World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

WORLD AGROFORESTRY CENTRE

Annual Report 2009-2010

Going Evergreen for a Climate–SMART Agriculture

A girl prepares vegetables for a family meal © Steve Mann

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

Our Mission
is to generate science-based knowledge about the diverse roles that trees play in agricultural landscapes and to use our research to advance policies and practices that benefit the poor and the environment.

Our Values
We strongly adhere to shared core values that guide our work and relationships with colleagues and partners:

- Professionalism
- Mutual respect
- Creativity

Our Focus
We pay particular emphasis to four areas in our work:

- Accelerating impact
- Enhancing science quality
- Strengthening partnerships
- Improving operational efficiency

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For a more comprehensive version of this report please visit www.worldagroforestry.org/ar2010

I believe the World Agroforestry Centre is well placed to face the challenges which the new Consortium will bring.

Message from **the Chair**

In terms of its scientific output, the World Agroforestry Centre has much to celebrate. We were rated as 'Superior' in the performance management system exercise conducted by the Consultative Group on International Agricultural Research (CGIAR) secretariat in 2009. The reason we were not scored as 'Outstanding' was because our scientists produced fewer publications than during the previous year, largely because they were focusing on the World Agroforestry Congress. If you look at the balance sheets, the Centre is also in good shape. Our budget is higher than ever before, and of the 15 centres belonging to the CGIAR, we ranked first in terms of short-term solvency and third in terms of long-term solvency at the end of 2009.

Yet this is also a time of great uncertainty, with the CGIAR undergoing the most profound reforms in its history.

In 2009, the CGIAR adopted a new business model. This involved the creation of a new Consortium which unites all the research centres under one legal entity and a new funding mechanism to harmonise donor contributions. The reforms place a strong emphasis on results, and future funding will be linked to performance. We can expect greater accountability and improved governance. The reforms will also change the nature of our relationships with other research centres. The creation of seven CGIAR Research Programmes (CRPs) will lead to more collaboration and less overlap.

I believe the World Agroforestry Centre is well placed to face the challenges which the new Consortium will bring. At a practical level, we intend to bridge any shortfalls in funding which occur during the transition period. More importantly, we have the staff and skills which are needed to make a real contribution to the new research agenda. Indeed, we expect to

be involved in six of the seven CRPs, bringing our unique expertise to solving problems of food insecurity, poverty, natural resource degradation and climate change. The Board will continue to play its oversight and guidance role as we work to steer the Centre through the turbulence of the transition.

Trees in agricultural landscapes are now more in demand than ever, for a variety of reasons. They can play an important role in reducing the gases that cause global warming, and help farmers adapt to climate change. At a time when the price of mineral fertilisers is rapidly rising, leguminous trees provide much needed fertility, virtually free of charge, and help to improve crop yields and farmers' incomes. In short, agroforestry has a major role to play in improving food security and creating a healthier environment. That is why the research conducted by the World Agroforestry Centre over the coming years, in partnership with others, will be more important than ever before.

Eric Tollens
Chair of the Board of Trustees

Trees play an important role in reducing the gases that cause global warming
©Photo Jianchu Xu

Saving the forests, **reinventing agriculture**

The fate of the world's forests has never been higher on the political agenda. 2011 is the International Year of Forests, and a great many organisations, including the World Agroforestry Centre, are raising awareness about the importance of sustainably managing forests, agroforests and trees on farms. If we lose the forests, we will not only lose irreplaceable biodiversity and a rich source of timber, fuelwood, wild foods and medicinal plants, but the life support systems and environmental services for hundreds of millions of people.

Forests don't end where agricultural land begins. What happens outside the areas officially classified as forests has a huge bearing on what happens inside them. Currently, 43% of the world's farm land – over 1 billion ha – has more than 10% tree cover. And 160 million ha has more than 50% tree cover. While the number of trees in forests is steadily declining, the number of trees on farmland is increasing. In many parts of the tropics, agroforestry is providing essential products and services that can relieve the pressure on the forest domain.

There are a number of reasons why agroforestry is an integral part of the forest story, and why it is destined to become increasingly important over the coming years. Several of these are highlighted through the articles featured in this report.

Over the past 20 years, the World Agroforestry Centre has pioneered the practice of participatory tree domestication, focusing, in particular, on bringing wild fruit species out of the forests and onto farmland. Now, tens of thousands of smallholders in Africa, Latin America and Asia are growing superior, high-yielding varieties of indigenous trees like the African plum and the bush mango.

The benefits have been twofold. Farmers are increasing their incomes and investing the profits from agroforestry to pay school fees, improve their homesteads and gain

access to better health care. At the same time, the domestication programmes have meant that rural families no longer have to harvest food from the natural forests. This has significantly reduced pressure on wild resources, as have other agroforestry activities, such as the growing of woodlots on farms.

Deforestation is responsible for approximately one-fifth of greenhouse gas emissions. It is now widely accepted that projects aimed at Reducing Emissions from Deforestation and Forest Degradation (REDD) could play a vital role in the battle against global warming. However, our research has shown that a significant portion of the forest-related carbon emissions occur outside areas that are designated as forest. For example, in Indonesia, around a third of these emissions occur outside forests. The implications are clear: REDD projects will only tackle part of the problem.

The focus must be re-oriented to a whole landscape approach. That is, Reducing Emissions from All Land Uses or REALU, a direction that the World Agroforestry Centre has pioneered on the international stage.

One of the best ways of doing this is by encouraging agroforestry practices on farmland. Indeed, the Intergovernmental Panel on Climate Change (IPCC) estimates that 600 million ha of unproductive cropland and pasture could be converted to high productivity agroforestry, and an additional 300 million ha of land currently under some form of agroforestry could be better managed.

This would help to sequester huge quantities of carbon, improve local livelihoods and – once again – take pressure off natural forests and biodiversity. Furthermore, agroforestry systems, by their very nature, support a much richer biodiversity than land with few or no trees. To give just one example, the jungle rubber smallholdings in Indonesia, where farmers grow rubber and other tree crops covering over 3.3 million ha, contains 60–80% of the biodiversity of primary tropical forest.

Agroforestry helps to sequester huge quantities of carbon and improve livelihoods ©Photo World Agroforestry Centre archives

Hope is evergreen

This brings me to the, potentially, most critical reason why agroforestry should be at the heart of both forest and food security policy. The story begins in Africa, whose population will rise from around 800 million today to 1.8 billion by 2050. If the future is an extension of the recent past, the omens are grim. Per capita food production in sub-Saharan Africa declined by 20% between 1970 and 2000. Grain yields have scarcely risen since the 1960s and remain below a tonne per ha, compared to 2.5 tonnes for cereal yields in South Asia and 4.5 tonnes for East Asia.

Fewer than 25% of African farmers apply any inorganic fertiliser at all to their crops. Most are forced to grow the same food crops, year after year, on the same plot of land, leading to declining soil fertility, meagre crop yields and hunger.

But this is not a situation without hope. On the contrary, Evergreen Agriculture is already helping to transform landscapes and livelihoods on a dramatic scale. This is a form of more intensive farming that integrates trees with annual crops, maintaining a green cover on the land throughout the year. These farming systems combine agroforestry with the principles of conservation farming, which is practised on around 100 million ha of land worldwide. Farmers disturb the soil as little as possible, keep the soil covered with organic material such as crop residues, and rotate a diverse range of crops. These include, crucially, leguminous species that help to replace soil nutrients such as nitrogen.

> *"Evergreen Agriculture, as it is practised now, provides a glimpse of a better future, where the land is managed more sustainably and annual food crops are produced under a full canopy of trees."*

One particularly special 'fertiliser tree' is *Faidherbia albida*, an indigenous acacia that is already a natural component of farming across many parts of Africa. Its expanded use has made it a cornerstone of Evergreen Agriculture. *Faidherbia* agroforests exhibit 'reverse leaf phenology,' meaning that they shed their nitrogen-rich leaves during the early rainy season and remain dormant throughout the crop-growing period. The leaves grow again when the dry season begins. This makes them highly compatible with food crops. They do not compete with them for light, nutrients or water during the growing season.

In Malawi, maize yields are typically 2-3 times higher when the crop is grown under a canopy of *Faidherbia*. In both Zambia and Malawi, over 100,000 farmers have extended their conservation farming practices to cultivate food crops with *Faidherbia*. The maize grown near the trees is far more productive than the maize beyond the canopy, thanks to the nutritious boost to soil fertility and soil water conservation provided by the trees. In Niger, there are now more than 4.8 million ha of *Faidherbia* agroforests, significantly enhancing millet and sorghum production, as well as farmers' incomes. By increasing soil fertility and crop yields, Evergreen Agriculture also helps to take pressure off natural forests.

Evergreen Agriculture, as it is practised now, provides a glimpse of a better future, where the land is managed more sustainably and annual food crops are produced under a full canopy of trees. The approach has attracted the attention and support of politicians, policymakers and non-governmental organisations on a major scale, as well those who are really going to make a difference, the farmers.

In 2009, at a meeting organised by the African Union in Addis Ababa, Ethiopia, ministers of agriculture, land and livestock from across the continent published a declaration committing their governments to increasing the number of farmers practising agroforestry-based conservation agriculture. A few months ago, I explained the research

behind Evergreen Agriculture to over 800 leaders working in agriculture at the African Green Revolution Forum in Accra, Ghana. There was strong acclamation that indeed, we must transform the way that trees can benefit the way food is produced. It was recognized that African food production needs to double by 2050, but that cannot be achieved by simply doing more of the same: doubling fertiliser use, fuel use, pesticide use and so forth. In short, the old production models are not suited to present realities. What we need are fresh, out-of-the-box solutions to the food and population crisis – and Evergreen Agriculture is one of them.

Aldo Leopold, the great American environmental thinker, once said: "Don't worry too much about how fast you're going, as long as you are going in the right direction." The robust solutions of Evergreen Agriculture, based on the best of local knowledge and rigorous science, are now taking Africa in the right direction.

The right policy support will be critical in seeing the potential of Evergreen Agriculture fully developed on millions more smallholder farmers' fields. Therefore, in 2010, we launched the Agroforestry Policy Initiative. Its goal is to accelerate the positive changes in government support that can enhance the multifunctional roles of agroforestry on the ground. The initiative has received strong support from the World Bank, the UN Food and Agriculture Organisation (FAO), the Collaborative Partnership on Forests and other leading organisations. Thus, we are embarking on a global comparison of best-practice in policy formulation and implementation. We foresee that this, and other complementary actions, will stimulate a serious acceleration in deploying agroforestry for food security while creating a climate–SMART agriculture*.

Dennis Garrity
Director General

In Niger, there are now more than 4.8 million ha of Faidherbia agroforests, significantly enhancing millet and sorghum production, as well as farmers' incomes.

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Visit: http://www.worldagroforestry.org/evergreen_agriculture

*Climate-SMART agriculture: agriculture that sustainably increases productivity, resilience (adaptation), reduces GHGs (mitigation) and enhances achievement of national food security and development goals.

RESEARCH HIGHLIGHTS

Science has an important role to play in providing guidance to policymakers when they are faced with contentious and controversial issues. In Indonesia, the World Agroforestry Centre made an important contribution to the debate about the environmental costs of palm oil development. And in China, our scientists helped to dispel some of the myths surrounding the causes of the devastating drought in Yunnan province.

Challenging the prevailing wisdom

Over the past five years, Indonesia's palm oil production rose by 13.4% and exports by 16.2% a year. This dramatic increase was largely stimulated by the rising demand for biofuels, particularly among the European Union member countries. "From a European perspective, replacing fossil fuels with biofuels is an attractive way of reducing carbon emissions," explains World Agroforestry Centre scientist, Meine van Noordwijk, "but there can be considerable environmental costs in countries where biofuels are produced."

There has been a heated debate about the pros and cons of palm oil production in Indonesia. On the one hand, the industry has made some bold claims about the environmental benefits of establishing palm oil plantations; indeed, the Indonesian Palm Oil Commission has even stated that plantations consume more carbon

dioxide, and release more oxygen, than tropical forests. Environmental groups, in contrast, point out that vast areas of native forests have been cleared to make way for plantations, and that this has led to serious loss of biodiversity and high emissions of carbon dioxide, the main gas implicated in global warming.

To get to the bottom of the matter, van Noordwijk and his colleagues conducted a pilot study on the carbon footprint of palm oil production. Focusing on two areas in Sumatra and Kalimantan, they developed a relatively simple method to calculate the carbon budget of palm oil development, taking into account land clearance prior to establishing plantations, the balance of carbon emissions and carbon absorption during the life of the plantations, and the transport and processing of palm oil.

A key finding was that palm oil plantations store around 40 tonnes of carbon per hectare over their 25-year lifespan. In contrast, logged-over tropical forests, large areas of which have been cleared to make way for palm oil plantations in Indonesia, can store 70–200 tonnes of carbon per hectare. Pristine tropical forests can store double this amount.

The implications are clear. Conversion of forests to palm oil plantations should only be considered on land where above-ground carbon stocks are less than 40 tonnes per hectare; in other words, on grasslands or heavily degraded scrubland. Conversion of areas with high carbon stocks will lead to a net loss of carbon, with the draining of peat soils leading to particularly high losses. The researchers also suggest that palm oil companies should set aside specific areas for conservation, thus providing the twin benefit of sequestering carbon and enhancing biodiversity.

By planting the right trees in the right places, it is possible to mitigate some of the negative impacts of climate change

From the outset, the World Agroforestry Centre was determined to prove that it was independent, and subservient to neither palm oil companies nor the environmental lobby. “I believe we’ve managed to do that,” says scientist, Sonya Dewi. “I also think that we have convinced most people in the industry that palm oil development does have a significant environmental cost when it involves the clearance of carbon-rich forests. At the same time, we have provided evidence that palm oil development is not, *per se*, a bad thing, contrary to what some environmentalists claim.”

Yunnan’s drought – sorting fact from fiction

During the past half century, Yunnan province, in south-west China, has become progressively warmer and experienced an increase in extreme climatic events. However, nothing prepared its inhabitants for the recent drought. Between September 2009 and May 2010, the province received 60% less rainfall than normal. Over 8 million people – a fifth of the population – suffered from a shortage of drinking water and initial estimates for crop losses were set at US$ 2.5 billion.

Environmentalists were quick to point the finger of blame. Some claimed that the drought was caused by the large number of dams which had been constructed on the Mekong River and its tributaries. “That simply wasn’t the case,” explains Jianchu Xu, an ecologist with the World Agroforestry Centre. “The dams regulate streamflow, but they don’t have any impact on the regional climate.”

Other environmental groups claimed that the drought had been caused by widespread tree planting, particularly of eucalyptus. For many years, the Chinese government has been planting around 4 million hectares of fast-growing trees annually, most on dry and marginal lands. “It is true

that tree-planting programmes can have an impact on the local hydrology, but they cannot be blamed for major events such as the Yunnan drought," says Xu, drawing on research conducted in Yunnan's Kejie watershed.

Over a 40-year period, the area under forest in the watershed increased by over 22%, largely at the expense of grassland, although there were significant transfers from cropland, barren land and human settlement. The research found that afforestation and reforestation had led to an increase in evapotranspiration – the process by which trees take water from the soil and release it into the atmosphere – and a decrease in surface water and stream flow, especially during the wet season. On the positive side, the forests had increased water flow during the dry season.

These and other research findings show that tree-planting programmes can influence the local hydrology, but there is nothing to suggest that they are responsible for the recent drought in Yunnan province. Nor is there any evidence that the Yunnan drought, a once-in-a-century event, was caused by global warming.

"Ultimately, there is little we can do to prevent major droughts," says Xu, "but this doesn't mean that trees do not have an important role to play during times of drought." By planting the right trees in the right places, and by taking people's livelihoods and the environment into account, it is possible to mitigate some of the negative impacts of climate change.

Yunnan province in south-west China has experienced extreme climatic events, including prolonged drought ©Photo Jianchu Xu

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Large areas of agricultural land in sub-Saharan Africa are degraded. This is one reason why crop yields have barely risen during recent decades. In Tanzania, soil erosion is also causing serious environmental problems by increasing the rate of sedimentation in Lake Tanganyika. Scientists from the World Agroforestry Centre have helped to identify the cause of the problem and possible solutions.

Surveying – and restoring – degraded lands

Some 10 million people live around Lake Tanganyika, located in eastern Africa. However, the livelihoods of most of the population is threatened by pollution, overfishing and – arguably most important of all – erosion and sedimentation. Erosion is a problem for farmers, as they are losing soil fertility. Sedimentation causes eutrophication, a process of nutrient enrichment which could pose a threat to many aquatic species, and therefore to local fishing communities. To tackle the problem, the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) established the Strategic Action Programme for Lake Tanganyika.

"The main aim of the project is to reduce sedimentation, and in order to do that we first had to identify degradation hotspots," explains World Agroforestry Centre scientist, Fergus Sinclair. The researchers began by mapping the topography, using satellite imagery and aerial photography. They then looked at vegetation changes over time by 'back processing' satellite imagery from the past 30 years.

Remote sensing expert, Thomas Gumbricht, found that about 40% of the lake basin had lost some of its vegetation, and there had been a particularly significant decrease between 2001 and 2008. “By combining information from the long-term series of satellite images, and a higher-quality short-term series, we have been able to develop an index of land degradation,” explains Gumbricht. “This has helped us to identify the 5% of the basin most likely to be suffering from serious degradation.”

Most of the degradation hotspots are in Burundi and Tanzania, although certain critical areas have also been identified in the Democratic Republic of Congo and Zambia. Besides tracking vegetation changes over time, Gumbricht has been able to show where sedimentation has changed the nature of the shoreline, and by analysing sediment colour, he has been able to establish where it has come from.

Once the project had identified the degradation hotspots, researchers were able to focus on planning remedial activities. Two teams of students conducted detailed surveys, which involve mapping and interviews with local communities.

“We now have a better understanding of the factors that led to degradation and the sort of interventions farmers are prepared to adopt. The basic assumption is that planting the right trees in the right place will help to improve soils and restore degraded landscapes,” explains Sinclair. Various strategies are now being promoted by national and local extension services, including the planting of fertiliser trees to improve soil fertility, establishing woodlots and fruit orchards, and introducing farming practices which help conserve the soil. There has been a strong emphasis on capacity building, with regional workshops and training exercises involving a wide range of partners.

Planting the right trees in the right place will help to improve soils and restore degraded landscapes

Crop yields in sub-Saharan Africa have barely risen in recent decades, mainly due to degradation of large tracts of agricultural land ©Photo Thomas Gumbricht

Interpreting past and present

Mapping the vegetation of the whole of Africa is one thing; doing it in such a way that you can track changes over time, quite another. Yet this is precisely what researchers at the World Agroforestry Centre are currently doing. “Remote sensing, using data provided by satellites, presents the best way for monitoring and surveying ecosystem health,” explains Thomas Gumbricht. “However, there are all sorts of problems to overcome when using satellite imagery taken in earlier times.”

With the support of the United Nations Environment Programme (UNEP), Gumbricht had processed satellite images for the whole of Africa going back to the year 2000. He is currently analysing data taken from images going back to the 1970s. This will provide a picture of how vegetation, and soil health, has changed over the past four decades.

Processing satellite imagery over a period of time is much more demanding than the analysis of single-date images. Among other things, Gumbricht has had to ‘correct’ data to take into account different atmospheric conditions, clouds and the cloud shadow, variations in satellite reflectance and other factors. “It is a bit like taking lots of different accents and ending up with the Queen’s English,” he says.

Gumbricht has developed techniques for ‘getting rid’ of clouds and is now able to distinguish between bare soil and harvested fields – both of which were impossible before. He has developed highly sophisticated techniques that are able to track the annual vegetation growth by measuring the amount of chlorophyll in images provided by Moderate Resolution Imaging Spectroradiometer (MODIS) satellites.

The remote sensing methodologies developed by Gumbricht and his colleagues are helping to support a number of research projects. They have played a crucial role in identifying degradation hotspots around Lake Tanganyika. The information is being used by the Africa Soil Information Service, in conjunction with ground sampling, to analyse soil health at 60 randomly selected sites in sub-Saharan Africa. Most of the research conducted by the World Agroforestry Centre is conducted on small sites scattered across the tropics. The remote sensing data will help scientists to identify other areas where there are similar conditions, which might benefit from some of the interventions which have been tried and tested by the Centre.

High-end science this may be, but that does not mean it is of interest to just the chosen few. “We are making all the data from our remote sensing research as widely available as possible so that people without the relevant technical skills can use the information,” says Keith Shepherd, a leading soil scientist. This means that researchers and extension workers will be able to use the data generated in Gumbricht’s Nairobi office to improve soils – and crop yields – in remote parts of Africa.

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Deforestation accounts for approximately 20% of greenhouse gas emissions, so saving forests is a good way of tackling global warming. Hence the idea of Reducing Emissions from Deforestation and Forest Degradation, or REDD. However, in many countries a significant portion of forest-related carbon emissions occur outside areas officially designated as 'forest'. This means that REDD projects will only tackle part of the problem. That's why the World Agroforestry Centre is promoting REALU – Reducing Emissions from All Land Uses.

Time to get REALU – in India and beyond

A research and development project managed by the World Agroforestry Centre in India provides a glimpse of what a REALU carbon scheme might look like on the ground. 'Enabling Smallholders to Improve their Livelihoods and Benefit from Carbon Finance' is already attracting considerable interest from public and private sector carbon buyers.

"Smallholders in India, especially in the tribal areas, face many problems," explains Pal Singh, the World Agroforestry Centre's Regional Coordinator for South Asia. "Their farms are often small, many are poorly educated, they are disorganised and find it difficult to negotiate or even get loans. In addition, they are particularly vulnerable to climate change. In the areas where we have chosen to work, extension services are also very poor."

In collaboration with national agricultural research centres in Andhra Pradesh, Rajasthan, Orissa and Uttarakhand, Singh and his colleagues identified four 'grids', several kilometres square, each with around 1000 farming families. They began by conducting baseline studies of carbon stocks, using methodologies accepted by the Kyoto Protocol's Clean Development

Mechanism (CDM), and held a series of meetings with local communities, at which they described a range of activities that they could undertake to either reduce their carbon emissions or sequester carbon. These range from installing energy-efficient stoves to adopting conservation farming practices, from planting fruit trees to improving irrigation systems.

"It is entirely up to the families to choose what to do. We simply provide technical advice and some of the basic materials that they need," explains Singh. "We explained to them from the beginning that this is not a cash handing-over exercise, but that the activities they undertake will help them to improve their farming practices and – very importantly – their incomes."

Later, it is hoped, the project will also provide the communities with sales for the carbon they sequester. In each area, 'producer companies', owned by the local farmers, have been established and these will eventually be in charge of marketing carbon. It is too early to say how much carbon the grids will sequester, and precisely how profits will be shared, but the project has already attracted the attention of prospective buyers.

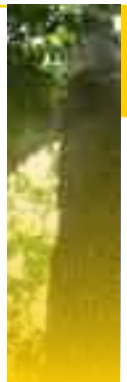
A French company, Danone, has said it would like to buy carbon from such projects. The International Finance Corporation (IFC) has expressed interest in buying carbon in order to offset some of the emissions from pulp mills whose construction it is currently funding. A cement company in Mumbai has contacted Singh with an order. The initial funding for the project came from the Indian government, but other donors are now expressing an interest in expanding the project to other areas.

Carbon schemes, whether established under the voluntary arrangements or under the CDM, must show 'additionality'; in other words, the sellers must be able to prove that the carbon would not otherwise have been saved or sequestered. "If we hadn't established this project, nothing would have happened in these areas," explains Singh, "and if we can make carbon projects work here, in these poor and neglected tribal areas, we can make them work anywhere." REALU could soon become a reality over much larger areas in India.

How much should carbon cost?

The carbon market is potentially worth billions of dollars, and many believe it could be used not only to sequester carbon, but help poor farmers improve their incomes. But how much should they be paid? "If voluntary carbon schemes are overgenerous, then everybody will want to join, and the schemes will be unaffordable," says Olu Ajayi, a World Agroforestry Centre scientist based in Malawi. "However, if they are paid too little, this could lead to exploitation, with farmers dropping out of the schemes."

In a research project involving 177 farmers, Kelsey Jack of Harvard University and Ajayi compared two different



Size matters

Devising ways of measuring carbon stocks in agricultural landscapes is a prerequisite to establishing schemes that pay farmers to save or sequester carbon. So far, the difficulty of doing this has deterred some organisations and schemes – among them the European Union (EU) Emissions Trading System – from including agricultural landscapes. To solve the problem, World Agroforestry Centre scientists, with support from the Carbon Benefits Project, have established a pilot scheme to measure carbon in western Kenya.

Johannes Dietz and Shem Kuyah randomly selected and harvested 72 trees. They measured everything from their diameter, height and crown to their underground biomass and developed a formula which can be used to measure carbon in landscape which consists of a mosaic of cropland, pasture and woodland. It is the first time this has ever been done in the region and at this scale.

"We have proved that it is technically possible to measure carbon in a mosaic landscape," explains Dietz, "and our formula will provide a much higher level of accuracy than the ones that are currently available." Many of these fail to properly assess the carbon stored in the largest trees. This research shows that size matters, because even though few in number, these large trees harbour most of the carbon in mosaic landscapes.

ways of setting carbon prices. The first involved a 'reverse auction.' The farmers' opportunity costs of tree planting were revealed by asking them what price they would like to be paid for planting trees which sequester carbon on a half acre piece of land. Farmers who bid lower prices, and were therefore willing to invest in tree planting at lower cost, won the contract. Those who bid higher than the 'clearing price', which was determined by the funds available, were rejected by the scheme. In this case, 37% of the farmers were accepted, and paid the clearing price, even when it was higher than their bid. The clearing price was then offered to another group of farmers, 99.5% of whom accepted it.

Both groups were given the same number of trees, the same technical support and the same contract. Jack and Ajayi then compared the performance of the two groups. Farmers who had bid in the reverse auction had a higher tree survival rate than those in the other group, and showed a higher level of compliance with their contract. "This study shows that organisations establishing trees for carbon schemes shouldn't just pick an arbitrary figure," says Ajayi. "They should aim to assess the opportunity costs of joining the schemes, in terms of land lost to crops, labour and so on, as revealed by the farmers themselves."

There is, however a trade-off. Although the reverse auction identifies farmers who will show the highest levels of compliance, it may potentially cost more.

A reality check

"It is often implied that small-scale farmers could benefit from the carbon market," says World Agroforestry Centre scientist Eike Luedeling, "but the rate at which they can sequester carbon will depend on the environment in which they find themselves."

In 2010, Luedeling studied the carbon sequestration potential of parkland agroforestry in the West African

> *The carbon market could be used to help poor farmers improve their incomes*

Farmers could benefit from the establishment of fertiliser trees such as *Sesbania sesban* which capture nitrogen from the atmosphere and make it available to crops
©Photo Gudeta Sileshi

Sahel. The aim was to find out how much carbon could be sequestered and whether it could attract small-scale farmers into the carbon market. The answer to these questions was: not much and probably not.

Using ecological niche modelling and drawing on previous research, Luedeling found that the Sahelian parkland has the potential to sequester about 20 tonnes of carbon per hectare over 50 years. Across the entire Sahel this would amount to a considerable quantity of carbon, but only 0.4 tonnes per hectare per year. Assuming a price of US$10–US$30 per tonne of CO_2, farmers could expect to earn US$15–US$44 per hectare per year, without factoring in the transaction costs of setting up, registering and monitoring carbon deals.

"The trees here simply don't grow quickly enough to be of interest to the carbon market," says Luedeling, "but that doesn't mean agroforestry cannot play an important role in helping farmers adapt to climate change." Current models suggest that the Sahel is likely to become progressively hotter and drier, and Luedeling believes farmers could benefit from establishing fodder banks, fertiliser trees and live fences – even if these will not help them tap the carbon market.

REALU in Peru

Is it possible to set up REALU carbon schemes in a country like Peru? This is a question that Julio Ugarte and Sandra Velarde of the World Agroforestry Centre were hoping to answer. "While there are obstacles to REALU, we still believe it can be achieved," says Ugarte. "It would undoubtedly lead to a greater reduction in emissions and significant benefits for local people."

Peru is one of five countries – the others are Cameroon, Indonesia, Nepal and Vietnam – involved in the REALU-1 project funded by the Norwegian Agency for Development Co-operation (NORAD). During the past year, the World Agroforestry Centre and its partners in Peru held a series of workshops in, and synthesised research from, Ucayali, San Martin and Loreto, the three most heavily deforested regions in the Peruvian Amazon. Working with a wide range of interested organisations, they analysed the causes of deforestation and looked at the sort of institutions which would be needed if REALU projects are to be established.

The main drivers of deforestation are shifting cultivation, linked to political and economic activities. At present, the state is responsible for managing forest resources, as well as the goods and services they provide. "REALU is a very real possibility and has widespread support," explains Velarde, "but it will require changes to current laws, institutional arrangements and policies."

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Some parts of the world are getting hotter, some colder; some are getting wetter, some drier. The frequency of floods, droughts and other severe weather events is also increasing. This has profound implications for hundreds of millions of smallholders who grow trees on their farms. The World Agroforestry Centre is looking at how they, and their tree crops, could adapt to climate change.

Facing up to a changing world

"One way of adapting involves changing the mix of species, for example by encouraging drought-tolerant trees if the climate is getting drier," explains Ian Dawson, the lead author of a major review on climate change and agroforestry genetic resources. However, these compositional adjustments, as they are known, need to be accompanied by other measures which involve maintaining, enhancing and improving the management of trees on farms.

The authors of *Climate Change and Tree Genetic Resource Management* have identified three possible strategies. The first involves the human translocation of seeds and seedlings to areas where they can survive and thrive under new conditions. This may also involve the transfer of associated microorganisms, such as nitrogen-fixing bacteria and animal pollinators. However, choosing which species will flourish, and which will not, is far from easy. "Translocation isn't a major problem for annual crops, because if farmers grow a certain crop and it doesn't succeed, they won't grow it again the next year," explains Dawson. It's a different matter with agroforestry species, which may take 20 years to mature and whose suitability can be difficult to assess over a short period of time.

The second strategy involves encouraging local genetic adaptation to changing environmental conditions. The review found that a number of features enable tree species in natural stands to adapt to change. These include large population size, high levels of genetic diversity and high seed yields. The problem for smallholders is that most trees

on their farms have small effective population sizes, thus reducing their ability to adapt. However, measures can be taken to encourage greater on-farm genetic diversity and genetic change to promote adaptation. Farmer-to-farmer exchange networks for seeds and seedlings can help, and so can 'diversity fairs'. The latter are currently being promoted in the West African Sahel by John Weber, a scientist with the World Agroforestry Centre.

The final strategy involves planting species which tolerate a wide range of environmental conditions, such as *Pinus patula* and many *Eucalyptus* species. These are now grown throughout the tropics in environmental conditions which vary greatly. However, the authors of the review warn that these species often have an aggressive disposition and may displace others of value to farmers.

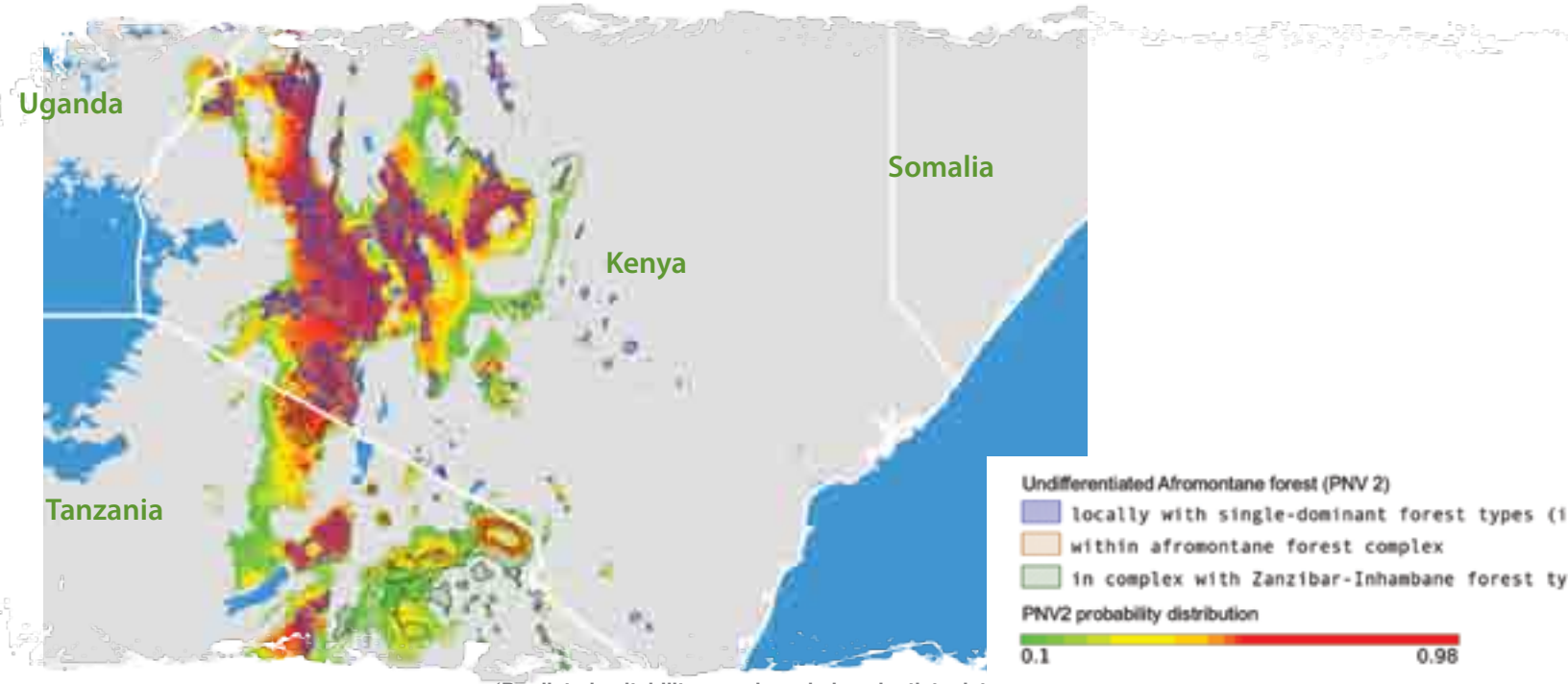
> *There is need to encourage on-farm genetic diversity and genetic change to promote adaptation*

"For the review, we drew on over 100 scientific papers, but more research needs to be done," explains Dawson. In particular, we need to know more about fruit trees and how to help them adapt. Fruit trees appear to be especially vulnerable, partly because most depend on animal pollinators to yield fruit and these pollinators are themselves sensitive to climate change.

The right tree in the right place

If tree species are going to be successfully translocated – one of the strategies for adaptation identified in the review paper – we need to predict where they will grow well. "The best way to find out whether a particular species will thrive in a particular area is to plant it there and see what happens," explains Roeland Kindt, an ecologist at the World Agroforestry Centre. "However, there are over 60,000 tree species in the world and in practical terms we simply do not have the resources to do this for more than a handful."

There is, however, an alternative, currently being explored by the Vegetation and Climate Change in East Africa (VECEA) project. Led by Forest and Landscape Denmark, the project has been developing 'potential natural vegetation maps' for East Africa. These are created by combining detailed vegetation maps drawn up by surveyors during colonial times, when there was more



'Predicted suitability maps' can help scientists det particular areas ©Photo Paulo Vannbreugel

natural vegetation, with current knowledge about the flora in seven East African countries. “It wasn’t just a question of finding old maps, but finding old botanists too,” says Kindt. Once the old maps had been digitised, the botanists ‘populated’ them with tree species.

It is hoped that these will help farmers to decide which trees are suitable for their area and where they should look for seeds and tree seedlings if they cannot find them locally. Kindt believes that they will prove particularly useful to national tree seed centres and non-governmental organisations involved in tree-planting projects. The researchers are also producing ‘predicted suitability maps’ for different vegetation types, from dry to moist forest. These maps form the starting point to enable scientists, and others involved in agroforestry, to predict which species will grow well, and where, under different climatic conditions.

Revealing the past, planning for the future

“If we want to make reliable predictions about the future, we need to have an understanding of how the climate has changed in the past,” says Aster Gebrekirstos, a postdoctoral fellow at the World Agroforestry Centre and Göttingen University, Germany. “However, the oldest instrumental climate data we have for Africa goes back just 60 years.” Fortunately, the science of dendrochronology, which involves the study of growth patterns in tree stems, can help scientists to unravel the past.

Working in Ethiopia, Tanzania and Burkina Faso, Gebrekirstos has looked at the way in which different species have reacted to climate variability and change. During times of drought, trees develop narrow annual rings. When there is plenty of rain, the distance between annual rings is wider. She has also looked at stable isotope (of both carbon and oxygen) variations in tree rings over time, and examined the uptake of different carbon isotopes under different climatic conditions. Plants prefer to fix carbon dioxide that contains carbon 12, the lighter form of the carbon atom. However, if trees are stressed, they will close their stomata and ‘fix’ more carbon 13, which they reject under more favourable conditions.

By studying the growth rates of trees during recent decades, for which good climate data exist, Gebrekirstos has been able to use the pattern of annual rings to reconstruct the climate of the past, going back many centuries. “The research is also providing information about the way in which different agroforestry species have responded to drought and how efficiently they use water,” she explains. This will help scientists to provide guidance to farmers about the appropriate species to plant if the climate becomes progressively drier.

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Developing and promoting agroforestry technologies which can transform lives and landscapes lies at the heart of our work. However, if agroforestry's potential is to be fully realised, we also need to form partnerships with other organisations working in the field of rural development to influence policy. This is done through the Agroforestry Policy Initiative.

Shaping the future

In August 2009, the World Agroforestry Centre launched the concept of a major new initiative at the Second World Agroforestry Congress, held in Nairobi, Kenya. "The Agroforestry Policy Initiative will support national and local policy reforms that reduce barriers and improve incentives for private investment in agroforestry," explains Director General Dennis Garrity.

Almost half of the world's agricultural land has 10% tree cover, and there is huge potential to increase this area and make it more productive. Governments have a key role to play by revising outdated policies and regulations that deter farmers from planting or managing trees on farms. It can be done. Take, for example, the remarkable transformation which took place after Niger relaxed its *Code Forestier* and allowed farmers to harvest trees from their own land. Farmers in this arid region dramatically increased the cultivation of trees on 5 million hectares of land. One of the trees they favoured was *Faidherbia*, whose nitrogen-fixing properties enabled farmers to improve fertility and crop yields.

A range of influential organisations, including the World Bank, the United Nations Food and Agriculture Organisation (FAO), the International Union of Forest Research

Organisations (IUFRO) and the Collaborative Partnership on Forests are now working together to support agroforestry policy reform processes. It is hoped that this will lead to the introduction of policies which stimulate agroforestry, such as improving farmers' rights to plant, manage and harvest trees, improve coordination among different ministries with roles in supporting agroforestry, and create competitive markets for tree products and environmental services.

Besides launching the Agroforestry Policy Initiative, the World Agroforestry Centre and its scientists helped to institute significant policy changes in 2009 and 2010. Here are some examples from Asia.

A new law for the Philippines

The World Agroforestry Centre was one of the main organisers of two national conferences on climate change adaptation, held in 2007 and 2009, and it has conducted extensive research on the institutional reforms needed if the Philippines is to successfully adapt to climate change and adopt measures to sequester carbon. The Centre has also played a significant role in influencing national policy.

Scientist Rodel Lasco was a member of the technical working group established by the Philippines Senate Committee on Environment and Natural Resources. The group liaised closely with the Senate Committee to draft the 2009 Climate Change Act, which established a new Commission on Climate Change. The Act and the Commission will shape the country's policies on climate change in the coming years. Lasco has also helped to draft the country's REDD (Reducing Emissions from Deforestation and Forest Degradation) strategy. "This is a significant document, as it sets the stage for how the Philippines will engage in the REDD process," he says.

Greening the state

The Indian state of Chhattisgarh has become the first in the country to develop its own agroforestry policy. Over 80% of the state's population depends on agriculture for their survival. "The new policy will now promote tree planting on farms," explains Pal Singh, the World Agroforestry Centre's Regional Coordinator for South Asia.

The policy, which Singh helped to draft, will make it easier for farmers and organisations to gain approval for agroforestry projects on both public and private land, and get a fair price for their produce. This will be particularly significant for tribal communities, whose main livelihoods depend on agroforestry, as they suffer from stringent rules and regulations on the felling and transport of specified tree species. Under the new policy the state guarantees that it will buy agroforestry products at predetermined prices, known as the minimum support price.

"This is very important," says Singh. "It means that there is now a minimum guaranteed price for agroforestry products in Chhattisgarh, just as there is for rice and wheat crops." However, producers will still be at liberty to sell their produce to any other buyer if they so wish. "Such a policy is expected to result in hassle-free development of agroforestry in the state," says Singh.

Indonesia's model for the future

In 2009, Indonesia's Ministry of Forestry declared the village of Lubuk Beringin, in Sumatra's Jambi province, as the first ever 'Hutan Desa' – or village forest – in Indonesia. This gives the village the right to manage a watershed protection forest, opening the door for the wider application of negotiated agreements which will enable local communities to receive payments for protecting environmental services.

Research by the World Agroforestry Centre helped to influence the thinking of Indonesia's policymakers. The research was conducted as part of the country's preparations for REDD along with other research on biodiversity and various forms of land uses in the area. "If communities don't have rights of tenure in the forests, then they cannot participate in a meaningful way or

Forming partnerships with other organisations working in the field of policy influence is key if the potential of agroforestry is to be fully realized.

derive benefits from REDD agreements" explains Ujjwal Pradhan, the Centre's Regional Coordinator for Southeast Asia. By designating the village forest as a Hutan Desa, he says, the government of Indonesia has acknowledged the significance of community land tenure. This recognition is important for securing the livelihoods of the people and for negotiating environmental agreements.

Lubuk Beringin can serve as a pilot learning site for the Government of Indonesia, development organisations and donors. A recent decision by the Australian government to invest A$ 3 million in REDD pilot schemes in Jambi can draw on opportunities to introduce Hutan Desa agreements to similar settings in the neighbouring district.

Rewarding good practice

Over the past 10 years, the Manupali watershed, in southern Philippines, has undergone major development. A proliferation of banana plantations and other agribusinesses has not only changed the landscape, but has also led to an increase in conflict with indigenous communities and other farming groups. Much of the tension revolves around competition for water.

Having conducted research in this area for many years, scientists from the World Agroforestry Centre were ideally placed to study the changing patterns of water use, the hydrological demands of different land use and the relationships between user groups. Scientists Caroline Duque-Piñon and Delia Catacutan have also made a significant contribution in framing local land-use policies.

"Most of the groups we interviewed were concerned about overlapping water rights, rather than the scarcity of water," says Duque-Piñon. "However, the rapid hydrological appraisal which we conducted suggested that water scarcity was also an issue, and needed to be addressed by improving land-use practices."

Fortunately, many of the groups competing for water realised that they needed to strike some sort of deal about its allocation. "These voluntary agreements have helped to defuse conflict – in the short term, at least," explains Catacutan, "but our research suggested that there was also need to change local policy."

With the help of the World Agroforestry Centre, the local government of Lantapan began to review its policies. In 2009, it enacted a Municipal Ordinance which established an incentive scheme to encourage smallholders to adopt and invest in sustainable land-use practices. It is now investing in seven different types of incentive, such as subsidised crop insurance, provision of microfinance and improved extension services. The incentives are encouraging farmers to reduce their dependence on fertilisers and pesticides, plant trees, adopt conservation farming practices and improve their water management.

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Poverty in Africa is predominantly a rural phenomenon, with women and those living in marginal agricultural areas being hardest hit. Helping them to gain better access to the market would help to reduce poverty and raise incomes. Recent research in East Africa, funded by the Ford Foundation, provides new insights into which commodities and crops are providing the greatest benefits for marginal groups.

Making the most of markets

An analysis of farming families' access to markets in Kenya and Uganda was undertaken by scientists from the Tegemeo Institute of Egerton University, Kenya, Makerere University, Uganda, and the World Agroforestry Centre. The study – 'Participation in Markets by Women, the Poor and Other Marginalised Groups in Rural Kenya and Uganda' – used nationally representative data that had been previously gathered from 900 households in Uganda and 1500 households in Kenya between 2000 and 2007. The data covered everything from demographics to incomes, from farming practices to the ownership of transport, from the distance it took to travel to markets to access to credit.

"We found that there was a high level of diversification, with farming families growing a wide variety of crops, and this applied to women and the poor as much as it did to men and the better off," explains Dagmar Mithoefer of the World Agroforestry Centre. "However, marginal groups tend to sell a lower share of their produce, in both Kenya and Uganda."

The research suggests that marginal groups have better access to some markets than others. In Kenya, it seems that poor households were improving their incomes by producing and selling fruits, bananas and vegetables in the local markets. Indeed, 88–90% of women were growing fruit,

mangoes being the most popular, and they were almost as likely to sell their fruit as men. Up to 95% were growing vegetables, and were only slightly less likely to sell them than men. Taking the poor in general, 85% were growing fruit, 90% vegetables and 75% bananas, and they were selling approximately a quarter of what they grew. Indeed, more Kenyan households were selling fruit than maize, the major food crop.

In Uganda, the most promising market-oriented strategy for improving incomes involved the sale of bananas and dairy produce.

Many farmers, including poorer households, were also diversifying their livestock portfolios. In Kenya, the percentage of poor households keeping sheep and goats increased from 45% to 52% between 2000 and 2007 and the number of poor selling poultry increased from 7% to 27% over the same period of time.

So what are the implications for the investment policies of donors, governments and non-governmental organisations? Frank Place, an Impact Assessment Advisor at the World Agroforestry Centre, warns against easy generalisations. “The key findings in Kenya and Uganda concur in some areas, but differ in others,” he says. “This indicates that there is no single approach for enhancing market participation by poor, the women and other marginal groups.” Nevertheless, there are certain promising commodities – for example, fruit in Kenya, vegetables and milk in both Kenya and Uganda.

The research also revealed which factors do most to help marginal groups boost their participation in markets. “Group membership is very important,” says Mithoefer. “Regardless of whether you look at women, the poor or those living in remote areas, people do better when they belong to an organised group.” Another key factor is the ownership of transport and communication equipment, such as mobile phones. These, too, help to improve access to the market.

Group membership helps marginalised communities boost their participation in markets

Many poor households in Kenya and Uganda are improving their incomes by selling fruits, vegetables and dairy produce in local markets ©Photo World Agroforestry Centre archives

Making the most of Kenya's mangoes

During the 1970s, Jürgen Griesbach, a German development worker, introduced dozens of exotic mango varieties to Kenya from as far afield as Brazil and India. In those days it was much easier to import germplasm. He established orchards at research stations run by the Kenya Agricultural Research Institute (KARI) and on prison farms in Central and Eastern Kenya, where there was space and free labour. Staff and inmates learnt to graft mangoes and to date, the prisons still supply improved varieties to local farmers.

"It is largely because of Griesbach's work that mangoes are now so widely grown in Kenya," explains Katya Kehlenbeck, a scientist at the World Agroforestry Centre. "However, their full potential has yet to be realised." A pilot study by Kehlenbeck and her colleague Emanuela Rohde has provided the first significant assessment of the varieties available in Kenya and the problems which are holding the industry back. Their findings are based on detailed surveys at three KARI research stations, five prison farms and six individual farms, where they found a total of 50 varieties. The researchers also interviewed mango traders and exporters.

"We found that there was a serious lack of knowledge about which varieties were suitable for which agro-ecological conditions," says Kehlenbeck. "There is also an urgent need to develop early and late season varieties, since around 50% of the crop goes to waste during the short harvesting season." Furthermore, poor quality fruit and the use of banned pesticides mean that Kenyan exporters are unable to tap the potentially lucrative European market.

The researchers have identified a number of measures which could be taken to improve mango productivity in Kenya. Among other things, there is an urgent need to evaluate and characterise available rootstock and varieties in order to select the most suitable ones. The researchers also suggest that Kenya could benefit from importing new varieties that have been developed in major mango-producing countries such as India. However, there are some considerable bureaucratic hurdles to overcome, as the days of legally transporting seedlings and saplings in suitcases are long gone.

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Much of our research is conducted in partnership. We work with a wide range of organisations, including other centres within the CGIAR, national research institutes, universities and non-governmental organisations. Our scientists also have a close working relationship with the communities and families who are using agroforestry to improve their livelihoods and the environment.

Working with the people who really matter

Seeing the light

Most people are under the impression that vegetables grow best in full sunlight, including the people who should know best. But do they? This is one of the questions a research project in West Java sought to answer. “Traditionally, farmers here have worked on the principle that the more sunlight the better when growing vegetables,” says James Roshetko, a scientist with Winrock International and the World Agroforestry Centre. “When we began our research in Nanggung, just 11% of farmers had any experience of intercropping vegetables with tree crops.”

Working in collaboration with Bogor Agriculture University and Winrock International, the World Agroforestry Centre set up a series of on-farm experiments to evaluate the performance of seven species of vegetables, all with a strong market demand, under three different light regimes, ranging from full sunlight to low light.

For six of the vegetables – amaranth, kangkung, eggplant, chilli, tomato and katuk – production per plant was higher under medium light than under full sunlight. Amaranth, for example, produced 15.3 g per plant under medium light, compared to 5.5 g under sunlight; eggplant produced 833 g and 488 g respectively. When assessed in terms of production per area, amaranth and chilli both achieved higher yields per hectare under medium light than under full sunlight, even though the presence of trees meant there was less space available for vegetables. Furthermore, production costs per kilogram were lower for all vegetables under medium light. Less labour was required for weed control as the tree shade reduced weed growth.

"The research suggests that these vegetables grow best under the conditions which are found in one of the main agroforestry systems practised in West Java, where farmers grow fruit trees, timber trees, banana and annual crops in one integrated system," says Roshetko. He also points out that the research was conducted during a year of lower than average rainfall, and the vegetables benefitted from being in medium shade as they had lower rates of evapo-transpiration. Nevertheless more research needs to be done on the quality of vegetables under different light conditions, and the appropriate crop rotations, the study provides valuable evidence about the benefits of understory vegetable production. This is precisely the sort of information the extension services need if they are to help farmers improve their productivity.

Green pesticides and their potential

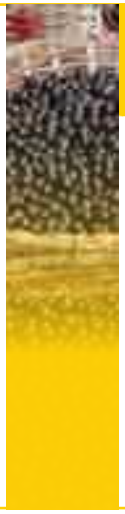
Long before agrochemical companies developed synthetic pesticides, farmers were using substances found in wild plants to control insects and other creatures that threatened their crops and livestock. However, relatively little research has been done on the subject and knowledge about 'pesticidal' plants is scanty. A research programme conducted by scientists from the World Agroforestry Centre, the Royal Botanical Gardens, UK, and the Natural Resources Institute, UK, in partnership with universities in Malawi and Zimbabwe, has shed new light on the importance of these plants for farmers in Zambia and Malawi.

Scientists interviewed over 260 farming families about their use of pesticidal plants and conducted laboratory tests to analyse the active ingredients of selected species and their efficiency. "We found that most farmers were very knowledgeable about the pesticidal properties of a large number of plants," says Gudeta Sileshi of the World Agroforestry Centre, "although they use relatively few on a regular basis."

One of the most popular concoctions was made from the leaves of *Tephrosia vogelli*. This is sprayed in liquid form on vegetables to protect them from insects and used as a dry compound to deter weevils in granaries. The researchers found that it was just as effective as some commercial pesticides. Since many farmers use it as a fertiliser tree – it helps to enhance soil fertility – it is widely available.

However, other useful pesticidal species appear to be suffering from overharvesting and habitat loss, and their use is therefore restricted. Efforts are now being made to domesticate some species. For example, protocols have been developed for the propagation of *Securidaca longependuculata* and *Bobgunnia* (*Swartzia*) *madagascariensis*, which are high-value pesticidal and medicinal plants.

> *Green pesticides could play an important role in protecting farmers' crops, livestock and food stores*



Tools for change

According to Julio Ugarte, a scientist with the World Agroforestry Centre, the lack of a sustainable supply of seeds and seedlings is a major restraint to expanding the adoption of agroforestry in Latin America. To tackle the problem, the Centre and its local partners launched a new manual, or toolbox – *Semillas de especies arbóreas para los agricultores* – for the management of agroforestry tree species germplasm. This brings together information that will enable farmers and extension workers to produce and distribute high-quality seeds and seedlings. The manual presents a wide range of strategies to increase the flow of seeds and seedlings. It also highlights the role that the private sector can play in developing a market that favours self-sufficiency, good quality and the efficient use of resources.

"More research needs to be done, both on the species used and on duration of time for which the active ingredients are effective," says Sileshi. Safety issues also need to be better researched. For example, some farmers use an extract of the monkey orange, *Strichnos spinosa*, to protect their livestock from ticks, but the active ingredient, strychnine, is highly toxic (and also used as a rodent poison). Sileshi believes that green pesticides could play a much more important role in protecting farmers' crops, livestock and food stores in future, but that will only happen if policies and incentives support the necessary research and development.

Prize for progress

In 2010, a farmer-led initiative supported by the World Agroforestry Centre in Cameroon was one of just 25 recipients of the biennial Equator Prize, which recognises and celebrates outstanding community efforts to reduce poverty through conservation. RIBA Rural Resource Centre provides training in agroforestry, nursery management, watershed protection, apiculture and microfinance to the farming communities who live in the mountainous Northwest Region. During recent years, the number of farmers planting nitrogen-fixing tree crops has risen, as have crop yields, and the average number of trees planted per household has increased from 10 to over 120.

RIBA is one of several resource centres which are training farmers on how to domesticate wild species of fruit tree. "The Equator Prize recognises the tremendous work which has been done by the resource centre and local farmers," explains Zachary Tchoundjeu, World Agroforestry Centre's Regional Coordinator for West and Central Africa. "It is also international recognition of the importance of the participatory tree domestication approach that we have pioneered." This story is told in 'Trees for Change' Booklet No. 4, *The Fruits of Success*.

RIBA Rural Resource Centre, a recipient of the biennial Equator Prize, provides training in agroforestry and nursery management ©Photo Julius Atia

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Annexes

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Ujjwal Pradhan, Regional Coordinator - Southeast Asia

Keith Shepherd, Leader, Global Research Project - Land Health

Fergus Sinclair, Co-Leader, Global Research Project - On-farm Productivity

Virendra Pal Singh, Regional Coordinator - South Asia

Zacharie Tchoundjeu, Regional Coordinator - West and Central Africa and Co-Leader, Global Research Project - Agroforestry Germplasm

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Meine van Noordwijk, Chief Science Advisor

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Australian Agency for International Development (AusAID)
Australian Centre for International Agricultural Research (ACIAR)
Belgian Technical Cooperation
Bill and Melinda Gates Foundation
Bogor Institute of Agriculture
Canadian International Development Agency (CIDA)
Centre for Development Research
Centre for Mountain Ecosystem Studies
Centro Internacional de Agricultura Tropical, Colombia
Chinese Academy of Science
Comart Foundation
Common Market For East and Southern Africa (COMESA)
Conservation International Foundation
Cooperation of Common Fund for Commodities
Cornell University
Danish Centre for Forest, Landscape and Planning
Darwin Initiative
Department for International Development (DFID) UK
Department of Foreign Affairs, Government of Italy
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
Dian Tama Foundation
Directorate General for Development Cooperation, Belgium
Earth Institute - Columbia University
Ebony Enterprises Ltd
European Union
Flemish Government, Ministry of Agriculture, Belgium
Food and Agriculture Organisation of the United Nations
Ford Foundation
Forest Action Network
Forum for Agricultural Research in Africa
Georg-August-Universitat Gottingen
Global Mountain Programme
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Government of China
Government of Japan
Government of the Philippines
Government of South Africa
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Heifer International
HK Logistics Pty Limited
IFAR Wilfried Thalwitz Scholarship
India Council for Agricultural Research
Indonesian Palm Oil Board
Indonesian Palm Oil Commission
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria - Spain
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International Food Policy Research Institute (IFPRI)
International Fund for Agricultural Development (IFAD)
International Institute for Sustainable Development (IISD)
International Network for Bamboo and Rattan (INBAR)
International Plant Genetic Resources Institute (IPGRI)
International Rice Research Institute (IRRI)
International Tropical Timber Organisation (ITTO)
Internationale en Recherche Agronomique pour le Développement (CIRAD)
Irish Aid
Katholic University
Kenya Agricultural Research Institute (KARI)
Kyoto University
Leibniz Centre for Agricultural Landscape Research e.V.
Leuser NOEL
Macaulay Land Use Research Institute
Mars Incorporated
McKnight Foundation
Millennium Challenge Account
Ministry of Agriculture, Government of Peru
Ministry of Foreign Affairs (Climate, Energy, Env. & Water Dept.), Netherlands
Ministry of Foreign Affairs (Education Department), Netherlands
Ministry of Foreign Affairs of Denmark
Ministry of Foreign Affairs, Finland
Natural Resources Institute
Norad - Norwegian Agency for Development Cooperation
North Carolina State University
Packard Foundation
Partnership for Governance Reforms in Indonesia
Plan International
Rights and Resources Group
Rockefeller Foundation
Swedish International Development Cooperation Agency (SIDA)
Swiss Agency Development and Cooperation (SDC)
The Centre for International Forestry Research (CIFOR)
The Nature Conservancy
Third World Organisation for Women in Science (TWOWS)
Tropical Agronomic Centre for Research and Teaching (CATIE)
Unilever
United Nations Development Programme (UNDP)
United Nations Environment Programme (UNEP)
United States Agency for International Development (USAID)
United States Department of Agriculture
Waseda Environment Research Institute
William J. Clinton Foundation
World Bank
World Conservation Union
World Wildlife Fund

Financial highlights

For the year ended 31 December 2009 *(In US Dollars '000)*

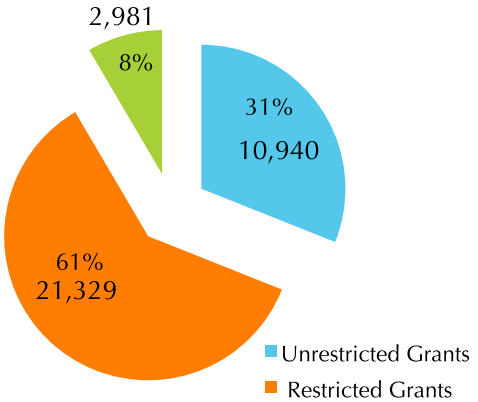
Statement of Financial Position

	Note	2009	2008
ASSETS			
Current Assets			
Cash and cash equivalent	5	16,436	15,509
Short term investments	6	13,624	3,881
Accounts receivables			
Donor	7	4,799	6,936
Employees		198	123
Other CGIAR Centers		277	476
Other	8	3,145	1,828
Inventories - net	9	95	103
Prepaid expenses		433	332
Total current assets		39,007	29,188
Non-Current Assets			
Property, Plant and Equipment - net	10	5,493	5,285
Long term investments	11	2,108	1,785
Total Non-current assets		**7,601**	**7,070**
TOTAL ASSETS		**46,608**	**36,258**
LIABILITIES AND NET ASSETS			
Current Liabilities			
Accounts payable			
Donor	12	15,057	7,742
Employees	13	885	719
Other CGIAR Centers		344	302
Other	14	917	1,399
Accruals	15	4,027	3,471
Total current liabilities		**21,230**	**13,633**
Non-Current Liabilities			
Accounts payable			
Employees	16	5,014	3,862
Total Non-current liabilities		**5,014**	**3,862**
TOTAL LIABILITIES		**26,244**	**17,495**
NET ASSETS			
Unrestricted			
Designated	17	12,168	12,168
Undesignated	17	8,196	6,595
		20,364	18,763
TOTAL LIABILITIES AND NET ASSETS		**46,608**	**36,258**

Statement of Activities

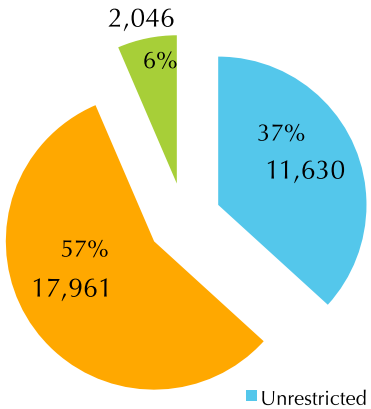
	Note	2009 Unrestricted	2009 Restricted Temporary	2009 Total	2008 Total
Revenue, Gains and other Support					
Grant Revenue	Exhibit 1, 1a & 1b	10,940	21,329	32,269	29,591
Other revenue and gains	18	2,981	-	2,981	2,046
Total Revenue and gains		13,921	21,329	35,250	31,637
Expenses and Losses					
Program related expenses	19	9,987	16,397	26,384	23,314
Management and general expenses		4,419	705	5,124	4,488
CGIAR Gender and Diversity program	Exhibit 4		4,227	4,227	2,751
Sub Total expenses and losses		14,406	21,329	35,735	30,553
Overhead cost recovery		(2,086)		(2,086)	(1,950)
Total expenses and losses		12,320	21,329	33,649	28,603
Net Surplus / (Deficit)		1,601	-	1,601	3,034
Expenses by Natural Classification					
Personnel cost		8,004	6,293	14,297	11,839
Supplies and Services		4,011	9,928	13,939	10,914
Collaborators/Partnerships		775	2,892	3,667	3,363
Operational Travel		1,107	1,946	3,053	3,471
Depreciation		509	270	779	966
Overhead cost recovery		(2,086)		(2,086)	(1,950)
Total		**12,320**	**21,329**	**33,649**	**28,603**

Income 2009 (in US $)



TOTAL: US$ 35,250

Income 2008 (in US $)



TOTAL: US$ 31,637

Board statement on risk management

> Risk mitigation strategies include implementation of systems of internal controls which, by their nature, are designed to manage rather than eliminate risks.
>
> Eric Tollens
> *Chair of the Board*

The Board of Trustees and Management of World Agroforestry have reviewed the implementation of the risk management framework during 2009 and the Board is satisfied with the progress made.

The Board of Trustees has responsibility for 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:

- misallocation of scientific efforts away from agreed priorities;
- loss of reputation for scientific excellence and integrity;
- business disruption and information system failure;
- liquidity problems;
- transaction processing failures;
- loss of assets, including information assets;
- failures to recruit, retain and effectively utilize qualified and experienced staff;
- failures in staff health and safety systems;
- failures in the execution of legal, fiduciary and Centre responsibilities;
- withdrawal or reduction of funding by donors due to the financial crisis;
- the CGIAR change management process may impact the centre negatively in terms of funding or non-prioritization of agroforestry in the mega programs and;
- subsidisation of the cost of projects funded from restricted grants and/or partial non-delivery of promised outputs, due to inadequate costing of restricted projects.

The Board has adopted a risk management policy that includes a framework by which the Centre's management identifies, evaluates and prioritises risks and opportunities across the organization; 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, System Office 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 organization. Key practices employed in managing risks and opportunities include business environmental scans, clear policies and accountabilities, transaction approval frameworks, financial and management reporting, and the monitoring of metrics designed to highlight positive or negative performance of individuals and business processes across a broad range of key performance areas. The design and effectiveness of the risk management system and internal controls is subject to ongoing review by the Centre's internal audit service, which is independent of the business units, and which reports on the results of its audits directly to the Director General and to the Board through its Audit 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.

Eric Tollens
Chair
Board of Trustees

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 current system comprises three main components:

- Results: comprising outputs, outcomes and impacts
- Potential to perform: consisting of quality and relevance of current research (publications), institutional health (governance, culture of learning and change and diversity) and financial health (short-term solvency, long-term financial stability and efficiency of operations)
- Stakeholder perception: a survey conducted every three years.

This PM System provides the Centres with a method to better understand their own performance and demonstrate accountability. In 2009, the World Agroforestry Centre was rated "Superior" based on the performance-linked measurements of the CGIAR. A summary of the results is given below.

Results for the World Agroforestry Centre

1. Composite measure of Centre research publications: 4.98

1A: Number of peer-reviewed publications per scientist in 2009 that are published in journals listed in Thomson Scientific/ISI: 1.00

1B: Number of externally peer-reviewed publications per scientist in 2009 (excluding articles published in journals listed in the Thomson Scientific/ISI): 2.00

1C: Relative rating of Centre's best publications regarding journal impact factor: 1.98

2. Percentage of scientific papers that are published with developing country partners in refereed journals, conference and workshop proceedings in 2009: 36.43

3. Science Council assessment of Centre outcome reports: 7.8

4. Composite indicator on Centre impact assessment culture: 81.3

INSTITUTIONAL HEALTH

Governance

5A: Summary score on governance checklist: 98.4

5B: Assessment of Board statements: 2.00

Culture of learning and change

5C: Summary score on culture learning and change checklist: 67.1

Diversity

5D: Percentage of women in management: 16.7

5E: IRS nationality concentration: first most prevalent nationality – USA, 10%; second most prevalent nationality – Belgium and UK, 7%

Financial health

6A: Long-term financial stability (adequacy of reserves): 165 days where the minimum benchmark is 75 days

6B: Cash management on restricted operations: 0.2 where the benchmark is less than 1.0

Selected publications

Books

Southeast Asia Network for Agroforestry Education (SEANAFE). 2010. Teaching forest policy analysis. A guide for forestry departments and university faculties in Southeast Asia. Principles, examples, and materials working document. Bogor: RECOFTC.

Galudra G, Sirait MT, Pasya G, Fay CC, Suyanto S, van Noordwijk M, Pradhan U. 2010. RaTA. A rapid land tenure assessment manual for identifying the nature of land tenure conflicts. Bogor: World Agroforestry Centre.

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Maimbo, MM, Oduor AR,Cherogony K, Nyolei D, Gachene C, Biamah EK, O'Neil M, Iiyama M, Mogoi, J. 2010. Rwanda irrigation master plan. Kigali: Ministry of Agriculture and Animal Resources (MINAGRI).

Journal articles

Abasse T, Weber JC, Katkore B, Boureima M, Larwanou M, Kalinganire A. 2010. Morphological variation in Balanites aegyptiaca fruits and seeds within and among parkland agroforests in eastern Niger. Agroforestry Systems, DOI: 10.1007/s10457-010-9323-x.

Achten WMJ, Maes WH, Aerts R, Verchot L, Trabucco A, Mathijs E, Singh VP, Muys B. 2010. Jatropha from global hype to local opportunity. Journal of Arid Environments 74.

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Akinnifesi FK, Sileshi GW, Ajayi OC, Akinnifesi AI, de Moura EG, Linhares JFP, Rodrigues I. 2010. Biodiversity of urban home gardens of Sao Luis city, northeastern Brazil. Urban Ecosystem 13.

Asaah EK, Tchoundjeu Z, Wanduku TN, van Damme P. 2010. Understanding structural roots system of the 5-year old African plum tree (D. edulis) of seed and vegetative origins (G. Don) H.J. Lam. Trees 24.

Asfaw S, Mithöfer D, Waibel H. 2010. Agrifood supply chain, private-sector standards, and farmers' health: evidence from Kenya. Agricultural Economics 41.

Asfaw S, Mithöfer D, Waibel H. 2010. What impacts are EU supermarket standards having on developing countries' export of high-value horticultural products? Evidence from Kenya. Journal of International Food & Agribusiness Marketing 22 (3).

Beedy TL, Snapp SS, Akinnifesi FK, Sileshi GW. 2010. Impact of Gliricidia sepium intercropping on soil organic matter fractions in a maize-based cropping system. Agriculture, Ecosystems and Environment 138.

Trees for Change

Pye-Smith C. 2010. *The fruits of success: a programme to domesticate West and Central Africa's wild fruit trees is raising incomes, improving health and stimulating the rural economy.* ICRAF Trees for Change no. 4. Nairobi: World Agroforestry Centre.

Pye-Smith C. 2010. *A window on a better world. An innovatiove agroforestry development programme is transforming lives and landscapes in rural Cameroon*. ICRAF Trees for Change no. 5. Nairobi: World Agroforestry Centre.

Pye-Smith C. 2010. *Les fruits du succès. Un programme visant à domestiquer les arbres fruitières sauvages en Afrique occidentale et centrale accroît les revenus de la population, lui assure une meilleure santé et stimule l'économie rurale*. ICRAF Les arbres pour le changement no. 4. Nairobi: World Agroforestry Centre.

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Pye-Smith C. 2010. *Fodder for a better future: how agroforestry is helping to transform the lives of smallholder dairy farmers in East Africa.* ICRAF Trees for Change no. 6. Nairobi: World Agroforestry Centre.

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For a comprehensive list of publications, visit our publications page: www.worldagroforestry.org/af/publications

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TRANSFORMING LIVES AND LANDSCAPES

WORLD AGROFORESTRY CENTRE

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