 1996, PABRA has released over 550 new bean varieties across Africa, many of which have transformed beans from a subsistence crop to a cash crop – marking CIAT's focus on raising incomes of smallholder farmers.

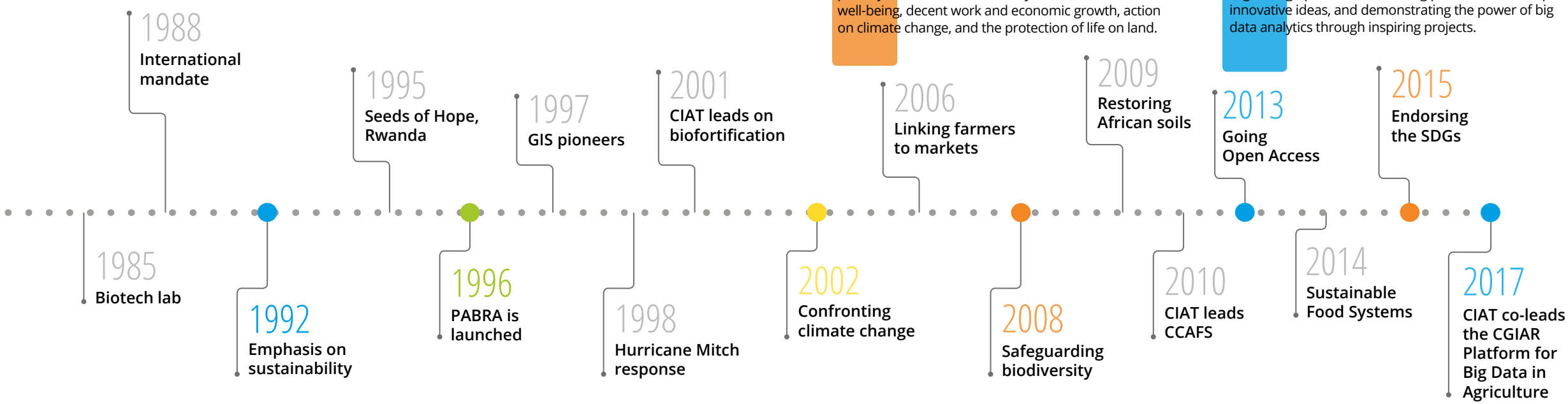
2002
Confronting climate change
Armed with evidence of our changing climate, CIAT establishes a program to investigate ways for farmers to respond to the situation. In particular, the Center's expertise in geographic information systems (GIS) and other modeling tools will be used to investigate how climate change will impact agricultural production in the future. In 2010, CIAT took the lead of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) under the CGIAR's first 2010–2016 portfolio of Research Programs.

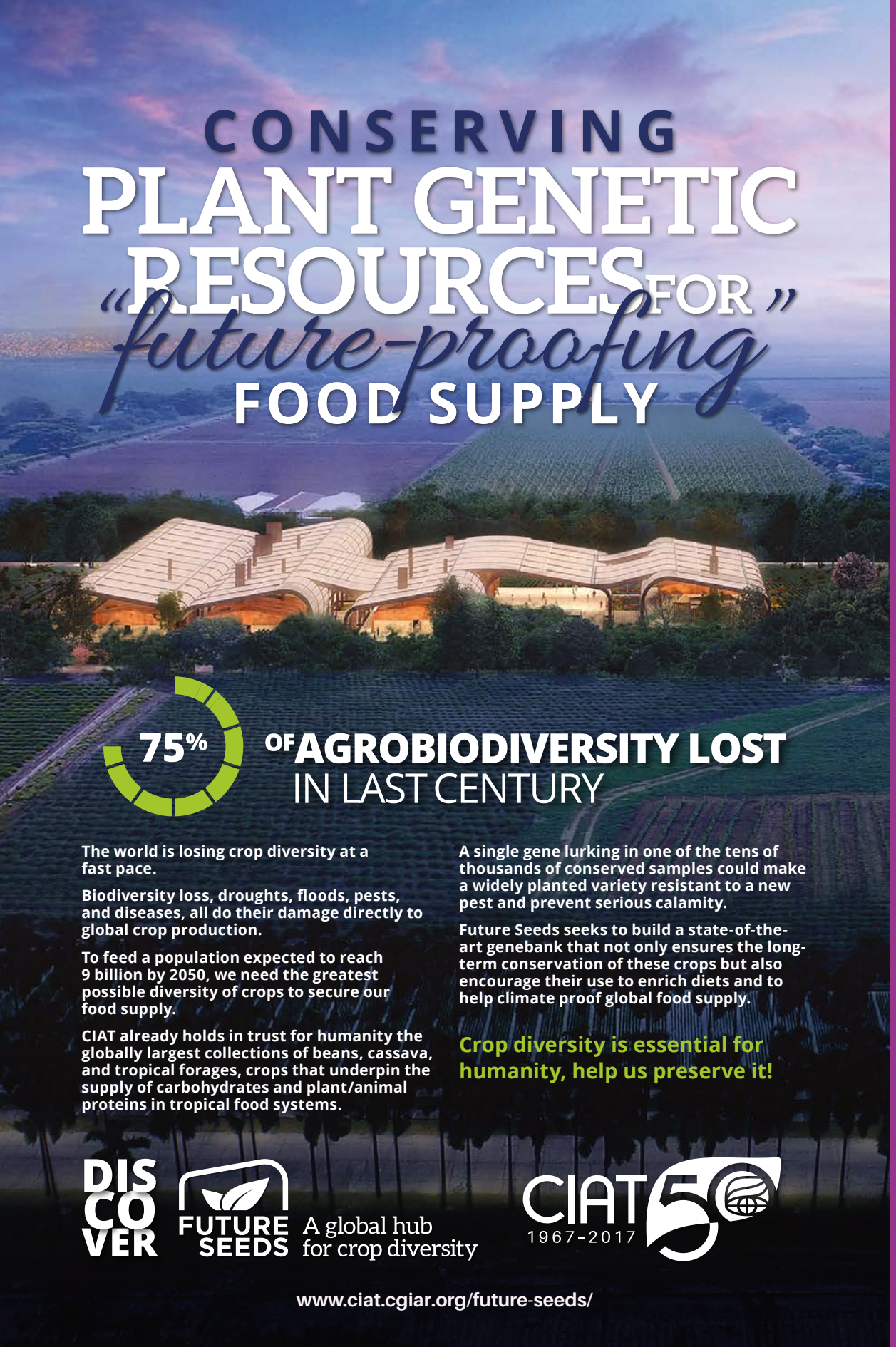
2008
Safeguarding biodiversity
Under the auspices of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), signed two years previously, CIAT sends its first shipment of seeds to the Svalbard Global Seed Vault in northern Norway. Buried in permafrost near the North Pole, the so-called "Doomsday Vault" aims to safeguard duplicate collections of seeds from genebanks around the world. In the event of conflict or natural disaster, seeds would be repatriated to countries to help them reestablish crop production.

2013
Opening access to research
CIAT views access to accurate and timely information as global public goods, essential to the worldwide effort to fight hunger and poverty. In 2013, CGIAR centers officially commit to making all research outputs Open Access by 2018. Opening research, including publications, products, and raw data, ensures that more people can read and apply CIAT's research findings.

2015
CIAT endorses the SDGs
CIAT endorses the United Nations' new Sustainable Development Goals, the ambitious successor to the *Millennium Development Goals*. Six of the seventeen goals reinforce the global importance of CIAT's mission to pursue sustainable development on multiple fronts: poverty reduction, food security, universal health and well-being, decent work and economic growth, action on climate change, and the protection of life on land.

2017
CIAT co-leads the CGIAR Big Data Platform
The ultimate goal of the CGIAR Platform for Big Data in Agriculture (2017–2022), which is co-led by CIAT and IFPRI, is to harness the capabilities of big data to accelerate and enhance the impact of international agricultural research by providing global leadership in organizing open data, convening partners to develop innovative ideas, and demonstrating the power of big data analytics through inspiring projects.





FIFTY YEARS AND 50 wins

In 1967, the majority of poor and hungry people in the tropics were smallholder farmers. Increasing the productivity of their crops was, therefore, the critical entry point for CIAT's research. Since that time, we have been concerned with nearly every aspect of tropical agriculture: the crop varieties that farmers grow, the production systems they manage, the agricultural landscapes they inhabit, the markets in which they participate, and the policies that influence their options and decisions.

FOOD SECURITY AND NUTRITION

1 **CIAT provides cassava, bean, and forage materials stored in its genebank free of charge** for the purposes of research, breeding, or training for food and agriculture now under the terms of the International Treaty on Plant Genetic Resources for Food and Agriculture, which it signed in 2006.

2

Over the years, CIAT has distributed:

- 37,390 accessions (441,225 samples) of bean germplasm to 105 countries since 1973.
- 6,492 accessions (43,458 samples) of cassava germplasm to 84 countries since 1979.
- 13,692 accessions (90,624 samples) of tropical forage germplasm to 110 countries since 1980.

Over 23,000 accessions of beans, cassava, and tropical forages have been shared with researchers in CIAT's host country, Colombia. Through the Plant Treaty, CIAT has also received new accessions of wild beans for use in its bean breeding program.

3

4 **CIAT bean breeders have developed beans containing about 60% more iron and up to 50% more zinc** – two important nutrients for human health. They include the varieties BIO101 and BIO107 – released in Colombia's Santander department, where they produce good yields and are of the shape, size, and color preferred by farmers.

5 **High-iron beans released in Rwanda in 2012 have been shown to reverse iron deficiency and anemia** in young women in just four-and-a-half months. Lack of iron can impair cognitive and physical development in children. High-iron beans have also been released in Uganda, Colombia, and Guatemala.

6 **Pro-vitamin A-rich cassava** developed by CIAT and the International Institute of Tropical Agriculture (IITA) as a contribution to the World Food Prize-winning HarvestPlus initiative **is helping tackle vitamin A deficiency**, especially among women and children in Nigeria, Uganda, and the Democratic Republic of the Congo. Vitamin A deficiency can cause vision loss and blindness, and impair the immune system.

CIAT provided technical assistance and forage grass hybrids for farmers enrolled in Rwanda's One Cow per Poor Family initiative launched in 2006. As well as improving production of meat and milk, the grasses help ensure animals survive the dry season, when other feed sources are scarce.

8 **CIAT and partners have developed "quick-cook" beans** (as well as precooked bean snacks) to reduce the amount of time and energy households, typically women, spend preparing nutritious meals.

A BETTER DEAL FOR FARMERS AND CONSUMERS

9 **In late 2015, CIAT deployed new drought-resilient white beans to Ethiopia**, where erratic weather was threatening yields. Most commonly used in the production of baked beans, the country's export market for white beans is worth over US$100 million a year, providing incomes for around 3 million smallholder farmers.

10 **Climbing beans – the type that climb up stakes like a vine, and are up to three times more productive than bush beans** – are providing an eco-efficient solution for improving nutrition for farming families in densely populated places such as Rwanda, Burundi, and Western Kenya.

11 **Today, improved climbing beans are planted on more than half of Rwanda's bean production area**, a 45% increase since 1985. Bean yields have increased from 0.7 to 1.1 tons per hectare and, in the last decade, the country has been transformed from a net importer to an exporter of beans, with exports valued at US$12–20 million.

12 **The adoption of improved cassava varieties** resulting from research by CIAT and its partners in **Southeast Asia** has generated **benefits worth almost US$12 billion** over the last 20 years.

13 **Cassava variety KU 50, bred by scientists at CIAT and Kasetsart University in Thailand**, is better adapted to a wider variety of growing conditions, has less of an impact on soil quality, and provides roots with high starch content. Between 1993 and 2011, Thai cassava farmers earned an estimated US$1.56 billion dollars from KU 50.

14 In 2003, CIAT and partners released a **new cassava variety, Nataima-31,** which was bred for whitefly resistance, high yield, and good cooking qualities. **Yields outperformed local varieties** in Colombia's Tolima department, even without pesticide applications. Nataima-31 is now being grown commercially in several areas of Colombia, Ecuador, and Brazil.

In the 1970s, **ranchers in Colombia's Llanos region replaced native grasses with selected varieties of *Brachiaria* forages** developed at CIAT. **Meat production per hectare increased 10-to-15 fold**, with economic benefits estimated to exceed US$1 billion.

Sown forages could relieve Africa's severe shortage of feed and sustain its ongoing livestock revolution. A recent CIAT study shows that planting *Brachiaria* hybrids could bring smallholder livestock farmers in East Africa tens of millions of dollars in revenue from increased milk production alone.

17 **The time it takes to raise cattle was reduced from 4 years to about 20 months in Brazil thanks to new varieties of forage grasses developed by CIAT and the Brazilian Agricultural Research Corporation (EMBRAPA).** Improved feeding, backed by strong tax incentives, has already resulted in significant reduction of Brazil's greenhouse gas emissions.

Sixty percent of the improved rice varieties released in Latin America and the Caribbean can be traced back to parent varieties developed by CIAT, preliminary research suggests. Related benefits are estimated at US$860 million for the period 1967–1995. Rice consumers are the main beneficiaries, receiving almost 60% of all the gains generated by adoption of improved varieties.

19 **The world's third largest consumer goods company, Unilever, has adopted CIAT's LINK Methodology in support of its Sustainable Living Plan.** This is helping it develop inclusive trade relationships and source products from smallholder farmers around the world.

20 **In Latin America alone, there are over 50 cases in which CIAT's LINK Methodology has been used as a development, evaluation, or business tool** to build more inclusive and sustainable business models between producers associations and buyers.

BUILDING RESILIENCE

21

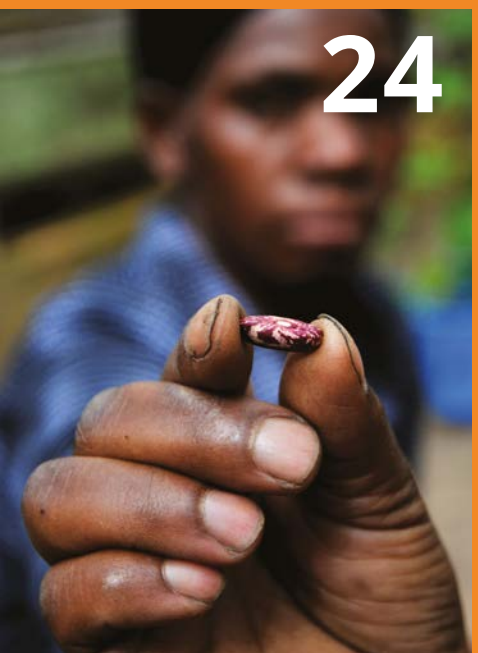
CIAT's cassava collection of over 6,700 accessions includes approximately 30 species of cassava wild relatives. Breeders around the world are using these species to produce cassava varieties with more protein and greater resistance to drought and diseases.

22

CIAT scientists are about a year away from defining cassava's pan-genome. This will allow scientists to identify genes responsible for increasing yields, boosting protein content, and improving resistance to pests. This will also make possible the breeding of cassava *in silico* (by computer simulation) to establish the most effective combinations of parent plants to produce offspring with the most valuable traits.

23

After the 1994 genocide in Rwanda – as genetic resource facilities were destroyed and seeds were eaten – CGIAR centers launched a project called "Seeds of Hope" **to ensure that Rwandan farmers were supplied with the varieties of seeds they had before**, suited to their soil and climate, and resistant to local pests and diseases. Through the following decade, CIAT, Catholic Relief Services (CRS), and CARE Norway collaborated on a series of seed aids and seed system security guides.



24

CIAT scientists at Kawanda genebank in Uganda safeguard the largest collection of beans in Africa. East African bean breeders are using this diversity to develop new high-iron and drought-tolerant bean varieties. Five such varieties were released in Uganda in 2016.

25

The first high-iron, drought-resistant beans were released in Uganda and distributed to Tanzania, Malawi, Kenya, Madagascar, Ethiopia, and South Sudan in 2016.

26

After Hurricane Mitch tore through Central America in 1998, CIAT's GIS team worked with the Canadian Space Agency to help relief workers identify areas most affected, and determine suitable crops and locations for replanting.

27

CIAT scientists have discovered 30 new types of "heat-beater" beans able to handle an average 4-degree Celsius temperature increase.

Selected *Brachiaria* forage grasses can greatly help mitigate climate change thanks to their capacity to inhibit nitrification, a natural process that causes the conversion of nitrogen into nitrous oxide (N_2O), a greenhouse gas 300 times more potent than CO_2. With the seven-fold rise in the use of nitrogen fertilizers since the 1970s, tackling nitrification is crucial to tackling climate change.

28

29

In 2014, 170 rice growers with 1,800 hectares in Colombia's Córdoba department avoided big economic losses by following a recommendation to skip a growing season due to forthcoming drought. The recommendation, made by the country's rice growers association Fedearroz, was based on CIAT climate simulations.

30

In 2015, CIAT and its partners used crop and climate models to show the likely impact of climate change in sub-Saharan Africa and, for the first time, when changes in policy and practice need to take place to avoid the loss of suitability of key staple crops such as maize, beans, and banana.

31

Research by CIAT and CCAFS led the Nicaraguan Government to prioritize the adaptation of smallholder coffee and cocoa farms to the impact of climate change in its 2013 National Adaptation Plan for Agriculture (NAPA). The NAPA helped attract major investment, including US$24 million from the International Fund for Agricultural Development (IFAD) to help finance that adaptation.

32

In Colombia, Terra-i – a near-real time deforestation monitoring tool developed by CIAT and its partners – revealed massive deforestation in 2008 and 2009. The Colombian government used the information to revise its estimates and set new targets to tackle deforestation ahead of the 2009 climate negotiations in Copenhagen.

In Peru, Terra-i is being used by the Ministry of Environment as the official early-warning system for land cover and land-use change, producing a monthly update or alert system and pin-pointing deforestation hotspots.

33

34

CIAT's research helped design the Tana-Nairobi Water Fund, which was launched in 2015 thanks to The Nature Conservancy (TNC) and partners. The Fund, the first of its kind in Africa, is a public-private scheme aimed to increase farm productivity upstream, while improving water supply and cutting costs of hydropower and clean water downstream. It is expected to generate US$21.5 million in long-term benefits to Kenyan citizens, including farmers and businesses.

35 **CIAT's research helped put a value on ecosystem services in Peru's Cañete River Basin.** In 2014, the country's Congress approved a law promoting compensation mechanisms for equitable sharing of economic benefits from vital services provided by the country's diverse ecosystems.

36 **CIAT virologists have developed a diagnostic technique to efficiently detect the presence of viruses infecting cassava,** including those associated with cassava frogskin disease (CFSD).

37

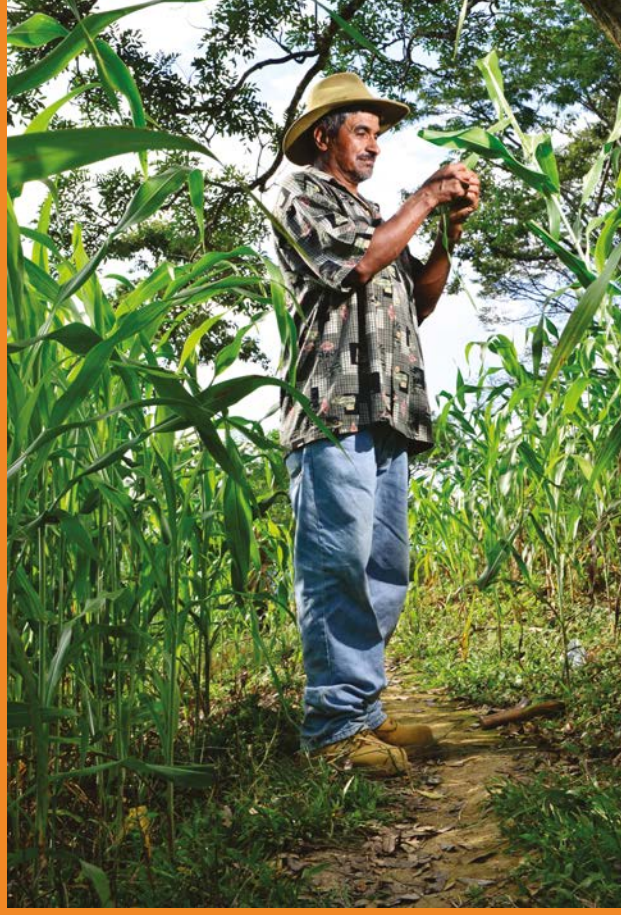
In 2014, **scientists from Indonesia's Bogor Agricultural University release about 3,000 parasitic wasps with CIAT and FAO's support to thwart cassava mealybug invasion.** Similar biocontrol responses were implemented in Vietnam in 2013 and Thailand in 2010, as well as in Africa in the 80s, where it saved a whopping US$20 billion for the cassava sector. **The introduction of the wasp in Africa by IITA is recognized as one of the most successful pest control programs in the world.**

38

More than 30,000 smallholder farmers in Kenya, Ethiopia, Tanzania, and Uganda have taken up the climate-smart version of a "push-pull" crop production system developed by the International Centre for Insect Physiology and Ecology (*icipe*) and which aids the elimination of stem borer, a devastating insect pest of maize and other cereals. The "push-pull" system integrates drought-tolerant *Brachiaria* grasses developed by CIAT as a "trap" crop for the pest, while also being used to feed cattle.

39

The climate-smart agriculture (CSA) country profiles produced by CIAT, CCAFS, and partners are helping countries take the next step in implementing their climate change adaptation and mitigation plans. The briefs outline the country-specific CSA considerations and highlight their relation to adaptation, mitigation, productivity, institutions, and finance.



40

The adoption through participatory research of agro-ecological farming systems, such as Quesungual in Honduras, Nicaragua, and El Salvador, has helped restore soil moisture, prevent erosion, reduce deforestation, and mitigate climate impacts by replacing slash-and-burn practices with "slash-and-mulch" methods, which maintain tree cover. The Quesungual slash-and-mulch agroforestry system was originally developed by FAO in the early 1990s.

41

By building up an arable layer on the infertile acid soils of the savannas of Colombia's Llanos region in the early 2000s, farmers were able to greatly increase their productivity and economic returns on investments. This was made possible thanks to soil improvement and conservation practices, including crop and pasture rotation, vertical corrective tillage, correction of soil nutrient deficiencies, and sowing improved forages adapted to the region's soils.

42

CIAT contributed to the dissemination of integrated soil fertility management (ISFM) principles by informing the Bill & Melinda Gates Foundation's African Soil Health Initiative (2007). ISFM entails practices adapted to local conditions, including the use of fertilizer, organic inputs, and improved crops.

GLOBAL PARTNERSHIPS FOR IMPACT

43

Through the Pan-Africa Bean Research Alliance (PABRA), which CIAT created in 1996, over 450 improved bean varieties have been released across sub-Saharan Africa, and millions of farming households accessed quality seed. PABRA currently works to improve bean production and access in 30 countries.

PABRA 20 YEARS
Pan-Africa Bean Research Alliance
Transforming agriculture since 1996

FLAR

44

Since CIAT created the Latin American Fund for Irrigated Rice (FLAR) in 1995, it has evolved into a strong regional organization encompassing 36 public and private sector partners in 17 countries, which influences about 80% of the 27.8 million tons of rice produced in Latin America and the Caribbean.

45

Since the 1990s, CIAT has promoted the "Learning Alliances" model in Central America and Africa as a way to successfully scale up development impact. Learning Alliances can be understood as a process where researchers and development practitioners combine forces, skills, and funds, and where research outputs are shared, adapted, used, and improved upon to effectively translate research findings into development outcomes.

46 **Over five decades, CIAT has hosted and collaborated with tens of thousands of visiting researchers** from universities, the private sector, other CGIAR Centers, and local organizations.

47

CIAT co-established the African Network for Soil Biology and Fertility (AfNet) in 1988 to build the capacity of African institutions to conduct interdisciplinary and integrated soil fertility management (ISFM) research at regional and international levels.

48

CIAT mentored current and future leaders in agricultural science such as Rwanda's Minister of Agriculture and Animal Resources, Gerardine Mukeshimana, who worked with then CIAT bean breeder and current Bean Program leader, Steve Beebe, to gain exposure to drought selection techniques.

49

CIAT emeritus scientist Rainer Schultze-Kraft received the 2016 Friendship Award from the Chinese government for his long-term work with tropical forage scientists in the country. The award – presented by China's Vice Premier Ma Kai – is considered the highest accolade that foreign experts working with Chinese institutions can receive.

50

The Ethiopia Bean Research Programme led by the Ethiopian Institute of Agricultural Research (EIAR) has won the country's highest scientific award – the Gold medal and Cup – for the impact of its bean research, which has transformed the lives of millions of farmers. Dr. Berhanu Amsalu Fenta, Coordinator of the National Lowland Pulses Research Program, who received the award on behalf of EIAR, is a former PhD student supported by CIAT.

Publications: Our top pick for 2016

Here is our top pick of 2016 publications. If you have missed them, don't worry.
Go online now: http://ciat.cgiar.org/publications/

178 refereed journal articles in 2016 → **72% are Open Access!**

These Altmetric donuts provide a colorful visualization of the type and level of attention received by publications online.

TWEETERS | FACEBOOK | BLOGS | GOOGLE+ | REDDITOR | WIKIPEDIA

Khoury et al. 2016. **Origins of food crops connect countries worldwide**. Proceedings of the Royal Society B - Biological Sciences 283: 2060792.
http://dx.doi.org/10.1098/rspb.2016.0792
CGSpace link: http://hdl.handle.net/10568/75695

Wollenberg et al. 2016. **Reducing emissions from agriculture to meet the 2 °C target**. Global Change Biology 22(12): 3859–3864.
http://dx.doi.org/10.1111/gcb.13340
CGSpace link: http://hdl.handle.net/10568/73438

Rippke et al. 2016. **Timescales of transformational climate change adaptation in sub-Saharan African agriculture.** Nature Climate Change 6:605–609 p.
http://dx.doi.org/10.1038/NCLIMATE2947
CGSpace link: http://hdl.handle.net/10568/72509

Trijatmiko et al. 2016. **Biofortified indica rice attains iron and zinc nutrition dietary targets in the field**. Scientific Reports 6:19792.
http://dx.doi.org/10.1038/srep19792
CGSpace link: http://hdl.handle.net/10568/70994

Frelat et al. 2016. **Drivers of household food availability in sub-Saharan Africa based on big data from small farms.** Proceedings of the National Academy of Sciences of the United States of America (PNAS) 113(2):458–463.
www.pnas.org/cgi/doi/10.1073/pnas.1518384112
CGSpace link: http://hdl.handle.net/10568/70134

Other publications:

Decision and Policy Analysis Research Area

Challinor et al. 2016. **Current warming will reduce yields unless maize breeding and seed systems adapt immediately.** Nature Climate Change 6:954–958. http://dx.doi.org/10.1038/NCLIMATE3061

Castañeda-Álvarez et al. 2016. **Global conservation priorities for crop wild relatives.** Nature Plants 17 p. http://dx.doi.org/10.1038/nplants.2016.22

Butt et al. 2016. **The impact of residential combustion emissions on atmospheric aerosol, human health, and climate.** Atmospheric Chemistry and Physics 16(2):873–905. http://dx.doi.org/10.5194/acp-16-873-2016

Schroth et al. 2016. **Vulnerability to climate change of cocoa in West Africa: patterns, opportunities and limits to adaptation.** Science of the Total Environment 556(15):231–243. http://dx.doi.org/10.1016/j.scitotenv.2016.03.024

Francesconi et al. 2016. **Using the soil and water assessment tool (SWAT) to model ecosystem services: a systematic review.** Journal of Hydrology 535(April):625–636. http://dx.doi.org/10.1016/j.jhydrol.2016.01.034

Harmel et al. 2016. **Uncertainty in monitoring *E. coli* concentrations in streams and stormwater runoff.** Journal of Hydrology 534:524–533. http://dx.doi.org/10.1016/j.jhydrol.2016.01.040

Agrobiodiversity Research Area

Roa et al. 2016. **Plant genetic resources: needs, rights, and opportunities.** Trends in Plant Science. 1–4 p. http://dx.doi.org/10.1016/j.tplants.2016.06.002

Pulido-Tamayo et al. 2016. **EXPLoRA-web: linkage analysis of quantitative trait loci using bulk segregant analysis.** Nucleic Acids Research 44(W1):W142–W146. http://dx.doi.org/10.1093/nar/gkw298

Sempéré et al. 2016. **Gigwa—Genotype investigator for genome-wide analyses.** GigaScience. BioMed Central Ltd., 5:36. http://dx.doi.org/10.1186/s13742-016-0131-8

Torres et al. 2016. **The impact of heating and soaking on the *in vitro* enzymatic hydrolysis of protein varies in different species of tropical legumes.** Food Chemistry 194:377–382. http://dx.doi.org/10.1016/j.foodchem.2015.08.022

Sarah et al. 2016. **A large set of 26 new reference transcriptomes dedicated to comparative population genomics in crops and wild relatives.** Molecular Ecology Resources. http://dx.doi.org/10.1111/1755-0998.12587

Haas et al. 2016. **Consuming iron biofortified beans increases iron status in Rwandan women after 128 days in a randomized controlled feeding Trial 1–3.** The Journal of Nutrition 146(8):1586–1592. http://dx.doi.org/10.3945/jn.115.224741

Rao et al. 2016. **Root adaptations to soils with low fertility and aluminum toxicity.** Annals of Botany 118(4):593–605. http://dx.doi.org/10.1093/aob/mcw073

Morante et al. 2016. **Discovery of new spontaneous sources of amylose-free cassava starch and analysis of their structure and techno-functional properties.** Food Hydrocolloids 56:383–395. http://dx.doi.org/10.1016/j.foodhyd.2015.12.025

Greenfield et al. 2016. ***Beauveria bassiana* and *Metarhizium anisopliae* endophytically colonize cassava roots following soil drench inoculation.** Biological Control. Elsevier B.V., 95:40–48. http://dx.doi.org/10.1016/j.biocontrol.2016.01.002

Bechoff et al. 2016. **Cassava traits and end-user preference: relating traits to consumer liking, sensory perception, and genetics.** Critical Reviews in Food Science and Nutrition. Wiley-Blackwell Publishing Ltd., 12 p. http://dx.doi.org/10.1080/10408398.2016.1202888

Soils and Landscapes for Sustainability Research Area

Viscarra et al. 2016. **A global spectral library to characterize the world's soil**. Earth-Science Reviews 155 (April):198–230. http://dx.doi.org/10.1016/j.earscirev.2016.01.012

Zomer et al. 2016. **Global tree cover and biomass carbon on agricultural land: the contribution of agroforestry to global and national carbon budgets.** Scientific Reports. Nature Publishing Group, 6:29987. http://dx.doi.org/10.1038/srep29987

Richards et al. 2016. **Limits of agricultural greenhouse gas calculators to predict soil N_2O and CH_4 fluxes in tropical agriculture.** Scientific Reports 6:26279. http://dx.doi.org/10.1038/srep26279

De Palma et al. 2016. **Predicting bee community responses to land-use changes: Effects of geographic and taxonomic biases.** Scientific Reports. Nature Publishing Group, 6:31153. http://dx.doi.org/10.1038/srep31153

Hammond et al. 2016. **The Rural Household Multi-Indicator Survey (RHoMIS) for rapid characterisation of households to inform climate smart agriculture interventions: Description and applications in East Africa and Central America.** Agricultural Systems 9 p. http://dx.doi.org/10.1016/j.agsy.2016.05.003

CGIAR Research Programs

Liu et al. 2016. **Similar estimates of temperature impacts on global wheat yield by three independent methods.** Nature Climate Change 6:1130–1136. http://dx.doi.org/10.1038/NCLIMATE3115

Calvin et al. 2016. **Agriculture, forestry, and other land-use emissions in Latin America.** Energy Economics 56:615–624. http://dx.doi.org/10.1016/j.eneco.2015.03.020

Calderón et al. 2016. **Achieving CO_2 reductions in Colombia: Effects of carbon taxes and abatement targets.** Energy Economics 56:575–586. http://dx.doi.org/10.1016/j.eneco.2015.05.010

Financial highlights

Major efforts during the 2016 fiscal year focused on the development of the second phase of the CGIAR Research Programs. For CIAT, this meant major contributions across the CGIAR portfolio of global research programs, and intensive effort to bring new innovations to the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and establish the CGIAR Platform for Big Data in Agriculture.

The Platform provides a significant opportunity to leverage the data collected over 50 years in the CGIAR System to speed innovation, support informed decision making, and scale up science-based development solutions. It will drive CGIAR-wide efforts to provide global leadership in organizing open data, as well as convene a large number of external partners, to inspire new ways to approach agriculture, environment, and food security research and to achieve impact.

In Asia, CIAT continued to build on important priorities in several countries including Vietnam, Indonesia, Philippines, and China. Resilience and climate-smart agriculture were major themes in our new research projects.

A major highlight in Africa was the renewal of the Pan-Africa Bean Research Alliance (PABRA), which focuses on improving economic growth, nutrition, gender equity, and the natural resource base for better livelihoods of smallholder households in sub-Saharan Africa. Additionally, in 2016, sustainable solutions were scaled out through interventions to increase soil health and soil carbon sequestration, and research projects explored the socioeconomic and environmental potential of improved forages in crop–livestock systems.

Closer to CIAT headquarters in Latin America and the Caribbean, our work focused on scaling out climate-smart agriculture, and providing policy makers with decision support tools. In addition, CIAT's genebank, which provides vital raw material for our crop breeding programs, moved closer to a much needed revitalization through the *Future Seeds* initiative (see page 68).

Global partnerships continued to play a central role in our activities. Our partners, whether donors, governments, private sector actors, or NGOs, contribute greatly to CIAT's keen focus on innovation – as we put science to work in response to some of the most complex issues faced by society.

Statement of activity
(expressed in thousands of US$

	2016	2015
Revenues and gains		
Windows 1 & 2	40,944	51,823
Window 3	31,388	34,572
Bilateral	21,903	24,024
Total grant revenues	**94,235**	**110,419**
Other revenues and gains	328	318
Total revenues and gains	**94,563**	**110,737**
Expenses and losses		
Research direct expenses	49,888	52,782
CGIAR collaborator expenses	23,007	33,287
Non-CGIAR collaborator expenses	15,242	16,134
General and administration expenses	7,689	8,389
Other expenses and losses	(35)	323
Total operating expenses	**95,791**	**110,915**
Financial income	1,133	1,087
Financial expenses	(179)	(493)
Surplus (deficit) for the year	**(274)**	**416**

Donors and partners

- Australian Centre for International Agricultural Research (ACIAR)
- Corporation for the Sustainable Development of La Macarena Special Management Area (CORMACARENA), Colombia
- Department of Agriculture's Bureau of Agricultural Research (DA-BAR), the Philippines
- Federal Government of Mexico
- Food and Agriculture Organization of the United Nations (FAO)
- Howard G. Buffett Foundation, USA
- McKnight Foundation, USA
- Ministry of Foreing Affairs, Norway (MFA)
- Monsanto Fund, USA
- National Science Foundation (NSF), USA
- The World Bank
- UK Department for International Development (DfID)
- United Nations Environment Programme (UNEP)
- United States Department of Agriculture (USDA)

- African Agricultural Technology Foundation (AATF), Kenya
- African Development Bank (AfDB)
- Austrian Development Agency (ADA)
- Autonomous Regional Corporation of Valle del Cauca (CVC), Colombia
- Biotechnology and Biological Sciences Research Council (BBSRC), UK
- Brazilian Agricultural Research Corporation (EMBRAPA)
- Catholic Relief Services (CRS), USA
- Committee for Sustainability Assessment (COSA)
- DuPont Pioneer, USA
- German Development Bank (KfW)
- Inter-American Development Bank (IDB)
- International Development Research Centre (IDRC), Canada
- International Union for Conservation of Nature (IUCN)
- Irish Aid
- Japan International Research Center for Agricultural Sciences (JIRCAS)
- Keurig Green Mountain, Inc., USA
- Ministry of Agriculture and Irrigation (MINAGRI), Peru
- Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan
- Ministry of Agriculture, Livestock and Fisheries (MALF), Kenya
- Public Enterprises of Medellín (EPM), Colombia
- Regional Fund for Agricultural Technology (FONTAGRO)
- Swiss National Science Foundation (SNSF)
- Syngenta, Switzerland
- US Overseas Cooperative Development Council (OCDC)
- World Resources Institute (WRI), USA

- Australian Department of Foreign Affairs and Trade (DFAT)
- Bayer S.A., Colombia
- Chinese Academy of Agricultural Sciences (CAAS)
- French National Institute for Agricultural Research (INRA)
- Future Earth
- Global Environment Facility (GEF)
- International Fertilizer Development Center (IFDC)
- International Institute for Environment and Development (IIED)
- Ministry of Agriculture and Cooperatives of the Kingdom of Thailand
- Ministry of Environment and Sustainable Development (MADS), Colombia
- National Federation of Coffee Growers (FNC), Colombia
- National Institute of Forestry, Agriculture and Livestock Research (INIFAP), Mexico
- Nutrition Research Institute (IIN), Peru
- Solidaridad, the Netherlands
- Technical Centre for Agricultural and Rural Cooperation (CTA)
- The Nature Conservancy (TNC), USA
- UTZ Certified, the Netherlands
- Villum Foundation, Denmark
- World Coffee Research (WCR)

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50
Building
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since 1967

WORD SEARCH
Challenges and solutions

Food security and nutrition

I I M N W N E O M A R K E T S
J N D A T A U C A N E M I A B
Q U F N L V I T A M I N S D R
G C D O U N D H R S Z O W I E
R A L I R T U H U I S U Y E E
E P P I V M R T E N E A T T D
S A O I M E A I R A G N V S I
E C L R U A R T T I L E T A N
A I I O E S T S I I T T R S G
R T C N I Y C E I O O I H U W
C Y Y A F R I C A T N N O O O
H E D U C A T I O N Y F M N M
A T Y K N O W L E D G E O R E
F H A R V E S T P L U S P O N
C R O P S A W A R E N E S S D

Africa
anemia
awareness
beans
biofortification
breeding
capacity
cassava
children
climate
crops
data
diets
diversity
education
food
HarvestPlus
health
hunger
information
iron
knowledge
malnutrition
markets
nutrients
nutrition
policy
research
science
stunting
vitamins
women

Better business for farmers and consumers

E D N U K C O T S E V I L N R
I R P O R B E Q U I T Y Y O E
N I U R I B U N I A H C F I D
T N E T O T A S M O N I A T L
E C Q S C D A N I E M L R A O
R L U S E U U M I N I O M Z H
M U A E E C R C R Z E P E I L
E S L C F E I T T O A S R L L
D I I C O F D R S I F T S A A
I V T A F H W S P A O N I B M
A E Y E T A V I R P R N I O S
R V O L A T I L I T Y F W L N
Y C E C O N O M I C S Y N G E
E S U P E R M A R K E T S I D
S D O O H I L E V I L F A I R

access
business
cash
chain
dairy
data
ecoefficiency
economics
equality
equity
fair
farmers
food
globalization
inclusive
information
infrastructure
intermediary
livelihoods
livestock
markets
policy
poverty
prices
private
production
profit
roads
seeds
smallholder
subsistence
supermarkets
trade
urbanization
volatility

WORD SEARCH
Challenges and solutions

Building resilience

Y M I T I G A T I O N E T N V
N T H N L N C R D D N N Y O A
O C I I S H O I E V A C V I R
I L O L A T S I I D N T S T I
T S A N I E A R S E N M A A A
A N G N A B O B I I E E E T B
M E E S S N A C I T C T G S I
R S E T M C I N S L A E O E L
O S F E W F A Y I M I C D R I
F W N A F O S P I A I T N O T
N T C E C O R L E A T C Y F Y
I P O D C C C K L S G S A E S
D C D E M O G R A P H Y U D M
E Z D E G R A D A T I O N S C
L A N D N O I T A R O T S E R

adaptation
CCAFS
change
climate
control
cope
data
decision
deforestation
degradation
demography
diseases
ecoefficiency
economics
ecosystems
environment
gender
information
instability
land
lanscapes
mitigation
nature
network
pests
policy
predictions
restoration
risks
scenarios
smallholder
social
soil
sustainability
transition
variability

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