



AN ANNUAL REPORT FOR THE
WORLD AGROFORESTRY CENTRE

Trees For Life

2013-2014



Our vision

Our vision is a rural transformation in the developing world as smallholder households increase their use of trees in agricultural landscapes to improve food security, nutrition, income, health, shelter, social cohesion, energy resources and environmental sustainability.

Our mission

The Centre's mission is to generate science-based knowledge about the diverse roles that trees play in agricultural landscapes, and to use its research to advance policies and practices, and their implementation that benefit the poor and the environment.

Our core values

- Professionalism
- Mutual respect
- Creativity
- Inclusiveness

Our strategic goals

- Building livelihoods by generating knowledge, choice and opportunities
- Improving landscapes and their sustainability by better managing their complexity
- Transforming agroforestry impacts to large-scale through policy, innovation and partnerships

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: Ibrahim Mohamedou, a local farmer, waters his plants at an IFAD-supported nursery, part of an anti-desertification programme near the village of Zabon Moussou in Niger

Photo credit: David Rose/Panos.

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*Tuma Galmuka Uka with the seedling of a moringa cabbage tree (*Moringa stenopetala*). The trees produce high yields even during droughts, and they are an important source of food, medicine, fodder and fuel.*



CONGRESS MAPS OUT AGROFORESTRY'S FUTURE

"Once every five years we celebrate the role of tree-based systems in human prosperity with an international congress," blogged Director General Tony Simons during the 3rd World Congress on Agroforestry. Jointly organized by the World Agroforestry Centre, the Indian Council of Agricultural Research, the Indian Society of Agroforestry and Global Initiatives, the Congress took place in Delhi, India, in February 2014. Its theme was 'Trees for Life: Accelerating the Impact of Agroforestry.'

Attended by over 1000 people from 80 countries, the Congress broke new ground, according to Ravi Prabhu, Deputy Director General of the World Agroforestry Centre: "It attracted a very high-level policy audience for the first time, and we have never had a congress when the host country announced that it was putting in place a national agroforestry policy. This was a huge event."

"There are 6 million scientists in the world but less than 0.1% of them would likely describe themselves as an agroforestry scientist... All scientists, and indeed all 7.2 billion humans alive today, rely in one way or another on tree products and services – and therefore in a way rely on agroforestry scientists. Yes, give yourself a clap."

Tony Simons
Director General

The president of India, Shri Pranab Mukherjee, officially opened the Congress, telling delegates: "The cylinders can no longer remain idle; it is time to fire." He publicly launched the National Agroforestry Policy, which had been agreed by Cabinet the previous week. The policy will enable farmers to reap the benefits of agroforestry and adopt climate-smart agricultural practices. "2014 should be a defining moment for tree-based systems to address climate change," he said.

The National Agroforestry Policy is in line with recommendations made by the National Advisory Council of the Government of India, which had suggested setting

up a National Agroforestry Mission with an investment of 2000 million rupees (US\$33 million). It is envisaged that funds made available to the mission will help to leverage a further 80,000 million rupees (US\$1.3 billion) of investment. This will be used to promote sustainable agricultural practices and increase food production.

As Secretary of the National Advisory Council, World Agroforestry Centre Board member Rita Sharma played a key role in promoting the agroforestry policy initiative. Pal Singh, until recently the World Agroforestry Centre's Regional Coordinator for South Asia, was also an influential presence during discussions.

The second day of the Congress was devoted to science, with a plenary session and 12 parallel sessions. Scientists from across the globe also presented over 350 posters showcasing their research. "There was plenty of new thinking and innovative science on show," reflects Ravi Prabhu, "with many presentations and posters focusing on subjects such as biofuels and gender, which hadn't received such prominent coverage at previous congresses."

During the seven weeks around the event, the WCA2014.org website received over 60,000 visits from 188 countries. Almost 200 blogposts were published and there were over 4000 tweets related to the Congress, in theory reaching some 2.6 million people. Facebook posts about the conference were read by over 17,000 people, and just under 2000 people watched live streaming of the Congress. The blog competition offered scientists a platform to showcase their projects, and proved a major success, with seven of the 10 most viewed pages being competition blogs.

Everyone who attended the Congress received a copy of *Trees for Life: Creating a More Prosperous Future through Agroforestry*, a lavishly illustrated book which draws heavily on the 'Trees for Change' series.

Milestones from the regions

2013 was a big year for the World Agroforestry Centre's Southeast Asia programme, which celebrated 20 years of research and development with events in Indonesia and the Philippines.

At a meeting in Jakarta in November, scientists were able to share their experiences with a distinguished audience which included representatives of development organizations, research centres and government ministries. Regional Coordinator Ujjwal Pradhan listed recent achievements of the Centre's Indonesian programme. These included a memorandum of understanding to support a new agroforestry research centre in West Java; the inauguration of a regional early-career scientist programme; and the launch of three important projects which will enable the government of Indonesia to achieve its emission reduction targets. The projects are being led by Sonya Dewi. In December 2013, she was appointed as the first coordinator of the Centre's Indonesia country programme.

Other speakers included Bambang Hartano, Director of Research and Development of Forest Productivity, who spoke on behalf of the Minister of Forestry; Dennis Garrity, founding Regional Coordinator of the Centre's Southeast Asia programme, via video link from his home in Nairobi; and Wahjudi Wardoyo and Iman Santosa, former and current Director Generals of Indonesia's Forestry Research and Development Agency (FORDA).

The event concluded with the launch of three books: *20 years of working towards a sustainable Southeast Asia 1993–2013*; *Negotiation-support toolkit for learning landscapes*; and the English-language version of the Indonesian *National Strategy of Agroforestry Research 2012–2030*. The latter was launched at this event in recognition of the strong partnership between FORDA, which was celebrating its 100th anniversary, and the World Agroforestry Centre. "With the publication of this

document, research and development activities in the field of agroforestry have a clear direction," said Dr Santoso.

The World Agroforestry Centre was one of the sponsors of Philippine's First International Agroforestry Congress, which was held in Bohol in March 2014 under the banner of "Agroforestry: Greening and feeding the nations in the 21st century."

Jointly organized by the Philippine Agroforestry Education and Research Network (PAFERN), University of the Philippines Los Baños Institute of Agroforestry and Bohol Island State University, the meeting explored how agroforestry can help to increase farmers' productivity and incomes, and at the same time create healthier soils and capture carbon.

The keynote speech was delivered by Ravi Prabhu of the World Agroforestry Centre. "What we need is a green economy, which is low in environmental impacts, efficient in use of natural resources, resilient in managing risks through natural capital and socially inclusive," he said, before setting out a vision of how agroforestry can green and feed the world.

Rodel Lasco, Coordinator of the Centre's Philippine office and a contributor to the latest report of the Intergovernmental Panel on Climate Change (IPCC), explored how farmers in the Philippines can use agroforestry to help them adapt to climate change and sequester greenhouse gases. The Congress also heard about a range of research projects which show that agroforestry and conservation agriculture with trees have a key role to play in improving food security and protecting farmers against typhoons and other severe weather events (see pages 27 and 56).





Researchers have been identifying areas in western Nepal that are likely to experience climate change in the future.

India's National Agroforestry Policy

Despite the numerous benefits which many farmers and landowners gain from agroforestry, no specific scheme or policy existed to promote the practice in India. All this is now set to change.

“Since the mandate for agroforestry fell within the cracks of various ministries and departments and state governments, no serious institutional effort had been made to develop a coherent agroforestry policy,” says Pal Singh, who until recently was the World Agroforestry Centre’s Regional Coordinator for South Asia. “What we needed, and what we now have, is a national agroforestry policy.”

Much of the credit for its development must go to Rita Sharma, a member of the World Agroforestry Centre’s Board of Trustees and Secretary to the Government of India’s National Advisory Council (NAC). In 2013, the Council established a working group to develop a national agroforestry policy. The working group’s deliberations were attended by key ministries, research institutes and representatives of NGOs and industry, including the Ministry of Environment and Forests, the Ministry of Agriculture, the Indian Council of Agricultural Research (ICAR), the Ministry of Rural Development and the World Agroforestry Centre.

Agroforestry policy and related issues were discussed at nine national-level consultations, involving – in Pal’s words – a wide range of stakeholders, stockholders and stickholders. The outcomes and recommendations from each consultation were fed into the one that followed, thus making the process cumulative and inclusive.

The consultations came up with 10 major policy recommendations. These were circulated to various agencies for comment, and posted on the Internet for a wider critique. Feedback was incorporated into the policy document at another national-level consultation. The document was then submitted to the Government of India. After obtaining approval at Cabinet level, the document was laid in front of both Houses of Parliament. Plans are presently underway to prepare a roadmap and guidelines for a separate Agroforestry Mission/Board, which will facilitate the recommendations of the policy at national level.

“India’s national agroforestry policy is a major event and historic achievement,” says Pal Singh. “It is the first national agroforestry policy in the world and other nations are expected to follow suit in the near future.”





CHANGING THE WAY WE WORK

To meet the needs of a rapidly expanding population, global food production will have to increase by around 60% by 2050. The amount of new land that can be brought into production is limited, hence the need for "sustainable intensification". This involves producing more crops and livestock from the same area of land, while at the same time reducing the negative environmental impacts associated with many current farming practices.

Trees can be a key component of sustainable intensification. However, there's a problem. Although there is plenty of evidence to show that agroforestry can enhance soil fertility, increase crop production and provide a range of other goods and services, it is much harder to identify which particular tree species and management options will be suitable for a particular farmer.



Photo © ICRAF

Trees on farms can enhance soil fertility.

"In the past, we tended to design research activities on the assumption that what works with farmers in one site will work with lots of others," says Fergus Sinclair, a systems scientist at the World Agroforestry Centre. "Efforts are then made to scale up adoption of options that worked in a few pilot sites across large areas and this doesn't always work."

One of the reasons why scaling up from pilot sites is often patchy is because local conditions – soils, climate, farming practices, livelihood systems, markets and policies – vary from one place to another. This means that solutions to problems must vary too. However, it is common for development organizations to promote only what they think is best practice, without testing a range of different options across different situations. "So, we don't learn what the best-fit options are," says Fergus.

To overcome these problems, the World Agroforestry Centre is championing a new way of doing research. This involves embedding research 'in' development, rather than conducting research 'for' development. The semantic difference may be slight, but the impact is far-reaching for research organizations and development agencies, as well as for the smallholder farmers they serve¹.

Richard Coe, a research methods guru at the World Agroforestry Centre, points out that a lot of development spending is based on flimsy evidence about the interventions required to generate the desired impact. "We can certainly improve on this if we can persuade development partners to use 'planned comparisons' in the way they structure their activities, and then monitor performance so that we can see what works in different contexts," he says.

¹ Coe R, Sinclair F, Barrios E. 2014. Scaling up agroforestry requires research 'in' rather than 'for' development. *Current Opinion in Environmental Sustainability*, 6:73–77

A new kind of cooperation

Several of the projects described in the following pages – including the Trees for Food Security project in Ethiopia and Rwanda (page 21), the Agroforestry and Forestry in Sulawesi project (page 50), and the Agroforestry for Livelihoods programme in Vietnam – are trialling the new research in development approach. This involves characterizing variation in context and then testing out a range of agroforestry practices, chosen through participatory processes with farmers, under different conditions. Scaling up is then an iterative process, where feedback on performance of different options in different contexts refines our understanding of best-fit options.

"There simply isn't enough research money to test the scaling up of different options over large areas," says Fergus. "That's why the development agencies are so important." The Centre's development partners are being encouraged to test out the best-fit options in a systematic way. This requires not only careful design of which options to try out in different contexts, but rigorous monitoring and evaluation over time. This process enables researchers and their partners to match agroforestry practices to sites and farmer circumstances and adapt them to local conditions.

However, selecting the most appropriate agroforestry technologies is just one side of the story. Researchers and their development partners also need to work with government agencies and the private sector to establish effective delivery mechanisms, efficient markets and appropriate policies necessary for their adoption. "Today, when we talk about agroforestry options we are referring to change in farming practices, supply of inputs and markets for outputs and the institutional arrangements, such as land and tree tenure, which condition them," says Fergus.

One lesson that's been learned the hard way is that there are no silver bullets. Take, for example, the case of

alley cropping. Plot-level trials with a few fast-growing shrub species led scientists to believe that growing crops between rows of nitrogen-fixing trees could have a transformative impact across Africa. There were ambitious attempts to scale up alley cropping, but adoption was patchy. Eventually it became clear that the technology only worked under very specific conditions, in terms of soil and climate, and when land was scarce and labour abundant.

The research in development approach, in contrast, recognizes the importance of ecological, social and institutional complexity from the outset. It also emphasizes that researchers and development agencies will have the greatest impact when they collaborate closely with one another.



Researchers and development partners need to work with government agencies and the private sector to establish effective delivery mechanisms.

Photo © ICRAF



A NEW RESEARCH PROGRAMME FOR THE MEKONG

Humidtropics, a CGIAR research programme covering humid and sub-humid tropical Africa, Asia and the Americas, aims to help poor farming families boost their incomes by improving their agricultural practices, while at the same time preserving the land for future generations.² The four action areas are located in the Central Mekong region of Southeast Asia, the West Africa humid lowlands, the East and Central African highlands, and Central America and the Caribbean.

The research programme in the Central Mekong Action Area, which is led by the World Agroforestry Centre, was officially launched at a workshop in Hanoi, Vietnam, in May 2013. The 40 or so participants were then taken on a three-day field trip to Son La in Northwest Vietnam.

"The workshop and field trip were all about launching a research-for-development platform with our many partners, analysing the situation on the ground, and identifying places and points of intervention where we can encourage sustainable intensification of different agricultural systems," says Ingrid Oborn, the World Agroforestry Centre focal point for the Humidtropics programme.

Prior to the workshop, researchers had identified three key areas in which to work. These include the so-called green triangle, which encompasses remote, upland areas in Laos, Vietnam and China; the golden triangle, an area shared between Myanmar, China, Thailand and Laos; and the development triangle, which includes contiguous areas in Cambodia, Laos and Vietnam that are urgently in need of development. Approximately two-thirds of the 300 million people who live in the Central Mekong Action Area are dependent on agricultural activities for their livelihoods, and one in five people lives below the poverty line.



² <http://humidtropics.cgiar.org/>



Picking tea in the Upper Mekong.

There are considerable variations – ecological, socio-economic and cultural – between the triangles. For example, much of the land in the green triangle is devoted to monocultural maize and bananas. These crops are typically grown on steep slopes, leading to serious problems of erosion and land degradation. In the Chinese portion of the golden triangle, many farming families have switched from swidden agriculture to monocrop rubber. This has helped to increase their incomes, but at a considerable cost to the environment. The increasing dependence on single crops – such as rubber in the golden triangle – means that farmers are particularly vulnerable to fluctuations in commodity prices.

During the workshop and field visit, scientists were able to analyse the challenges facing farmers and identify possible "entry points" for intensifying agricultural production and improving livelihoods. Humidtropics research in the Central Mekong is focusing on a number of activities, including improving integrated tree-crop-livestock systems, introducing vegetable and fruit production for home consumption and the market, improving upland rice production and establishing sustainable systems combining food and cash crops with agroforestry.

Some of the activities involve existing research projects; others will be new. Whatever the case, bilateral grants are combined with funding from CGIAR research programmes, such as the one on Humidtropics. An example of the former is the Agroforestry for Smallholders Livelihoods in Northwest Vietnam project, which seeks to increase incomes by encouraging farmers to grow tree crops (see box on next page). An example of the latter includes the green rubber project in China. This is all about alleviating poverty and enhancing environmental integrity by introducing innovative agroforestry practices to existing rubber plantations. "These sorts of projects will be the backbone of our Humidtropics research in Central Mekong," says Ingrid.

Creating complex agroforestry systems in a difficult environment

Northwest Vietnam is a tough place to live, and a tough place to launch research projects. This is a mostly mountainous region with a variety of landscapes, varied rainfall, and different patterns of vegetation and farming systems. It is a socially complex area as well, with 30 different ethnic groups, each with its own language and way of doing things. In recent decades, the population has rapidly risen, and so has the pressure on forests. Considerable areas have been lost and land degradation is now affecting the productivity of many farming families.

"Farmers in the Northwest region face many challenges," says Delia Catacutan, the World Agroforestry Centre's Country Coordinator for Vietnam. "They have to cope with small farm sizes, poor access to major markets, the lack of non-farm livelihood opportunities and climatic variability." In most years, dry and cold spells limit farmers to just one crop of maize, which they plant on steep hillsides. There is little wonder, says Delia, that in their efforts to maximise production and income from limited area of land, farmers seldom consider planting trees.

However, a five-year project managed by the World Agroforestry Centre and supported by the Australian Centre for International Agricultural Research (ACIAR) – Agroforestry for Smallholders Livelihoods in Northwest Vietnam – is hoping to change all this. Launched in 2012, the initiative seeks to increase the productivity of crop and livestock systems and encourage more diverse and sustainable production systems. In such a complex environment, there can be no one-size-fits-all solution; rather, a range of innovations are required.

"Farmers need incentives if they are going to shift to more sustainable practices, such as contour ploughing and integrating trees into their maize fields," says Delia. "Our project cannot provide most of the incentives that farmers need, but by working with local partners we're helping to develop these incentives and encourage more sustainable and productive practices."

Soon after the project was launched, the research partners established a number of trial plots, using different combinations of trees and annual crops on hillsides. Some of these are now being adopted by farmers. For example, a native fruit tree *Docynia indica* – *son tra* in the local language – is being intercropped with maize



A H'mong farmer returning home after working on her upland field.

and different grasses. The fruit trees provide farmers with a good source of cash and a range of environmental benefits. Another agroforestry system which is working well involves planting macadamia trees with crops such as coffee and soya bean. Again, this is helping farmers to improve their incomes and at the same time manage their land in a more environmentally-friendly way.

The project has also established a network of nurseries to improve the availability of high-quality germplasm. This is essential if agroforestry is to be expanded across the region. Project partners are also looking at ways to improve market access for agroforestry products.

In March 2014, scientists from the World Agroforestry Centre and representatives from ACIAR led a two-day field trip to Northwest Vietnam. They held discussions with local farmers about the development of the agroforestry trials, and assessed the project's achievements and shortcomings. This was part of the mid-term review, led by Tony Bartlett and Geoff Morris of ACIAR. Also in attendance were 30 representatives from seven organizations, including partners such as the Department of Agriculture and Rural Development, Tay Bac University, and the Northern Mountainous Agriculture and Forestry Science Institute.

It was agreed that considerable progress had been made, but more needs to be done over the next three years. Tony Bartlett, for example, emphasized that the project needs to pay more attention to working out how to transfer new technologies to farmers.



MAKING THE MOST OF AFRICA'S GENES

In December 2013, the African Plant Breeding Academy was launched at the World Agroforestry Centre's headquarters in Nairobi. "This is one of the most exciting things ever to happen in Africa in the field of plant breeding," says Tony Simons. "Between 2000 and today, scientists sequenced the genomes of less than 100 plant species. During the next four years, our initiative alone plans to add 100 more."

The Academy is an initiative of the African Orphan Crops Consortium (AOCC), which was established in 2011. The Consortium's aim is to improve the quality, productivity and climatic adaptability of plants such as baobab and breadfruit, custard apple and cape tomato, tree grape and tamarind. These orphan crops have been used by African farmers in some cases for centuries. However, with a few exceptions, they have been largely ignored by science as they generally play a minor role in international trade.

One of the brains behind AOCC is Howard Yana-Shapiro, Chief Agricultural Officer at Mars, Inc. He recognized that Africa's orphan crops could play a major role in tackling malnutrition and diseases caused by vitamin deficiencies. "Stunted children do not reach their full potential, physically, mentally or economically," he said at the Academy's opening ceremony. "We believe this work can help complement the low nutritional content of staple food. The crops will be bred to optimize their health-giving properties."

At the launch Prof Onesmo ole MoiYoi, Chair of the Kenya Agricultural Research Institute (KARI), pointed out that poor nutrition during foetal development commits an individual to develop traits that can be passed on to their grandchildren. For example, during the Second World War, a Nazi blockade in part of the Netherlands led to high levels of malnutrition the consequences of which are still being felt three generations later.



Howard Yana-Shapiro of Mars, Inc. with World Agroforestry Centre Director General Tony Simons at the opening ceremony.

Photo © ICRAF

Breeding for a healthy future



Photo © ICRAF

Baobab is one of the species which will benefit from the programme.

The AOCC is an unusual collaboration, involving the African Union's New Partnership for Africa's Development (NEPAD), Mars, the World Agroforestry Centre, Beijing Genomics Institute, Life Technologies Corporation, World Wildlife Fund, University of California (UC Davis) and the Biosciences East and Central Africa–ILRI hub. Each is bringing its own specific expertise – and in some cases financial backing – to the project.

Hosted in Nairobi by the World Agroforestry Centre, the Academy will train 250 plant breeders in modern genomics and marker-assisted selection techniques for orphan crop improvement over a five-year period. The training programmes have been designed by UC Davis. The first session, which began the day before the official launch of the Academy, involved 24 participants from 11 African countries.

The scientists trained at the Academy will use four gene-sequencing machines, provided by Life Technologies Corporation and installed at the Centre's headquarters, to help describe the genomes of the 100 chosen orphan crops. According to Xun Xu, Deputy Director of Beijing Genomics Institute, the new machines are a million times faster and cheaper to use than the 'old-generation'

equipment. "All the delicious vegetables of the Chinese cuisine have been sequenced," he said at the opening ceremony. Now it is the turn of Africa's crops.

The genetic mapping of orphan crops will help scientists to identify specific gene sequences linked to desirable traits, such as high vitamin content, drought-tolerance, pest-resistance and high yields. The information will be made freely available on the Internet. "This means that countries and research organizations will be able to pick out specific genetic sequences and use these to develop new varieties with the traits they want," says Ramni Jamnadass, head of the World Agroforestry Centre's Tree Diversity, Domestication and Delivery Programme.

Although agricultural policy-making in Africa has largely focused on export crops, the amount of food sold in local markets for local consumption currently exceeds exports by a factor of three. "By 2030, 10 times as much food will be sold in Africa's local markets as is exported," says Tony Simons. "The question is: will urban consumers be eating cholesterol-laden trans-fats or healthy, vitamin-rich orphan crops?" It is hoped that this project will help to ensure it's the latter.

Improving livelihoods with sustainable biofuels

In recent years, biofuels – fuels derived from biomass – have become the subject of heated debate. Spurred on by national mandates and subsidies, many countries have resorted to using edible food crops as biofuels feedstock. This has contributed to rising prices of commodities like maize and wheat, with disastrous consequences for poor people in some of the least developed countries. At the same time, the rush to satisfy the increasing demand for bioenergy has led to forest clearance and the loss of biodiversity.

However, it should be possible to produce biofuels sustainably and deliver economic, environmental and social gains. A new project, launched at the UN climate change conference in Bonn, Germany, in July 2013, is focusing on how to use biomass, especially from smart agroforestry systems, to provide clean energy and additional income for rural communities, and at the same time enhance local food security and increase the resilience of small-scale farmers to climate change.

"Ultimately, the success of any large-scale biofuel project comes down to rigorous science that can determine what crops to grow, and where and how to grow them," says the Programme Manager, Navin Sharma who joined the World Agroforestry Centre in 2013 after more than 20 years' experience in industrial R&D. "Collaboration among research institutes, development organizations, business, civil society and governments must also be in place."

Supported by the International Fund for Agricultural Development (IFAD), the four-year "Programme for the Development of Alternative Biofuel Crops" is being implemented by the World Agroforestry Centre in India, Brazil and Africa, in partnership with various centres of excellence. The programme consists of three complementary components: research and development; local energy provision to enhance food security; and knowledge sharing and capacity building, together with policy studies and awareness campaigns.

The programme is pursuing a landscape approach, targeting integrated food and energy systems while promoting native multifunctional crops such as macauba, pongamia, simarouba and neem. These are crops with high potential for energy production, as well as animal feeds, fertilizers and other products. Many grow well on marginal degraded lands; some can even improve the productivity of food crops and livestock in well-designed systems.

"What we as researchers have to do is figure out how we can make biofuel systems more effective, efficient and socially just at the same time," says Henry Neufeldt, head of the Climate Change Unit at the World Agroforestry Centre.



Macauba is a very productive biofuel plant with a variety of other uses

Photo © Embrapa/Favaro



A MAJOR PROJECT FOR DRYLAND AFRICA

Over the next five years, approximately 70,000 households in 800 villages in five sub-Saharan African countries will benefit from a major new project. Funded by the Government of Netherlands Directorate General for International Cooperation (DGIS), the 'Enhancing water and food production for rural economic growth' project is being driven by farmers, supported by national organizations and coordinated by the World Agroforestry Centre.

The €40 million project is focusing on areas in Burkina Faso, Ethiopia, Kenya, Mali and Niger with high population density and a high dependence on food aid. It has three principal aims. It will improve water and food security; promote commercialization of the rural economy; and create an institutional environment that supports better water and food security, and promotes economic growth.

During the second half of 2013, lead organizations for each country were selected, based on their experience in the field. For example, in Ethiopia the project is now being managed by World Vision, which first opened an office there in 1975. Regional meetings were held in 2013 to develop key steps towards a smooth launch of the project in each country. A meeting with all the lead organizations was also held to develop ways of working collaboratively with partners at national and international levels.

Declining soil fertility, meagre yields, poor water management and frequent food shortages – these are the realities of daily life for many people in the areas where the project is active. Using a variety of approaches, the project will help farmers to improve soil and water management. This will involve the rehabilitation of around 500,000 hectares of degraded land. Agroforestry will play an important role in the project. In semi-arid areas trees can improve soil fertility by providing leaf litter and nitrogen. Indeed, research by the World Agroforestry Centre in

sub-Saharan Africa has found that the presence of older, nitrogen-fixing trees can increase millet and sorghum yields by up to 30%. Trees also provide fodder for livestock and fruits for human consumption, as well as medicines, fuelwood and timber.

Besides coordinating the project, the Centre will conduct baseline surveys and be closely involved in monitoring and evaluation of the project. According to Frank Place, ICRAF's Impact Assessment Advisor, the strength of the project lies in its partnership design. This encourages farmers and farmer organizations to articulate the needs of different types of farmers. The project also benefits from the support of skilled partners from various development agencies, backed by the expertise of international organizations.



Photo © ICRAF

Approximately 70,000 households will benefit from the new drylands project.

Strengthening partnership in Vietnam



Photo © ICRAF

Delia Catacutan and Trieu Van Hung exchange documents during the signing ceremony

In December 2013, the President of the Vietnam Academy of Forest Sciences, Trieu Van Hung, and the World Agroforestry Centre's Country Coordinator for Vietnam, Delia Catacutan, signed a formal agreement to increase cooperation between the two organizations. "This agreement formally acknowledges the extent of our cooperation with the Academy and sets out a clear path for deepening the relationship," reflected Delia during the signing ceremony.

The agreement emphasizes four main areas of cooperation. Among other things, these will help to increase the capacity of the Academy in agroforestry research and ensure that the two

organizations work closely together on a range of research projects.

"Last year, we reopened the agroforestry unit as part of our silviculture division and we want to extend our research into tree improvement in domestication, especially in the north-west, to help farmers in remote areas where we do not yet have research activities," said Dr Hung. "This agreement with the Centre will add considerable strength to our existing human resources and we expect much more progress in research and in sharing knowledge and information."

Children picking cherries in Tajikistan.





TREES AND FOOD SECURITY

Most of the food consumed in Eastern Africa is produced by smallholder farmers. However, their productivity has been falling, frequently as a result of declining soil fertility. In parts of Ethiopia, water scarcity, uncontrolled grazing and the high demand for tree products is leading to severe environmental degradation and declining yields. In Rwanda, many farmers grow their crops on steep slopes, and their land is suffering from severe soil erosion.

Tackling these problems, and providing farmers with the means to increase their productivity, lies at the heart of a major project managed by the World Agroforestry Centre. "Our objective is to encourage resource-poor farmers to grow more trees as a way of improving their food and nutritional security," explains Catherine Muthuri, the project coordinator.

Launched in 2012, the four-year Trees for Food Security project is funded by the Australian Centre for International Agricultural Research (ACIAR). During the first two years, the initiative focused on two distinct agro-ecological zones – semi-arid and sub-humid – in Ethiopia and Rwanda. Here, researchers, extension workers and farmers have been testing a range of agroforestry options. During the second phase, the most successful agroforestry options will be scaled up within country and 'scaled out' to Uganda and Burundi. The project is targeting agro-ecological zones that are home to over 30 million rural people, some 10 million of whom face acute food shortages.

Understanding the status quo

Approximately 1200 households were interviewed across four agro-ecological zones in Ethiopia and Rwanda. Researchers gathered information on a wide range of socio-economic and biophysical factors, including tenure, farming systems, access to markets and soil health, and at each site 100 households provided detailed information about the use of trees on farms. The survey data form a baseline against which project impact can be measured;

they also provide key insights into how farmers currently view and use trees.

"Among other things, the data are helping us to understand what motivates farmers to plant and retain trees, why they prefer some tree species to others, and what sort of benefits they get," explains Miyuki Iiyama, who is managing the baseline surveys. "Our results show that the trees people value in Ethiopia vary from wetter to drier conditions, as well as from farm to farm within agro-ecological zones, based on household characteristics."

In terms of species diversity, Ethiopian farmers manage the natural regeneration of trees in their crop fields for fuel, subsistence needs, including fodder and building materials, and environmental services – such as erosion control and water retention. This is the predominant form of agroforestry in these areas, followed by the planting of high-value trees for timber and fruit. Different agroforestry practices, such as scattered trees in fields, live fences and windbreaks – had distinct associations with specific agro-ecological conditions, household characteristics, farm and off-farm income strategies and access to markets.

Miyuki and her colleagues found that farmers in the wetter areas of Ethiopia tended to have a higher proportion of land planted to high-value agroforestry than those in drier zones. In contrast, farmer-managed natural regeneration, while ubiquitous everywhere, was more common in the drier zones. The prevalence of trees on farms confirms that they play an important role, providing farmers with a range of goods and services.

"One clear message to come out of our research is that governments and non-governmental organizations should encourage farmers to grow a range of different species for a range of different purposes which not only suit their livelihood objectives, but also promote tree diversity at landscape level," says Fergus Sinclair, who leads the Centre's agroforestry systems research.

Testing what works

The World Agroforestry Centre and its international research partners, including the International Maize and Wheat Improvement Centre (CIMMYT), have designed a series of long-term trials in partnership with the Ethiopian Institute of Agricultural Research and the Rwanda Agricultural Board. “Our aim is to look at how different crops perform under different conditions, with different combinations of trees,” explains Catherine Muthuri. Although the project comes to an end in 2016, she hopes that the Centre’s presence in Ethiopia and Rwanda, and the attractiveness of the projects for research students, will mean that the trials have a long-term future.

As part of the scaling up strategy, scientists from the Centre, led by Edmundo Barrios, organized two participatory trials design workshops (See box: Looking for best fits). Each workshop was attended by staff from national agricultural research and extension services, universities, government offices and non-governmental organizations, as well as local farmers. These hands-on capacity building workshops were designed to guide a participatory process to come up with ‘best-fit’ agroforestry options.

For example, at sites in Ethiopia where uncontrolled livestock grazing has led to severe erosion and loss of grassland, farmers are testing the planting of different trees as living fences. Other agroforestry activities have been designed to increase soil fertility, provide fruit and improve the supply of livestock fodder.

A new way of doing research

In the past, many research projects have made the mistake of assuming that just because something works in one place, or on one farm, it will work in another. In short, they have failed to take account of the complexity of conditions on the ground, and the variations in soil types, climate, access to markets and so forth that can occur over relatively small distances.

The Trees for Food Security project seeks to avoid these problems by adopting a “research in development” approach (see page 10). This involves testing a range of different options in different situations, with the help of development organizations like World Vision. This will enable the project partners to conduct planned comparisons over time, and assess the relative advantages and disadvantages of different agroforestry practices for different conditions. This allows the project to scale up adoption of locally adapted agroforestry practices over large areas, reaching tens of thousands of farming families.

“One of the strengths of this project has been the involvement of many different partners, and the fact that it is embedded within government processes,” says Catherine. The project will have a range of different outcomes. It will provide guidance about what sort of agroforestry systems work best under different conditions. It is already building the capacity of extension agencies and researchers in the region. Most importantly, it should improve the food and nutritional security of tens of thousands of farming families.



Photo © ICRAF

Farmers in Ethiopia are boosting maize yields by using nitrogen-fixing shrubs.

Looking for best fits



Photo © ICRAF/ Anne Kuria

The participatory trials design workshop in Rwanda.

"Blending local and technical knowledge is a key principle for fostering relevant, credible and legitimate action research in agriculture," says Edmundo Barrios, who was responsible for organizing two participatory trial design workshops in Ethiopia and Rwanda in 2013. "At the workshops, scientists, farmers and other agricultural professionals benefited from working closely together."

In 2011, Edmundo led the development and design of a methodological guide which enables researchers and others to blend local and scientific knowledge on soil fertility management.³ Selected tools of the InPaC-S guide, published by the World Agroforestry Centre, the Brazilian Agricultural Research Corporation (Embrapa) and the International Centre for Tropical Agriculture (CIAT), were adapted and used in workshops by Edmundo and Richard Coe, a research methods expert at the World Agroforestry Centre.

On the first day of the workshop, approximately 30 representatives of national research institutes, extension

agencies, universities, government departments and NGOs were provided with basic training on InPaC-S tools to identify, classify and prioritize local knowledge on soil fertility management. The following day, trainees used the tools in the field, where they were joined by some 40 farmers representing local communities. The local knowledge generated in the field was a key input during the development of skills required to blend local and scientific knowledge on soil fertility management and agroforestry.

The workshop participants came up with five 'best-bet' agroforestry technologies which they considered worth testing in the field as possible candidates for scaling up. "Trials designed for farmers' fields have now been carried out at many different sites, under differing conditions, for example in terms of soil types, climate, and farmer capacity to purchase and use inputs," says Richard Coe. "This allows us to match practices to sites and farmer circumstances and drives local adaptation."

³ www.worldagroforestry.org/downloads/publications/PDFs/BI7459.PDF



FRUITS FOR A HEALTHY LIFE

Fruit consumption in East Africa is among the lowest in the world. While the average person in Europe and the United States consumes over 280g of fruit per day, East Africans eat less than 40g – one-fifth of the intake recommended by the World Health Organization. This is a dismal statistic for a region which is blessed with a great variety of indigenous and exotic fruit trees. And it is one reason why 44% of children under the age of five suffer from stunting, and why so many adults are undernourished. They simply aren't getting sufficient minerals and other nutrients in their diets.

So what's the solution? "We believe that agroforestry has a key role to play in improving food and nutritional security in developing countries," says Ramni Jamnadass, head of the Tree Diversity, Domestication and Delivery unit of the World Agroforestry Centre. She is also leading activities within the CG-wide programme Agriculture for Nutrition and Health (A4NH).

Precisely how agroforestry and trees can help to improve nutrition was a major topic for discussion at a conference organized by the UN Food and Agriculture Organization (FAO) in May 2013. The theme of the conference, which was held in Rome, was "Forests for Food and Nutrition Security". Director General Tony Simons delivered the keynote address, and other contributions were made by Ramni and her colleague Katja Kehlenbeck. Tony stressed the importance of promoting a diverse range of fruit, timber, medicinal, fodder and fertilizer trees. He also suggested that there should be long-term investments in forests and trees as a way of replacing food aid.

Ramni and her colleagues were among the authors of two papers titled 'Agroforestry for food and nutritional security' and 'The contributions of forest foods to sustainable diets', published in a special issue of *Unasylva*.⁴ They also contributed two background papers for the conference. These provided a review of current research and evidence about the role of agroforestry in nutrition and food security. The team also helped to define specific impact pathways for future research.



Photo © ICRAF

A diet rich in fruits such as mangoes can help to reduce malnutrition and stunting among children.

⁴ Jamnadass R et al. 2013. Agroforestry for food and nutritional security, *Unasylva*, Vol 64, pp23-29, 2013/2.

Diversification is the key

"We believe that one of the best ways of contributing to improved nutritional security will involve smallholder farmers having a portfolio of trees producing fruit all year round," says Stepha McMullin, a social scientist with the World Agroforestry Centre. If farmers grow just one or a few fruit species, they face the limitations of seasonality, with periods when they have little or no fresh fruits. Furthermore, there are often market gluts – for example, of popular species such as mango, which has a short harvest period – and this leads to low prices for farmers and high levels of wastage.

Besides creating more diverse agroforestry systems, people living in rural areas in sub-Saharan Africa, and in areas where fruit consumption is low, need to diversify their diets. "At present, up to 70% of the total calories in the average diet in East Africa come from the staple foods like maize and cassava," says Stepha. "This means that most people lack a diversity of foods in their diets which can provide the essential vitamins and micronutrients they need."

A diet rich in fruit could go a long way towards improving nutrition and food security. Needless to say, it is important that farmers – and researchers – focus on fruits which will provide the greatest nutritional benefits. Guava, for example, contains 370mg of vitamin C per 100grams of fruit, which is 10 times more than mango, and indigenous baobab can contain up to 500mg per 100grams fruit pulp.

More research needs to be conducted on developing germplasm with desirable traits, such as high vitamin levels. Fruiting Africa, a research programme supported by the European Commission (EC) via the International Fund on Agricultural Development (IFAD), was launched in 2013. This initiative will focus on developing and distributing high-quality fruit germplasm in Kenya and Mali, and training farmers on tree management and how to generate additional income through fruit production and processing. In the framework of A4NH, research on both fruit consumption patterns and nutrient contents of fresh and

processed fruits is being carried out within the framework of the Agriculture for Nutrition and Health programme. The African Plant Breeding Academy, launched at the Centre's headquarters in Nairobi in 2013, will also play a key role in the development of Africa's neglected indigenous crops (see page 15).



Most African children need to increase their fruit intake.

Improving incomes of smallholder farmers could also improve food and nutritional security. "If you have year-round availability of fruit, you will eat more fruit, but you'll also have a surplus to sell," says Stepha. However, fresh fruit quickly rots and goes to waste. Another impact pathway identified by Stepha and her colleagues involves research on setting up fruit-based enterprises manufacturing products such as juices, dried fruits and jams. In 2013, the Centre launched a research programme on adding value to indigenous fruits in partnership with the Kenya Forestry Research Institute (KEFRI) and Jomo Kenyatta University of Agriculture and Technology (JKUAT).

Women have a particularly important role to play in improving food and nutrition security. "They're excellent at engaging in collective action, and we see them as the most effective change agents," says Stepha. In smallholder farmer communities, women are often the primary producers as well as the primary carers. They are the ones who prepare the food, and have the best understanding of their families' nutritional needs.

Photo © ICRAF

tropiTree: a database of genetic markers for tropical trees

The first mapping of the human genome cost around US\$1000 million. Precisely the same exercise can be repeated now, taking a fraction of the time, for a millionth of the price. The dramatic decrease in the cost of the tools to sequence genes has important implications for research in the field of agroforestry, according to Ian Dawson, an Associate Fellow with the World Agroforestry Centre. "With the low cost of new methods, we can now design tools for studying the genetics of trees cheaply and quickly," he says. "In the past, the costs involved were always a major limitation for researching 'non-model', genetically under-researched species such as trees, but not anymore."

In a collaboration between the World Agroforestry Centre, the James Hutton Institute in Scotland, the Kenya Forestry Research Institute and other partners, Ian and colleagues have developed an interactive, open-access database which

provides detailed information on genetic markers for 24 trees species which are of importance to smallholders in complex tropical agroforestry systems.⁵ On average, more than 5,000 genetic markers are available per species in the database, a massive increase in the resources available for the study of these trees.

"The tropiTree database is open to anybody who wants to use it," says Ian. "Scientists can use it to choose genetic markers for studying the breeding systems of trees and for understanding their genetic diversity and 'connectivity' in farm landscapes." These will provide a better understanding of how to manage trees productively in agroforestry systems. Scientists can also use the database to identify genetic markers in particular regions of interest in the genome, such as in genes that are responsible for adaptation to climate change.



Photo © ICRAF

⁵ <http://bioinf.hutton.ac.uk/tropiTree>

SHELTER FROM THE STORM

In November 2013, the Leyte area of the Philippines was struck by super-typhoon Haiyan, or Yolanda as it was locally known. According to the UN Food and Agriculture Organization (FAO), the damage to agriculture caused by the typhoon amounted to over US\$700 million, and coastal communities lost two-thirds of their fishing equipment. Climate change predictions suggest that typhoons in the Philippines are likely to become more violent, and their paths less predictable, in the coming decades.

However, recent research suggests that agroforestry could reduce the impact of typhoons. This was the message delivered by Craig Jamieson, a researcher at the World Agroforestry Centre, at the Philippines First International Agroforestry Congress, held in Bohol in March 2014.

Working with Rodel D Lasco, Philippines office Country Coordinator, Craig is developing and promoting the concept of using integrated mangrove systems to defend coastal areas from extreme weather events, and at the same time improve local livelihoods. They plan to refine the concept with a major energy company, using a test site in central Philippines.

Integrated mangrove systems have two distinct zones. On the seaward side, mangroves help to protect the land against wind and waves. They also act as breeding grounds for fish. On the landward side of the mangroves is an area described as the harvest zone. This is ideal habitat for nipa palm (*Nypa fruticans*), which is an excellent source of sugar for biofuels or as feed for livestock. This zone also provides attractive feeding grounds for crabs that thrive among the mangrove roots. "What we need to do is link livelihoods, food and mangroves," suggests Craig.

Integrated mangrove zones provide a number of benefits. On one hand, they can help to protect the coast from violent storms; on the other hand, they can improve the livelihoods of local people by providing additional sources of income. Craig believes that payments for environmental services (PES) schemes could reward coastal communities for protecting and promoting agroforestry systems such as these. A number of his colleagues have already been

researching PES opportunities through the USAID-funded B+WISER project.



Photo © ICRAF

Agroforestry could reduce the impact of typhoons.

Conservation agriculture is also climate-smart

The Congress also heard about the climate-smart benefits of conservation agriculture. In December 2012, typhoon Bopha, locally known as Pablo, struck Mindanao, causing immense damage to agricultural crops. Maize and banana monocultures were flattened over large areas. However, farms practising conservation agriculture, which involves minimal tillage, keeping the soil covered with organic matter and crop rotation, experienced much less damage, and recovered more quickly, than conventionally-farmed areas.

At its research site in Claveria, Mindanao, the World Agroforestry Centre has set up a conservation agriculture with trees training centre. Here, scientists conduct research on different conservation agriculture systems, rainwater harvesting, vermiculture and rubber agroforestry systems. The research is providing evidence to support the expansion of conservation agriculture with trees throughout the Philippines and in other parts of Southeast Asia which have similar conditions. A video about the training centre was shown during the Philippines First International Agroforestry Congress: <https://vimeo.com/90294432>.



EXPLORING THE DEMAND FOR FRUITS AND VEGETABLES IN MIDDLE-INCOME PERU

Throughout Latin America income growth and changing diets have often translated into rising levels of obesity. Peru is no exception. Over 40% of the adult population in Peru is overweight or obese. According to the Peruvian Society of Endocrinology, almost half the cases of diabetes are caused by obesity, which is also responsible for 23% of heart disease and more than 7% of cancers.

Increasing fruit and vegetable consumption could help to counteract Peru's obesity epidemic, which is largely the result of sedentary lifestyles and the consumption of foods rich in fat, salt and sugar, but poor in minerals, vitamins and other micronutrients. Despite the importance of fruits and vegetables for addressing chronic diseases, we know little about consumption patterns in urban areas of middle-income countries such as Peru.

To investigate this issue, Jason Donovan, marketing specialist with the World Agroforestry Centre, has been working with Peru's Instituto de Investigación Nutricional. In early 2014, they surveyed 300 households in San Juan de Lurigancho, a diverse community with over one million residents on the outskirts of Lima, to analyse consumption patterns and determine the importance of fruit and vegetables to the diets of predominantly middle-income consumers.

"...we're hoping that agroforestry plays a major role in improving the diets of consumers, and that people will want to eat agroforestry produce."

Jason Donovan
Marketing Specialist

"Traditionally, researchers in the CGIAR and elsewhere have carried out their research starting from the supply-side – the smallholder farmer – and worked along the value chain to the consumer," says Jason. "Now, we're taking a new approach by

looking at what people living on the outskirts of Lima are really eating, and what they want to eat."

The research is part of a project on nutrition-sensitive value chains within the Agriculture for Nutrition and Health Programme led by the International Food Policy Research Institute (IFPRI). The World Agroforestry Centre is one of several CGIAR organizations that have received seed funding for their work on fruit value chains in Peru and Kenya. Most of these projects are looking at malnutrition and micronutrient deficiencies in a rural context. The Latin America office, in contrast, has chosen to focus on over-nutrition in urban areas. The research recognizes that many parts of the world are rapidly becoming wealthier and more urbanized. In theory, this could lead to greater demand for locally produced fruits and vegetables.

At the time of going to print, Jason and his colleagues were still analysing the data gathered from the first household survey. While it is too early to draw any definitive conclusions, Jason believes that the study will show low consumption of fruits and vegetables by households on the outskirts of Lima. However, initial analysis suggests that there are considerable variations in consumption among household members, with children eating more fruit and vegetables than their parents.

The next stage of the research will focus on collecting quantitative data from 60 selected households to reveal some of the underlying factors behind consumption patterns. Why does rising income not lead to greater consumption of fruits and vegetables? Why does consumption vary among households and within households? What needs to change in the urban environment to encourage greater consumption?



Photo © ICRAF

Increasing consumption of fruits in Peru could help counteract the obesity epidemic.

Jason hopes that the research will lead to more investigation into how urban consumption patterns are linked to smallholder farmers and the role of markets in the sale and promotion of healthy foods. "Of course, we're hoping that agroforestry plays a major role in improving the diets of consumers, and that people will want to eat agroforestry produce," says Jason. "If that turns out to be the case, we will have a powerful demand-led justification for our research and for motivating the private sector to get behind agroforestry."



A REVOLUTION IN KENYA'S KITCHENS?



Charcoal briquettes are much cheaper than lump charcoal and burn for longer.

Cooking requires energy, and in countries like Kenya most of this comes from trees. Over the past two decades, the use of charcoal – the cooking fuel of choice for 82% of the urban population and 34% of the rural population – has risen by 64%. Every year, 22 million cubic metres of wood is carbonised to make charcoal, which means there is a direct link between hot meals and the loss of trees.

“...the use of charcoal briquettes means people can maintain their traditional diets, as they burn much longer than charcoal.”

Mary Njenga
Scientist

In Nairobi alone, households use 700 tonnes of charcoal a day. The by-product of this process is some 90 tonnes of charcoal dust. Not long ago, this went to waste, polluting drains and watercourses.

However, increasing numbers of households, especially in the poorer informal settlements, are now combining the dust with either soil, paper or animal dung to make charcoal briquettes.

"It's a simple technology that is helping to solve some very big problems," says World Agroforestry Centre scientist Mary Njenga. Mary's research, undertaken for her doctorate studies at the University of Nairobi in

partnership with the Centre, the Swedish University of Agricultural Sciences (SLU) and Michigan State University, shows that the use of charcoal briquettes provides a whole range of benefits. It's win-win-win, with not a loser in sight.

Briquettes made from charcoal dust burn for about four hours, compared to just two and a half hours for the same weight of lump charcoal. "Many of the families who use charcoal have stopped cooking the traditional meal of *githeri* – green maize and dried beans – because it takes so long to cook," says Mary. "But the use of charcoal briquettes means people can maintain their traditional diets, as they burn much longer than charcoal." Charcoal briquettes are nine times cheaper, in terms of their energy value, than lump charcoal and 15 times cheaper than kerosene. This means that poor families can spend less on fuel, leaving more to spend on food and other goods.

There are also considerable health benefits. Women in Kenya suffer high rates of respiratory problems, caused by the burning of firewood and charcoal, and emissions are very harmful to babies and children who are usually strapped to their mothers' backs. The use of charcoal

briquettes reduces carbon monoxide emissions by a factor of three and fine particulate matter by a factor of nine.

The use of charcoal briquettes also reduces emissions of carbon dioxide, one of the principal gases responsible for global warming. Mary and her research colleagues calculated that cooking *githeri* with charcoal leads to emissions of 6kg CO₂e, compared to 1kg CO₂e when using charcoal briquettes. Assuming the trees which gave rise to the charcoal are replanted, these figures are reduced to 2kg and 0.2kg, respectively. In short, using charcoal briquettes is much less damaging to the environment.

By using materials which would otherwise go to waste – such as charcoal dust and other organic municipal waste, coconut husks, sugarcane bagasse and maize stovers –

briquettes take less of a toll on trees than charcoal. Already, dozens of communities in Nairobi are manufacturing their own briquettes using simple techniques of combining biomass, soil and water. Using more high-tech methods, a large company called Chardust is producing commercial quantities for sale. But much more could be done.

"If the councils were to use municipal waste to make briquettes for urban use, this would translate into a big saving of trees as most charcoal is produced in rural areas and consumed in urban areas," says Mary. She adds that further research needs to be done on quality control of briquettes, the role of the technology in providing affordable and cleaner cooking fuel in the face of climate change, and the impact of innovations on food and nutritional security.



Putting briquettes out to dry in Kibera, one of the poor settlements in Nairobi.



RESEARCHING PESTICIDAL PLANTS

Synthetic pesticides, first introduced in the 1940s, have helped hundreds of thousands of commercial farmers to control pests and increase their yields. However, they have many disadvantages, especially for small-scale farmers in developing countries. They are costly, frequently difficult to source and easy to adulterate. Many are also highly toxic: the World Health Organization (WHO) estimates that 200,000 people die every year as result of synthetic pesticide poisoning.

Fortunately, there are safe and effective alternatives. "For thousands of years, farmers have made use of pesticidal plants," explains World Agroforestry Centre scientist, Parveen Anjarwalla. "Unlike many synthetic compounds, products made from pesticidal plants tend to be affordable, difficult to adulterate, safe to use and accessible to people living in rural areas."

In 2012, the African Dryland Alliance for Pesticidal Plant Technologies (ADAPPT), a long-term collaboration between the University of Greenwich, the Royal Botanic Gardens, Kew, and several African partners, invited Parveen and her colleagues to undertake research on the harvesting and propagation of pesticidal plants.

"In all our research, we are looking for ways of improving food security and reducing poverty."

Daniel Ofori
Tree scientist

The project got underway with a training workshop in January 2013. Held at the Centre's headquarters in Nairobi, the workshop on 'Sustainable production, harvesting and conservation of botanical

pesticides' attracted 20 participants from the farming community and another 20 from research institutions, government departments and development agencies. The aim was to bridge the gap between farmers and scientists, and share experience and knowledge about the use of pesticidal plants and their cultivation.

During the next six months, research focused on nine pesticidal plants. "Since this was a relatively short project, we identified plants which are commonly used in East Africa and whose seeds are readily available," says Parveen.

The main focus of the research was on harvesting, processing and handling, and propagation and cultivation.

Many of the pesticidal plants investigated by the researchers have a wide range of properties. Take, for example *Tagetes minuta*, a native of South America and an invasive weed in Africa. Powdered plants are used against weevils in maize and beans, and an extract is effective against aphids and red spider mites. Livestock farmers use a concoction from the plant to treat intestinal parasites in cattle, and vegetable farmers grow *Tagetes* as a live pesticidal plant to reduce nematode infestation in the soil.

The uses of plants like *Tagetes* has been the subject of long-term research by the University of Greenwich and Kew Gardens. The World Agroforestry Centre was able to add value by providing information on how the plants should be harvested, processed and propagated. The main outputs of the project included a series of nine pesticidal plant leaflets. The target audience includes extension agencies, researchers and farmers' organizations.

"In all our research, we are looking for ways of improving food security and reducing poverty," says Daniel Ofori, a senior scientist. "Pests are one of the greatest problems facing small-scale farmers in sub-Saharan Africa. If we can promote greater use of pesticidal plants, that will help farmers to increase their productivity and their incomes." It will also help farmers and local communities avoid the health-threatening problems associated with the use – and misuse – of synthetic pesticides.



Tagetes minuta is a source of powerful insecticides.

Photo © Flickr, Ma Africa



Digging for water in a dried up river bed in Uganda.



AGROFORESTRY AND CLIMATE CHANGE – TELLING THE STORY

"Soon after I arrived in Nairobi, I realized that scientists here had done a tremendous amount of work on issues related to climate change and agroforestry, but the knowledge was very dispersed," reflects Cheikh Mbow, a senior climate change scientist at the World Agroforestry Centre. It was time, he believed, to bring the research together in one place, and that is precisely what he and his colleagues have done during the past two years.

In 2013, the Elsevier journal *Current Opinion in Environmental Sustainability* (COSUST) published a special issue on agroforestry, food security and climate change. The project was overseen by Cheikh and the papers – 26 in all – were edited by a team comprising Cheikh, Henry Neufeldt, Peter Minang, Eike Luedeling and Godwin Kowero. Over 80 scientists from the World Agroforestry Centre, universities, and international and national agricultural research stations contributed to the project.

The COSUST special issue showcases the depth and range of the research undertaken by World Agroforestry Centre scientists and their colleagues. Apart from general reviews, articles focus on specific aspects of how agroforestry can improve food security and help farmers to reduce their emissions and adapt to climate change. For example, Sammy Carsan and his colleagues explore the role of agroforestry in agricultural intensification in Africa; Aster Gebrekirstos and her colleagues look at the opportunities and applications of dendrochronology in Africa; Evelyn Kiptot, Steven Franzel and Ann Degrande focus on gender, agroforestry and food security; and Miyuki Iiyama and her colleagues explore the potential of agroforestry for the provision of sustainable wood fuel in sub-Saharan Africa.⁶

There is a strict peer-review process for articles published in the COSUST Journal, which is highly rated in terms of its impact and citations. The special issue on agroforestry

received wide coverage in blogs and on websites, and attracted the attention of key decision-making processes.

For example, Cheikh was invited to attend the European Commission's annual meeting on food security in November 2013.⁷ He contributed to a high-level panel discussion, together with the President of Niger, the Director General of the International Food Policy Research Institute (IFPRI), two members of parliament and other distinguished guests. As a result of the COSUST publication, he was also invited to a learning event in Jeddah, Saudi Arabia, by the Islamic Development Bank.

On the international stage

The Copenhagen Accord called on countries which have signed up to the United Nations climate change convention to submit voluntary greenhouse gas emission reduction pledges for the year 2020. The aim is to limit global average temperatures to 2°C or less, compared to pre-industrial levels. By late 2013, 32 countries had heeded the call.

Since 2010, the United Nations Environment Programme (UNEP) has brought together a diverse group of scientists from across the world to answer two key questions: Are the pledges for 2020 enough to keep the world on track to meet its 2°C target? Or will there be a gap between ambition and reality? The answers can be found in the latest update of UNEP's *Emissions Gap Report*, which was launched shortly before the 18th Conference of the Parties (COP 18) climate change meeting in Warsaw in November 2013.

Henry Neufeldt, head of the World Agroforestry Centre's climate change research, was responsible for writing the chapter which explores how national agricultural policies can promote development while substantially reducing emissions. This provides an overview of the policies which

⁶ <http://www.sciencedirect.com/science/journal/18773435/6>

⁷ <http://eudevdays.eu/topics/food-security-food-justice-building-blocks-just-and-sustainable-global-food-system>



Photo © ICRAF/Cheikh Mbow

The burning of forests emits large quantities of carbon dioxide.

“The IPCC report will be the Bible on climate change issues until the next report comes out in five years time, and the sections on AFOLU will be widely cited for years to come.”

Henry Neufeldt, head of the World Agroforestry Centre’s climate change research

have proven to be effective in reducing emissions and increasing carbon uptake in the agricultural sector.

"Besides contributing to climate change mitigation, the measures described in the chapter are helping to enhance the sector's

environmental sustainability and at the same time provide other benefits," says Henry. The chapter explores three key examples: the use of no-tillage practices; how to improve nutrient and water management on rice production; and agroforestry.

The *Emissions Gap Report* was the focus of two well-attended side events at the Warsaw conference, one organized by UNEP and the other by the World Agroforestry Centre. Henry was also the lead author of

a paper published in *Agriculture and Food Security* titled, 'Beyond climate smart agriculture: towards safe operating spaces for global food systems'.⁸ Other authors included Bruce Campbell, Director of the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) and John Beddington, former Chief Scientific Advisor to the UK government.

In early 2014, the United Nations Intergovernmental Panel on Climate Change (IPCC) published its third report, the most exhaustive analysis to date on climate change science. The lead author of the working group on Agroforestry, Forestry and Other Land Uses (AFOLU) was Cheikh Mbow. "In terms of the impact of publication, you can't get much higher than this," says Cheikh's colleague, Henry Neufeldt. "The IPCC report will be the Bible on climate change issues until the next report comes out in five years time, and the sections on AFOLU will be widely cited for years to come."

⁸ <http://www.agricultureandfoodsecurity.com/content/2/1/12>



Photo © www.sxc.hu

Future Earth

In 2013, World Agroforestry Centre scientist Cheikh Mbow was invited to join the Future Earth Science Committee. A new 10-year international research initiative, Future Earth aims to develop the knowledge needed to respond effectively to the risks and opportunities facing the global environment. It will mobilize thousands of scientists and strengthen partnerships with policymakers and others to provide sustainable solutions to pressing problems.

"Over the last 30 years, many scientific institutions have done excellent work, but all too often they have been working in silos, with little cooperation between them," says Cheikh. "Future Earth is going to help to bring these institutions together so that they work more closely." Cheikh represents Africa on the Future Earth science committee, which will benefit from his wide experience of issues related to climate change.

BUILDING RESILIENCE TO CLIMATE CHANGE

Helping farmers become more resilient to climate change is one of the main purposes of a project in Western Kenya. A collaboration between the Coady International Institute and the World Agroforestry Centre, the project is funded by the COMART Foundation in Canada. The first phase, which involved four communities in the Kisumu region, ran from 2008 to 2010. The second phase began in 2011.

"We are using asset-based community-driven development principles – or ABCD – and value chain analysis to help local communities work out the best way of using their assets and improving their welfare," says Lisa Fuchs, who has been conducting an impact assessment for the project.

One of the tools being used is 'the leaky bucket'. Individuals and communities are encouraged to think about the income coming into their households, and their expenditure. This has sometimes led to radical changes in behaviour. "Some men have even given up drinking, thanks to the leaky bucket analysis," says Lisa. More importantly, the use of this and other tools, including value chain analysis, has helped communities to think more clearly about how to improve their productivity and incomes. As a result, they have taken up high-value agroforestry and horticulture.

"One of the best outcomes has been in the Middle Nyando block," says Henry Neufeldt, head of climate change research at the World Agroforestry Centre. "Communities which had abandoned growing coffee some time ago have now begun growing the crop again, with impressive results." Following the use of the 'leaky bucket', farmers belonging to the Toben Gaa Self-Help Group in Kipkelion West sub-county decided to take up coffee-growing again. Neighbouring communities saw how successful they were, and there are now 27 societies growing coffee in the area.

During the past year, the Toben Gaa Self-Help Group has benefited from various training sessions, for instance on group dynamics, leadership and record-keeping. Like other communities involved in the project, the group has been

actively implementing a village savings and loan scheme, and this has helped them to mobilize their own resources and channel funds towards specific activities. They have identified tree seedling production and tomato-growing as interesting value chains, and are now developing these.

In order to ensure the success of their agroforestry ventures, the community sold their goats. "We do not regret having had to do away with goats," said Joseph Maritim, the group secretary. "Now we have rain and our coffee production has more than tripled. What else could be more rewarding than this? Our wives have also been saved the burden of walking long distances in search of fuelwood." The community is planning to plant more trees.

"These activities are helping to boost the local economy and improve people's livelihoods," says Henry Neufeldt. Just as importantly, the activities promoted by the project are ensuring that communities are in a better position to withstand climatic shocks in the future. Henry and his colleagues are currently preparing a proposal for the third phase. This will involve scaling up experiences to a larger number of communities.



Communities have adopted agroforestry to improve their incomes.



CREATING AN ENDURING PARTNERSHIP IN PERU

During the past year, the World Agroforestry Centre has strengthened its ties with Peru's Ministry of Environment (MINAM). "Our relationship with MINAM really began to take off in April 2013," says Valentina Robiglio, who oversees the World Agroforestry Centre's research on climate change mitigation in Latin America and coordinates the new phase of Reducing Emissions from All Land Uses (REALU), recently renamed 'Secured Landscapes'.

Valentina and colleagues from the International Centre for Tropical Agriculture (CIAT) organized a workshop in Pucallpa, the capital of Ucayali Region, on tools and approaches to land use planning which can be used to assess the best ways of reducing carbon emissions and identify low carbon emission development pathways. The workshop took place under the umbrella of the ASB Partnership for the Tropical Forest Margins, which initiated a REALU project in Ucayali's Padre Abad province, one of the most deforested regions in the Amazon, in 2010.

"As a result of this training, MINAM is now looking at the possibility of using the LUWES methodology in its land-use planning processes,"

Valentina Robiglio
Landscape and Climate Change Scientist

As well as inviting local organizations and regional government departments, Valentina and her co-organizers encouraged staff from MINAM in Lima to attend. Participants were trained in the use of the Land-Use Planning for Low Emission

Development Strategies (LUWES) methodology. LUWES provides a set of tools and principles which enable those involved in land-use planning to work out scenarios on how best to reduce emissions without causing undue economic and social hardship.

"LUWES was originally developed by our colleagues in Southeast Asia, so this is a great example of the 'international public goods' nature of our research



ICRAF is carrying out research on tools and approaches to land use planning which can be used to reduce carbon emissions.

Photo © ICRAF/ Tito Marcos

products, showing how innovations from one region can be effectively deployed across the other side of the globe," says Jonathan Cornelius, the Centre's Regional Coordinator for Latin America.

Following the Pucallpa workshop, staff from the World Agroforestry Centre attended meetings in Lima with the National Forest Conservation Programme, *Programa Bosques*, and the Directorate of Land Use Planning, two units within MINAM. "We discussed how we could collaborate and support each of the units and presented a series of approaches and tools that could be adapted and applied in the local context," says Valentina. These included LUWES and other support tool-kits for "Learning Landscapes", as well as the Option by Context co-learning framework. As a result, ICRAF is now working on a pilot to identify options for cocoa agroforestry in Ucayali, a region where cocoa is rapidly expanding, often at the cost of forest.

In February 2014, collaborators from the ASB Partnership for the Tropical Forest Margins, including the World Agroforestry Centre and CIAT, were invited by MINAM's National Forest Conservation Programme and the Directorate of Land Use Planning to present the LUWES methodology in a three-day demonstration workshop in Lima.

Working in groups and using ABACUS software, participants were able to combine information on land use, carbon stocks and profitability for land-use systems in the Ucayali region, where research on this topic has been carried out by the ASB partners over several years. The results included an analysis of the opportunity costs of avoided deforestation, estimates of CO₂ emissions under different scenarios, and the calculation of reference emission levels for REDD+ (Reducing Emissions from Deforestation and Forest Degradation) projects.

"As a result of this training, MINAM is now looking at the possibility of using the LUWES methodology in its land-use planning processes," says Valentina. As every region in Peru has a mandate to create land-use plans, LUWES could help them to come up with targets for reducing greenhouse gas emissions in their development plans.

The World Agroforestry Centre and MINAM are currently finalizing a formal Memorandum of Understanding. This will pave the way for further specific activities, both in this field and in others of mutual interest, such as land health surveillance.



GETTING TO GRIPS WITH SMALLHOLDER EMISSIONS

Agricultural activities are directly responsible for 14% of human-generated greenhouse gas emissions, and a much greater share – around 30% – if the clearance of forests to make way for crops and livestock is included. Most of the land-use change emissions come from developing countries, and in Africa predominantly from farms which are managed by smallholders. However, our understanding about the effect of smallholder farmers on the climate system is weak, and in some places non-existent.

"We have very little data for greenhouse gas emissions from agricultural land in developing countries, with the exception of methane from rice systems in Southeast Asia," says Todd Rosenstock, an Environmental Impact Scientist with the World Agroforestry Centre. According to Todd, there are only 20 or so studies focusing on soil emissions from smallholder systems in Africa.

"This emerging research network will provide robust and transparent information about whether climate change mitigation can work for smallholders."

Todd Rosenstock
Environmental Impact Scientist

Does this matter? "Yes, it does," he says. "For example, AGRA – the Alliance for a Green Revolution in Africa – would like smallholder farmers to increase their use of nitrogen fertilizer to around 75kg per hectare on maize." At present, average nitrogen fertilizer use is under

10kg per hectare. "I think it's important that fertilizer use is increased in Africa, but at present we have absolutely no idea what effect this would have on the environment," says Todd.

To get to grips with smallholder greenhouse gas emissions, a major study was launched in 2013. The Standard Assessment of Mitigation Potential and Livelihoods in Smallholder Systems (SAMPLES) programme will identify pro-poor mitigation options for smallholder farming

systems, with the aim of providing real benefits for farmers while reducing their emissions of greenhouse gases. SAMPLES is being overseen by the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), and involves several CG centres, with the World Agroforestry Centre leading the work programme on drawing up guidelines for measuring greenhouse gases in smallholder systems.

"Smallholder systems tend to be very complex systems, with all sorts of greenhouse gas exchanges," says Todd. Getting accurate measurements may mean looking at the role of cattle, the use of manure, how the soil is cultivated, the burning of residues and other activities. Furthermore, measuring greenhouse gases tends to be expensive, time-consuming and often error-prone. This goes some way towards explaining why so little work has been done on smallholder climate budgets in the past.



Photo © Bjorn Sander (IRRI)

The Philippines is one of the countries to benefit from the SAMPLES project.



Photo © ICRAF

Field trials with students in the Nyando Valley in Western Kenya.

To overcome these problems, Todd and his colleagues – some 40 scientists from 15 countries – are devising a protocol, for use by scientists and development organizations, which will help to generate reliable data on emissions baselines and allow rigorous comparisons of mitigation options. The protocol will be published as a book in 2015.

Besides drawing up the guidelines, the SAMPLES programme is also mapping hotspots of greenhouse gas emissions, with the aim of identifying where the greatest sources of emissions are, and where the most vulnerable populations are found. This will help to provide guidance about where to establish mitigation schemes.

The programme also has a strong element of capacity building, and it is providing short training courses for technicians, masters students and others involved in climate change science at two pilot projects, one in the Philippines, and the other in Western Kenya. These will be among the initial areas where the guideline protocols will be tested.

SAMPLES started working at two pilot sites. Today, the consortium has expanded to 15 sites and farming systems in 10 countries. "This emerging research network will provide robust and transparent information about whether climate change mitigation can work for smallholders," says Todd. "These are critical inputs for highly charged international negotiations and national partners."

We are now fully carbon neutral

In January 2013, the World Agroforestry Centre headquarters in Nairobi was officially certified carbon neutral. A year later, the whole organization followed suit, making the Centre the first CGIAR institution to achieve this goal. "Offsetting does not mitigate climate change, but buys time to allow for mitigation of emissions in the future," says Henry Neufeldt, who manages the World Agroforestry Centre's investment in carbon accounting and offsetting.

"During 2013, carbon footprint focal persons were appointed for each office," says Henry's colleague Audrey Chenevoy. "Most of the focal persons work in administration, and they are now responsible for gathering all the data on flights, water and electricity use, transport, waste and so on."

In April 2013, the focal persons gathered at a workshop in Abidjan, Côte d'Ivoire, and under the guidance of Audrey they agreed on protocols for data collection. Carbon payments in 2014 were based on the Centre's carbon footprint for 2012. This amounted to 4752 tonnes CO₂e, almost 60% of which was related to activities at the headquarters.

The Centre has introduced a system of levies which are channelled into the carbon footprint fund. For example, research units pay US\$25 for each international flight; US\$5 for each regional flight; and US\$3 for domestic flights. Commuting is also included in the scheme.

The Nairobi headquarters is locked into a two-year deal supporting the Meru and Nanyuki Community Reforestation Project in Kenya. Carbon credits covering the footprint for the rest of Africa are supporting a REDD+ project in Madagascar; those for Latin America have gone to Amazonian rainforest conservation project in Brazil; and credits from Southeast Asia and South Asia are supporting

the Rimba Raya REDD+ project in Indonesia. All these transactions have been arranged on behalf of the Centre by the CarbonNeutral Company. Greenhouse gas emissions related to the 3rd World Congress on Agroforestry, held in Delhi, were offset through support for the South India Improved Cook Stoves Project.



Photo © ICRAF/

Carbon offset payments are helping to support a forest conservation project which benefits the orangutan in Indonesia.



In the Indian drylands, crop roots are often used as cooking fuel.



TREES – THE KEY TO SURVIVAL IN DRYLANDS

Droughts, floods, rapid population growth, poverty, poor access to government services and conflict are among the many challenges that communities living in the drylands of Eastern Africa face. These areas have absorbed large quantities of humanitarian aid, much of it aimed at tackling the problems of food insecurity. However, until recently little effort was devoted to developing strategies to increase the resilience of dryland communities.

This is beginning to change, according to Jan de Leeuw, a drylands scientist at the World Agroforestry Centre. "In recent years, we've seen a revival of support for projects focusing on livestock and crop development," he says. "However, there has been relatively little work on using trees as a way of strengthening people's resilience. That's partly because knowledge about the role trees can play in sustaining livelihoods in Africa's drylands is so scattered."

"Yes, you will lose crops if there is no rain, but you won't lose the trees. Trees are very resilient, and they can help communities cope better during droughts and other threats."

Jan de Leeuw
Drylands Scientist

But not any more. In July 2013, the World Agroforestry Centre organized a writeshop with support from the UK Department for International Development (DFID). During the course of the five-day writeshop, 50 scientists and development workers produced the draft text

for a new book. *Treesilience – an assessment of the resilience provided by trees in the drylands of East Africa* provides the most comprehensive account to date of the role trees can play in sustaining livelihoods, protecting the environment and restoring degraded lands.

"It's all about getting away from the paradigm of agriculture in drylands as inherently vulnerable," says Jan. "Yes, you will lose crops if there is no rain, but you won't lose the trees. Trees are very resilient, and they can help communities cope better during droughts and other threats."

Fast, efficient and productive

During the month leading up to the writeshop, Jan and the co-organizers circulated a draft outline of chapters. This was revised in light of the feedback, so that those involved were familiar with the book they would be working on during the writeshop.

For Mary Njenga, one of the co-organizers, this was an entirely new experience. "I thought the writeshop was excellent," she says. "It provided an opportunity to bring together a very diverse group of individuals, all with different types of knowledge, based on hands-on experience."

The time-limited nature of the writeshop ensured that the task of producing text was swiftly achieved. The participants were split up into groups of two to four, with each group being assigned a specific chapter or sub-chapter on a topic with which they were familiar. The main chapters focus on the need for resilience, a conceptual framework on trees and resilience, the distribution and ecology of trees in the Eastern Africa drylands, the benefits from ecosystem services provided by trees, a series of case studies, closing knowledge gaps and opportunities for action.

"I think the scientists enjoyed writing 3000–4000 words in a week, in close collaboration with their colleagues," says Mary. "It was very different from producing a 14–20-page academic paper over a period of months, which is what often happens." After the workshop, the texts were refined, with each chapter and sub-chapter going through a rigorous peer review process.

A policy brief, *Towards greater resilience in the drylands: trees are the key*, captures the key messages from the writeshop. It describes the role of trees, as providers of goods and services, and the importance of secure land and tree tenure. The way forward involves promoting a diverse

range of economically viable tree-based products, supporting apiculture, promoting large-scale production and propagation of multipurpose trees, investing in water harvesting, and encouraging efficient charcoal production.

Treesilience is clearly an idea whose time has come. The book was widely blogged about in the NGO and aid world and, perhaps not by coincidence, in December 2013 the TreeSilience Alliance was established in Johannesburg during the 3rd Global Conference on Agriculture, Food Security and Climate Change. Its members include Oxfam, Care International, Concern Worldwide, Catholic Relief Services and the CGIAR network, of which the World Agroforestry Centre is a member. The alliance aims to improve the resilience of millions of farmers by promoting climate-smart agriculture. Treesilience provides much of the information that's needed to turn aspiration into reality.



Photo © ICRAF

In dryland Africa, shea fruits are an important source of income for many communities.



HARVESTING GREEN WATER

Two-thirds of all the rainwater which falls on sub-Saharan Africa is wasted, not least because tens of millions of smallholder farmers adopt land-use practices which fail to capture green water – rainwater which is converted into biomass through the process of evapo-transpiration.

Scientists have been grappling with this issue for a long time, according to Maimbo Malesu of the World Agroforestry Centre. Recent research in Kenya has helped them to come up with a solution. "Our studies suggest that by adopting agroforestry practices, farmers could increase their use of green water and reduce water losses," says Maimbo. The research was commissioned by the United States Agency for International Development (USAID), which was looking for information to guide its five-year investment plans. Maimbo and his colleagues conducted land-use and water assessments of five ecosystems in Kenya, including Mau Forest and the Aberdares.

"... agroforestry has a very important role to play in capturing green water on farmland."

Malesu Maimbo
Programme Coordinator, Water Management

Between 2000 and 2008, 300,000 hectares of land in Mau Forest was converted from closed forest, bush and scrub to agriculture. This has led to a significant increase in soil erosion and the siltation of lakes and ponds, which were reduced in

size by 32,000 hectares. "Because these areas were opened up for farmland, there was a huge loss of water," explains Maimbo. Using the Climate Change Knowledge portal, a tool developed by the World Bank, the scientists were able to predict what is likely to happen in the future. "Rainfall and temperatures are expected to increase in East Africa, and under a business-as-usual scenario water run-off will also increase in the Mau Forest," he says. "Unless measures are taken, droughts and water shortages will become more frequent."

It's a very different story in the Aberdares, a range of mountains to the west of Mt Kenya. The government evicted large numbers of squatters between 2000 and 2008 and the area devoted to crops declined by 267,000



Photo © ICRAF/Alex Oduor

Agroforestry can help to capture green water on farmland.

hectares. Farmland is now reverting to scrub and forest. During the same period, water bodies expanded by 6000 hectares.

There is a simple explanation for the differing fate, and prospects, of these two areas. Annual agricultural crops utilize 6–9% of rainfall; trees, in contrast, can capture up to 40%, converting it into green biomass. "Obviously, closed canopy forests will capture more water than orchards and other forms of agroforestry," says Maimbo, "but agroforestry has a very important role to play in capturing green water on farmland."

Does this mean that the Kenyan government, and other authorities, should adopt the sort of practices which have restored forest land in the Aberdares? "Many people would argue that that mass evictions are not the right approach, as they do not take into account local needs," says Maimbo. "However, it should be possible to find a solution midway between the two extremes." And that solution involves agroforestry and rainwater harvesting.



A TALE OF TWO VILLAGES



Photo © ICRAF

Research in the Ethiopian highlands provided insights into why some communities adopt agroforestry practices, and others don't.

Agroforestry can transform lives and landscapes. Trees and shrubs grown on farms provide fruit, timber, resins, fuelwood and livestock fodder. They also improve soil fertility, regulate water supplies and help farmers adapt to changing climatic conditions. Which begs the question: if agroforestry can bring so many benefits, why don't we see lots of trees on every farm?

Research in the Ethiopian Highlands provides some interesting insights into why there are lots of trees in some landscapes, while few in others. The work was part of the USAID-funded Africa RISING (Research in Sustainable Intensification for the Next Generation) programme, which in the Ethiopian Highlands is managed by the International Livestock Research Institute (ILRI).

One of the early-win projects focused on local knowledge in Tigray, a semi-arid region in northern Ethiopia. Genevieve Lamond of Bangor University led the knowledge acquisition, in partnership with the World Agroforestry Centre and Mekelle University. A two-week training event was held in the village of Abreha We Atsbeha, which has many trees. Emelda Hachoofwe, an MSc student from Bangor University, went on to collate knowledge about agroforestry technology transfer both there and in Adi Gudom, a nearby village with few trees.

For some 15 years, Abreha We Atsbeha had benefited from various programmes designed to improve food security and

watershed management. The landscape had suffered from high levels of erosion due to overgrazing and deforestation, and this had led to declining crop yields. As a result, most of the 900 households suffered from food insecurity. People were hungry.

The government's Productive Safety Net Programme and other initiatives introduced various practices, including the construction of erosion control structures and livestock exclusion zones, which helped to restore the pastures and increase productivity and incomes. Today, 85% of the population have enough food to eat all year round.

"The community developed a detailed understanding of how vegetation management in the upper watershed, and especially restrictions on free grazing, conserved groundwater resources and improved soil fertility on crop land," says Genevieve.

Between 2004 and 2007 the amount of irrigated land in Abreha We Atsbeha more than doubled. Farmers also benefited from high-value fruit trees and the introduction of beekeeping, with honey yields rising from 13 to 31 tonnes between 2007 and 2010. The introduction of zero grazing dramatically increased the availability of high-quality livestock fodder, and some farmers even rent out their *Faidherbia albida* trees, so that farmers who don't have these trees on their own land can feed the nutritious pods they produce to their cattle.

But it hasn't worked everywhere

The same government initiatives tried to introduce many of the measures that worked in Abreha We Atsbeha in Adi Gudom, but without much success. "The landscape has remained almost treeless, apart from the planting of eucalyptus along one watercourse," says Martha Cronin, a World Agroforestry Centre researcher. Although farmers in Adi Gudom know about the success of the watershed programme in Abreha We Atsbeha, which won the Equator Prize for community-led environment and poverty solutions in 2012, they have not developed a productive agroforestry landscape themselves.

Genevieve and Martha believe there are several reasons why trees are improving livelihoods in one village, but not the other. These include time, the motivation to act, local leadership and different agroecological conditions. Projects involving land restoration and grazing controls began much earlier in Abreha We Atsbeha and were prompted by the community experiencing extreme food insecurity. Just as importantly, the grassroots implementation of the programme there, and the inspired leadership of one

farmer, helped to convince other farmers of the positive benefits of excluding livestock from overgrazed land and incorporating trees on their farms.

"In Adi Gudom, you still see lots of free grazing and the majority of farmers don't want to use a cut-and-carry system to feed their livestock because they don't see a connection between free grazing, loss of vegetation and soil loss, as was evident in the Abreha We Atsbeha site," says Martha. "Instead, farmers value free grazing for loosening the soil and spreading manure on crop land." It goes without saying that free grazing mitigates against tree establishment as livestock eat young tree seedlings.

The research in Tigray shows that agroforestry projects are most likely to succeed when they are community-based, with strong local leadership able to adapt intervention options to suit local circumstances. "This research illustrates how fine scale variation in context requires us to adapt agroforestry options to local circumstances," says Fergus Sinclair, leader of systems research at the World Agroforestry Centre. "We now explicitly consider variation in context when developing agroforestry interventions, and we are partnering with development organizations to test them directly with farmers."



MAKING A DIFFERENCE IN ACEH

The Indonesian province of Aceh was the scene of a decades-long conflict between an independence movement and the government. This was brought to an abrupt halt when Aceh was struck by an earthquake and tsunami on 26 December 2004. Over 170,000 people were killed and vast areas of productive farmland destroyed. According to the UN Food and Agriculture Organization (FAO), 48% of rice land, 75% of upland agricultural systems and over two-thirds of the province's livestock were lost.

Immediately after the tsunami, the priority was reconstruction of essential services. However, aid and development agencies soon began to focus on food production. This meant, among other things, ensuring that farmers had access to high-quality rubber, cocoa, fruit and timber seedlings.

With support from the Canadian International Development Agency (CIDA, recently renamed the Department of Foreign Affairs, Trade and Development - DFATD), the World Agroforestry Centre launched the Nurseries of Excellence (NOEL) project in 2007. During the next two years, scientists and technicians from the Centre trained more than 5000 farmers, a third of whom were women, on how to establish and manage tree nurseries. In 2013, four years after the project ended, they returned to the province to produce a video about its impact.

Among those interviewed was Hamdan, leader of a farmers' group which runs a successful nursery business, thanks to training and support from NOEL. The project helped the group to register as suppliers of quality seedlings, and in 2013 they renewed their certificate with the provincial government. Their seedlings are much sought after as they have a good reputation for excellence and high productivity.

"This is a classic example of the importance of quality germplasm," says Jim Roshetko, former leader of the NOEL project and senior scientist with the Centre's Southeast Asia programme and Winrock International. "Farmers want

trees that will produce both quantity and quality products. To achieve that, high-quality seedlings are needed along with proper management. That was the whole point of establishing 'nurseries of excellence'."



Many of the farmer groups who benefited from the NOEL project are still operating, four years after the project ended.

Jim and his colleagues trained more than 60 farmers as specialist trainers. They subsequently shared their knowledge with other farmers, creating a snowball effect that has increased the knowledge of thousands of small-scale farmers and improved their ability to make the land more productive. "The knowledge NOEL gave us, especially in the Bayu Sepakat farmers' group, has spread widely," said Usman, one of the trainers interviewed in the video. "Thanks to the training we received from NOEL, we are not only selling seedlings, but also sharing knowledge as a gift when farmers buy from us."

All too often, research and development projects lose their impetus when the managers leave. NOEL, in contrast, has had a lasting influence. "We can now see productive agroforestry systems on land that was previously idle," says Jim. "Some are already beginning to bear fruit or produce latex or other products. It's great to see that farmers continue to benefit from what we taught them and are able to build better lives for themselves."

Progress in Sulawesi

In last year's annual report we reported on the progress of the Agroforestry and Forestry in Sulawesi (AgFor Sulawesi) project. Funded by DFATD (formerly CIDA), the project is led by the World Agroforestry Centre, with the assistance of the Center for International Forestry Research (CIFOR), Winrock International, the National Planning and Development Agency of Indonesia and several local partners.

The aim of the project is to improve rural livelihoods by raising on-farm productivity, encouraging better environmental management, and improving governance. The initial focus has been on South and Southeast Sulawesi, two provinces which suffer from high levels of poverty and still possess significant tracts of natural forest. The project will expand to Gorontalo Province in 2014.

Between April to September 2013, 1070 individuals gained greater knowledge about sustainable natural resource management through formal and informal workshops and trainings. The baseline livelihood study was published in English and Indonesian as well as technical guidelines in Indonesian for smallholder cacao, coffee, rubber and black pepper systems. Over 2300 people, 30% of whom were women, were trained in agroforestry management at 112 events, and almost 1500 people, 31% of whom were women, were trained in nursery management and tree propagation at 103 events. Several thousand people also benefited from training sessions on marketing, establishing demonstration trials, participatory governance, the development of land-use models and various other activities.



Farmers tending a pepper garden in South-east Sulawesi

“We are very pleased with the progress to date,” says Jim Roshetko, Senior Team Leader of the AgFor Project. “We have worked collaboratively with local partners, including government agencies, to improve knowledge and capacity of farmers and communities. This has helped us achieve project goals and, more importantly, it's ensuring that communities will continue to benefit after 2016, when the project ends.”

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TRANSFORMING COCOA PRODUCTION

In 2010, the Vision for Change (V4C) project was launched in Côte d'Ivoire. A public-private partnership involving the World Agroforestry Centre, Mars Inc. and a range of national institutions, V4C is helping to increase yields and improve the livelihoods of hundreds of thousands of cocoa farmers.

Côte d'Ivoire supplies more than a third of the world's cocoa, and the crop accounts for about 10% of the country's GDP and 40% of its exports. It also provides a living for some 6 million people. However, despite its importance, the sector faces serious challenges, including declining productivity and high levels of pests and diseases.

In March 2014, V4C partners held a review in Abidjan, during which scientists, agronomists and project managers were able to reflect on the achievements of phase 1 of the project, which came to an end in December 2013. These fell under three main headings: germplasm; innovation platforms; and sustainable management. The science review evaluated progress, analysed the challenges and made recommendations which will help to shape phase 2 of the project, which runs from 2014 to 2017.

Achievements during the first phase were considerable. One of the highlights of the germplasm work was the setting up – reported in last year's annual report – of a new somatic embryogenesis laboratory. A highly efficient protocol for sterilizing field-grown cocoa flower explants has been developed, as well as regeneration of somatic embryos and plantlets for some clones. To increase the availability of improved planting material, over 18 hectares of irrigated clonal gardens have been established from existing high-yielding cultivars.

By the end of phase 1, the project had set up 16 Centres de Développement du Cacao (CDCs), equipped with facilities for planting material propagation. Each CDC is managed by a field technician and supervised by a research assistant. The dissemination pathway for delivering improved inputs and rehabilitation services to farmers is the CDC-CVC model. The Cocoa Village Centre (CVC) is

a small rural enterprise, owned by an individual living in the cocoa-producing communities.

The overall goal of the sustainable management work stream has been to provide systematic support to develop and improve farm management practices which can be demonstrated by the CDCs and adopted by farmers. Good soil fertility management requires appropriate recommendations and timely application of fertilizer, based on the prevailing nutrient status of the soil and trees. Soil surveys were conducted in the project area covering 50,000 hectares in five CDC catchments, and a soil processing unit was built at Soubré. During the first phase, the project also took a leading role in developing a risk management protocol for the cocoa swollen shoot virus, a major threat to cocoa production in Côte d'Ivoire.

"Continued research is required at both on-farm and landscape levels for sustainable intensification of the cocoa cropping system," says Christophe Kouame, the World Agroforestry Centre's Country Director in Côte d'Ivoire. "Adoption studies and delivery of the triple productivity package to farmers through the CVCs will be expanded during the second phase."



Photo © ICRAF

The project is helping to improve cocoa productivity.



ENRICHING COCOA GARDENS IN CÔTE D'IVOIRE

Côte d'Ivoire produces 40% of the world's cocoa, but the industry is in crisis. Many cocoa gardens are old and suffer from declining productivity. The average farmer in Bas-Sassandra region, a major cocoa growing area, gets just 400 kilograms per hectare per year, less than half the potential yield under good conditions.

Since its launch in 2010, the Vision for Change (V4C) project, a public-private partnership involving Mars Inc, the World Agroforestry Centre and national institutions, has been helping farmers to increase their yields and improve their incomes. This is mainly being done by grafting improved scions of high-yielding cultivars onto old trees, and by encouraging farmers to adopt good agricultural practices.

"Our research suggests that it's possible for farmers to get good cocoa yields and at the same time benefit from planting a range of different trees in their cocoa gardens."

Fergus Sinclair
Leader, Agroforestry Systems

However, recent research by the World Agroforestry Centre suggests that farmers could also improve yields and incomes by shifting away from cocoa monoculture to species-rich cocoa agroforestry. This was one of the key messages that came out of

a national strategy meeting for agroforestry research on cocoa, held in Grand-Bassam in February 2013.

"Traditionally, government agencies and extension workers in Côte d'Ivoire have encouraged farmers to grow coffee under full sun," says Fergus Sinclair, who leads the Centre's research on agroforestry systems. Full-sun cocoa cultivation maximizes short-term yields, but productivity can only be sustained if farmers can afford to apply large quantities of inputs such as fertilizers and pesticides. In Côte d'Ivoire, the majority cannot. Hence the dramatic decline in yields.

For many years, cocoa growers were warned not to retain a long list of forestry species in their cocoa gardens. They

were also told, among other things, that many native species acted as vectors for the cocoa swollen shoot virus, despite the fact that there is little scientific evidence to support this assertion.

While the authorities championed full-sun cocoa, organizations like the Rainforest Alliance and UTZ promoted certification schemes which reward farmers through price premiums for adopting more environmentally-friendly practices. Environmental criteria include the integration of native shade trees in cocoa gardens.



Cocoa drying at a homestead in Gligbeaudji.

At the February strategy meeting, Fergus and his colleagues argued that it should not be a matter of either/or: either full-sun cocoa, or species-rich low-yielding cocoa agroforests. "Our research suggests that it's possible for farmers to get good cocoa yields and at the same time benefit from planting a range of different trees in their cocoa gardens," he says. "Besides providing important

environmental services like buffering against climate variability and improving soil fertility, trees provide farmers with key products such as fruit and timber, which they can either use themselves or sell in the market."

Research by Emilie Smith Dumont provides compelling evidence that cocoa farmers are sympathetic to the principles of agroforestry, even though government agencies have long counselled against intercropping cocoa with native trees. In 2012, she and her colleagues interviewed 355 farmers in Bas-Sassandra region. They identified over 100 different tree species in cocoa gardens, and found that 95% of farmers wanted to grow more tree species on their land. The farmers provided the researchers

with detailed information about how 32 species interact with cocoa in terms of soil moisture retention, soil fertility improvement and pest and disease interactions.

"The cocoa landscapes in South-West Côte d'Ivoire appear to be at a turning point," says Emilie. "Their productivity is declining, along with their conservation value. However, our research suggests that both issues could be addressed by promoting appropriate tree diversity and good management practices, supported by a policy environment that includes security of land and tree tenure, certification schemes and more efficient value chains."

Who wants what?

If farmers are to be encouraged to adopt cocoa agroforestry – as opposed to cocoa monoculture – we need to understand the reasons why they favour some species and not others. To gain an insight into farmers' preferences, scientists from the World Agroforestry Centre and the University of California, Davis, interviewed 400 cocoa farmers in and around Soubré in Côte d'Ivoire.

Farmers tend to favour trees which have a market value. This is particularly true for better-off farmers living near towns. However, poorer farmers and those living in isolated areas are more likely to intercrop their cocoa with tree crops that provide products they can use themselves, such as oil and fruit.

"We also found that where people came from had a significant influence on the trees they grow in their cocoa gardens," says Amos Gyau, a markets researcher with the World Agroforestry Centre. "In communities made up

of immigrants from countries like Burkina Faso, farmers are only prepared to make short-term investments, for example by planting fruit trees." This is because they lack security of land tenure, unlike native Ivoirians. The latter, in contrast, are far more willing to plant timber trees such as iroko, which take many years to mature.

Farmers who receive information from cooperatives and extension agencies about the benefits of intercropping are also more likely to plant trees in their cocoa gardens than farmers who haven't benefited from similar contacts. The researchers found that as increasing numbers of farmers in an area intercrop their cocoa with a specific tree, the likelihood of other farmers doing the same increases. Extension agencies could take advantage of this trend by focusing on the promotion of intercropping to a core population, then allowing additional farmers to learn from, and be influenced by, these early adopters.

MEASURING THE IMPACT OF TREES ON FARMS

It has become an article of faith for research organizations like the World Agroforestry Centre that trees on farms provide a whole range of goods and services. However, there is a surprising lack of quantitative evidence to back this up. "Researchers tend to be very good at talking about all the different functions of trees, yet little effort has been made to measure these functions, in particular at the same site, such as field, farm or landscape," says Ingrid Öborn, a Soil Scientist from the Swedish University of Agricultural Sciences and Senior Research Fellow at the World Agroforestry Centre.

A research project launched in 2010, involving the Swedish University of Agricultural Sciences, the World Agroforestry Centre, the Vi Agroforestry Programme in Kenya and the Jomo Kenyatta University of Agriculture and Technology, sought to answer the question: "Can integration of trees on farms contribute to enhanced agricultural productivity and resource utilization, and result in improved living conditions for smallholders?"⁹

Most of the research focused on smallholder farming systems in West and Central Kenya, but some activities were carried out in Tanzania, where researchers studied the soil properties required for the growing of *Allanblackia*, a native tree with oil-bearing fruits which is currently being domesticated as a crop for smallholder farmers.

"We measured a whole range of different interactions," explains Ingrid, the project leader, "including crop–livestock–tree systems, crop–tree systems, and crop–livestock systems." The team, which also included two PhD students, conducted interviews with farmers and ran training workshops and extension activities.

The research shows that in the study areas, farmers are integrating trees into their agricultural systems to obtain a



Intercropping trees with crops.

range of products and services, including better adaptation to climate change. They use a variety of tree species that have different functions, including the provision of fodder, fertility, firewood, fruit and shade. This is work in progress, and the data gathered is now being used to model productivity, resource flows and trade-offs at different scales.

According to Ingrid, the close interaction during project implementation between research, development and extension organizations has been particularly fruitful, and to the mutual benefit of all those involved. Furthermore, the training workshops and outreach activities proved beneficial to the farmers' field advisors. The findings about growing conditions in natural *Allanblackia* stands in Tanzania will inform future domestication work by the World Agroforestry Centre and its partners.

⁹ Can integration of trees and crops contribute to enhanced agricultural productivity, resource utilisation and livelihoods for smallholder farmers? An evaluation of the multifunctionality of agroforestry systems, by Ingrid Öborn et al, in the SLU Global Food Security Research and Education Programme 2010–2013. Available online at "<http://www.slu.se/en/international/slu-global/about-the-programme/slu-global-reports/>"



COFFEE AND CONSERVATION

The liberalisation of the global coffee market in the early 1990s had a profound impact on the smallholder farming communities who grow some of the finest Arabica coffee in the world on the flanks of Mt Kenya. Without access to a guaranteed quota-based market, they now had to compete with large-scale producers like Brazil and Vietnam. There were frequent gluts and prices plummeted.

As a result, coffee production in Kenya has decreased by more than 50% over the past two decades. A study carried out by Sammy Carsan, a tree domestication scientist at the World Agroforestry Centre, examined the impact of these changes on the abundance and variety of trees grown on farms. The findings, published in *Biological Conservation*, make disturbing reading. The decline in coffee farming on small farms could lead to significant losses of biodiversity as indigenous trees are replaced by exotics and annual crops.

Sammy and his team of researchers interviewed 180 coffee farmers during a three-month period. They conducted complete farm inventories, and asked farmers about their attitudes towards coffee and other crops. They categorized the farms according to their coffee yields over a period of five years. Approximately 15% of farmers were increasing the amount of coffee they produced; 25% were going in the opposite direction; and production remained stable on the remaining 60% of farms.

The study identified 190 different tree species, 78% of which were indigenous. While the levels of diversity were relatively high, which is not unusual for agroforestry systems, the actual number of indigenous trees was quite low.

"We found that the first category of farmers – with increasing production – tended to have slightly greater tree species diversity and larger trees," says Sammy, "and the indigenous trees included important species for conservation, such as *Prunus africana* and *Vitex keniensis*." The other two categories – those with stable or declining production – had fewer indigenous trees and more exotics, such as *Grevillea robusta* and various *Eucalyptus* species.

On farms with declining coffee production, farmers were seeking to supplement their coffee earnings with fast-growing timber species, fruit trees such as mango, banana, avocado and macadamia, and annual crops. Frequently, these were the younger farmers. "Many older farmers had remained loyal to coffee, partly because profits from coffee had helped to pay for the education of their children and the development of their farms," says Sammy. "Many also had dairy cows and other income streams." This may be one of the reasons why they had been able to maintain higher coffee yields and retain bigger indigenous trees on their farms.

Indigenous trees support a richer flora and fauna than exotic trees. The larger specimens are particularly important, as they provide nesting sites for birds and seeds for regeneration. The study suggests that loss of existing coffee agroforestry systems to annual food crops and fast-growing timber trees could seriously affect the region's biodiversity.



Photo © ICRAF/Sammy Carsan

The loss of coffee agroforestry systems could have a serious impact on biodiversity.

Restoring watersheds in the Philippines

In recent years, many watersheds in the Philippines have suffered from intensive resource extraction and mismanagement. Take, for example, the Gabayan watershed in eastern Bohol. Large areas of forest have been removed and much of the land is heavily degraded. Floods and droughts have become more frequent and soil erosion is leading to the sedimentation of irrigation networks. According to local farmers, the degradation of the watershed has led to a decline in productivity and incomes.

In 2013, David Wilson, a scientist at the World Agroforestry Centre, used the Soil and Water Assessment Tool (SWAT) to model the effects of different land-use practices on the ecosystem services provided by the watershed. Developed by USDA Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research, SWAT was designed to predict the environmental impact of land use, land management practices and climate change.

In this instance SWAT was used to simulate the impacts on hydrology under two scenarios. The first assumed business as usual, with current land-use practices continuing much as they are. The second examined the impact of introducing conservation agriculture with trees at strategic locations in the watershed.

The model suggests that conservation agriculture – a practice which involves minimal soil disturbance, keeping the soil covered throughout the year, and growing a diverse mix of crops – combined with the use of trees could do much to halt the degradation of the watershed. "Our results showed a significant reduction in sediment yield and sediment concentration in the Gabayan watershed under agroforestry and conservation agriculture," says David. "We were able to provide scientific evidence that agroforestry, combined with improved management practices, is an effective land-use strategy at the watershed scale."



Photo © ICRAF/ David Wilson

Agroforestry could help to improve water management in the Gabayan watershed.

The critically endangered Sumatran tiger frequently ventures into rubber plantations.





A NEW APPROACH TO RESEARCH

Collaboration and knowledge sharing is at the heart of a new approach to research, initiated in 2012. At a series of regional workshops organized by Anja Gassner, Head of the Research Methods Group at the World Agroforestry Centre, scientists agreed that it was time to work more closely together in 'sentinel landscapes'.

The idea was that scientists involved in the CGIAR Research Programme on Forests, Trees and Agroforestry would work together in a multidisciplinary way over extended periods of time in the same areas, and share their knowledge and data. By using precisely the same methodology in each of the sentinel landscapes, it would be possible to make valid comparisons between them.

"The landscape approach allows us to recognize that ecosystems and people are intertwined."

Anja Gassner
Head, Research Methods Group

At a workshop in Nairobi in 2012, scientists chose six 'Tier 1' sentinel landscapes – two each in Latin America, Asia and Africa – and two thematic landscapes, one for oil palm, and the other for production forests. Each of the Tier 1 sentinel

landscapes contains a range of habitats, from primary forest to agricultural land and agroforestry, representing various stages of the 'forest transition curve'. These areas are subject to rapid, human-induced change, and already the focus of considerable research activity.

"The landscape approach allows us to recognize that ecosystems and people are intertwined," says Anja. "Before we can effectively manage at a landscape level, we need to be able to assess landscape health in terms of both people's livelihoods and ecosystem services, such as soil fertility, carbon storage and biodiversity conservation."

In March 2014, 38 scientists from 14 research organizations met in Costa Rica to review progress in the sentinel landscapes. The meeting was hosted by the Center for Tropical Agricultural Research and Higher Education (CATIE), a regional organization which leads the Nicaragua/Honduras sentinel landscape and has played a key role in the baseline studies.

The workshop provided an opportunity for research teams from sentinel landscapes across the world to discuss research questions, sampling designs and data analysis. "It also provided a good opportunity for teams from the sentinel landscapes which have made the most progress to share their experience with researchers from other sentinel landscapes," says Jenny Ordoñez, a World Agroforestry Centre scientist based at CATIE's headquarters in Costa Rica.

Leading the way

One of the first tasks for researchers in the Nicaragua/Honduras sentinel landscape was to get the interest and involvement of local partners. After the kick-off workshop at the end of 2012, the team had to establish exactly where to work. Partners were sent a map with 13 randomly chosen sites. "We asked them to identify which sites they considered to be the best to work in, in terms of good representation of the variability of conditions in the landscape, accessibility and security," says Jenny. Eventually, the choice was whittled down to four sites. In both Nicaragua and Honduras, one of the sites is relatively heavily forested, and subject to rapid change; the other is more developed, with a mosaic of agriculture, agroforestry and secondary forest.

In June and July 2013, Tor-Gunnar Vågen of the World Agroforestry Centre and Leigh Winowiecki from the International Centre for Tropical Agriculture (CIAT) provided training for local research teams on how to conduct biophysical surveys, using the Land Degradation Surveillance Framework (LDSF) developed in Africa and described in previous annual reports.

Some 700 soil samples were collected at each site and by the end of 2013 researchers had completed the biophysical characterization. They found that erosion was most prevalent in areas which had the lowest tree densities. "Greater tree density was associated with high levels of carbon, better infiltration and less erosion," says Jenny. "In itself, that's not big news, but we now have excellent



Photo © ICRAF/Tor Vågen

The Mekong Sentinel landscape contains a mosaic of different land uses.

quantitative figures and baseline data for the biophysical factors in this sentinel landscape."

In a parallel exercise, three local organizations that were already familiar with the communities in the four chosen sites were trained to conduct socio-economic baseline surveys. Sandrine Freguin-Gresh from the French research organization CIRAD also carried out institutional mapping, which has provided a good insight into the functioning of local institutions and governance of natural resources.

At the Costa Rica workshop, scientists from all sentinel landscapes had a glimpse of the data gathered in the

Nicaragua/Honduras sentinel landscape and the West African sentinel landscape, which has also carried out its baseline studies. The data will enable scientists to analyse the links between decision-making and the health of the landscape and the people who live there. The other sentinel landscapes are now collecting their own biophysical and socio-economic baseline data.

"This is the first time we will have a rigorous and consistent methodology across a range of landscapes, allowing us to make comparisons about how people manage and use forests, agroforestry and tree genetic resources," says Anja Gassner.



LOOKING INTO THE FUTURE - FROM A TREE'S POINT OF VIEW

If you ask villagers in the arid lands to the south of the Sahara which trees they value most, many will tell you about *Parkia biglobosa*, commonly known as the African lotus bean or *nééré*. A handsome parkland tree, its pods contain a sweet yellow pulp which is a good source of carbohydrates. However, its real value lies in its seeds, which are crushed and fermented to make a spicy condiment, locally known as *dawadawa*. In rural areas, this is an important source of protein, calcium and fat, especially when staple foods are in short supply.

"You often find that the speed at which the climate is changing is greater than the speed of natural migration of tree species."

Roeland Kindt
Mapping and Data Expert

In the Sahelian region weather patterns are changing, and the climate is expected to get warmer over the coming decades. Precisely how this will affect trees like *Parkia* is the subject of a research programme involving the World Agroforestry Centre, Bioversity

International and several other partners. Led by Roeland Kindt, a mapping and data expert, the project is focusing on 15 fruit trees in Burkina Faso.

Using a technique known as ensemble modelling, which uses a number of different models rather than a single algorithm, the scientists are calculating where these species are likely to occur under different climatic conditions. "For each species, we've gathered as much data as we can about their present distribution, and looked at various bioclimatic variables," explains Roeland. Among other things, this involves calculating the maximum and minimum temperatures the species are currently subject to during the hottest and coldest months of the year.

Using future climate data provided by CCAFS (<http://www.ccafs-climate.org/data/>), scientists are then able to predict where the species are likely to grow best if, for example,

temperatures rise by an average 2°C over the next 30 years. The resulting species suitability maps – these will be refined over the coming years – will provide governments, non-governmental agencies and other organizations with the information they require to plan future planting strategies.

"You often find that the speed at which the climate is changing is greater than the speed of natural migration of tree species," explains Roeland. "That's when you need to consider 'assisted migration'." This involves giving species a helping hand by selecting seeds which are growing under conditions in one place that are projected to occur in another, and planting them there.

Roeland stresses that the accuracy of the species suitability models depends on the quality of the data, and there are still significant data gaps about the distribution of many trees in Burkina Faso and surrounding countries. However, the use of ensemble modelling means that their predictions are much more accurate than they would be if they used just one algorithm.



Parkia biglobosa is one of the most important trees in dryland areas south of the Sahara.

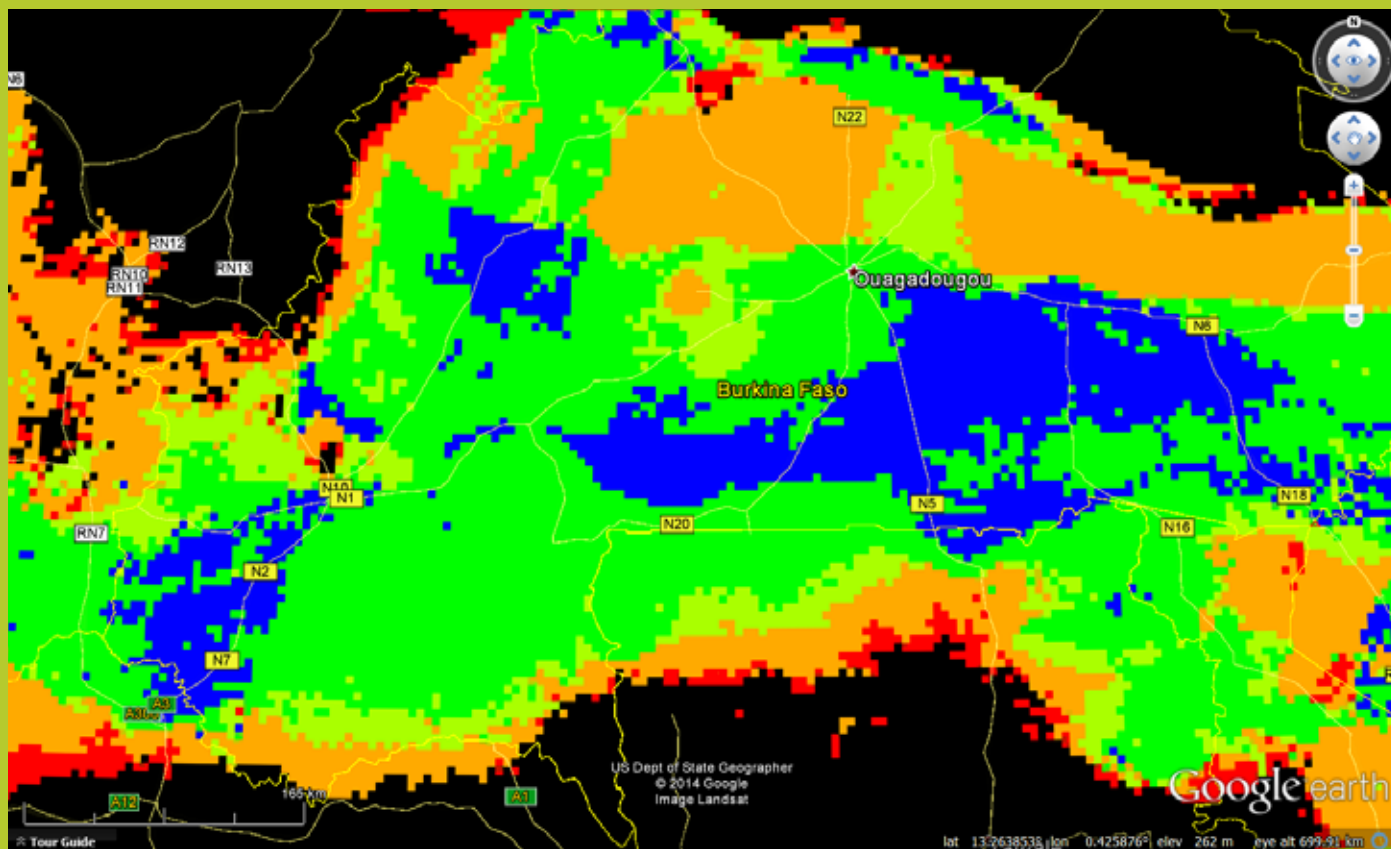
Photo © ICRAF

The one-stop information shop

"Let's say you're a botanist in Addis Ababa and you want to know about a certain tree species, I hope you would go to the agroforestry switchboard first," says Roeland Kindt. Launched in 2013, the switchboard currently documents the presence of over 22,000 plant species – not just trees – in 13 web-based databases.

The switchboard also provides hyperlinks to information on selected species in a number of other globally important databases, such as the Plant List, Tropicos, the Royal Botanic Gardens, Kew, and the Global Biodiversity Information Facility. "We see this as a one-stop shop for retrieving information," says Roeland.

During 2013, he added a new layer of information to the online maps developed by the Vegetation and Climate Change in East Africa (VECEA) project. Using an overlay of Google Earth, the VECEA maps provide guidance about which species will grow well, and where they will grow, under different climatic conditions. They are particularly useful for extension agencies and NGOs who are planning planting projects in East Africa. Users can now access distribution maps for 1022 plant species. For each species, VECEA assesses distribution under three headings of characteristic, present and marginal. The VECEA website is now linked to the agroforestry switchboard http://www.worldagroforestry.org/products/switchboard/index.php/name_like/Acacia/.



Distribution of *Parkia biglobosa* in Burkina Faso inferred by ensemble suitability modelling. Colours correspond to the number of models that predict the presence of this species (black: no model; red – blue: 1 – 5 models).



GETTING TO GRIPS WITH A COMPLEX WORLD

In 2012, the World Agroforestry Centre set up the GeoScience Lab as a new unit to support advanced spatial data analytics within the centre. Since then the GeoScience lab has developed an online portal for storing and analysing spatial data. "We've revolutionized the way the system works with the launch of the Landscapes Portal," says Tor-Gunnar Vågen, who leads the GeoScience Lab. "This gives us the potential to enhance the way we do science."

"We've revolutionized the way the system works with the launch of the Landscapes Portal."

Tor-Gunnar Vågen
Lead Scientist, GeoScience Lab

Scientists at the Centre – or indeed any other institution – can use the Landscapes Portal (<http://landscapeportal.org>) to store data, create maps, merge their own data with data from other scientists, and use a wide variety of analytical

tools. All the data and maps must be attributed, so their origins are traceable.

Although the Landscapes Portal is in its infancy, it had been used by over 2000 scientists by early 2014. Besides storing, sharing and analysing data, scientists were writing stories about their projects. "I think this attracts a lot of traffic," says Tor. "People like to read stories, for example about what's happening in projects in places like the Western Ghats in India or the sentinel landscapes in Central America."

Coping with complexity

During the past year, Tor and his colleagues have been working on the idea of linking social and economic databases in a more systematic way. The new Landscapes Portal is helping them to do that. To illustrate the point, Tor describes a recent programme of research and analysis which has focused on climate change and smallholder farming systems in East Africa.

Over a period of several years, the CGIAR Programme on Climate Change, Agriculture and Food Security (CCAFS) has conducted research at six benchmark sites in Uganda, Kenya, Tanzania and Ethiopia. At each site it has carried out baseline surveys to gather information about farming practices, diet, incomes, the risks faced by households and communities and other matters. At a later date, survey teams will revisit the same villages and ask the same questions, enabling researchers to make comparisons of behavioural changes and assess the influence of research and development projects.

In 2013, Tor combined data gathered by the CCAFS socioeconomic baseline surveys, and analysed by Anja Gassner and her team in the Research Methods Group, with geo-referenced biophysical information from the same sites. The latter had already been collected by scientists from the World Agroforestry Centre and the International Centre for Tropical Agriculture (CIAT), using the Land Health Surveillance Framework. This included data about various aspects of soil health, including soil organic matter, carbon content and erosion.

"By combining the two sets of data we were able to get a better understanding of the relationship between biophysical factors and changes made by farmers," explains Tor. The analysis found, to give just one example, that farmers whose land had low soil organic carbon content tended to make fewer changes to the way they farmed than farmers with land which had higher organic carbon content.

This is of far more than academic interest. "This sort of information provides evidence about the constraints, social or biophysical, which determine how farmers behave," says Tor. "That means that when extension agencies and development workers are planning interventions, they'll have a better idea about what will work, and what won't."

For example, if an area is particularly low in soil organic carbon due to inherent constraints such as high sand content, there's little point in offering farmers fertilizers to improve production without addressing the lack of organic

content in the soil, as the fertilizers won't have the desired effect. "What we're trying to do is unravel complexity and get a better understanding of the relationship between social and biophysical factors," says Tor.

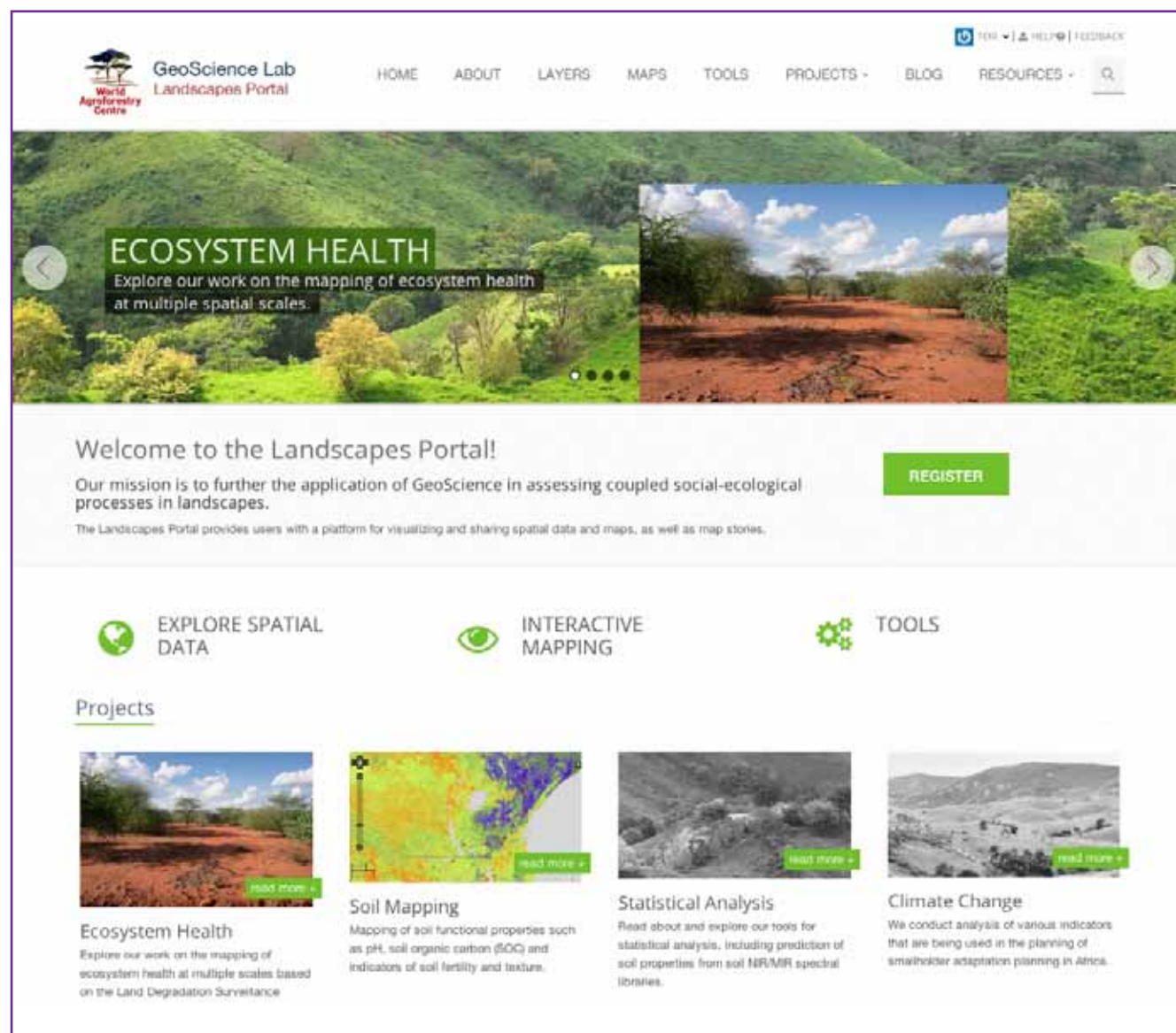


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A page from the Landscapes Portal website.



MEASURING WHAT MATTERS

In 2012, the World Agroforestry Centre, working in collaboration with Hubbard Decision Research, developed a new intervention decision model. This is now being used to help scientists work out what they need to measure in order to improve development interventions. "Traditionally, scientists have tended to measure things that are easy to measure, but this often adds little value to improving decision-making, because these are typically not the areas where there is greatest uncertainty," says Keith Shepherd, a senior scientist at the World Agroforestry Centre.

Impacts ranged from minus

**US\$5 billion to plus
US\$10.5 billion**

During 2013, Keith and his colleagues used the decision analysis and metrics framework to assess nine projects being carried out under the CGIAR Research Programme on Water, Land and Ecosystems. These included an

integrated water management programme in the Tana River basin in Kenya; research into alternatives to large dams on the Mekong River in Laos; evaluation of a government irrigation scheme in Ghana; and a risk assessment of investment in a water scheme in Northern Kenya and targeting of conservation agriculture.

"Researchers often find it difficult to identify what specific development decisions they are trying to influence, and that's one reason why they end up gathering data which has zero impact," says Keith. In a series of workshops, modelling exercises and online discussions, Keith and his team helped researchers and others involved in the projects to identify which decisions they were trying to influence, what alternatives to consider, and what sort of information they needed to gather.

Take, for example, the integrated river basin management project in the Tana River basin. Here, various research institutions belonging to the CGIAR were planning a range of interventions to improve land and water management and agricultural productivity. The researchers used a total

of 83 variables in the model. In 10,000 model simulations, the value of impacts ranged from minus US\$5 billion to plus US\$10.5 billion.

"The model thus indicated that there was a high risk of making the wrong choice, and that the potential size of loss from this was large," says Keith. Much to the researchers' surprise, the variable that had the highest information value was the economic impact of the project on migration. The value of having better information on migration, in terms of its potential impact on the investment decision, was as high as US\$470 million.

The decision and metrics framework encouraged the scientists to revise their research programme. They now have a much clearer idea about what they should be measuring. This means that the project is likely to have greater impact and, just as importantly, that the research will be cost-effective. "All too often," says Keith, "research programmes spend large amounts of money collecting data which simply isn't relevant to a project's success."

It has been shown that in most decision analyses done in the business sector there is an almost inverse relationship between the amount of management effort focused on a variable and its information value. This paradox is known as 'measurement inversion', and it affects scientific research as much as it does business.

Another project which took advantage of the decision analysis and metrics framework involves the setting up of crop seed distribution systems in West Africa. The biodiversity team in charge of the project held five modelling workshops, exchanged dozens of emails related to modelling and spent hundreds of cumulative staff hours on the exercise. Tellingly, the six variables with the highest information value were discussed in less than an hour, illustrating the 'measurement inversion' phenomenon. The variables with the highest information value were related to infrastructure degradation and the risk of producing

poor seeds, and curiously enough a variable as basic as average farm size. However, the process was important, as it encouraged the biodiversity team to redesign the project to ensure that the research effort addresses the issues that really matter.

The decision and metrics framework is helping scientists to improve the impact of their research. Just as importantly, it is helping to create lasting partnerships. To give just one example, Keith's team were closely involved in discussions about the Merti aquifer project in Northern Kenya.

This project aims to supply drinking water to the city of Wajir from a fossil groundwater body some 100 km away. This controversial scheme has been challenged by the local communities, who feel that overutilization of the groundwater might lead to the drying up of their wells.

According to Jan de Leeuw, a lead scientist on this project, "Our approach encouraged local councils, pastoralists,

politicians, hydrologists and business groups to work together to build an impact model for the project." The model will guide decision-making about whether and how the project should be developed.

Besides making science more useful for supporting development decisions, the approach taken by Keith's group also facilitates a kind of holistic science that research for development has been struggling to adopt. "In development contexts, we're always faced with a wide range of factors for which we have no hard data, but which everyone considers of critical importance," says Keith's colleague Eike Luedeling. "The ability to deal with imperfect and incomplete information in modelling agricultural systems has been a liberating experience for me." For the first time, Eike feels able to include all these critical factors into models, and this has greatly raised his confidence about the results being close to reality.



CHANGING THE WAY WE THINK ABOUT EXTENSION

In East Africa, volunteer farmers are playing a significant role in spreading knowledge among dairy farmers. This innovative approach to agricultural extension – known as the volunteer farmer trainer model – has been applied with great success within the East Africa Dairy Development (EADD) project, which seeks to double the incomes of 179,000 dairy farmers by improving dairy production and marketing.

"The success of the volunteer farmer trainer approach is changing the way we think about agricultural extension," says Steven Franzel, leader of the World Agroforestry Centre's research on Rural Advisory Services. "Here, the farmers themselves are the principal agents of change in their communities, with extension workers serving as facilitators." By June 2013, over 2000 volunteer farmer trainers, one-third of whom were women, were helping dairy farmers in Kenya, Uganda and Rwanda to raise their productivity and incomes.

Most of the training on better dairy production is practical,

"Seeing other farmers in the community improve their productivity as a result of my training gives me great satisfaction"

Agatha Buuri
Volunteer Farmer

and happens at demonstration plots maintained on volunteer farmer trainers' land. As the trainees embrace improved dairy farming methods, the volunteers pay them regular visits to follow up on their progress and respond to questions. Being residents,

volunteer farmer trainers use the local language and have a good understanding of local culture. This means that it is much easier for them to communicate with farmers than it is for outsiders. On average, each volunteer farmer trainer reaches five villages besides their own, travelling mostly on foot and covering up to 7km a day.

A policy brief published by the Centre describes the volunteer

farmer trainer model, and some of the challenges trainers face.¹⁰ In sparsely populated areas, for example, they have to travel long distances. However, such is their commitment that few of these challenges have proved insurmountable. Indeed, farmers involved in EADD have doubled the amount of milk they sell each day to chilling plants.

Evelyn Kiptot, a social scientist and lead author of the policy brief, recalls the testimony of one of the women she met. "Seeing other farmers in the community improve their productivity as a result of my training gives me great satisfaction," said Agatha Buuri from Kieni West District in Kenya. "It makes me feel good."

The volunteer farmer approach complements, rather than replaces, regular extension services run by the government, non-governmental organizations and the private sector. "Indeed, it is through these traditional avenues that the



A volunteer farmer trainer in Wakiso district, Uganda, training farmers on planting Gliricidia fodder shrubs from cuttings.

Photo © ICRAF/ Pius Lutakome

¹⁰ Kiptot E, Franzel S, Kirui J. 2012. Volunteer farmer trainers: improving smallholder farmers access to information for a stronger dairy industry, World Agroforestry Centre Policy brief 13.

volunteers receive technical support and training about innovations in the dairy sector," says Steven Franzel. "The volunteers also rely on qualified extension staff to address problems and questions they cannot handle on their own." However, he emphasizes that the model is unsuitable for complex high-risk practices which require specialized skills, such as those involving animal health issues.

Steve and his colleagues interviewed 100 volunteer farmer trainers and found that 61% said the main motivation was early access to new information and technology. However, 42% said they were doing it out of altruism. Over time many of them learned ways to earn money from providing training, selling seed from their demonstration plots, and starting small enterprises providing services such as making

silage or hay. The policy implications are that extension managers can benefit from finding out what motivates their farmer trainers and designing low-cost means of keeping them motivated.

In January 2014, the EADD partners launched the second phase of the project, which is funded by the Bill and Melinda Gates Foundation. The aim is to expand the project to assist more than 136,000 dairy farming families in Kenya, Uganda and Tanzania. Integrating the volunteer farmer trainer approach into producer organizations will be a priority for the World Agroforestry Centre. This will help to ensure that farmers access knowledge on feeds in the most cost-effective way.



Photo © ICRAF/ Pius Lutakome

A volunteer farmer trainer in Wakiso district, Uganda, training farmers on how to establish a tree nursery

Reference:

Kiptot d Franzel S. 2014. Voluntarism as an investment in human, social and financial capital: evidence from a farmer-to-farmer extension program in Kenya, *Agriculture and Human Values* 31:231-243. <http://link.springer.com/article/10.1007%2Fs10460-013-9463-5>



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Finance and Corporate
Services**



Dr Margaret Kroma
**Assistant Director General,
Partnerships & Impacts**



Ms Christine Larson-Luhila
Director of Human Resources



Ms Elizabeth Kariuki
Executive Manager

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Fergus Sinclair – Science Domain Leader – SD1 – Agroforestry Systems

Henry Neufeldt – Science Domain Leader – SD6 – Climate Change

Keith Shepherd – Science Domain Leader – SD4 – Land Health Decisions

Meine van Noordwijk – Chief Science Advisor, Principal Scientist

Peter Minang – Science Domain Leader – SD5 – Environmental Services

Ramni Jamnadass – Science Domain Leader – SD3 – Tree Diversity, Domestication and Delivery

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Antoine Kalinganire – Representative, Sahel Node

Christophe Kouamé – Programme Manager, Côte d'Ivoire

Clement Okia – Country Representative, Uganda

Delia Catacutan – Country Representative, Vietnam and Social Scientist

Ebenazar Asaah – Country Coordinator, Sierra Leone

Isaac Nyoka – Acting Regional Representative, Southern Africa

Javed Rizvi – Regional Coordinator, South Asia

Jeremias Gasper Mowo – Regional Coordinator, East and Southern Africa

Jerome Tondoh – Country Coordinator, Mali

Jianchu Xu – Regional Coordinator, East and Central Asia

Jonathan Cornelius – Regional Coordinator, Latin America

Jonathan Muriuki – Country Representative, Kenya

Kiros Hadgu – Country Representative, Ethiopia

Rodel Lasco – Country Coordinator, Philippines

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Ujjwal Pradhan – Regional Coordinator, Southeast Asia

Zac Tchoundjeu – Regional Coordinator, West and Central Africa



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Agropolis Foundation
Alliance for a Green Revolution in Africa (AGRA)
Association for Strengthening Agriculture Research in Eastern and Central Africa (ASARECA)
Australian Aid
Australian Centre for International Agricultural Research (ACIAR)
Belgium
Bill and Melinda Gates Foundation
BOTH ENDS (Environment and Development Service)
Brazilian Agricultural Research Corporation (EMBRAPA)
Canadian International Development Agency (CIDA)
Centre for Mountain Ecosystem Studies (CMES)
Centre on International Cooperation
Centro Internacional de Agricultura Tropical, Colombia (CIAT)
CGIAR Research Programme 1.1
CGIAR Research Programme 1.2
CGIAR Research Programme 2
CGIAR Research Programme 4
CGIAR Research Programme 5
CGIAR Research Programme 6
CGIAR Research Programme 7
China
Columbia Global Center in Eastern and Southern Africa (CGC Africa)
Common Market For East and Southern Africa (COMESA)
Commonwealth Scientific and Industrial Research Organization (CSIRO)
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)
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Ford Foundation
Global Crop Diversity Trust
Global Food and Farming Futures
Global Forum for Rural Advisory Services
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Heifer International
HK Logistics Ltd Global Solutions
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Intergovernmental Authority on Development (IGAD)
International Center for Agricultural Research in the Dry Areas (ICARDA)
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International Food Policy Research Institute (IFPRI)
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International Institute of Tropical Agriculture (IITA)
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International Maize and Wheat Improvement Center (CIMMYT)
International Water Management Institute (IWMI)
Internationale en Recherche Agronomique pour le Développement (CIRAD)
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Japan International Research Center For Agricultural Sciences (JIRCAS)
Macaulay Land Use Research Institute

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 Mars Inc
 McKnight Foundation
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 Natural Environment Research Council
 Natural Resources Canada
 Natural Resources Institute
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 Northern Rangelands Company Limited
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 Rainwater Harvesting Implementation Network
 Foundation
 Republic of South Africa
 Rights and Resources Group
 Rwanda Agricultural Development Authority
 Swedish University of Agricultural Sciences

Swiss Development Corporation
 Tegemeo Institute of Egerton University
 The Center for International Forestry Research (CIFOR)
 The Sustainable Trade Initiative (IDH)
 Unilever
 United Nations Environment Programme (UNEP)
 United Nations University – International Organization
 Center
 United States Agency for International Development
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 Universite Laval
 University of California, Davis
 University of Copenhagen
 Vrije Universiteit Amsterdam
 William J. Clinton Foundation
 World Bank
 World Cocoa Foundation
 World Vision
 WorldFish Centre



FINANCIAL HIGHLIGHTS

Statement of Financial Position

AS AT 31 DECEMBER 2013 (In US Dollars '000')

	Note	2013	2012
ASSETS			
Current assets			
Cash and cash equivalents	5	23,252	19,800
Short term investments	6	1,386	5,197
Accounts receivables			
Donor	7	11,929	11,077
Employees	8	282	155
Other CGIAR Centres	9	429	223
Other	10	3,128	3,165
Inventories - net	11	80	96
Prepaid expenses	12	1,087	1,178
Total current assets		41,573	40,891
Non-current assets			
Property and equipment	13	6,386	5,653
Long term investments	14	18,181	14,624
Total non-current assets		24,567	20,277
TOTAL ASSETS		66,140	61,168
LIABILITIES AND NET ASSETS			
Current liabilities			
Accounts payable			
Donor	15	20,320	17,306
Employees	16	787	688
Other CGIAR Centres	17	858	380
Other	18	2,062	1,919
Accruals	19	8,310	8,307
Total current liabilities		32,337	28,600
Non-current liabilities			
Accounts payable			
Employees	20	6,692	5,579
Total Non-current liabilities		6,692	5,579
TOTAL LIABILITIES		39,029	34,179
NET ASSETS			
Unrestricted			
Designated	21	14,309	16,658
Undesignated	21	12,802	10,331
		27,111	26,989
TOTAL LIABILITIES AND NET ASSETS		66,140	61,168

Income Statement

FOR THE YEAR ENDED 31 DECEMBER 2013 (In US Dollars '000)

	Note	2013	2012
Grant revenue	22	56,062	51,385
Other revenue and gains	23	1,422	1,713
Total revenues and gains		57,484	53,098
Research costs	24	50,196	46,170
General and administration	25	7,166	6,692
Total operating expenses		57,362	52,862
Financial income		-	-
Financial costs		-	-
Surplus for the year		122	236
Fair value gains/(losses) on financial assets measured at fair value through OCI		-	-
Actuarial gains/(losses) on post employment benefit obligations		-	-
Cash flow hedges		-	-
Total comprehensive surplus for the year		122	236



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 reputation 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 the Centre's 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 throughout the Centre. 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 Finance and Audit 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
11 April 2014



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

1. Composite measure of Centre research publications: **471/568 (83%)**

Number of peer-reviewed publications per scientist in 2013 that are published in journals listed in Thomson Scientific/ISI: **137**

Number of externally peer-reviewed publications in 2013: **334**

2. Percentage of scientific papers published with developing country partners in refereed journals, conference and workshop proceedings in 2013: **44%**

Institutional health

Percentage of women in management: **27.59%**

Financial health

Long-term financial stability (adequacy of reserves): **138 days** where the minimum benchmark is 90 days

Cash management on restricted operations: **0.59** where the benchmark is less than 1.00



PUBLICATIONS

Journal articles

- Ackom E, Alemagi D, Ackom N, Minang P, Tchoundjeu Z. 2013. Modern bioenergy from agricultural and forestry residues in Cameroon: potential, challenges and the way forward. [*Energy Policy* 63](#)
- Herrick JE, Urama KC, Karl JW, Boos J, Johnson MV, Shepherd KD, Hempel J, Bestelmeyer BT, Davies J, Guerra JL, Kosnik C, Kimiti DW, Ekai AL, Muller K, Norfleet L, Ozor N. 2013. The global Land-Potential Knowledge System (LandPKS): supporting evidence-based, site-specific land use and management through cloud computing, mobile applications, and crowdsourcing. [*Journal of Soil and Water Conservation* 68 \(1\)](#)
- Iiyama M, Newman D, Munster C, Nyabenge M, Sileshi GW, Moraa V, Onchieku J, Mowo JG, Jamnadass R. 2013. Productivity of *Jatropha curcas* under smallholder farm conditions in Kenya. [*Agroforestry Systems* 87](#)
- Kuyah S, Dietz J, Muthuri C, van Noordwijk M, Neufeldt H. 2013. Allometry and partitioning of above- and below-ground biomass in farmed eucalyptus species dominant in western Kenya agricultural landscapes. [*Biomass and Bioenergy* 55](#)
- Lescuyer G, Cerutti PO, Robiglio V. 2013. Artisanal chainsaw milling to support decentralized management of timber in Central Africa? An analysis through the theory of access. [*Forest Policy and Economics* 32](#)
- Mbow C, Chhin S, Sambou B, Skole D. 2013. Potential of dendrochronology to assess annual rates of biomass productivity in savanna trees of West Africa. [*Dendrochronologia* 31](#)
- Minang PA, van Noordwijk M. 2013. Design challenges for achieving reduced emissions from deforestation and forest degradation through conservation: leveraging multiple paradigms at the tropical forest margins. [*Land Use Policy* 31 \(2013\)](#)
- Muriuki JK, Kuria AW, Muthuri CW, Mukuralinda A, Simons AJ, Jamnadass RH. 2013. Testing biodegradable seedling containers as an alternative for polythene tubes in tropical small-scale tree nurseries. [*Small-Scale Forestry* 12 \(2\) \(online first\)](#)
- Nguyen Q, Hoang MH, Oborn I, van Noordwijk M. 2013. Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. [*Climatic Change* 117 \(1-2\)](#)
- Njenga M, Karanja N, Jamnadass R, Kithinji J, Sundberg C, Jirjis R. 2013. Quality of cooking fuel briquettes produced locally from charcoal dust and sawdust in Kenya. [*Journal of Biobased Materials and Bioenergy* 7](#)
- Osano PM, Said MY, De Leeuw J, Moiko SS, Kaelo DO, Schomers S, Birner R, Ogutu JO. 2013. Pastoralism and ecosystem-based adaptation in Kenyan Maasailand. [*International Journal of Climate Change Strategies and Management* 5 \(2\)](#)
- Paul BK, Vanlauwe B, Ayuke F, Gassner A, Hoogmoed M, Hurisso TT, Koala S, Lelei D, Ndabamenye T, Sixe J, Pulleman MM. 2013. Medium-term impact of tillage and residue management on soil aggregate stability, soil carbon and crop productivity. [*Agriculture, Ecosystems & Environment* 164](#)
- Ranjitkar S, Luedeling E, Shrestha KK, Guan KY, Xu JC. 2013. Flowering phenology of tree rhododendron along an elevation gradient in two sites in the Eastern Himalayas. [*International Journal of Biometeorology* 57 \(2\)](#)
- Siriri D, Wilson J, Coe R, Tenywa MM, Bekunda MA, Ong CK. 2013. Trees improve water storage and reduce soil evaporation in agroforestry systems on bench terraces in SW Uganda. [*Agroforestry Systems* 87](#)
- Sotelo Montes C, Weber JC, Silva DA, Andrade C, Muñoz GIB, Garcia RA, Kalinganire A. 2013. Growth and fuelwood properties of five tree and shrub species in the Sahelian and Sudanian ecozones of Mali: relationships with mean annual rainfall and geographical coordinates. [*New Forests* 45](#)
- Sow M, Hély C, Mbow C, Sambou B. 2013. Fuel and fire behaviour analysis for early-season prescribed fire planning in Sudanian and Sahelian savannas. [*Journal of Arid Environments* 89](#)
- Vrieling A, De Leeuw J, Said MY. 2013. Length of growing period over Africa: variability and trends from 30 years of NDVI time series. [*Remote Sensing* 5](#)
- Yang X-Q, Kushwaha SPS, Saran S, Xu J, Roy PS. 2013. Maxent modelling for predicting the potential distribution of medicinal plant, *Justicia adhatoda* L. in lesser Himalayan foothills. [*Ecological Engineering* 51 \(2013\)](#)

Books

Badege B, Neufeldt H, Mowo JG, Abdelkadir A, Muriuki J, Dalle G, Assefa T, Guillozet K, Kassa H, Dawson IK, Luedeling E, Mbow C. 2013. Farmers' strategies for adapting to and mitigating climate variability and change through agroforestry in Ethiopia and Kenya. Oregon: Oregon State University

Bernard F, Minang PA, van Noordwijk M, Freeman OE, Duguma LA (eds) 2013. Towards a landscape approach for reducing emissions: substantive report of Reducing Emissions from All Land Uses (REALU) project. Nairobi: ICRAF

Donovan J, Cunha M, Franzel S, Gyau A, Mithöfer D. 2013. Guías para el desarrollo de cadenas de valor: una revision comparativa. Turrialba: Costa Rica Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)

Lasco R, Pulhin F, Pulhin P. 2013. Guidebook on mainstreaming climate change in biodiversity planning and management in the Philippines. Los Baños: ICRAF

Pye-Smith C. 2013. Trees for life: creating a more prosperous future through agroforestry. Nairobi: ICRAF

Shrestha RM, Ahmed M, Suphachalasai S, Lasco R. 2013. Economics of reducing greenhouse gas emissions in South Asia: options and costs. Manila: Asian Development Bank

Trees for Change booklets

Pye-Smith C, Tarman AE, Janudianto, Rahayu S. 2013. Harapan yang Terhenti di Tengah Jalan Perbaikan terhadap ketersediaan benih dan bibit pohon berkualitas tinggi agar bermanfaat bagi jutaan petani kecil. *ICRAF Trees for Change No. 11*. Nairobi: ICRAF

Pye-Smith C, Tarman AE, Janudianto, Rahayu, S. eds. 2013. Kakao untuk Masa Depan. Program penelitian dan pelatihan inovatif untuk mengubah kehidupan masa depan petani kakao di Indonesia dan tempat lainnya. *ICRAF Trees for Change No. 9*. Bogor: ICRAF

Pye-Smith C. 2013. The quiet revolution: how Niger's farmers are re-greening the croplands of the Sahel. *ICRAF Trees for Change No. 12* Nairobi: ICRAF

HIGH QUALITY RESEARCH PUBLICATIONS REMAIN A CORE OUTPUT OF ICRAF'S ACTIVITIES

In 2013, ICRAF generated a total of 569 publications



334

Peer reviewed

91

Science in progress

81

Extension & policy outreach

63

Updates & progress

For a complete list of publications, visit our publications page on http://worldagroforestry.org/our_products/publications



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LIST OF ABBREVIATIONS

ABCD	Asset-Based Community Driven Development Principles
ACIAR	Australian Centre for International Agricultural Research
ADAPPT	African Dryland Alliance for Pesticidal Plant Technologies
AFOLU	Agroforestry, Forestry and Other Land Uses
AgFor	Agroforestry and Forestry
AGRA	Alliance for a Green Revolution in Africa
AOCC	African Orphan Crops Consortium
ARS	Agricultural Research Service
CATIE	Center for Tropical Agricultural Research and Higher Education
CCAFS	CGIAR Program on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIDA	Canadian International Development Agency
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Centre
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
COP	Conference of the Parties
COSUST	Current Opinion in Environmental Sustainability
DFATD	Department of Foreign Affairs, Trade and Development
DFID	Department for International Development
DGIS	Directorate General for International Cooperation
EADD	East Africa Dairy Development
Embrapa	Brazilian Enterprise for Agricultural Research
FAO	Food and Agriculture Organization of the United Nations
FORDA	Forestry Research and Development Agency
ICAR	Indian Council of Agricultural Research
ICRAF	World Agroforestry Centre
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
InPaC-S	Participatory Knowledge Integration on Indicators of Soil Quality
IPCC	Intergovernmental Panel on Climate Change
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
LDSF	Land Degradation Surveillance Framework
LUWES	Land-use Planning for Low Emission Development Strategies
MINAM	Ministry of Environment in Peru
NAC	National Advisory Council
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization

NOEL	Nurseries of Excellence
PAFERN	Philippine Agroforestry Education and Research Network
PES	Payments for Environmental Services
R&D	Research and Development
REALU	Reducing Emissions from all Land Uses
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RISING	Research in Sustainable Intensification for the Next Generation
SAMPLES	Standard Assessment of Mitigation Potential and Livelihoods in Smallholder Systems
SLU	Swedish University of Agricultural Sciences
SWAT	Soil and Water Assessment Tool
UC	University of California
UN	United Nations
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
V4C	Vision for Change
VECEA	Vegetation and Climate Change in East Africa
WCA	World Congress on Agroforestry
WHO	World Health Organization

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