World Agroforestry Centre

Annual Report

2016-2017

Our vision

An equitable world where all people have viable livelihoods supported by healthy and productive landscapes.

Our mission

To harness the multiple benefits trees provide for agriculture, livelihoods, resilience and the future of our planet, from farmers' fields through to continental scales.

Our value offer

ICRAF as a centre of scientific excellence has the world's largest breadth of agroforestry: expertise; published literature; methods; data; databases; partnership networks; and tree germplasm collections. Specifically, on rural landscapes and livelihoods we are the place to engage for:

- Providing robust evidence and analyses
- Making available social and technical solutions
- Assisting with design, decision and delivery options
- Developing capacities, convening and partnerships

Our core values

- Professionalism
- Mutual respect
- Creativity
- Inclusiveness

Our partners

The World Agroforestry Centre has always implemented much of its work in partnership with a range of public, private and international bodies. Our partnerships are based on a clear recognition of the value that is added through working jointly with partners and sharing strengths to achieve specific outcomes. We partner with universities, advanced research institutions, national agricultural research organizations, private sector organizations, and government and non-government agencies in the fields of agriculture, forestry, environment, conservation and climate change.

Cover photo: Veronica Mutethia, accompanied by her child, attends to seedlings at a tree nursery in Soroko, Lamu County.
Photo ©ICRAF/Tabitha Obara

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THE YEAR IN REVIEW

It is impossible to overestimate the importance of trees, both for the survival of the human race and the livelihoods of billions of people. Trees contribute over 10% of the US$3.1 trillion worth of GDP created by the agricultural sector. This does not include timber sales or activities which add value to raw commodities such as chocolate, cocoa and rubber. Nor does it include the non-monetized environmental and social benefits provided by agroforestry. Indeed, there is nothing better than a tree when it comes to sequestering carbon, bringing up water and nutrients from depth, building soil organic matter, enhancing fertility and creating more resilient agricultural landscapes.

During 2016, the World Agroforestry Centre (ICRAF) drew up a new strategy to meet the challenges of the next decade. This provided the opportunity for our scientists in some 30 countries to reflect on past achievements and fine-tune plans for the future. Our primary aim is to support the UN Sustainable Development Goals (SDGs) by harnessing the multiple benefits which trees provide. Agroforestry – agriculture with trees – can play a key role in achieving at least five of the 17 SDG focus areas. These include reducing poverty, developing sustainable systems of agriculture and improving food security, improving the efficiency of water use, helping to mitigate the impact of climate change, and halting the loss of biodiversity and restoring degraded ecosystems.

Our new Corporate Strategy identifies four priority research and development themes which will enable us to tackle what we consider the main global and regional challenges. These are: improving farmland productivity and resilience; restoring degraded landscapes; supporting sustainable tree product value chains; and tackling climate change and delivering key environmental services. This year's annual report groups our main achievements under these four challenges. Here, briefly, are some of the highlights.

The Trees for Food Security project, whose first phase came to an end in 2016, was designed to enhance food security by planting trees on farms in four East African countries (see page 19). The project provides farmers with a range of agroforestry options appropriate to the ecological and social context in which they find themselves. It has also established long-term trials to shed light on the influence of trees on different cropping systems, and promoted agroforestry through rural resource centres. According to an independent review, the project has been "extremely successful, with some substantial scientific, capacity, economic and social impacts already evident in the partner countries." Phase II of the project began in 2017.

Tackling land degradation and enhancing food security lies at the heart of the Drylands Development Programme (DRYDEV), which involves some 22 partners in Burkina Faso, Mali, Niger, Ethiopia and Kenya (see page 11). The project is working closely with farmers and farmers' organizations to identify the most appropriate ways to enhance food production, restore degraded land and improve access to markets and financial services. It is anticipated that over 250,000 farmers will benefit by 2018. During 2016, scientists in the World Agroforestry Centre also played a key role in restoration activities as far afield as India and Brazil, and the Centre hosted a major seminar on soil restoration in Nairobi which attracted over 150 government officials, NGO workers and scientists.

For many years, our commodity-focused research has sought to make tree crop value chains more sustainable. Since 2015, the World Agroforestry Centre's Green Rubber Project has established comprehensive databases about the impact of rubber plantations, both positive and negative, in China, Laos and Thailand, and set up multi-site experiments to evaluate the benefits of rubber agroforestry (see page 27). In 2016, the Centre collaborated with the Chinese Chamber of Commerce to draw up new guidelines for the sustainable development of the industry. These were launched at the Sustainable Rubber Conference in Yunnan Province, and will have a major influence on the development of the natural rubber industry.

Smallholder farmer planting Eucalyptus in between vegetable rows in Odisha, India
Photo ©ICRAF/Ashok Sahoo

We continue to operate at the forefront of research on developing new commodities. The four-year programme for the Development of Alternative Biofuel Crops aims to enhance local food security, improve incomes of smallholder farmers and contribute to climate change mitigation and adaptation (see page 30). At present, just 13% of the world's energy comes from renewable sources. The Centre's research suggests that biofuels derived from trees could help to increase this figure, and at the same time improve food security and rural incomes.

In Kenya, to give just one example, the project has conducted research on the development of biofuels using the seeds of croton trees, a native of East Africa found in farmers' fields. A key finding of the research, in Kenya and elsewhere, is that even when economic circumstances are not particularly favourable, co-products such as animal feed and fertilizers can help to make tree-seed biofuel production viable.

Combating climate change through agroforestry and ensuring rural communities benefit from, and protect environmental services are key components of several research programmes. 2016 saw the launch of a major new project which aims to establish some 30 community forest enterprises in Cameroon over the next five years (see page 37). The Dryad project will provide public finance, training and technical assistance. What makes it particularly unusual is that the community organizations supported by the project will receive funds on the basis of performance. Success, in other words, will be rewarded; performance won't be. As the Director General pointed out in his annual message, projects such as this one, where investment is linked to performance, will become increasingly important over the coming years.

The Biocarbon and Rural Development (BIODEV) project in West Africa came to an end in 2016, with the wrap-up meeting in Burkina Faso providing an opportunity to reflect on its achievements (see page 35). There had been some difficult times, with unrest in Mali and the Ebola virus in Sierra Leone restricting the project's scope, but there is no doubt that it succeeded in its aim of encouraging farmers to adopt agroforestry practices that generate high-value biocarbon. Besides improving the livelihoods of farming families, the practices we promoted provide a range of climate-related benefits, including carbon sequestration.

The World Agroforestry Centre has always prided itself on its ability to combine research with development. However, we have never lost sight of the importance of publishing high-quality, peer-reviewed scientific papers. During 2016, scientists from the Centre published 298 papers, some of which are described in the following pages. One, in particular, stands out. A study to assess the role of trees on agricultural land, and the amount of carbon they have sequestered, found that a remarkable change had taken place over the past 10 years: there had been a significant increase in tree cover. Agroforestry has truly come of age. As we approach our 40th anniversary in 2018, we will redouble our efforts to make agroforestry a mainstream practice throughout the developing world.

MESSAGE FROM THE BOARD CHAIR

Agroforestry is now recognized within the scientific and development communities as a sustainable land use option that could put an end to many of the critical global challenges currently facing the planet

As the World Agroforestry Centre (ICRAF) nears its 40th anniversary, agroforestry is now recognized within the scientific and development communities as a sustainable land use option that could put an end to many of the critical global challenges currently facing the planet. Today, agroforestry is being debated in policy circles, something that was unheard of a decade ago, and would not even have been conceived in the minds of ICRAF's founders.

A natural question that arises from this success is whether this is primarily due to the quality of the science produced by ICRAF and its application, or to significant changes in global policy where agroforestry is now considered a significant contributor to the resolution of critical global problems. The answer, of course, is that both have contributed to the current positioning of agroforestry in international fora. At the time of ICRAF's founding, global food security was the principal challenge. The 1987 publication of the Bruntland report expanded the call with its argument for a sustainable increase in agricultural productivity. Over the succeeding decades, planetary boundaries were developed as a metaphor for the ecological and resource limits on alternative pathways for meeting both global food security and husbandry of the natural resource base, both increasingly influenced by impending climate change.

Similarly, the science of agroforestry, as led by ICRAF, has evolved and expanded from an initial focus on agricultural productivity to its current multifunctional and multiscale research themes involving sustainable production systems, sustainable landscapes – including land restoration and optimizing hydrological response – and climate-smart agriculture. This research agenda clearly positions agroforestry as a response to the evolving development and policy agenda set out above. Moreover, ICRAF's field capacity in East and Southern Africa, West

and Central Africa, South Asia, Southeast Asia, East and Central Asia, and Latin America gives the Centre the ability to understand and adapt to local contexts, thus bridging local needs to global frameworks. The essential role of trees in landscapes as they affect sustainable livelihoods is at the core of ICRAF's vision for the future.

It is within this context, of ensuring relevance in a rapidly changing institutional and policy context, that the World Agroforestry Centre has developed a new strategy. The strategy sets out two important innovations that will better position ICRAF in an increasingly competitive and changing world, and strengthen the case for financial support for its work. Our four research themes (reduced from six), can be integrated around current and emerging development agendas. The intention is to build a flexible transdisciplinarity into the execution of ICRAF's research programme which ensures that the organization is working on the most relevant problems and that the activities are responsive to local contexts. Second, the new strategy not only presents a value proposition that responds to investors' search for value-for-money, but is also adaptable to rapid changes in development financing and the key role of the private sector in sustainable rural development. This value proposition sets out the products that ICRAF generates and combines them with a range of services that are critical in the design and implementation of sustainable land use options. As a producer of public goods in which the private sector does not have the incentive to invest, ICRAF believes that it can provide a full range of both goods and services essential for the development of public-private partnerships.

An expanding range of partnerships forms the basis of ICRAF's value proposition. A prime example of a research partnership is the Centre's participation in the next phase of the CGIAR Research Programme on Forests, Trees and Agroforestry (FTA). Working with its sister centre, CIFOR, the second phase of FTA has achieved a more integrated institutional approach to developing a research platform for the eponymous themes in FTA. Even with the uncertain funding, ICRAF sees continued value in the research partnerships developed within the programme.

This will be my last introduction to ICRAF's Annual Report, as I will step down as Board Chair at the end of the year. During my tenure, I have watched the World Agroforestry Centre mature as a research and development organization. The quality of its science has improved to the point that the institution is the go-to place for work on agroforestry. ICRAF's management and administrative systems continue to improve the efficiency of the Centre, and its governance has strengthened the mechanisms used to carry out its oversight and fiduciary responsibilities.

As noted in the introduction, ICRAF is in a strong position to champion agroforestry at the farm level, at the national level and on the global stage. I wish to thank the management and staff for the opportunity to participate in this important work and wish the Centre well as it looks forward to the next 40 years.

John Lynam
Board Chair

MESSAGE FROM THE DIRECTOR GENERAL

We have found that public-private partnerships have reduced research costs, encouraged innovation and raised the profile of agroforestry

Over the past decade, the World Agroforestry Centre has established close working relationships with a growing number of private sector companies. We have found that public-private partnerships have reduced research costs, encouraged innovation and raised the profile of agroforestry.

In October 2016, we hosted a meeting which was attended by high profile individuals from the public and private sectors with an interest in improving the welfare and performance of smallholder farmers. The theme was 'Investing in Performance'. The meeting showcased investment projects which are improving productivity and yielding significant environmental benefits. It explored innovative ways of using blended finance to balance the risk-reward ratio for producers, farmers and investors, and triggered the creation of an informal forum for networking.

A superb example of investing in performance is found in western Kenya. Some two million people live on the slopes of Mt Elgon, placing immense pressure on the environment. Deforestation, uncontrolled grazing and poor agricultural practices have led to the loss of biodiversity, high levels of soil erosion and declining productivity.

In 2016, Livelihoods, an investment fund whose founding members include Danone and Mars Inc., helped to launch a new project in the Mt Elgon area to tackle poverty and environmental degradation and improve the performance of small-scale dairy farmers. The 10-year project is being implemented by one of our non-governmental partners, VI Agroforestry.

Disbursement of the investment by Livelihoods is linked to proof of performance. For example, VI Agroforestry will only be rewarded if farmers adopt good agricultural practices, increase milk yields and reduce erosion. Brookside Dairies Limited is

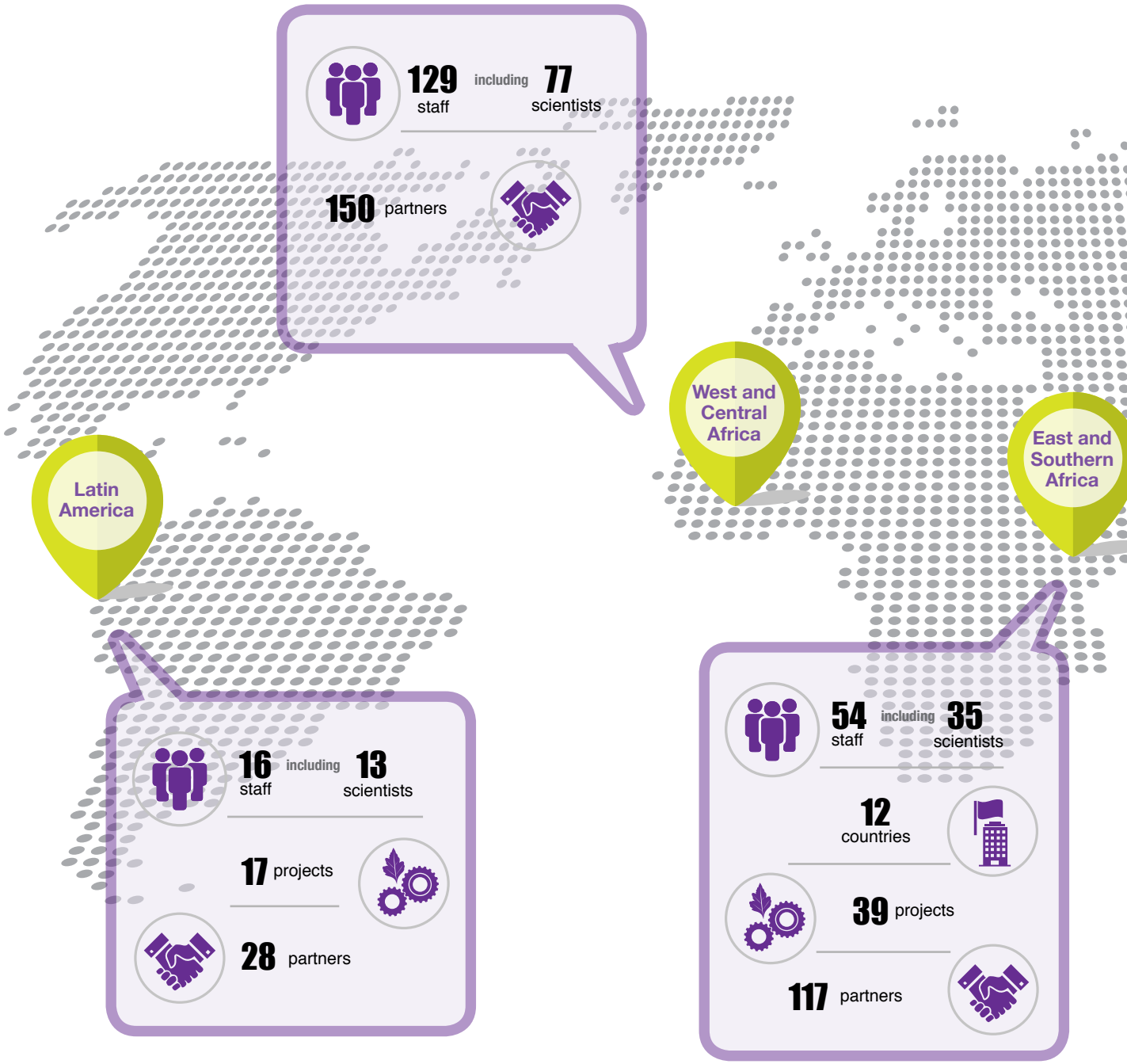
committed to purchasing the milk from 30,000 smallholder farmers, and if they increase production it will pay an extra Kshs 2 per litre, which will go into a revolving fund. A project managed by the European Union, aimed at reducing sedimentation in Lake Victoria, will also make payments if farmers reduce the amount of soil eroded into water courses.

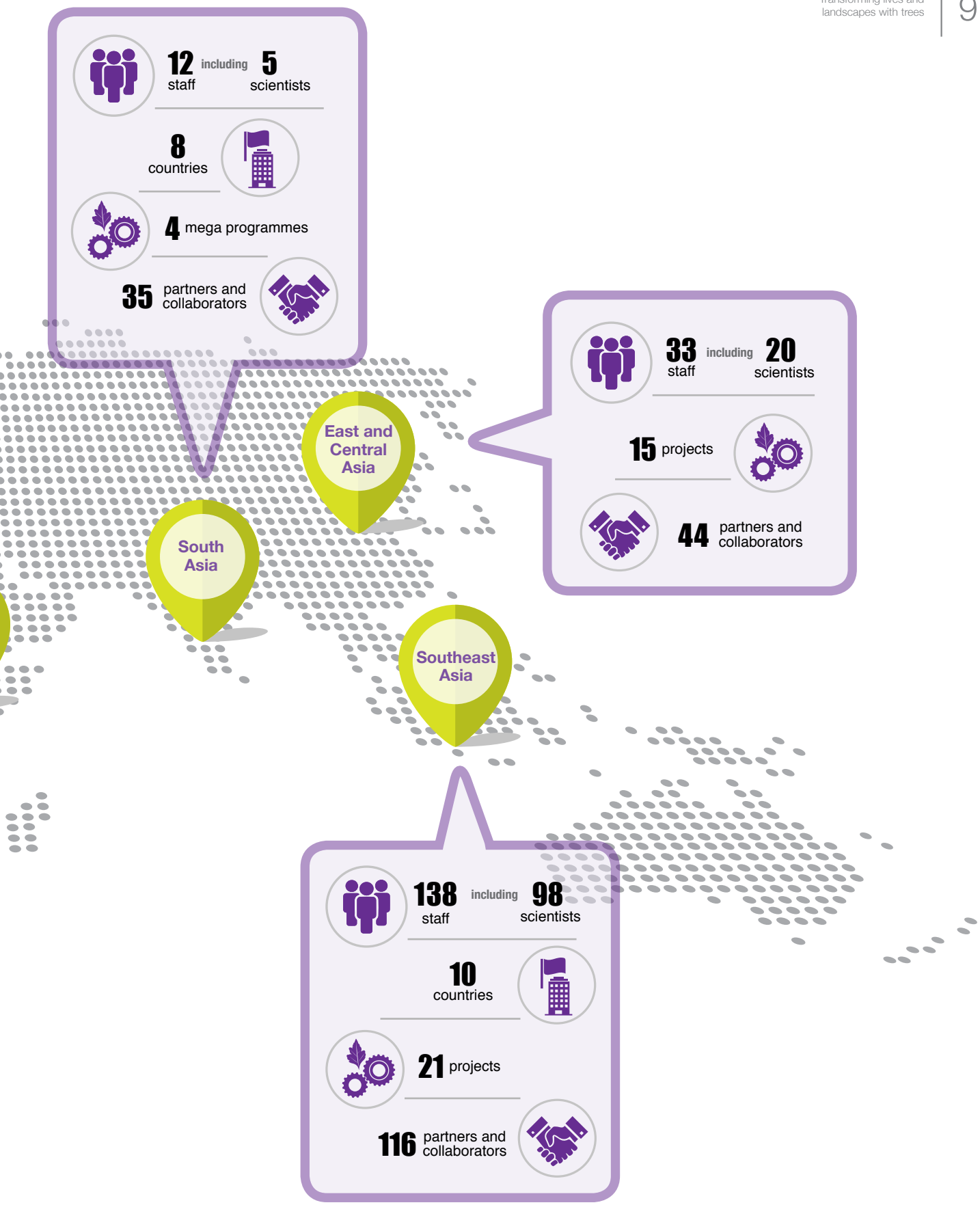
At a time when many donors are cutting back on their overseas development spending, projects such as these will become increasingly important.

Over the coming years, we look forward to providing advice and technical support to similar projects, where resources from the private sector are used to leverage public funds, and where reward is based on performance.

Tony Simons
Director General

ICRAF AT A GLANCE




12 staff including 5 scientists
8 countries
4 mega programmes
35 partners and collaborators
East and Central Asia
33 staff including 20 scientists
15 projects
44 partners and collaborators
South Asia
Southeast Asia
138 staff including 98 scientists
10 countries
21 projects
116 partners and collaborators

CHALLENGE 1:

RESTORING LANDSCAPES

Land degradation is one of the greatest threats to our planet's future. A range of international initiatives – such as the Bonn Challenge, a global aspiration to restore 150 million ha of degraded deforested land by 2020 – are designed to tackle the problem. Agroforestry is very much part of the solution and the World Agroforestry Centre is uniquely placed to contribute to land restoration programmes.

Story 1: Hope for Africa's drylands

Over 325 million people live in Africa's drylands, which covers 43% of the continent's land surface. Many of these areas suffer from high levels of degradation, poverty and malnutrition. Tackling these issues is the main aim of a five-year project funded by the Dutch Ministry of Foreign Affairs (DGIS) and managed by the World Agroforestry Centre. The Drylands Development Programme (DRYDEV) is improving water management, enhancing food security and promoting economic development in Burkina Faso, Mali, Niger, Ethiopia and Kenya.

"There have been plenty of administrative challenges, not least because there are 22 partners involved in the five countries, and it takes a lot of effort to coordinate and programme their activities," says Maimbo Malesu, a water expert working with DRYDEV. "However, I think we are making good progress, and in the past two years we have established a large number of activities." Over 20,000 farmers participated in various DRYDEV activities during 2015; almost half of them were women. It is anticipated that over 250,000 farmers will benefit from DRYDEV by the time the project comes to an end in 2018.

In East Africa, DRYDEV has taken a sub-catchment management approach, working in areas of up to 1000 square kilometres. "In each of the sub-catchments we have studied the drivers of degradation and conducted socio-economic assessments which have enabled us to target interventions," says Malesu.

Eight work packages cover a variety of different topics. For example, packages on agricultural commodity production and enhancing market access have focused on helping farmers to establish, or improve value chains for products such as chickens, goats, Irish potatoes, vegetables and honey. Other packages are concerned with on-farm water and soil management, improving financial access for rural communities, strengthening local government institutions and monitoring and evaluation.

On-farm water harvesting technique promoted by the programme
Photo ©ICRAF/Danyell Odhiambo

DRYDEV has worked closely with farmers and farmers' organizations to identify the most appropriate ways of enhancing production and restoring degraded land, using an options-by-context approach. This means assembling whatever information is available and making decisions on what works best in different situations.

DRYDEV has worked closely with farmers and farmers' organizations to identify the most appropriate ways of enhancing production and restoring degraded land, using an options-by-context approach

A similar approach has been taken by another project managed by the World Agroforestry Centre. The Restoration of Degraded Land for Food Security and Poverty Reduction in East Africa and the Sahel project, funded by the International Fund for Agricultural Development (IFAD), aims to improve food security in Niger, Mali, Ethiopia, Kenya and Tanzania. It is also exploring the best ways of identifying and scaling up interventions to restore degraded land. The project is working closely with DRYDEV, using 'planned comparisons' to establish which interventions work best in which places. "We are also working closely with IFAD country programmes," says Leigh Winowiecki, who is managing the project. "They're very happy to have us on board as we are collecting the sort of data that often doesn't get collected."

Many agroforestry projects simply gather statistics about – to give just one example – the number of tree seedlings delivered and planted. The IFAD-funded project, in contrast, is identifying which species of seedlings survive under different treatments and in different contexts. "Using this options-by-context approach, we will gain a much better understanding about which activities are likely to work best, and that's important when it comes to scaling up."

Story 2: Assessing restoration success in India

An estimated 120 million ha of land are classified as degraded in India. “They are called wastelands, but in practice they are ‘wasted lands’ and could be brought back into productive use with rehabilitation,” says Pal Singh, a scientist with the World Agroforestry Centre. Working out the best ways of doing this is one of the main aims of a project managed by the Centre, the Foundation for Ecological Security (FES) and the Center for International Forestry Research (CIFOR).

The project has studied the results of some 10 years of rehabilitation efforts employed by FES in five districts in the states of Rajasthan and Odisha. The researchers have measured the impact of a range of activities – including protection from overgrazing, agroforestry, erosion control, the use of check dams and trenches to conserve water – on vegetation, hydrology, biodiversity and soil quality. Sampling was done in such a way that the researchers could compare the state of rehabilitation sites with nearby control plots where there had been no rehabilitation.

In almost all the study sites, rehabilitation had helped to reduce erosion, increase vegetation and biodiversity, and improved hydrological conditions. Some of the changes were not only visible in the rehabilitated sites, but were also observed in downstream villages, where communities claimed significant improvements in water availability. As a result, they had begun to grow field crops in new areas. Rehabilitation had also led to in-migration of mammals and birds. However, its impact on soil chemical properties had been slow and practically negligible at all sites. It seems that in tropical climates, nutrient enrichment is compromised by continued losses through factors such as leaching, oxidation and surface run-off.

“Our findings indicate that efforts to improve degraded lands with the aim of bringing them into field crop production may have little chance of immediate success,” says Pal Singh. “Therefore, it may be better to start by assisting regeneration of native vegetation, for example, through control of overgrazing and planting trees, especially fodder and fuel species.” This will help to enhance biomass production and carbon sequestration, and hopefully improve soil quality in the long run.

Increasing desertification in Rajasthan
Photo ©ICRAF

Story 3: Guiding restoration practices in Brazil

Experts work on strategies for reconciling conservation and restoration with agroforestry-based production systems.
Photo ©ICRAF/Andrew Miccolis

In 2016, the World Agroforestry Centre's Brazil office launched a new guidebook, *Ecological Restoration through Agroforestry: Reconciling Conservation and Production*. "The main aim is to guide the adoption of agroforestry for the restoration of degraded lands, particularly in the Cerrado and Caatinga biomes, although the overall approach could also be used elsewhere in Brazil," says country coordinator, Andrew Miccolis. The project, which was supported by IUCN/Knowfor-DFID, identified 11 agroforestry options associated with a set of establishment and management techniques. The guide provides details of 19 key species and a general list of 130 priority species suitable for use in agroforestry programmes on degraded land.

***Ecological Restoration through Agroforestry* aims to guide the restoration of degraded lands in Brazil**

Based on the approach laid out in the guidebook, Miccolis has developed a rapid appraisal tool for assessing agroforestry systems and trade-offs between social, economic and ecological impacts based on 30 indicators. Working in partnership with The Nature Conservancy (TNC) and the Brazilian Agricultural Research Corporation (Embrapa), the Centre has begun piloting this tool as part of the Cocoa Forest Project. The tool generated recommendations on adjustments that could be made to the practices being used, as well as wider recommendations for scaling up sustainable cocoa agroforestry to restore degraded pastures.

During the next stage of the project the same methodology will be applied on a large number of farms. The assessments and recommendations, as well as the *Guidebook* methodology, are feeding directly into the Strategic Plan for the Development of Sustainable Cocoa in three municipalities with a total area of over 9 million hectares. The World Agroforestry Centre is leading the participatory development of this plan in partnership with TNC.

Story 4: Saving Africa's soil

In November 2016, the World Agroforestry Centre hosted a seminar at its headquarters in Nairobi with the theme *Soil restoration for achieving the 2063 and 2030 agendas in Africa*. Co-hosts included the Institute for Advanced Sustainability Studies from Germany and the governments of Benin, Burkina Faso, Ethiopia and Kenya. Over 150 government officials, NGO workers and scientists contributed to the three-day event. Topics included soil carbon and climate change, food security and nutrition, land governance, financing restoration and water management.

This was the first ever African soil seminar and it was particularly timely. By November 2016, 21 African countries had committed to restoring 63 million hectares of land by 2030 under the African Landscape Restoration Initiative, or AFR100. The goal is to restore at least 100 million hectares of degraded land on the continent, and there is no time to waste, according to seminar co-chair Alexander Muller, who serves on the World Agroforestry Centre's Board of Trustees. "We cannot wait until we get more data on soils to improve lives," he said. "I say yes to more science, but we need measures to improve things right away. There are no-regret activities like adding compost and addressing land tenure."

The meeting culminated in a communiqué from the four host governments. This called for "soil restoration that supports inclusive agricultural growth which focuses on the needs of the poor and the food-insecure." It also called for increased investments in soil rehabilitation, acknowledging that smallholders already make significant investments in improving their soils.

Earlier in the year, the World Agroforestry Centre and Mek'ele University organized a two-day field trip to the Tigray region in northern Ethiopia for 50 participants who had attended the AFR100 inaugural conference, held in Addis Ababa in October. On a tour of four watersheds, participants were able to see some remarkable examples of sustainable land and water management practices. They learned that the key ingredients to success are political support, community ownership, collective action, the use of bylaws and partnership.

AFR100 aims to restore at least 100 million hectares of degraded land in Africa.
Photo ©ICRAF

Under an IrishAID-funded project, the World Agroforestry Centre and other institutions are testing four types of land restoration technologies in Tigray. "We are helping farmers choose tree species to diversify their farms, and training them in rainwater harvesting," noted Niguse Hagazi, a forestry scientist in the Ethiopia office. He and his colleagues have also trained young people in nursery establishment and business management, and some have now established their own private nursery businesses.

Story 5: The science of restoration

Forest landcape restoration is important in climate change mitigation and adaptation.
Photo ©ICRAF/Ake Mamo

The International Union of Forest Research Organizations (IUFRO) recently commissioned a group of scientists, including Lars Graudal of the World Agroforestry Centre, to explore the best ways of restoring degraded landscapes. After analysing the literature and case studies, they developed a framework to show how forest landscape restoration could contribute to climate change mitigation and adaptation. The key findings have been distilled in a policy brief: *Restoring Forest Landscapes – A Win-Win for People, Nature and Climate.*

"We have looked at restoration activities in great detail," says Lars, "and developed a 'traffic light tool' to help decision-makers and local communities identify the potential benefits of restoration and where it could take place." The tool serves three main purposes: it is designed to inform decision-makers and others about the role of forest landscape restoration in climate change mitigation and adaptation; it can help with the participatory planning of restoration projects; and it can be used to evaluate projects against predefined criteria and implementation standards.

"Whatever the restoration project, you always come back to the importance of choosing the right planting material," says Lars. "That's why we do so much work on genetic resources, on choosing the right tree for the right place. That's absolutely vital for restoration projects."

Previous annual reports have described progress made by the Vegetation and Climate Change in East Africa (VECEA) project, a collaboration between the World Agroforestry Centre and the University of Copenhagen. The project has produced a series of maps which are designed to help people choose the right trees for the right place. These can be accessed on www.vegetationmap4africa.org.

Whatever the restoration project, you always come back to the importance of choosing the right planting material

In 2016, Roeland Kindt worked with Muhammad Ahmad and Benard Onkware from the World Agroforestry Centre's Geoscience Lab to further develop the Africa Tree Finder App, with support from the International Union for the Conservation of Nature (IUCN). The app should prove particularly useful for people involved in land restoration projects and for tree nursery owners and managers. It enables users to determine what vegetation type they are in, and which species could be used for a restoration project. For each species, the app provides local as well as Latin names, details related to seed treatment and germination, and information about their ecology. The app also tells users which species are most appropriate for different uses, for example, providing fruit, medicines or making charcoal.

Advancing soil science

A recent technological breakthrough is the addition of portable X-ray fluorescence spectroscopy (pXRF) to complement the World Agroforestry Centre's existing mid-infrared spectroscopy (MIR). With these two instruments, soil scientists can cover many soil-plant diagnostics important for agronomy with high reproducibility and low cost. "They form the basis for Rural Soil-Plant Spectroscopy Labs, which can be operated without the need for a stable electricity supply," says principal soil scientist, Keith Shepherd. These labs can provide farmers with soil and plant testing services at affordable prices.

The strength of MIR is that it provides a rapid fingerprint of soil mineralogy and organic composition. These properties determine the capacity of the soil to provide specific functions, such as nutrient and water supply and retention, water infiltration and resistance to erosion. However, MIR does not always provide insights into all soil nutrients, such as extractable phosphorus, potassium and micronutrients.

pXRF can provide the missing piece of the puzzle as it allows researchers to determine the element composition of plant materials, rapidly and at low cost, in one scan. This means they can now couple MIR soil testing with direct measurements of plant nutrition in agronomic trials. "Being able to get this data on large numbers of trials will allow us to digitally map crop nutrient deficiencies and responses, in addition to soil properties," says Keith. This sort of information is in high demand from governments, fertilizer companies and development organizations.

The World Agroforestry Centre has been working with Bruker Nano Analytics, the pXRF instrument manufacturer, to improve the pXRF technology, and with the One Acre Fund and the fertilizer company OCP to test these innovations. It has also been working with Rothamsted Research to support high-end chemistry for calibration development, under the umbrella of the Africa Soil Information Service (AfSIS).

CHALLENGE 2:

MAKING FARMLAND MORE PRODUCTIVE AND RESILIENT

To successfully tackle poverty and feed the burgeoning global population, each unit of land needs to produce more food, and do so in a way that doesn't degrade the environment. Much of our research explores how trees grown on farms can help to make agricultural systems more productive and more resilient.

Story 1: The transformative power of trees

"Trees are making a big difference in people's lives, especially in the areas we have been working, in terms of the products and services they now provide," says Catherine Muthuri, who leads the Trees for Food Security Project. Funded by the Australian Centre for International Agricultural Research (ACIAR), the project was designed to enhance food security by planting trees on farms in Ethiopia, Rwanda, Uganda and Burundi.

An independent review of the first four-year phase of the project concluded that it had been a resounding success. "I think the donors feel that they are getting what they want – good research, changes on the ground in terms of farmers reached and influenced, and value for money," says Fergus Sinclair, a systems scientist at the World Agroforestry Centre.

Sinclair has championed the idea that research should be embedded in development, rather than conducted as a separate enterprise. This means that the Centre and its partners have been able to provide farmers with a range of agroforestry options appropriate to the ecological and social context in which they find themselves.

Participatory, long-term and biophysical trials have helped to shed light on the influence of trees on different cropping systems. For example, research carried out in Ethiopia by one of the project partners, the International Maize and Wheat Improvement Center (CIMMYT), found that a nitrogen-fixing tree, *Faidherbia albida*, significantly reduces temperatures under its canopy, increases soil moisture and results in a greener wheat crop for a longer period of time, all of which leads to higher yields. Following pruning experiments, the World Agroforestry Centre advised farmers not to prune *Faidherbia* trees. In contrast, similar research in Rwanda found that pruning *Grevillea* trees in maize fields led to better yields.

In Rwanda, farmers have always made use of *Alnus* species – members of the alder family – but before the participatory trials they didn't understand their full potential, according to researcher, Ruth Kinuthia. "Before our project, farmers used the trees to stabilize soil on steep slopes and for livestock fodder," says Ruth. "But we managed to show them that by incorporating *Alnus* leaves into the soil they could enhance fertility and increase crop yields."

The project established six rural resource centres (RRCs), two in Ethiopia, two in Rwanda and one in both Burundi and Uganda. These have acted as training centres. They have also established nurseries for improved tree seedlings and demonstration plots. The most successful RRCs are run as commercial enterprises, generating income for the farmers' groups and cooperatives who manage them. "They have had a remarkable impact and played an important role in promoting agroforestry," says Catherine Muthuri. She is particularly heartened by the way the project has built capacity not just of local farmers, but national partners, researchers and government extension agents. In Ethiopia alone, over 6600 farmers have been reached through training, participatory trials and meetings.

This project has been extremely successful, with some substantial scientific, capacity, economic and social impacts already evident in the partner countries

Tony Bartlett, the forestry programme manager at ACIAR, noted, "From ACIAR's perspective, this project has been extremely successful, with some substantial scientific, capacity, economic and social impacts already evident in the partner countries." Haile Mituku, UNESCO's deputy permanent delegate for Ethiopia, had this to say: "I would recommend that this project have a second, third and fourth phase. The impact can be seen and felt, and the project has proven that it can be sustainable." Phase 2 was launched at the beginning of 2017. It involves scaling up the agroforestry technologies identified and developed during the first phase. There will also be further participatory trials and research into tree-crop interactions.

Farmers from an innovation platform in Kadahenda transporting grafted avocado from a rural resource centre in western Rwanda
Photo ©ICRAF/ Ake Mamo

Story 2: Influencing land-use policy in Vietnam

A H'mong farmer returning home after working on the upland field
Photo ©ICRAF/ Robert Fox

A five-year agroforestry project, funded by ACIAR and managed by the World Agroforestry Centre, has begun a process of transformation in North-West Vietnam. Decades of monocropping with maize and cassava has seriously degraded the landscape. The Agroforestry for Livelihoods of Smallholder Farmers (AFLI) project was designed to tackle the problem by introducing a range of best-practice agroforestry systems. These have helped to increase the incomes of poor farmers and restore eroded hillsides.

The project identified seven 'best-bet' agroforestry systems. To give just one example, farmers who replaced their maize monoculture with a mixture of fruit-bearing longan trees, forage grass and maize increased their net income by 50% over a period of just three years. At the same time, they significantly reduced erosion.

The project has also developed high-quality germplasm, with the main focus being on Sontra fruit trees, also known as the H'mong apple. Over 2400 trees were screened in 13 locations and 30 were selected for their high-yields, superior fruit morphology and good taste. These were then used as grafting material. The trees have helped many farmers to significantly increase their incomes, and some 20,000 were planted on 250 hectares of farmer demonstration trials and on 'exemplar landscapes' that were created as large-scale demonstration plots.

One of the objectives of the project was to improve market access for agroforestry products, and this was particularly successful with Sontra. Tay Bac Tea Special Food Company Ltd (TAFOOD) used the research results to develop and produce different processed products, thus creating new market opportunities. Nick Austin, ACIAR's Chief Executive Officer, described this as "a wonderful example of research being taken to the next level through private sector engagement. This is the type of engagement the Australian Aid programme is championing."

The project, which came to an end in 2016, has influenced government policy at both local and national level. In 2015, the provincial government of Yen Bai, host to one of the exemplar landscapes, began providing financial support to households planting Sontra, and to individuals and households adopting sustainable maize cultivation by planting grasses on contours. In 2016, agroforestry was included for the first time in the Action Plan of the agriculture and rural development sector as a measure to tackle climate change.

Story 3: Agroforestry empowers communities in Indonesia

In November 2016, local governments on Sulawesi Island joined farmers to celebrate the achievements of the Agroforestry and Forestry in Sulawesi: Linking Knowledge to Action (AgFor) project, which was coming to an end after five years of intense activity in three provinces. Funded by Global Affairs Canada and managed by the World Agroforestry Centre, the project addressed a range of rural development challenges by building livelihoods and enterprises, improving governance and strengthening environmental management.

The presence of AgFor in our district has raised understanding, improved knowledge and empowered the community so that they can be independent

"The presence of AgFor in our district has raised understanding, improved knowledge and empowered the community so that they can be independent," reflected Tony Herbiansyah, one of the district heads from Southeast Sulawesi Province. "Our farmers have gained knowledge and worked hard to achieve maximum results."

Farmer in South Sulawesi on his nursery farm.
Photo ©ICRAF/ Yusuf Ahmad

Since AgFor was launched in 2011, over 631,000 people, around half of whom were women, raised their incomes by up to 18% by adopting technologies promoted by the project. Farmers who were formerly dependent on a single commodity crop, and vulnerable to price fluctuation, benefited from the introduction of new crops and more diverse agroforestry systems.

On his first official trip outside Jakarta, the recently appointed Canadian ambassador, Peter MacArthur, noted that AgFor had improved participatory governance at the village level and coordination with local government agencies. He was also impressed by the way the project had tackled poor land management. Thanks to its activities, some 750,000 hectares of land is now being sustainably managed.

"AgFor is an outstanding example of how effective cooperation between farmers, local authorities, NGOs, researchers and the national government can achieve enormous results," says AgFor's project manager, James Roshetko of the World Agroforestry Centre.

Story 4: Seeing is believing in Central America

Recent research by scientists from the World Agroforestry Centre and the Tropical Agricultural Research and Higher Education Center (CATIE) has found that trees on farms make a major contribution to ecosystem services, food security and livelihoods in Central America. Studies undertaken on 120 farms in three municipalities in Nicaragua and Honduras have provided a detailed insight into the importance of agroforestry. "Although much of the forest has been transformed for agriculture and ranching, trees still play a very important role," says Geovanna Carreno-Rocabado, who led the research programme.

On 90 farms covering 850 hectares of productive land the researchers found 260 tree and palm species, three times more than in the last national Nicaragua report for trees outside forests. In terms of species richness, the five most common land use types have between 140 and 200 species. The average farm of 8.6 hectares harbours 45 different tree species at a density of 74 trees per hectare. In terms of species richness, coffee and cocoa systems – with 197 and 169 species respectively – are particularly important. Pastures support almost as many species, and 186 different species are used as fodder, live fencing and to improve soil fertility. Surprisingly, even annual crop systems such as grains support 140 tree species. Coffee and cocoa gardens are particularly important when it comes to sequestering carbon.

Geovanna and her colleague Jenny Ordoñez returned to the field to hold discussions with farmers after they had analysed their findings. "When you ask farmers how many trees they have, they often give very low figures," says Jenny. "But they have many trees and benefit greatly from them. We wanted them to know that."

She told one of the farmers, 67-year-old Virgilio Diaz, that he had 63 tree species on this farm – 38 of them were fruit species – and that if he had to buy the fruit and timber which he harvested every year for personal use, it would cost him over US$1000. He was amazed. Other farmers reacted in a similar manner.

Sharing these results is part of a strategy to increase awareness about the importance of trees on farms. The results of the project were shared in different activities organized by a platform in Nicaragua that promotes the links between science, education and rural development. The World Agroforestry Centre has been one of the platform organizers.

Jenny Ordonez sharing results of the study on trees with a coffee farmer. In the back you can still see some of the timber they have harvested from trees within their coffee field.
Photo ©ICRAF

Smart road planning for the Mekong

Scientists have used layers of data on biodiversity, climate, transport and crop yields to construct a colour-coded mapping system that shows where new roadbuilding projects should go to be most beneficial for food production, without being environmentally destructive. The authors of the research, published in *PLOS Biology*, are hoping that this will stimulate more fruitful discussions between developers and conservationists.

For proof of concept, the scientists focused on the Greater Mekong in South-east Asia. They found that a number of road proposals could destroy large areas of habitat without providing major benefits for the local populations or increased food security. They also identified where new roads could increase food production at limited environmental cost.

"The Mekong region is home to some of the world's most valuable tropical forests," says co-author Jianchu Xu of the World Agroforestry Centre. "It's also a region in which a lot of roads are going to be built, and blanket opposition is unlikely to stop this. Studies like ours help to pinpoint the projects we should oppose most loudly, while providing alternatives where environmental costs are lower and development benefits greater."

Reference

Balmford A, Chen H, Phalan B, Wang M, O'Connell C, Tayleur C, Xu J. 2016. Getting Road Expansion on the Right Track: A Framework for Smart Infrastructure Planning in the Mekong. *PLOS Biology*, http://dx.doi.org/10.1371/journal.pbio.2000266.

Sahelian trees harvest water

Forests have often been described as 'sponges' which store rainwater and slowly release it during dry periods. However, the sponge theory began to lose credibility when studies suggested that forest clearance generally leads to increased water yields, and afforestation to the opposite. But this trade-off theory – in which more trees means less water – rests on limited evidence in the tropics, and recent research refutes the commonly held belief that trees in drylands worsen water scarcity. Jules Bayala, a senior scientist with the World Agroforestry Centre, was the lead author of a paper, published in *Scientific Reports*, which shed new light on the issue.

The scientists found no available data in the literature on the relationship between tree cover and water yields at intermediate tree densities – such as those found in agroforestry parklands in the Sahel – and limited data concerning the specific mechanisms that determine groundwater reserves and dry seasons stream flows. This is an important omission, given that such open vegetation supports many of the world's poorest people.

Research based on groundwater budgets, calibrated with measurements of drainage and transpiration in West Africa, demonstrated that groundwater recharge was greatest at intermediate tree densities. In other words, moderate tree cover improves groundwater resources. Besides helping to harvest water, trees in these arid areas can also reduce evaporation losses and soil erosion; and of course they often provide fodder, fruit and medicines.

Reference

Ilstedt U, Bargués Tobella A, Bazié HR, Bayala J, Verbeeten E, Nyberg G, Sanou J, Benegas L, Murdiyarso D, Laudon H, Sheil D, Malmer A. 2016. Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. *Scientific Reports* 6:21930. DOI: 10.1038/srep21930.

A worm's eye view of trees

Living organisms in the soil, whatever their size, are an important element in the underground ecosystem and help to regulate key functions such as organic matter decomposition, nutrient cycling and soil structure. The larger among them – the soil macrofauna – have a significant impact through their feeding, nesting and burrowing habits. Inevitably, their activities are affected by the way in which farmers, and others, manage the soil and they tend to be aggregated near areas relatively rich in soil organic matter, such as those under the canopy of trees.

PhD research conducted by the World Agroforestry Centre's Living Soils Lab team and collaborators, led by Edmundo Barrios, assessed the spatial influence of three dominant trees in Kenya on soil macrofauna abundance, along a soil degradation gradient resulting from continuous cultivation for 10, 16 and 62 years. Some trees supported higher levels of macrofauna than others. For example, earthworm abundance was highest below the canopy of *Zanthoxylum gilleti*, especially on land that had been cultivated for a long period of time. In contrast, beetles were present in greater numbers beneath the canopies of *Croton megalocarpus* and termites under *Eucalyptus grandis*.

"Our research supports the idea that trees become increasingly important as 'resource islands' and refugia to organisms with increasing soil degradation," says Edmundo Barrios. This highlights the key role trees play in restoring and sustaining functions that underpin soil health. The observation that different tree species influence different soil macrofauna shows how important it is to maintain diverse tree cover.

Reference

Kamau S, Barrios E, Karanja NK, Ayuke FO, Lehmann J. 2017. Soil macrofauna abundance under dominant tree species increases along a soil degradation gradient. *Soil Biology and Biochemistry*, Volume 112, Pgs 35-46.

CHALLENGE 3:

SUPPORTING SUSTAINABLE TREE PRODUCT VALUE CHAINS

Landscapes and livelihoods around the world are being shaped by the spread of tree crops like rubber, palm oil and cocoa. Large-scale, monocultural plantations frequently have a negative impact on the environment and local communities. However, it doesn't have to be like that, and our research is helping to identify ways of making tree crop value chains more sustainable. We are also at the forefront of research into new tree crops.

Story 1: Promoting green rubber

Between 2000 and 2015, global production of natural rubber almost doubled, from under 7 million to over 12 million tonnes. Around 90% is grown in Asia. Rubber can be a very valuable smallholder crop, but when planted in vast monocultures it can do serious damage to soils and biodiversity, and its cultivation has frequently deprived local communities of their land.

The Green Rubber Project, funded by GIZ and managed by the World Agroforestry Centre, has been exploring how agroforestry can improve the environmental sustainability of rubber plantations in the Upper Mekong. The three-year project has established comprehensive databases about the impact, both positive and negative, of rubber plantations in China, Laos and Thailand. It has also set up multi-site experiments to evaluate the benefits of rubber agroforestry.

In southern Thailand, farmers have been growing rubber with a range of timber and fruit trees for a century or more. This has provided them with diverse sources of income, which is particularly important when rubber prices are low. "This sort of rubber agroforestry is also very sustainable, and doesn't lead to the environmental problems associated with intensive monocultures," says Rhett Harrison, leader of the Green Rubber Project.

According to Rhett, the project has achieved more than anticipated, in part because of a collaboration during 2016 with the Chinese Chamber of Commerce. "The Chamber was drawing up *Guidelines* for the sustainable development of the rubber industry and they asked for our recommendations," explains Rhett. "To help the process we organized fact-finding missions to southern Thailand and Cambodia." The former provided an insight into rubber agroforestry at its best; the latter into the problems caused by intensive monocultures, which is the model adopted by many Chinese companies when operating abroad.

The *Guidelines* were officially launched in October 2016 at the Sustainable Rubber Conference, jointly organized by the World Agroforestry Centre

Rubber tapping in Xishuangbanna, China.
Photo ©ICRAF/ Andrew Stevenson

This sort of rubber agroforestry is also very sustainable, and doesn't lead to the environmental problems associated with intensive monocultures

and Xishuangbanna Tropical Botanical Gardens (Chinese Academy of Science), Yunnan, China. The conference explored ways in which rubber growers could secure stable incomes and at the same time protect the environment and local livelihoods. Rhett believes that the *Guidelines* could have a major influence on the development of the natural rubber industry. They were developed in a very inclusive manner, involving input from NGOs and researchers as well as industry and government bodies.

The team also published a journal article in *PLOS One* which concluded that the rapid expansion of rubber plantations into higher elevations and nature reserves in and around Xishuangbanna poses a serious threat to biodiversity and environmental services, without producing the expected economic returns. The paper recommends that local governments should develop long-term strategies to balance economic benefits with environmental sustainability and assist farmers with the selection of land suitable for rubber production.

Reference

Chen H, Yi Z-F, Schmidt-Vogt D, Ahrends A, Beckschäfer P, Kleinn C, Ranjitkar S, Xu J. 2016. Pushing the Limits: The Pattern and Dynamics of Rubber Monoculture Expansion in Xishuangbanna, SW China. *PLoS ONE* 11(2): e0150062. DOI: 10.1371/journal.pone.0150062.

Story 2: Oil palm and the intensification dilemma

You will hear much talk nowadays about the 'land sparing' hypothesis. This postulates that intensifying agriculture will have a net positive effect on the environment, regardless of any direct negative consequences, as it will reduce the amount of land needed to meet the demand for agricultural products. The hypothesis suggests that sustainable intensification – for example of oil palm production – is good for biodiversity. It also suggests that sustainable intensification will reduce greenhouse gas emissions from deforestation and land degradation. But is this really the case?

Current European Union (EU) legislation requires member states to ensure that renewable energy accounts for at least 10% of energy consumption in the transport sector by 2020. Under its Reducing Emissions from Deforestation (RED) Policy, biodiesel, produced from crops like oil palm, must save at least 35% in emissions compared to fossil fuels.

Supplying large quantities of biodiesel to the market could involve intensifying production by increasing the use of nitrogen fertilizer. However, this could be counter-productive, according to recent research by the World Agroforestry Centre. "When fossil fuels are replaced by biodiesel, the reduction in greenhouse gas emissions risks being offset by additional emissions from higher fertilizer use," says chief scientist Meine van Noordwijk. The production of nitrogen fertilizers releases considerable quantities of carbon dioxide, the main gas implicated in global warming; and when applied to the land, nitrogen fertilizers release one of the most potent greenhouse gases, nitrogen dioxide.

However, there is a middle ground of optimal intensification, according to Meine and his colleagues, whose study evaluated palm oil production and fertilizer use on 23 plantations across the Indonesian production range. They found that current yields are approximately 66% of the maximum that could be achieved with the highest fertilizer use. "We believe that an increase to 80% is generally compatible with standards for the carbon footprint of production, but beyond that, negative effects prevail," says van Noordwijk. At present, most plantations use an average 141 kg of nitrogen fertilizer per hectare. The study suggests that this could be increased to around 200 kg, leading to higher yields without negatively affecting the carbon footprint of the plantations.

Reference

Van Noordwijk M, Khasanah N, Dewi S. 2016. Can intensification reduce emission intensity of biofuel through optimized fertilizer use? Theory and the case of oil palm in Indonesia, *GCB Bioenergy,* DOI: 10.1111/gcbb.123981.

Oil palm in Buol District, Central Sulawesi, Indonesia.
Photo ©ICRAF/ Arif Prasetyo

Story 3: A new biofuel for Africa

A four-year Programme for the Development of Alternative Biofuel Crops, managed by the World Agroforestry Centre and funded by the International Fund for Agricultural Development (IFAD) and the European Commission, has established pilot projects to develop biofuels from trees in India, Brazil and Kenya. The projects have also sought to enhance local food security, improve incomes of smallholder farmers and contribute to climate change mitigation and adaptation. In Kenya, the focus was on croton oil.

Farmers have often planted croton trees (*Croton megalocarpus*) along field boundaries to provide firewood and shade. However, their true value is only just being realized. The EcoFuels Kenya (EFK) Group began sourcing croton nuts from rural communities in 2012. Besides extracting oil, which can be used to power generators, irrigation pumps and other machinery, the company developed a number of other products from the husks and seedcake, including organic fertilizers and poultry feed.

Biofuel from croton can be used to power farm machinery.
Photo ©ICRAF

Since 2015, the World Agroforestry Centre has been working with the EFK Group to assess the sustainability of the croton value chain and identify research gaps, in order to support an expansion of the business. This involved conducting a value chain analysis, a baseline survey of 5000 collectors and an experiment to gauge farmers' willingness to plant croton.

The research points to a median additional income derived from croton collection and sale of approximately US$56 a year in Central Kenya, with one third of the collectors being able to earn US$60 to US$250 a year. This is significant in a country where half the rural population lives below the poverty line, surviving on less than US$200 a year per adult. The vast majority of farmers – 91% of respondents – said they were willing to plant croton trees. There is clearly plenty of scope for farmers to benefit more than they currently do from the trade.

"One of our key findings, both in Kenya and elsewhere, is that co-products are very important," explains biofuels programme officer, Rodrigo Ciannella. "Even under circumstances which aren't particularly favourable, co-products such as animal feed and fertilizers can help to make tree-seed biofuel production viable."

In 2016, the programme invested in modelling and mapping technologies. "The biofuels programme wanted to know which areas were most suitable for growing croton trees," explains GIS developer Mohammad Ahmad, "and we developed a mobile app to record the occurrence, and absence, of croton trees in randomly selected sites in Central Kenya." The GIS information will help the EFK Group identify areas suitable for establishing croton agroforestry.

At present, just 13% of the world's energy comes from renewable sources. The Centre's energy-focused research suggests that biofuels derived from trees could help to increase this figure, and at the same time improve food security and rural incomes.

Story 4: Making the most of indigenous crops

African Plant Breeding Academy Class II Graduation Ceremony
Photo ©ICRAF/ Martha Mwenda

The African Orphan Crops Consortium (AOCC) is identifying specific gene sequences linked to desirable traits, such as high yields or drought resistance, in 101 indigenous crops. A collaborative research effort involving Mars Inc., the World Agroforestry Centre, BGI, the University of California, Davis, and a range of other organizations, is working to improve the diets and livelihoods of 600 million people who live in rural sub-Saharan Africa.

In 2016, AOCC began sequencing the genomes of 21 new species, many of them trees. Their DNA was extracted in the AOCC laboratory at the World Agroforestry Centre's headquarters in Nairobi, then sent for analysis to BGI and to the Agricultural Research Council (ARC) in Pretoria, South Africa.

About 250 scientists will eventually benefit from training in modern genomics at the African Plant Breeding Academy

"The AOCC programme will enable us to understand which genes are associated with particular traits," says Prasad Hendre, a plant genomic scientist who manages the laboratory. "For example, we know that baobab fruit is very rich in Vitamin C and antioxidants. This research will help us to determine which genes are involved with those traits and match the gene sequences to the tree's phenotypic diversity." Scientists will then be able to identify particular physical characteristics associated with desirable genetic traits.

Training a new generation of African scientists is also one of the major aims of the AOCC programme. Some 250 scientists will eventually benefit from training in modern genomics at the African Plant Breeding Academy, which is based at the Centre's headquarters in Nairobi. The courses are designed and run by UC Davis. The first batch graduated in 2014, while the second batch of 25 scientists graduated in December 2016.

Story 5: Baobab: a fruit with a future

With their elephantine trunks and pendulous fruit, the baobab (*Adansonia digitata* L.) is the most majestic tree in Africa's savannas and arid regions. Research by scientists at the World Agroforestry Centre suggests it could also be one of the most useful, capable of providing valuable nutrition and an income for communities that live in areas frequently affected by drought and malnutrition.

The most important part of the baobab is its fruit pulp, which has five times more vitamin C than orange; it is also rich in calcium and iron. Baobab can be eaten raw, added to porridge or used to make a refreshing juice. However, there is considerable variability in the levels of vitamin C found in individual baobab trees, ranging from 126 mg to over 500 mg per 100 grams of edible fruit. There is also a great variation in the size of its fruit.

"We have found that baobab fruits collected from the Kenyan coast were significantly larger than fruits collected inland," says Stepha McMullin of the World Agroforestry Centre. "We are currently carrying out nutritional characterization of baobab fruit pulp and grafting experiments which will enable us to select superior mother trees for a baobab domestication programme."

The most important part of the baobab is its fruit pulp, which has five times more vitamin C than orange; it is also rich in calcium and iron

There are hundreds of other wild fruit trees in Africa which could also contribute more to food and nutritional security. However, it is thought that many indigenous fruit trees are decreasing, due to environmental factors and land-use change. There is an urgent need to identify priority indigenous fruit tree species and analyse their nutrient content. There should also be a strong focus on developing nutrient-sensitive processing techniques and establishing markets for new food products.

In 2016, the World Agroforestry Centre and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) teamed up with *Shamba Shape Up*, the Kenyan reality TV show, in an episode dedicated to nutritious trees and fruit crops, featuring baobab, mango and guava. *Shamba Shape Up* is a very effective way of getting information to the people who really need it, with over 8 million people in East Africa tuning in to watch every episode of the programme. (See also page 44)

Baobab seeds collected from fruit.
Photo ©ICRAF/ Ake Mamo

Story 6: Creating profitable value chains in Indonesia

President Joko Widodo (right) receiving a gift from Andi Buyung Saputra.
Photo ©ICRAF/ Shinta Purnama Sarie

Besides working with honey farmers, the project has also helped to develop more profitable value chains for indigenous fruits and other products

While many high-value commodities, such as black pepper, cocoa and rubber, have a long history of being traded in global markets, there are many lesser-known products with poorly developed value chains. In Indonesia, the Agroforestry and Forestry in Sulawesi (AgFor) project has been actively promoting the marketing and sale of a number of products harvested in forests and home gardens. At the request of farmers, the AgFor team has helped them develop business plans, packaging and labelling.

To give just one example, honey hunters in East Kolaka have traditionally harvested wild bee honeycombs some 40 m above the ground. They do this by climbing up trees, smoking out the bees and cutting down the honeycombs. Back on the ground, the honey is squeezed out of the combs, along with the eggs and pupae, into plastic water bottles. This is far from hygienic and the quality of the honey is variable. The 250 ml bottles sell for no more than US$1.20 – a meagre return for such arduous work.

“We thought the honey hunters could do better,” says AgFor’s marketing facilitator La Ode Ali Said. “We identified a more sustained and hygienic method, which involves carefully cutting the honey bag to slowly drain the golden liquid. It is then filtered through a fine mesh, resulting in very pure honey.” The honey is hygienically packaged and attractively labelled, and the 250 ml bottles sell for around US$5 in the provincial capital, Kendari.

Besides working with honey farmers, the project has also helped to develop more profitable value chains for indigenous fruits and other products, such as organic compost and fertilizers, palm sugar and sagu flour, which is used in pastries, drinks and soups.

Indonesia’s President, Joko Widodo, recently bestowed the right to manage customary forests – *hutan adat* – on nine indigenous communities, heralding the end of decades of uncertainty and the beginning of a new era of secure right to land. The Kajang people of South Sulawesi, partners in the AgFor project and one of the nine communities to receive certificates, were singled out for praise by the president.

Medicines from the wild

Livestock are the main source of income and food for tens of millions of people in sub-Saharan Africa. When their animals are sick or injured, they tend to rely on traditional remedies harvested from the wild. “Hundreds of plant species are used by livestock keepers to treat a wide range of ailments,” says Najma Dharani, lead author of *Traditional Ethnoveterinary Medicine in East Africa: A Manual on the Use of Medicinal Plants*, published by the World Agroforestry Centre in 2016. “They generally don’t have access to, or can’t afford, modern veterinary medicines and approaches.”

The manual, a collaboration between the World Agroforestry Centre and the Kenyan Ministry of Agriculture, Livestock and Fisheries, will be useful to those using traditional practices and researchers who want to gain a better understanding of their properties. To give just one example, livestock often suffer from a devastating disease called East Coast Fever, which is transmitted by a tick. The manual explains how leaves and fruit from baobab trees can be crushed, added to a saltlick and given to infected animals.

Najma acknowledges that the effectiveness of many of the treatments described in the manual has yet to be tested in formal trials; there is still work to be done in this area. However, she says a large body of knowledge within communities supports their use. The manual, which includes information on 53 different plant species, emphasizes that whenever possible, plant parts should be harvested in a manner that does not kill the plants. Some species are already rare, and one option is to protect them for ethnoveterinary purposes through on-farm cultivation. This is already being done successfully for *Warburgia ugandensis*, which is used to treat a range of conditions, including red water fever and sleeping sickness.

Reference

Dharani N, Yenesew A, Aynekulu E, Tuei B, Jamnadass R. 2015. *Traditional ethnoveterinary medicine in East Africa: a manual on the use of medicinal plants*. Nairobi: World Agroforestry Centre.

Expanding the debate on inclusive value chains

Improving access to high-value agricultural markets could help to lift tens of millions of low-income people out of poverty. Around three out of every four of the world’s poorest people live in rural areas, and many are dependent on agriculture for their income and survival. Yet debate on how to build value chains that benefit the rural poor has stalled in recent years.

A new book, published by the International Food Policy Research Institute (IFPRI), provides a comprehensive analysis of how to improve agricultural value chains, particularly those involving smallholder farmers. Scientists from the World Agroforestry Centre are among the contributors to *Innovation for inclusive value-chain development: Successes and challenges*, with Jason Donovan, an economist in the Latin American office, being co-editor of the book and co-author of five chapters.

The book helps to fill the gap in knowledge about the role of governments and NGOs in supporting smallholder participation in value chains, about trade-offs or undesired effects, and the elements most likely to reduce poverty. A wide range of case studies sheds new light on experiences in value chain development across the world, from Nicaragua to Vietnam.

The book looks at new market linkages and the role farmer organizations and contract farming can play in raising productivity. It assesses how to measure and identify successful value chain development. Chapters explore the challenges livestock-dependent people face; how urbanization and new technologies affect value chain linkages; and the best ways to increase gender inclusion and economic growth.

Reference

Devaux A, Torero M, Donovan J, Horton DE. 2016. Innovation for inclusive value-chain development: Successes and challenges. Washington DC: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/9780896292130

CHALLENGE 4:

TACKLING CLIMATE CHANGE, DELIVERING ENVIRONMENTAL SERVICES

Trees have a vital role to play in the battle against climate change by sequestering carbon and providing a range of other services. Combating climate change through agroforestry and ensuring that rural communities benefit from, and protect environmental services are key components of several major projects.

Story 1: Promoting high value biocarbon in West Africa

The four-year Biocarbon and Rural Development (BIODEV) project in West Africa, funded by the Finnish Ministry of Foreign Affairs, came to an end in 2016. Although the project went through some difficult periods – unrest in Mali and the outbreak of the Ebola virus in Sierra Leone restricted its scope – there was plenty to celebrate during the final wrap-up meeting, held in Burkina Faso in November 2016. The project was managed by the World Agroforestry Centre, in partnership with the Center for International Forestry Research (CIFOR), the Universities of Eastern Finland and Helsinki, Sierra Leone Agricultural Institute (SLARI), L'Institut de l'Environnement et de Recherches Agricoles de Burkina Faso (INERA) and a range of national and international organizations.

The main focus of the project was to encourage farmers to adopt agroforestry practices that generate 'high-value biocarbon'

"The main focus of the project was to encourage farmers to adopt agroforestry practices that generate 'high-value biocarbon'– practices which not only improve livelihoods but provide a range of co-benefits such as carbon sequestration to mitigate climate change and enhanced climate resilience," says Henry Neufeldt, head of climate change research at the World Agroforestry Centre. The project helped to strengthen the capacity of local institutions, increased adoption of agroforestry and other biocarbon practices, improved sustainable use of forests and introduced more efficient wood energy production practices. Scientifically rigorous and cost-effective carbon measurement systems were established by the project.

By adopting agroforestry practices, smallholder farmers have been able to meet their nutritional needs, and at the same time become more resilient to the impact of climate change. "Priority tree species were identified in Burkina Faso and Sierra Leone, and improved tree germplasm made available to farmers by the rural resource centres established through the project," said Antoine Kalinganire of the World Agroforestry Centre at the wrap-up meeting.

The community has played a major role in replanting trees in degraded areas of the Cassou Forest.
Photo ©ICRAF/ Susan Onyango

The rural resource centres (RRCs), established in four villages in Burkina Faso, played an important role as places for training, tree seedling propagation, vegetable cultivation and enterprise development. In 2015, the RRCs propagated some 250,000 seedlings for planting in degraded areas of Cassou Forest, providing communities who managed the centres with an income of around 12.5 million CFA (US$21,000), in addition to income generated by vegetable production and other activities within their demonstration plots. All of this led to increased tree cover and greater carbon capture, as well as improvements in local livelihoods.

Besides directly improving the lives of some 10,000 farmers, the project developed effective and cost-efficient carbon monitoring, reporting and verification systems. “The project helped to build the capacity of our national partners in Burkina Faso, Sierra Leone and Mali, and they now have the skills they need to measure and monitor carbon in the landscape,” says Ermias Betemariam, who led the work package on measuring and reporting of carbon stocks. He believes that the main impact of the project will be evident at a later date, once the trees planted by farmers and communities have matured. Ultimately, it is hoped that the activities promoted by the project will help them gain access to the carbon market.

Story 2: Rewarding performance in community forest management

Although community forests in Cameroon have been legally recognized for the past 20 years, they have failed to access significant financial support. As a result, they have made little progress in establishing viable forest enterprises. To rectify this, a new initiative funded by the UK Department for International Development (DFID) was launched in 2015. Over a five-year period, Dryad, named after an Ancient Greek forest deity, will provide public finance, training and technical assistance to approximately 30 community forest enterprises managing up to 100,000 hectares of forest land.

"This is a very innovative project," says Peter Minang, a scientist with the World Agroforestry Centre. "The community organizations that the project supports will receive funds on the basis of performance. No results will mean no money." The Dryad concept of performance-based finance has been developed by TMP Systems, which is providing technical support.

During the first year, the World Agroforestry Centre and TMP Systems selected four local NGOs to implement Dryad. They identified potential community forest enterprises, and are helping them to draft business plans for assessment by the World Agroforestry Centre. The four implementing organizations will provide training and technical advice, and help monitor progress once the enterprises start operating.

The community forest enterprises fall into three main categories: sustainable timber harvesting; harvesting non-timber forest products; and sustainable reforestation programmes, for example, on degraded land. "During the first year, up to 35% of the total investment is provided to the community forest enterprises," explains Peter. "The second tranche will only be made available if the communities can provide proof of progress, and achieve at least 50% of the performance indicators."

Dryad will help to establish sustainable enterprises which manage and maintain community forest land in a way that benefits local communities. The project will contribute towards forest conservation and deliver real benefits in terms of reducing emissions from deforestation and helping communities adapt to climate change.

Young men display wooden coat hangers made from timber. Sustainable timber harvesting creates income generation opportunities for communities. Photo ©ICRAF/ Lalisa Duguma

Story 3: Africa's ecosystem service partnership

The Ecosystem Services Partnership (ESP) is an international network of scientists and practitioners who work together to generate and share knowledge on research related to ecosystem services. In November 2016, the World Agroforestry Centre and partners hosted the first African ESP conference in Nairobi, Kenya. It attracted over 170 participants from 28 countries. The theme was *Ecosystem Services for Sustainable Development Goals in Africa*. "The aim of the conference was to enhance the participation of Africans within ESP and the quality of discourse exceeded our expectations," says Peter Minang, who chaired the conference's scientific and organizing committees.

During the opening session, Judi Wakhungu, Kenya's Cabinet Secretary in the Ministry of Environment, Water and Natural Resources, praised the fact that there were so many young people present. More than 10 students pursuing subjects related to ecosystem services in Kenyan universities were sponsored to attend the conference, and for the first time in ESP conference history there was an open session for young scientists.

Pushpam Kumar, Chief of the Ecosystem Services Economics Unit at the United Nations Environment Programme (UNEP), highlighted the importance of integrating the values of natural capital and ecosystem services to attain the UN's Sustainable Development Goals (SDGs). John Gowdy from Rensselaer Polytechnic Institute in New York suggested going beyond natural capital and seeing the environment as a public good that should be preserved for future generations by government policy.

There was also a strong focus on the importance of creating the right enabling environment to promote sustainable ecosystem management. Benjamin Cheboi, the Governor of Baringo County in Kenya, put emphasis on the need to encourage local and national leaders, as well as decision makers, to promote environmental conservation. It was agreed that there needs to be greater collaboration in Africa on the science, policy and practice of the ecosystem services concept.

A section of participants at the first African Ecosystem Services Partnership visit the Lake Naivasha basin.
Photo ©ICRAF

Story 4: Promoting best practice in Asia

A hands-on training workshop for cacao- and coffee-based farming systems in Lantapan, Philippines.
Photo ©ICRAF/ Amy Cruz

A deep understanding of smallholders' characteristics is essential if projects are to address their needs and improve their livelihoods, while simultaneously contributing to the provision of ecosystem services

In May 2016, the Ecosystem Services Partnership (ESP) held its first Asian conference with the theme, *Ecosystem Services for Nature-based Solutions* in Ansan City, South Korea, attracting delegates from across Asia. In a keynote presentation, Beria Leimona, an ecosystem services specialist, described the World Agroforestry Centre's experience in promoting tree-based agriculture in Asia using Payments for Ecosystem Services schemes. She stressed that a deep understanding of smallholders' characteristics is essential if projects are to address their needs and improve their livelihoods, while simultaneously contributing to the provision of ecosystem services.

The Climate-Smart, Tree-based, Co-Investment in Adaptation and Mitigation in Asia (Smart Tree-Invest) project team organized a session dubbed *Assessing vulnerability and resilience towards co-investment for ecosystem services in tree-based agricultural landscapes*. The researchers shared lessons learned and best practices from projects in Indonesia, Vietnam and the Philippines. They also discussed how to link research and field activities with policy.

Another session, organized by the CGIAR Research Programme on Forests, Trees and Agroforestry and the Korean Ecosystem Services Network, focused on experiences with ecosystem service co-investment. In the closing panel discussion, chief science adviser, Meine van Noordwijk highlighted the importance of the Asia region, which provides more than 50% of global environmental services and is home to more than 60% of the global population. He also discussed the potential for using local knowledge to improve livelihoods and environmental services, a practice which is already happening in many countries in the region.

Story 5: Understanding climate-smart agriculture

"People are putting billions of dollars into climate-smart agriculture and we need to know what works, where and why," says Todd Rosenstock, an environmental scientist with the World Agroforestry Centre. "That is one of the reasons why we are producing the CSA Compendium."

Climate-smart agriculture aims to increase farm productivity, help farmers adapt to climate change and reduce greenhouse gas emissions. It is clear from many years of research that what works in one area will not necessarily work in another. The Compendium, which will be available online in 2017, has been years in the making and involved a review of 145,000 scientific papers. The initial effort provides a detailed account of the effectiveness of over 75 management practices, extracted from more than 1,500 published papers on research conducted in Africa. "It is an evidence-based resource which will enable governments, organizations and individuals to identify the best practices for specific farming contexts both in terms of how they affect productivity, resilience and mitigation," says Rosenstock.

The meta-analysis has been conducted by the World Agroforestry Centre in partnership with the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), FAO, and the International Center for Tropical Agriculture (CIAT). According to Rosenstock, a range of organizations in Africa are already making use of the data gathered for the Compendium. For example, an international NGO operating in Tanzania informed Rosenstock that information in the Compendium has already led to changes in its approach to implementing climate-smart agriculture projects.

In 2016, the project published two CSA X-ray infographics. Funded by the US Agency for International Development (USAID), these four-page data-driven technical briefs are printed on laminated paper so they can be used in the field. One of the X-rays focuses on conservation agriculture in East and Southern Africa; the other on conservation agriculture in Tanzania.

The X-rays provide a detailed analysis of scientific knowledge about a range of interventions. They analyse interventions not only in terms of productivity, resilience, or climate change mitigation, but also their ability to mitigate climate risks, the business case for investment and barriers to adoption. "The X-rays look at both the positive and negative aspects of climate-smart agricultural practices, and the context in which they work, or don't work," says Christine Lamanna, a decision scientist with the World Agroforestry Centre. "We hope that people will use them as a basic filtering mechanism to discuss interventions or inform their activities." She and Rosenstock hope these will be the first of many X-rays.

Dorothy Achieng practices climate-smart agriculture on her farm in Kenya.
Photo ©CCAFS/ T. Muchaba

Trees on farms: the missing link in carbon accounting

A team of researchers from various institutions in Africa, Asia and Europe carried out a study to assess the role of trees on agricultural land and the amount of carbon they have sequestered from the atmosphere over the past decade. Their paper, published in *Scientific Reports*, shows that a remarkable change is taking place. Tree cover on agricultural land has increased significantly across the globe in recent years.

"Remote sensing data shows that in 2010, 43% of all agricultural land globally had at least 10% tree cover, up from 8% in the preceding decade," says Robert Zomer of the World Agroforestry Centre, lead author of the study. "Given the vast amount of land under agriculture, agroforestry may already be making a significant contribution to global carbon budgets." Brazil, Indonesia, China and India showed the largest increase in tree cover over the last 10 years.

"The results of our spatial analysis indicate that trees on agricultural land sequestered close to 0.75 gigatons of carbon dioxide globally per year over the past decade," says Henry Neufeldt, head of climate change research at the World Agroforestry Centre. The research suggests that trees on agricultural landscapes could play a major role in greenhouse gas mitigation.

Reference

Zomer RJ, Neufeldt H, Xu J, Ahrends A, Bossio D, Trabucco A, van Noordwijk M, Wang M. 2016. Global tree cover and biomass carbon on agricultural land: The contribution of agroforestry to global and national carbon budgets. *Scientific Reports* 6, Article number: 29987. DOI:10.1038/srep29987.

Equity and the carbon market

In some situations, the carbon market could make the poor poorer and the rich richer, according to a research project whose findings were published in the journal Land Use Policy. 'Roots of inequity: how the implementation of REDD+ reinforces past injustices', describes how the Kasigau Corridor REDD+ project in Kenya affected local communities.

REDD+ projects – the acronym stands for reduced emissions from deforestation and forest degradation plus forest conservation, sustainable management of forests and enhancement of carbon stocks – aim to reduce carbon dioxide emissions from forest land. During the UN climate conference in Mexico in 2010 it was agreed that REDD+ projects should include social safeguards aimed at addressing equity issues. As well as helping to tackle climate change, they should ensure that one group doesn't lose out at the expense of another.

Although the implementers of the *Kasigau Corridor REDD+ project* sought to address equity issues when designing the project, they were hampered by historical patterns of land ownership which had left the majority of local people with little or no land entitlement. "Large landowners who had previously abandoned the land suddenly realized that its value was now much higher because of carbon payments," says World Agroforestry Centre scientist Fergus Sinclair, co-author of the paper. As a result, they decided to reassert their control over the land at the expense of communities who had previously benefited from squatting, farming, hunting and firewood collection.

"If you want to create equitable REDD+ projects, you need to take into account the needs of marginalized people, and this is something that did not happen at *Kasigau,"* says Sinclair. He and his colleagues suggest that it is critical for projects to frame equity transparently and through a participatory process. Policy makers may have to demand that project implementers and certifiers give voice to marginalized groups and those with few resources.

Reference

Chomba SW, Kariuki J, Lund JF, Sinclair F. 2016. Roots of inequity: How the implementation of REDD+ reinforces past injustices. *Land Use Policy*, Vol. 50, p. 202-213.

Money from thorn trees?

There are all sorts of reasons why East African farmers love the thorn tree *Faidherbia albida*. Its spreading roots protect the soil from wind and water erosion. The tree also fixes atmospheric nitrogen, which helps to fertilize the soil, leading to higher crop yields. In addition, its pods provide nutritious fodder for sheep and goats. Like all trees, it also sequesters carbon.

Recent research by the World Agroforestry Centre and its partners, reported in *Agroforestry Systems*, suggests that communities could benefit from using *Faidherbia* as a way to raise money in the carbon market. Working in six regions in Malawi, the researchers devised equations most suitable for estimating the total above-ground biomass stored in *Faidherbia* trees. These equations can now be used to measure carbon storage in standing trees under similar circumstances. The largest tree they sampled, with a girth of 116 cm diameter at breast height, held carbon dioxide equivalent to the amount produced by eight medium-size cars in one year.

Measuring the carbon stored in trees is the starting point for entering the global carbon credits market. The researchers noted that were Malawi to enter the market, carbon payments for *Faidherbia* could become an incentive for farmers to keep these valuable agroforestry trees on their farms.

Reference

Beedy TL, Chanyenga TF, Akinnifesi FK, Sileshi GW, Nyoka BI, Gebrekirstos A. 2015. Allometric equations for estimating above-ground biomass and carbon stock in *Faidherbia albida* under difference management systems in Malawi. *Agroforestry Systems,* Vol 90, Issue 6, p. 1061–1076.

CHALLENGE 5:

REACHING OUT, SCALING UP

Establishing agroforestry projects is one thing. Ensuring that hundreds of thousands of people benefit, rather than just a few hundred, is entirely another matter. 'Scaling up', as it is known, is now a major preoccupation for research and development agencies, including the World Agroforestry Centre.

Story 1: Volunteer farmers lead the way

Funding for public sector agricultural extension has significantly declined in recent years, which means that government agencies in many developing countries are no longer able to reach all farmers. In Africa, volunteer farmer trainers are helping to fill the gap. The East African Dairy Development (EADD) project, set up in 2008 with the aim of doubling the income of 179,000 dairy farmers in Kenya, Uganda and Rwanda, has recruited and trained over 3,000 volunteer farmers to help their peers adopt improved livestock feed technologies.

"We found that this was a very successful form of agricultural extension," says Steven Franzel, who leads the World Agroforestry Centre's research on rural advisory services. Studies of volunteer farmer trainers across East Africa confirm that trainers typically train 16 to 24 farmers per month, depending on the country.

Largely as a result of the experience in East Africa and research results and recommendations from the World Agroforestry Centre, the volunteer farmer trainer approach has now been adopted by 83 organizations in four East African countries: 70 cooperatives associated with the EADD project; six other cooperatives and producer organizations; and seven other organizations, including NGOs and government agencies. Many of the cooperatives are large organizations, with 3000 or more members, most being dairy farmers.

"Our research suggests that the farmer-to-farmer extension approach is very cost-effective, can reach large numbers of farmers, and helps NGOs and government agencies to increase the numbers of farmers they reach," says Evelyne Kiptot, social scientist from the World Agroforestry Centre. Unlike government extension agents, volunteer farmer trainers do not receive any payment, but are motivated by a range of non-financial factors. For example, trainers gain skills that they can use on their own farms. In addition, being a volunteer trainer improves their social status. The cooperatives in Rwanda which are using the farmer trainer approach are no longer receiving any support from the EADD project.

Story 2: Assessing the power of television

Christopher Chepkarwa, a volunteer farmer trainer, grows fodder trees, shrubs and grass for dairy cattle.
Photo ©CCAFS/ Sherry Odeyo

Years of research had found that dairy farmers feeding protein-rich fodder shrubs to their cattle significantly improved their milk yields and incomes

The rapid spread of television sets, and television channels, has created a new opportunity to reach millions of farmers within a short period of time. Television programmes that are informative and entertaining – known as 'edutainment' – can have a significant impact, according to recent research summarized in a *Good Practice Note* published by the Global Forum for Rural Advisory Services (GFRAS). Edutainment programmes can help viewers make informed choices, stimulate discussion, link viewers to services and influence policy.

Take, for example, *Shamba Shape Up*, a Kenyan TV programme produced by the Mediae Company. Presented by well-known actors, it focuses on a different farm each week. After each transmission, viewers can send an SMS text to the programme producers to get a free pamphlet on the week's topic.

The World Agroforestry Centre provided support for four shows on fodder shrubs. Years of research had found that dairy farmers feeding protein-rich fodder shrubs to their cattle significantly improved their milk yields and incomes. An impact assessment conducted by the University of Reading found a significant uptake of practices featured in *Shamba Shape Up*, and increased incomes for farmers who watched the show. Indeed, it was estimated that in 2014 the impact of *Shamba Shape Up* on the dairy sector in East Africa was worth US$24 million through increased milk production.

Evelyne Kiptot, the lead author of the GFRAS *Good Practice Note*, points out that about half the people who send SMS texts requesting further information about *Shamba Shape Up* live in urban areas. "In future, we'd like to find out exactly what impact the programme is having on urban viewers, many of whom farm or advise close relatives who farm," she says. Whatever the outcome of this research, the message is clear: edutainment is one of the best ways of influencing farmer behaviour and also reaching the youth.

Reference

Kiptot E, Franzel S, Nora C, Steyn, A-M. 2016. Edutainment TV for disseminating information about agriculture. Note 22. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lausanne, Switzerland.

Story 3: India's mission for success

On the opening day of the last World Congress on Agroforestry, held in New Delhi in February 2014, India's President, Shri Pranab Mukherjee, announced a historic National Agroforestry Policy to promote the growing of trees on farms. The government subsequently established the National Agroforestry Mission as the implementation vehicle for the policy, with a budget of around US$250 million. The World Agroforestry Centre has been actively involved in its development and implementation.

The Mission is housed in the Ministry of Agriculture and Farmers Welfare (MoA&FW), which is providing 60% of the cost of agroforestry programmes. There is a strong focus on states which have decreed that at least 20 tree species which are grown on farms should no longer be subject to restrictions on felling and transit. The remaining 40% of the cost is covered by the states, 10 of which have developed scaling up programmes for agroforestry. These are expected to establish up to 15 million new trees, and cover an area of 20–25,000 ha in each state.

"These initiatives are expected to generate confidence among farmers about their freedom to harvest and make use of trees, and create interest in planting more trees on their farms," says Javed Rizvi, South Asia regional director for the World Agroforestry Centre. "The mission also expects to generate more resources from the government and private sector, and this will help to support the scaling up of agroforestry in future."

The financial support provided by the National Agroforestry Mission and the states covers the initial cost of planting and taking care of the plants until they have grown above browsing height. The mission also has provisions for capacity building and skill enhancement, market support, adding value, and monitoring and evaluation. "Already 100,000 farmers in states as far apart as Gujarat and Tamil Nadu have started benefitting from the policy, as they are now earning some income from species that they were previously prohibited from marketing," says World Agroforestry Centre scientist, Pal Singh. "Nursery operators providing seedlings for these species are apparently having difficulties meeting demand."

Lehri Lal, a farmer in Rajasthan, India, has established an orchard which will sequester carbon and provide him with fruit and an income.
Photo ©CCAFS/ CharliePye-Smith

Expanding agroforestry in the Democratic Republic of Congo

During recent years, the Forests and Climate Change in the Congo Project, which is managed by the Center for International Forestry Research (CIFOR), has worked with a range of partners to strengthen forestry research in DRC and the protection Virunga National Park in North Kivu province. As part of the project, scientists from the World Agroforestry Centre have supported farmers around the periphery of the park to plant tree species which provide them with fruit, timber and other products. The aim is to take pressure off the park and restore lands degraded by years of conflict.

It is a measure of the success of the project that the provincial Minister of Agriculture, Fisheries, Livestock and Rural Development, Christophe Ndibeshe Byemore, highlighted the importance of agroforestry at a three-day workshop held in April 2016 in the provincial capital, Goma. The workshop was attended by 46 participants from a wide range of organizations. “The main theme was how we could develop a strategy to scale up agroforestry,” says Emilie Smith Dumont, lead researcher from the World Agroforestry Centre.

During the workshop, participants looked back at their agroforestry accomplishments over the past three years, and at the lessons learned. One NGO had diversified into coffee production; many communities had planted native species rather than exotic eucalypts, which had been favoured in the past; others had planted fodder shrubs to feed their dairy cattle and a variety of trees and shrubs to tackle erosion on steep hillsides. All these activities, in one way or another, are proof that agroforestry is making a promising contribution to local livelihoods and the creation of a more sustainable landscape.

However, the participants identified a range of constraints to scaling up agroforestry, one of the most important being lack of secure land tenure, especially for women. “This is the elephant in the room, not just here but over much of Africa,” says Smith Dumont. “If smallholders don’t have secure tenure over the land they use, they will be reluctant to invest in long-term activities that cost money.” If agroforestry is to thrive in areas like North Kivu, it will require a change of land tenure policy.

STORIES FROM THE REGIONS

Eastern and Southern Africa Region

The challenges

The vast majority of countries – and most people – in this region rely on agriculture as the main economic activity. Although much progress has been made in recent years, many communities still suffer from food insecurity, especially in drier areas. Land degradation and forest loss are significant problems. Agroforestry has the potential to enhance agricultural production, but the lack of quality germplasm, poor extension services and limited recognition of agroforestry limits widespread adoption.

Our impact

Our research in maize-growing areas has demonstrated that combining mineral fertilizers with fertilizer trees can reduce expenditure on fertilizers by 50%, and deliver yields comparable to those of maize treated with the full dose of inorganic fertilizers. In Ethiopia, rural resource centres are improving the income of women and young people. Farmers participating in a major dairy project in Uganda, Kenya and Tanzania have increased milk production by 17%, thanks in part to the introduction of improved feeds using fodder trees. The regional programme is helping countries to develop their agroforestry strategies.

Patricia Masikati, Zambia

Story from the field

A Shona proverb says 'it is a good thing to be many but the challenge is too many hands in one bowl finishes the soup quickly.' In our culture we always used to eat together from the same bowl. The same applies to natural resources in our communal areas. Population increase translates into increased competition for shared resources, resulting in degradation and conflicts within communities. My work aims to find ways of increasing the productivity of current production systems. My other focus is on marketing and the creation of flexible agricultural commodity groups. I am currently involved in strengthening farmer groups producing village chickens, soya beans and common beans in Solwezi, Zambia.

Key projects

Developing Value Chain Innovation Platforms to Improve Food Security in Eastern and Southern Africa

The four-year project is funded by the Australian Centre for International Agricultural Research (ACIAR). Its main objective is to enhance food security through greater engagement of smallholder farmers with markets.

Agroforestry Food Security Programme Phase II-Extended: Enhancing food security through integration of fertilizer trees with mineral fertilizers

The three-year project, funded by the Flanders Government, is being implemented in two districts in Malawi. It will improve soil fertility and help to increase farm productivity. It will also help farmers to store carbon and reduce greenhouse gas emissions.

East Africa Dairy Development (EADD) Project

The project, funded by the Bill and Melinda Gates Foundation, aims to improve the lives of 315,000 smallholder farmers in Kenya, Uganda and Tanzania. It is implemented through a consortium led by Heifer International. The World Agroforestry Centre leads the feeds and feeding system component of the project.

Intensification of maize-legume based systems in the semi-arid areas of Tanzania to increase farm productivity and improve the natural resource base

The objective of this USAID-funded project is to provide pathways out of hunger and poverty for smallholder families through sustainable intensification of farming systems. The project will reach 82,800 farmers.

Southeast Asia Region

The challenges

Southeast Asia is a dynamic and diverse region, many parts of which are undergoing dramatic change. Rapid development has led to mounting pressure on the region's natural resources. The current rate of degradation threatens many of the countries' impressive, but fragile, poverty gains. Climate change poses an additional risk.

Our impact

We are an 'asked for' partner when it comes to addressing regional and local challenges related to the use and abuse of natural resources. Broad impacts have been achieved by linking knowledge to action in agroforestry management and markets. In Vietnam, our research has had a positive impact on lives and landscapes through the introduction of viable agroforestry options on sloping land. Massive numbers of farmers in Indonesia have been trained in nursery and agroforestry management.

In the Philippines we pioneered land care research in watersheds in the uplands. Our work on agroforestry options, participatory land use planning, climate change and policy issues linking agriculture, forestry and ecosystem services has been widely appreciated throughout the region.

Tam Le Thi, Vietnam

Story from the field

Vietnam is considered one of the countries most vulnerable to the effects of climate change. Farmers face hot spells and drought in summer, flooding in the autumn and cold spells in winter. These natural hazards threaten their livelihoods, posing the question: how can smallholder farmers mitigate and adapt to climate change without compromising their food sercurity? I believe the answer lies in agroforestry and climate-smart agricultural practices. In projects supported by the Climate Change, Agriculture and Food Security (CCAFS) programme and USAID, I apply my background in crop science, agroforestry and farmer knowledge to

research and scale out agroforestry and climate-smart agricultural practices. Recently, I've had the incredible opportunity to help reduce the loss of agricultural production from natural hazards by equipping farmers with better updated climate and weather forcast and seasonal calendars.

Key projects

Agroforestry and Forestry in Sulawesi: Linking Knowledge with Action (AgFor)

The Canadian-supported AgFor project worked with local communities, civil society groups, conservation organizations, universities and governments to improve farmers' incomes through agroforestry and improved natural resource management practices. (See also page 22)

Locally-Appropriate Mitigation Actions in Indonesia (LAMA-I)

This Danish-funded project focuses on building the capacities of local governments to achieve low-emission development. LAMA-I will help local and national government agencies to reach the targeted reductions in emissions and increase economic growth.

Participatory Monitoring by Civil Society of Land-use Planning for Low-emissions Development Strategies (ParCiMon)

This EU-funded project works in three districts in Papua, which is the province richest in forest in Indonesia. ParCiMon is building technical and organizational capacity among civil society groups to develop land-use planning, and implement monitoring and evaluation, to achieve low-emissions development.

Agroforestry for livelihoods of smallholder farmers in Northwest Vietnam (AFLI)

The ACIAR-sponsored project addresses issues of shifting cultivation and monocropping, which has been identified as the main cause of soil erosion and declining yields in north-west Vietnam. (See story on page 21)

Development of timber and non-timber forest products' production and market strategies for improvement of smallholders' livelihoods in Indonesia (Kanoppi)

With funding from ACIAR, the project is enhancing and expanding smallholders' involvement in the management of commercial, forestry-based products in eastern Indonesia.

Green Economy and Locally Appropriate Mitigation in Indonesia (GELAMA-I)

The GIZ-funded project supports the Government of Indonesia's efforts to mitigate climate change by strengthening sub-national governments' ability to develop locally appropriate mitigation actions (LAMA).

Climate-smart, Tree-based, Co-investment in Adaptation and Mitigation in Asia (Smart-Tree-Invest)

Funded by IFAD, this project works across Indonesia, Philippines and Vietnam using action research to improve the livelihoods and resilience of smallholder farmers by reducing their vulnerability to climate change.

Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B-Wiser)

Climate change will exacerbate watershed degradation, put biodiversity under more stress, intensify natural disasters and undermine economic development. This USAID-funded project in the Philippines aims to address the driving forces behind the rapid loss of biodiversity and degradation of watersheds.

ASEAN-Swiss Partnership on Social Forestry and Climate Change (ASFCC) This regional SDC-sponsored project is helping farmers to derive an income from non-timber forest products (NTFPs). It also supports member states in the development of social forestry and agroforestry. The World Agroforestry Centre has been actively involved in Cambodia, Indonesia, Myanmar, Philippines, Thailand and Vietnam.

West and Central Africa Region

The challenges

Until recently, agricultural growth in West and Central Africa regions has largely been a result of an expansion of the area under crops or grazing, rather than higher yields. Demographic pressures have exhausted available land and average farm sizes are falling. Shorter fallow periods, mono-cropping and the inadequate use of fertilizers have contributed to declining soil fertility and soil erosion. Climate change is likely to make these problems worse.

Our impact

Throughout the region, we focus on promoting sustainable tree-based farming systems, and better market access for tree products, to enhance food security. We have been helping small-scale farmers and vulnerable communities by improving access to knowledge and information, by introducing agroforestry technologies, by encouraging sustainable resource management and by promoting rural resource centres. We have also established a number of public-private partnerships.

Djalal Ademonla Arinloye, Mali

Story from the field

Among the Sahel countries, Mali is one of the countries most affected by climate change. Smallholder farmers, and especially women, suffer from inadequate and erratic rainfall, land degradation, lack of labour and time-saving technologies, low availability of nutritious species, conflicts over the use of natural resource and ineffective extension service. These issues encouraged me to take an interest in promoting climate-smart agroforestry technologies that support market access, food and nutritional security, and public-private partnerships. I have had a wonderful opportunity to lead a consortium of NGOs and private sector partners under the SmAT-Scaling project. This aims to enhance access to, and use of, tree-based climate-smart technologies through effective scaling-up of proven agroforestry technologies. We are using the rural resource centre approach and innovation platforms to reach over 200,000 farmers.

Key projects

Dryad: Financing Sustainable community forest enterprises in Cameroon

Funded by DFID, the goal of Dryad is to enhance viable community forest enterprises with sustainable livelihoods and environmental benefits through performance-based public finance and support mechanisms. (See story page 37)

SmAT-Scaling: Scaling up Climate-Smart Agroforestry Technologies for improved market access, food and nutritional security in Mali

Funded by USAID, SmAT-Scaling seeks to enhance access to, and use of, tree-based climate-smart technologies in order to increase food and nutritional security, as well as build the resilience of farming systems.

BRACED: Building Resilience and Adaptation to Climate Extremes and Disasters

BRACED aims to improve the integration of disaster risk reduction and climate adaptation methods into development approaches. BRACED will build the resilience of sedentary and nomadic populations in 13 countries across Africa, South Asia and Southeast Asia. The World Agroforestry Centre is working primarily in Chad to introduce new agroforestry, soil conservation and watershed management techniques.

Vision for Change, Cocoa sustainability in Côte d'Ivoire (V4C)

A 10-year project funded by Mars Inc., Vision for Change is tackling the main constraints to cocoa production, including aging plantations, pest and disease problems and the lack of land for new plantations. The project is helping to raise productivity, diversify incomes and contribute to community development.

Building Biocarbon and Rural Development in West Africa (BIODEV)

The purpose of this project is to develop and implement science-based, high-value biocarbon approaches to sustain rural development across a range of contrasting locations in pilot countries in West Africa, and to disseminate results and build capacity for their scaling up. (See pages 35)

FoodAfrica

This Finnish-funded project aims to improve food security in West and East Africa through capacity building in research and information dissemination. The World Agroforestry Centre is in charge of developing management strategies for overcoming key soil micronutrient deficiencies.

Latin America Region

The challenges

Latin America is a vast region characterized by sociocultural and biophysical diversity, ongoing economic transformation and high inequality and poverty. The region's unique natural ecosystems, and the local and global environmental services they sustain, are seriously affected by land degradation. Extreme climate change vulnerability—for example, in the Andes and Central America—adds to the challenges which agroforestry must respond to.

Our impact

In Latin America, knowledge and technologies generated by the World Agroforestry Centre provide vital underpinning for improved policy and practice. They include widespread use of our germplasm, quantification of environmental and livelihood benefits of trees and agroforestry, better understanding of value chains and agribusiness development, mainstreaming of concepts such as tree domestication, support for training in agroforestry-based climate-smart agriculture, guidance on land restoration, enhanced understanding of land use change, and the introduction of advanced land use planning tools. We work closely with partners at all levels to transform knowledge into impact.

Trent Blare, US

Stories from the field

Early-career scientists Trent Blare (US), Martín Reyes (Peru) and Marta Suber (Italy)

We work principally in Peru, a diverse country ranging from arid coasts and high snowy peaks to vast Amazonian rainforests, where many groups of peoples coexist. Peruvian forests are exposed to agricultural expansion as the search continues for new opportunities for economic growth. About 60% of deforestation in the Amazon has been caused by the activities of small- and medium-sized farmers. This reality is coupled with market demands for sustainable products, which could encourage the use of agroforestry systems and have consequences for climate change mitigation and adaption.

Martin Reyers, Peru

Marta Suber, Italy

As young scientists working in Peru, we contribute in different ways. Marta's role is to investigate the enabling context of the conversion of forest to agricultural land, and how it is related to carbon markets. Martín focuses on understanding the complexity of smallholder landscapes in the Amazon. He actively supports regional authorities by demonstrating how various agroforestry systems could be an important option for restoring forest landscapes. Trent examines how smallholders can strengthen inclusive markets in agroforestry products, ensuring the participation of women, young people and other marginalized groups.

Key projects

Oil palm diversification: reconciling conservation with livelihoods

We view oil palm as a highly productive crop with great potential for positive development impact, and positive environmental impact, if wisely managed. The project builds on work led by Natura on the development of agroforestry-based oil palm production. Working closely with farmers and others, our research will target three main areas of innovation: production systems, business models and adding value. The ultimate aim is to scale up agroforestry practices throughout the province of Pará in the Brazilian Amazon.

Advancing the restoration of degraded smallholder landscape mosaics

This project, supported by the International Union for the Conservation of Nature (IUCN), seeks to increase the pace and scale of forest landscape restoration by developing decision-support tools to design interventions at the landscape scale in the interests of multiple stakeholders.

Support for the development of agroforestry concessions in Peru

This project supports a ground-breaking, and as yet untested and unregulated, provision in the new Peruvian Forest Law, which allows for the establishment of Agroforestry Concessions on public land. We will help to develop effective approaches to operationalizing the new law. We want to ensure that smallholder farmers have a right to practise agroforestry at the frontiers of deforestation.

A learning platform for building local food networks in Cusco, Peru

This three-year project will help to build sustainable local food networks in Cusco. The lessons learned there will contribute to the debate about sustainable local food networks in other developing regions. The project, a collaboration between the World Agroforestry Centre and a local NGO, COPEME, is working directly with existing networks and groups intending to establish new networks.

South Asia Region

The challenges

The main challenges in our diverse region include widespread hunger, poverty, poor health, energy insecurity, environmental degradation and gender. Climate change is a serious threat. Agroforestry's full potential as a multifunctional land-use system is yet to be fully realized, but this is beginning to change.

Our impact

The successful implementation of the National Agroforestry Policy of India, and now the Mission on Agroforestry, has brought agroforestry into the mainstream development agenda. Its positive impacts are visible in India and attracting the attention of neighbouring countries. Strengthening the capacity of national partners in soil analysis, geoinformatics and agroforestry mapping will have a significant impact.

Devashree Nayak, India

Story from the field

Devashree leads multi-disciplinary projects to increase the adoption of agroforestry technologies, with a special focus on gender participation. She has been actively contributing towards the development and implementaion of the National Agroforestry Policy of India. She is also involved in research on livelihood improvement, enhancing on-farm productivity of fruit trees, climate change and gender issues. She received a "Young Scientist Award" from the Odisha Environment Congress in 2014.

Key projects

Collaborative Research Programme (2016-2020) between the World Agroforestry Centre and the Indian Council of Agricultural Research (ICAR)

This focuses on nine thematic areas, covering 12 major projects or activities. These include agroforestry species domestication; enabling tribal communities to improve their livelihoods through agroforestry systems; and the rehabilitation of degraded lands through agroforestry.

National Agroforestry Policy of India and its out-scaling

We are working closely with government departments on the implementation of the National Agroforestry Policy and Sub-Mission on Agroforestry. The success of the Indian policy has stimulated requests for support from the governments of Nepal and Bangladesh. (See story on page 45)

Programme for the Development of Alternative Biofuel Crops

The project is funded by the International Fund for Agricultural Development (IFAD). India is one of the three countries involved in this programme. (See story on page 39)

Rehabilitation of degraded lands through assisted regeneration of vegetation in Rajasthan and Odisha, India

The principal goal of this study was to assess the impact of assisted regeneration on degraded lands by monitoring soil, vegetation and water parameters in semi-arid and sub-humid areas in Rajasthan and Odisha. (See story on page 13)

Technical support to formulate a National Agroforestry Policy, Nepal

The South Asia Region is working with the government of Nepal on the formulation of a National Agroforestry Policy, with funding from the Climate Technology Centre and Network (CTCN). We are one of the members of the Inter-Ministerial Core Committee (IMCC) set up to coordinate policy formulation.

East and Central Asia

The challenges

The main challenge from an agroforestry perspective is how to develop sustainable solutions tailored to specific local needs, for example, by developing alternatives to the cash crop monocultures which have increasingly replaced natural forests. Food security and environmental degradation are of particular concern in mountain communities, which are vulnerable to climate change.

Our impact

Our work has attracted the attention of several governments who are incorporating solutions we have developed into their activities. To give just two examples, the bioclimatic stratification and modelling approach which we developed has been adopted by Yunnan Environmental Protection Department for biodiversity conservation; and data from our projects will be used to improve infrastructure planning in the Mekong region.

Gbadamassi Gouvide O. Dossa, China

Story from the field

We face so many challenges that choosing the main one might be an impossible task, so instead I want to highlight some of our most important resources: the ideas, energy and enthusiasm of young people. My work in Benin, China and elsewhere has taught me that it's crucial to work in multidisciplinary teams and be open to ideas from different fields. We need to bring people from different backgrounds, different mindsets and even different generations together to unlock creative solutions. I have been lucky to have supervisors who have not only helped me, but have given me the opportunity to help others. As a result, I've been able to set up a series of capacity building workshops for students and staff in Kunming, China. I hope initiatives like this will help our up-and-coming researchers benefit from the knowledge and experience of senior staff and partners. As a result, they will be better able to tackle the many challenges we face.

Key projects

The Mountain Futures Initiative

This project aims to improve the livelihoods of mountain communities by supporting their efforts to achieve their visions for the future. Initial outputs will include a book, a web-based platform for knowledge exchange and films.

Sustainable Rubber Projects

We are conducting research into how rubber expansion has affected rural livelihoods and investigating the effects of monoculture rubber on ecosystem services. We are also identifying factors which limit the uptake of green rubber practices. (See story on page 27)

China–Africa Cooperation on Calotropis Fibre

Governments, researchers and companies from China and Africa are working together to make commercial use of the Calotropis plant, which could provide an environmentally-friendly, high-quality source of textile fibre in sub-Saharan Africa.

Revitalizing Ecological Calendars in the Asian Highlands

We are working with communities to catalogue local ecological knowledge and combining it with the latest climatological data in order to revitalize traditional 'ecological calendars' as a tool for boosting the ability to adapt to climate change.

Mining Site Restoration

We are working with Yunnan Phosphate Chemical Group Co to develop new approaches for restoring severely degraded mining sites, and testing the application of new cultivation and species-selection techniques.

ANNEXES

OUR PEOPLE
Board of Trustees

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Prof. Lisa Sennerby Forsse

Ms. Bushra Naz Malik

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Dr. Keith Shepherd – Leader, Land Health Restoration and Investments
Dr. Lars Graudal – Co-leader, Improved Tree Germplasm, Diversity, Products and Value Chains
Dr. Peter Minang – Leader, Environmental Services and Landscape Governance
Dr. Ramni Jamnadass – Co-leader, Improved Tree Germplasm, Diversity, Products and Value Chains

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Dr. Isaac Nyoka – Southern Africa Node
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Dr. Jianchu Xu – East and Central Asia
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Dr. Sonya Dewi Santoso – Indonesia

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Dr. George Okwach – Drylands Development (DRYDEV) Programme
Dr. Ramni Jamnadass – African Orphan Crops Consortium (AOCC) Laboratory

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Dr. Karl Hughes – Monitoring, Evaluation and Impact Assessment
Dr. Mehmood Hassan – Capacity Development Unit
Dr. Thomas Zschocke – Knowledge Management Unit
Dr. Tor-Gunnar Vågen – Geo Science Unit

Non-Research Support Units

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Mr. Jose Mendez – Internal Audit Unit
Mr. Peter Murunga – Security Unit
Mr. Stephen Dean – ICRAF/ILRI Joint Information and Communications Technology Unit
Ms. Anne Munene – Grants and Sub-Grants Unit
Ms. Catharine Watson – Programme Development Unit
Ms. Jeanne Finestone – Communications Unit
Ms. Idah Ogoso – Human Resource Unit

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Agrofuturo Global SL

Agropolis Foundation

Australian Centre for International Agricultural Research (ACIAR)

Bill and Melinda Gates Foundation

Bioversity International

Canadian International Development Agency (CIDA)

Catholic Relief Services

Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

Centre for International Cooperation

Centro Internacional de Agricultural Tropical (CIAT)

CGIAR Fund

Chemonics International

Columbia Global Center in Eastern and Southern Africa

Common Market for East and Southern Africa (COMESA)

Concern Worldwide

Cooperation of Common Fund for Commodities

CORAF/WECARD

Cornell University

Danish Centre for Forest, Landscape and Planning

Danish International Development Agency (DANIDA)

Department for International Development (DfID)

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Ebony Enterprises Ltd

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German Academic Exchange Service

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Government of Japan

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Hunan Yunjin Group

IDH, The Sustainable Trade Initiative

Indian Council for Agricultural Research

Intergovernmental Authority on Development (IGAD)

International Centre for Research in Organic Food Systems

International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)

International Fund for Agricultural Development (IFAD)

International Institute for Environment and Development (IIED)

International Institute of Tropical Agriculture (IITA)

International Livestock Research Institute (ILRI)

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Princeton University

Programme for the Sustainable Management of Natural Resources

Rwanda Natural Resources Authority

SNV Netherlands Development Organization

Starfish Initiatives

Swedish University of Agricultural Sciences

Swiss Development Corporation

The Center for International Forestry Research (CIFOR)

The Interprofessional Fund for Agricultural Research and Council

United Nations Environment Programme (UNEP)

United Nations Office for Project Services (UNOPS)

United States Agency for International Development (USAID)

United States Department of Agriculture

University of California, Davis

University of Copenhagen

University of Ghana

World Bank

World Cocoa Foundation

World Conservation Union (IUCN)

World Resources Institute

World Vision International

WYG International

Yayasan Social Investment

FINANCIAL HIGHLIGHTS

Statement of Financial Position as at 31 December 2016 (in USD '000)

	Note	2016	2015	1 January 2015
		USD'000	USD'000	USD'000
Non-current assets				
Property and equipment	5	6,502	7,091	8,470
Intangible assets	6	755	847	-
		7,257	**7,938**	**8,470**
Current assets				
Held for trading financial assets	7	14,888	14,376	15,544
Inventories	8	41	51	58
Receivables and prepayments	9	28,371	30,158	29,933
Cash and cash equivalents	10	15,799	24,897	25,962
		59,099	69,482	71,497
Total assets		**66,356**	**77,420**	**79,967**
Represented by:				
Net assets	11	25,484	26,945	27,752
Non-current liabilities				
Retirement benefit obligation	12	5,693	5,860	5,810
Current liabilities				
Accounts payable	13	35,179	44,615	46,405
		40,872	50,475	52,215
Total net assets and liabilities		**66,356**	**77,420**	**79,967**

The Centre's financial statements were approved for issue by the Board of Trustees on 21 April 2017

Statement of Activities for the Year Ended 31 December 2016 (in USD '000)

	2016				2015			
	Unrestricted	Restricted - CRPs	Restricted - Non-CRP	Total 2016	Unrestricted	Restricted - CRPs	Restricted - Non-CRP	Total 2015
Grant Revenue								
Window 1 & 2	-	10,668	-	10,668	-	13,068	-	13,068
Window 3	40	16,388	2,095	18,523	597	17,457	1,081	19,135
Bilateral	304	26,864	3,952	31,120	318	25,749	4,581	30,648
Total Grant Revenue	**344**	**53,920**	**6,047**	**60,311**	**915**	**56,274**	**5,662**	**62,851**
Other Revenue and Gains	2,725	-	-	2,725	2,086	-	-	2,086
Total Revenue and Gains	**3,069**	**53,920**	**6,047**	**63,036**	**3,001**	**56,274**	**5,662**	**64,937**
Expenses and Losses								
Research Expenses	3,489	32,386	4,211	40,086	4,385	37,220	3,642	45,247
CGIAR Collaborator Expenses	-	1,569	-	1,569	-	836	-	836
Non CGIAR Collaborator Expenses	-	14,430	87	14,517	-	12,145	124	12,269
General and Administration Expenses	978	5,535	1,749	8,262	581	6,073	1,896	8,550
Other Expenses and Losses	-	-	-	-	-	-	-	-
Total Expenses and Losses	**4,467**	**53,920**	**6,047**	**64,434**	**4,966**	**56,274**	**5,662**	**66,902**
Financial Income	373	-	-	373	316	-	-	316
Financial Expenses	(603)	-	-	(603)	172	-	-	172
Surplus /(Deficit)	**(1,628)**	**-**	**-**	**(1,628)**	**(1,477)**	**-**	**-**	**(1,477)**

BOARD STATEMENT ON RISK MANAGEMENT

The Board of Trustees have reviewed the risk register and the proposed mitigating actions. The Board endorses the current risk ratings, having considered the requirement for any amendments.

The Board of Trustees has the responsibility of ensuring that an appropriate risk management process is in place to identify and manage current and emerging significant risks to the achievement of the Centre's business objectives, and to ensure alignment with CGIAR principles and guidelines as adopted by all CGIAR Centres. These risks include operational, financial and reputational risks that are inherent in the nature, modus operandi and locations of the Centre's activities. They are dynamic owing to the environment in which the Centre operates. There is potential for loss resulting from inadequate or failed internal processes or systems, human factors or external events. Risks include:

1. Misallocation of scientific efforts away from agreed priorities;
2. Loss of reputation for scientific excellence and integrity;
3. Business disruption and information system failure;
4. Liquidity problems;
5. Transaction processing failures;
6. Loss of assets, including information assets;
7. Failure to recruit, retain and effectively utilize qualified and experienced staff;
8. Failure in staff health and safety systems;
9. Failure by the Consortium to execute legal and fiduciary responsibilities;
10. Withdrawal or reduction of funding by donors due to the financial crisis;
11. Subsidization of the cost of projects funded from restricted grants and/or partial non-delivery of promised outputs, due to inadequate costing of restricted projects;
12. Failure by the lead Centre to comply with the terms of the agreement and/or not delivering on the agreed outputs could affect ICRAF as a participating centre; and
13. Non-prioritization of agroforestry in the CRPs due to lack of funding.

The Board has adopted a risk management policy that includes a framework by which management identifies, evaluates and prioritizes risks and opportunities across the Centre; develops risk mitigation strategies which balance benefits with costs; monitors the implementation of these strategies; and periodically reports to the Board on results. This process draws upon risk assessments and analysis prepared by staff of the Centre's business unit, internal auditors, Centre-commissioned external reviewers and the external auditors. The risk assessments also incorporate the results of collaborative risk assessments with other CGIAR Centres, office system components, and other entities in relation to shared risks arising from jointly managed activities.

The risk management framework seeks to draw upon best practices, as promoted in codes and standards promulgated in a number of CGIAR member countries. It is subject to ongoing review as part of the Centre's continuous improvement efforts.

Risk mitigation strategies include the implementation of systems of internal controls, which, by their nature, are designed to manage rather than eliminate risk. The Centre endeavours to manage risk by ensuring that the appropriate infrastructure, controls, systems and people are in place. Key practices employed in managing risks and opportunities include business environmental scans, clear policies and accountabilities, transaction approval frameworks, financial and management reporting, and the monitoring of metrics designed to highlight positive or negative performance of individuals and business processes across a broad range of key performance areas. The design and effectiveness of the risk management system and internal controls is subject to ongoing review by the Centre's internal audit service, which is independent of the business

units, and which reports on the results of its audits directly to the Director General and to the Board through its Audit and Risk Management Committee.

The Board also remains very alive to the impact of external events over which the Centre has no control other than to monitor and, as the occasion arises, to provide mitigation.

John Lynam
Chair, Board of Trustees
21 April 2017

PERFORMANCE INDICATORS

The Performance Measurement (PM) system of the Consultative Group on International Agricultural Research (CGIAR) measures the performance of the Centres it supports in terms of their results and potential to perform.

The PM system provides the Centres with a method to better understand their own performance and demonstrate accountability. The results are presented below.

Results for the World Agroforestry Centre

Publications
Composite measure of Centre research publications:

247 Number of peer-reviewed publications per scientist in 2016 that are published in journals listed in Thomson Scientific/ISI

367 Number of externally peer-reviewed publications in 2016

25% Percentage of scientific papers published with developing country partners in refereed journals, conference and workshop proceedings in 2016

53% Percentage of Open Access articles in ISI Journals

Institutional health

26.81%
Percentage of women in management

Financial health

Short-term solvency (the number of days of working capital to fund expenditures)

152 days against a benchmark of **90-120**

Long-term financial stability (adequacy of reserves)

111 days where the minimum benchmark is **90**

SELECTED PUBLICATIONS

In 2016, the World Agroforestry Centre generated a total of 575 publications

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LIST OF ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
AFLI	Agroforestry for Livelihoods of Smallholder Farmers
AfPBA	African Plant Breeding Academy
AFR100	African Landscape Restoration Initiative
AfSIS	Africa Soil Information Service
AgFor	Agroforestry and Forestry in Sulawesi: Linking Knowledge with Action
ANADER	L'Agence nationale d'appui au développement rural
AOCC	African Orphan Crops Consortium
ARC	Agriculture Research Council
ASEAN	Association of Southeast Asian Nations
ASFCC	ASEAN-Swiss Partnership on Social Forestry and Climate Change
B-Wiser	Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience
BGI	Beijing Genomics Institute
BIODEV	Biocarbon and Rural Development
BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CATIE	Tropical Agricultural Research and Higher Education Center
CCAFS	Climate Change, Agriculture and Food Security
CFA	Central African Franc
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIFOR	The Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
COPEME	Consorcio de Organizaciones Privadas de Promocion al Desarrollo de la Micro y Pequena Empresa
CRP	CGIAR Research Programme
CSA	Climate-Smart Agriculture
CTCN	Climate Technology Centre and Network
DFID	Department for International Development
DG	Director General
DGIS	Dutch Ministry of Foreign Affairs
DNA	Deoxyribonucleic Acid
DR&SS	Department of Research and Specialist Services
DRC	Democratic Republic of Congo
DRYDEV	The Drylands Development Programme
EADD	East African Dairy Development
EC	European Commission
EFK	EcoFuels Kenya
Embrapa	The Brazilian Agricultural Research Corporation
ESP	Ecosystem Services Partnership
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FES	Foundation for Ecological Security
FTA	Forests, Trees and Agroforestry
GDP	Gross Domestic Product
GELAMA-I	Green Economy and Locally Appropriate Mitigation in Indonesia
GFRAS	Global Forum for Rural Advisory Services

GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ICAR	Indian Council of Agricultural Research
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IMCC	Inter-Ministerial Core Committee
INERA	L'Institut de l'Environnement et de Recherches Agricoles de Burkina Faso
INIA	Instituto Nacional de Innovación Agraria
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
IUFRO	International Union of Forest Research Organizations
LAMA-I	Locally-Appropriate Mitigation Actions in Indonesia
MIR	Mid-Infrared Spectroscopy
MoA&FW	Ministry of Agriculture and Farmers Welfare
NASC	National Agricultural Science Centre
NGO	Non-Governmental Organization
NTFPs	Non-Timber Forest Products
OCS	One Corporate System
ParCiMon	Participatory Monitoring by Civil Society of Land-use Planning for Low-emissions Development Strategies
PM	Performance Measurement
pXRF	portable X-ray Fluorescence Spectroscopy
RED	Reducing Emissions from Deforestation
REDD	*Reduced Emissions from Deforestation and Forest Degradation*
RRC	Rural Resource Centre
SDG	Sustainable Development Goal
SLARI	Sierra Leone Agricultural Institute
SMS	Short Message Service
TAFOOD	Tay Bac Tea Special Food Company Ltd
TNC	The Nature Conservancy
TV	Television
UC	University of California
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US$	United States Dollar
USA	United States of America
USAID	United States Agency for International Development
V4C	Vision for Change
VECEA	Vegetation and Climate Change in East Africa
VIP4S	Value Chain Innovation Platforms to Improve Food Security

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