



World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

FALLING BY THE WAYSIDE

Improving the availability of high-quality tree seeds and seedlings would benefit hundreds of millions of small-scale farmers





The World Agroforestry Centre, an autonomous, non-profit research organization, aims to bring about a rural transformation in the developing world by encouraging and enabling smallholders to increase their use of trees in agricultural landscapes. This will help to improve food security, nutrition, income and health; provide shelter and energy; and lead to greater environmental sustainability.

We are one of the 15 centres of the Consultative Group on International Agricultural Research (CGIAR). Headquartered in Nairobi, Kenya, we operate six regional offices located in Brazil, Cameroon, India, Indonesia, Kenya and Malawi, and conduct research in 18 other countries around the developing world.

We receive funding from over 50 different investors. Our current top 10 investors are Canada, the European Union, Finland, Ireland, the Netherlands, Norway, Denmark, the United Kingdom, the United States of America and the World Bank.



A mango orchard at one of Kenya's prison farms.

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Foreword

In many parts of the world, agroforestry is transforming the lives of rural communities. Species such as rubber, cocoa, mango and teak are major cash crops. Nitrogen-fixing trees improve soil fertility; fodder trees improve milk yields; and trees provide fuelwood, fruits, fibre, medicines and much else. Agroforestry can also help farmers adapt to climate change and sequester carbon dioxide, one of the gases responsible for global warming.

However, agroforestry can only achieve its full potential if farmers have access to high-quality tree seeds and seedlings. The fact that so many lack such access amounts to a great scandal – one which has been largely ignored by governments and policymakers.

This booklet tells a story which deserves the widest possible audience. Every year, tens of millions of farmers in the developing world sow tree seeds and plant tree seedlings of poor and variable quality. It may take years before they realise that they have devoted space and energy to nurturing trees which will fail to provide the yields, income and other benefits they anticipated.

Over the past two decades, the World Agroforestry Centre (ICRAF) and Forest & Landscape Denmark (FLD, University of Copenhagen) have conducted research on tree seed and seedling supply systems around the world. Based on our experience, we have devised solutions which could dramatically improve the quality of planting material and the livelihoods of millions of farmers. These include the introduction of certification systems



Sorting oil-rich Allanblackia seeds in Tanzania – potentially a major new crop for African farmers.

appropriate to developing countries. We also believe that it is time to rethink the role of National Tree Seed Centres and introduce measures that enable the private sector to play a more prominent role in the sale and distribution of seeds and seedlings.

This is a complex and rather unglamorous subject, which may explain why it has received relatively little attention, and limited financial support, from organizations involved in development. Fortunately, there have been some notable exceptions. We are particularly grateful for the support provided for our research by the Danish International Development Agency (Danida), the International Fund for Agricultural Development (IFAD) and the World Bank.

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Introduction: Quality matters

A farmer decides to plant a variety of wheat or maize which he has never used before, tempted by the promise of high yields. He prepares his land, sows the crop and waits. Come harvest time, he is sorely disappointed: the variety he has chosen fails to prosper and the yields are poor. He sees this as a wasted year, but at least it is just one year. Next year, he will plant a different variety.

Now, just imagine he has planted the seeds or seedlings of fruit trees which failed to perform as he hoped. It wouldn't be a matter of waiting just one year, before shifting to a different variety. It could be eight or nine years before the farmer sees that he has chosen the wrong variety or planted seeds or seedlings of poor quality. That's eight or nine years wasted. This is precisely what is happening to tens of millions of farmers around the world: they are using sub-standard planting material and suffering as a result. In short, they are failing to realize the full potential of agroforestry.

The benefits of agroforestry

In many parts of the world, agroforestry – planting trees on farmland – is changing people's lives. The stories below give a glimpse of its transformative powers.

Mercy Nyoike, who farms a small patch of land on the flanks of Mt Kenya, used to get half a litre of milk a day from each of her goats. Now they provide her with

► *Mercy Nyoike is among the many livestock farmers in Kenya who grow fodder trees.*



Private nurseries play a vital role in providing farmers with high-quality tree seedlings in Kenya. Juja Tree Nursery, near Nairobi.



four times that much. That's partly because she has crossbred the local goats with a more productive breed. But she has also planted 'fodder trees', which are providing her goats with a rich source of protein. In the past, her family struggled to survive, but the fodder trees and the extra milk have made all the difference. "I've been able to pay school fees for my children and we've also earned enough to build a new house," she says proudly.

Nelson Mkwaila, a smallholder in southern Malawi, shudders when he recalls the time, around a decade ago, when he was having trouble feeding his family. Then he began to plant 'fertilizer trees' like *Gliricidia* in his fields. Before long, the soils improved and his maize yields increased. Later, he learnt how to graft high-yielding fruit trees. Now his fields are studded with guava, peach, apple, pawpaw and other fruit trees. His children's health has improved, thanks to a diet rich in vitamins, and his income has risen.

You will hear similar stories if you talk to farmers in Cameroon who have benefited, like Mrs Nyoike and Mr Mkwaila, from advice and training provided by the World Agroforestry Centre. Christophe Missé is one of many farmers who have learnt how to graft superior varieties of indigenous fruit trees. He has planted hundreds of African plums and established a commercial nursery which produces 7000 seedlings a year. "With the money I've made, I've built a new house, and I can now pay for two of my children to go to private school," he says.

In Asia and Latin America, as in Africa, farmers use the profits from agroforestry for much the same purposes. They improve their homesteads, invest in their land, take advantage of modern healthcare and ensure that their children get a decent education.

Over 1 billion hectares of farmland – representing 43% of the land used for agricultural purposes – now has more than 10% tree cover. These agroforestry systems are home to around 560 million people, or a third of those living on farmland. While the area under

forest continues to decline throughout the world, tree cover on farmland is increasing. To give just one example, remote sensing surveys of 64 different locations in Uganda found that the area of natural forest declined by 50% between 1960 and 1995, while the area of agricultural land with trees increased by 22%. A similar pattern of land-use change is being repeated across much of the world.

Agroforestry provides farmers with a range of benefits. Trees are important cash crops – think, for example, of rubber, cocoa, oil palm, mango, teak and some indigenous fruit trees – and provide many farmers with their main source of income. Nitrogen-fixing trees help to improve soil fertility and crop yields; fodder trees raise the productivity of domestic livestock. Trees grown on farms also provide farmers with timber and fuelwood, fruits and nuts, resins, medicines and shelter. Just as significantly, agroforestry helps farmers to spread risk, so that when a crop fails, or the market for a particular product plunges in value, they have other goods to use and sell.

► By planting nitrogen-fixing trees, farmers can improve soil fertility and crop yields.



However, the farmers whose stories are told at the beginning of this chapter are the fortunate ones. There are many millions of others who do not have access to high-quality tree seeds and seedlings. “In many parts of the developing world, farmers are forced to use poor-quality seeds and seedlings, and this means they’re not getting the most from their tree crops,” explains Ramni Jamnadass, global leader of the World Agroforestry Centre’s research programme on domestication and superior germplasm. “What farmers need is a system which provides high-quality planting material, at an affordable price, near where they live.”

This booklet focuses on Kenya, where the World Agroforestry Centre and Forest & Landscape Denmark (FLD) have conducted much of their research on tree seed and seedling supply systems, and to a lesser extent on Indonesia and Cameroon. However, the problems and challenges described in these countries are familiar to farmers throughout much of the developing world.

“In the end, it all comes down to one thing: how can we increase smallholder productivity?” says Jens-Peter Barnekow Lillesø, a seed systems specialist at FLD. “We must devise better and more efficient ways of getting high-quality tree seeds and seedlings to farmers. If we succeed, this will make a huge difference to tens of millions of people.”



Cokro Warsito grafting clonal rubber onto hardy rootstock at his nursery in Sumatra, Indonesia.

Chapter 1: A CHEQUERED HISTORY

Farmers near Meru, a small town to the north of Mt Kenya, are fortunate, as they don't have to go far if they're searching for high-quality tree seedlings. There are several nurseries in the area selling a wide range of species at competitive prices. One of the best is owned and managed by John and Janet Magaju.

"By the time I married my husband in 1985, he'd already set up a small nursery," recalls Mrs Magaju. "At first, he began planting wildings from the forest so that he could grow timber to build a house. Then some of the neighbours asked if they could buy his seedlings, and he began to develop the tree nursery."

The business expanded rapidly after the Magajus received training from the World Agroforestry Centre in grafting techniques and nursery management in 2000. "Before, we used to sell mango seedlings grown from seed for 5 KSh [US\$0.05] each," says Mrs Magaju. "Now we sell grafted mango for 100 KSh [US\$1]." Profits from the nursery have been used to build a smart one-storey house and pay school fees for five children. Every year, the nursery sells many thousands of fruit seedlings, as well as large quantities of *Calliandra* seedlings, a fodder shrub used by dairy farmers, and timber trees such as *Grevillea* and eucalyptus.

Janet Magaju and her husband have established a thriving nursery near Meru, on the flanks of Mt. Kenya.



▲ The Magajus have developed a reputation for providing high-quality material to farmers and gardeners.

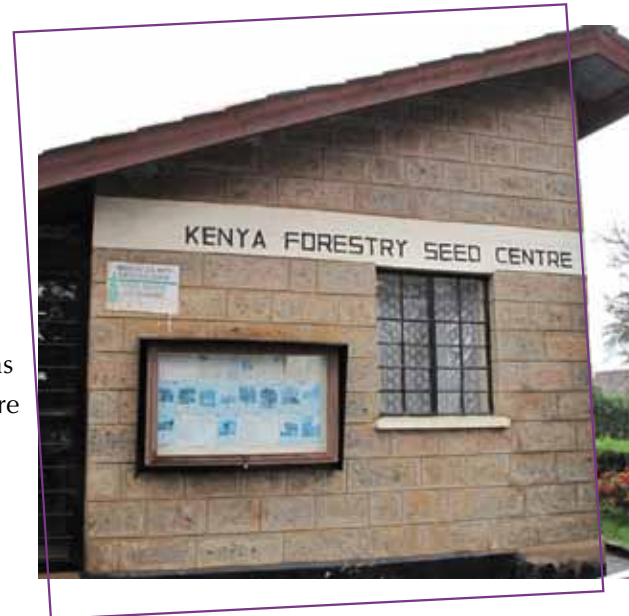
This is just one of approximately 2600 nurseries which provide tree seedlings for farmers around Mt Kenya. Some produce just a few hundred seedlings each year; others tens of thousands. But few are as well managed, or provide such high-quality material, as the Magajus' nursery.

“We found that 90% of the seed used by the nurseries around Mt Kenya comes from farmers' fields, and much of this is of poor quality,” explains Anne Mbora, a researcher with the World Agroforestry Centre. This is either because the seeds have been harvested from poor-quality trees, or because of the way the seed has been collected and stored. As a result, many farmers – probably the majority – are using sub-standard planting material. To understand why this has happened, we need to look at how the sector has developed over recent decades.

The role of the state

In the 1980s and 1990s, national tree seed centres were established in 21 African countries with support from the Danish International Development Agency (Danida) and other donors. “During the early years, we focused on providing high-quality exotic tree species, such as eucalyptus, to the Kenya Forestry Service,” says Peter Angaine, manager of the Kenya Forestry Seed Centre, “but gradually our role changed and we began to supply a range of agroforestry species to farmers.” However, here, as elsewhere in the developing world, the national seed centre failed to reach the vast majority of smallholders.

► *However well they are managed, most national tree seed centres are not meeting the needs of most smallholder farmers.*



Subsequently, donors and governments encouraged national tree seed centres to sell seeds and seedlings to sustain their businesses, rather than invest in seed-source development. “Once the national centres began focusing on making money from their operations, they cut down on providing advice and training and abandoned some of the less profitable activities,” says Lars Graudal, head of research at FLD. These included the maintenance of high-quality seed sources for many useful agroforestry trees.

Conserving or establishing seed sources should be a high priority in many parts of the tropics where nearly all the indigenous trees used in agroforestry are still wild. With the loss of biodiversity and the degradation of natural stands of forests the potential for domesticating and improving productivity of many indigenous agroforestry crops is declining.

Many of the national tree seed centres set up in Africa during the 1970s and 1980s no longer function or struggle to survive. Others, such as those in Kenya and Tanzania, continue to operate, with the profits from the sale of seeds supplementing reduced levels of government support. From a commercial point of view, these centres are often well managed. “If you look at the Tanzania Tree Seed Centre in Morogoro, it operates profitably and efficiently, supplying the public sector with tree seedlings,” says Lillesø. “However, it still probably only reaches about 10% of smallholder farmers – and that is a major drawback of centralized, government-controlled seed supply systems.”

Another drawback stems from the dual roles of these centres. Besides operating as commercial enterprises selling seeds, they also advise their governments on legislation related to the collection, sale and distribution of tree seeds and seedlings. According to Lillesø, this can lead to a conflict of interests. “The centres may support and promote legislation which benefits their own businesses and hinders the development of the private sector,” he says.

Uncivil society?

Many non-governmental organizations (NGOs) are also operating in a way which undermines private nurseries and encourages the distribution of poor-quality planting material.

During recent years, Mbora has been involved in training sessions held at the Kenya Forestry Research Institute (KEFRI) in Meru. Here, farmers' leaders learn about every aspect of seed collection and nursery management; afterwards they transmit this new-found knowledge to members of their groups. Many complain that even if they are producing high-quality seedlings, they frequently have problems finding a market. Take, for example, the experience of Simon Maingi, a farmer and forest guard. Following training in Meru in 2010, he established his own nursery, where he raises seedlings of *Grevillea robusta*, *Vitex keniensis* (Meru oak) and *Prunus africana*. "I still have thousands of unsold seedlings, and they grow bigger all the time," he says.

One of the reasons why he is failing to sell his seedlings is because he is being out-competed, unfairly in his view, by nurseries run by NGOs. Scientists working for the World Agroforestry Centre have found this to be a common problem. "Many of these NGO-established nurseries are distributing seedlings at very low, subsidized cost, or free of charge, and this undermines the private nurseries," explains Mbora.

This is a familiar problem throughout much of the developing world. However, this is not just a marketing issue. "The vast majority of NGOs pay little attention to the issue of quality," says Lillesø, reflecting on his experience in East Africa. "They think in terms of distributing 50,000 or 100,000 trees – not 50,000 or 100,000 *high-quality* trees." As a



▲ A private, roadside nursery near Nanyuki, Kenya.

result, most farmers continue to rely on planting material raised from seed which has been haphazardly harvested by unregistered and untrained collectors. The result: poor yields – whether of fruit, timber or other tree products – and meagre profits. (See Box 1: The quality issue)

The lack of quality control

If agroforestry is to flourish in developing countries, there needs to be a system of certification that promotes the use of the best planting material and enables farmers to judge the quality of seeds and seedlings they buy. At present, Kenya Forestry Seed Centre, like several other national tree seed centres in Africa, uses a certification scheme devised by the Organization for Economic Cooperation and Development (OECD). The 'Forest Seed and Plant Scheme' was designed to ensure the availability of high-quality seeds for industrial plantations in developed countries. According to researchers at FLD, the system is inadequate when it comes to certifying tree seeds in countries like Kenya.

"The OECD system presupposes that there is an agency which controls all the seed sources, and the distribution of seed, within a country," says Gaudal. "But national tree seed centres supply no more than 10% of the tree seeds used by smallholder farmers." Furthermore, the OECD certification system was designed for temperate species which have undergone rigorous field tests. Such tests have not been conducted for indigenous species in Africa.

Gaudal believes that a workable certification scheme, guaranteeing the collection and delivery of high-quality tree planting material, should recognize where the germplasm comes from – plantations, farmland, natural forests, seed orchards (established specifically for seed production), or from vegetative propagation – and specify the appropriate systems of collection and distribution. "There need to be realistic and acceptable certification schemes that support market development and the provision of good-quality material, without unduly hindering the trade," says Gaudal. We return to the subject of certification in the final chapter.

Box 1: The quality issue

The quality of tree seeds depends on their physiological properties, which are influenced by the seeds' maturity at the time of harvesting, the way they are stored and their genetic composition.

Many national tree seed centres claim that they are the only ones who can supply seeds of good physiological quality, as they have the necessary cold storage and testing facilities. However, research by Jonathan Muriuki of the World Agroforestry Centre found that seed provided by national tree seed centres was no better, physiologically, than seed harvested and distributed by farmers outside the formal system.

"This suggests that a decentralized seed distribution system – where material is stored at ambient temperature and tested in small nurseries – is just as capable of providing good-quality seed, in terms of its germination qualities, as a centralized system," says Jens-Peter Barnekow Lillesø of FLD.

The way seeds are harvested affects genetic composition. "Unless there is a wide genetic base, trees are vulnerable to inbreeding depression," explains plant geneticist Ian Dawson. This can significantly reduce their productivity. It is recommended that collectors gather seeds from 30 or more different trees of the same species within any one area, but this frequently doesn't happen.

If collectors follow these recommendations, they will end up with large quantities of seeds. This only makes commercial sense if they can sell the seeds. This means that collection and sale of seeds must be coordinated. National tree seed centres have a key role to play in supporting collection and distribution networks. The centres could also map the recommended areas for planting for all the seed sources in a country and provide information on handling and storage.



In Indonesia, rubber farmers need the best-quality seedlings if they are to prosper.

Chapter 2: THE IMPORTANCE OF ENTREPRENEURS

The Indonesian province of Aceh has had more than its share of suffering. By the time its coastal towns and villages were devastated by a tsunami in 2004, its people had already endured three decades of civil war. During this period it profited little from activities which were helping villagers in other parts of Indonesia to increase their crop yields and incomes. There were few tree nurseries and individuals and organizations had to travel through dangerous territory to get hold of improved varieties of rubber and cocoa. Most farmers continued to use low-yielding local varieties.

The tsunami, which killed some 200,000 people, hastened the end of the civil war, which was concluded with a Peace Agreement. Two years after the tsunami, the World Agroforestry Centre launched the 'nurseries of excellence' (NOEL) programme with the support of the Canadian International Development Agency (CIDA). Its aim was to help farmers establish nurseries of high-quality clonal rubber, cocoa, timber and fruit seedlings. "We saw this as the best way of improving agroforestry in the affected areas," says James Roshetko of the World Agroforestry Centre and Winrock International.

Fifty-six nurseries were established between 2007 and 2009. Of these, 24 were 'spontaneous', set up by farmers who had been impressed by the activities they had observed from a distance. Field staff from the World Agroforestry Centre, led by Roshetko and Pratiknyo Purnomosidhi, conducted intensive training sessions at the nurseries. "We needed a lot of input," recalls Usman, a rubber farmer in Rimbong village. "We'd never had any nurseries in this area before, so everything was new to us."

► Pratiknyo Purnomosidhi of the World Agroforestry Centre discussing rubber issues with a local farmer in Aceh.



The 'Nurseries of excellence programme' managed by the World Agroforestry Centre has helped farmers in Aceh, Indonesia, to establish nurseries of high-quality seedlings.

Some farmers also benefited from study tours to other parts of Sumatra, where rubber farmers have more than doubled their yields during recent years. Prior to the tsunami, average rubber yields in Aceh were a meagre 800–1200 kilograms per hectare per year. Once the produce of the NOEL nurseries reaches maturity, many of Aceh’s farmers will have much more rubber to sell than they had in the past.

Research suggests that there are three factors which determine the success of tree nurseries in Indonesia. First, farmers need access to good-quality planting material. Second, nurseries only succeed if those managing them receive comprehensive training with frequent follow-up visits. Third, nurseries which want to operate commercially must have good access to the market. In Aceh, the World Agroforestry Centre has supplied nurseries with high-quality clones and provided training. There is also a high demand for seedlings, as government departments are currently undertaking a massive reforestation and rehabilitation programme.

Roshetko and Pratiknyo have studied the evolution of the nurseries established under the NOEL project. Approximately three-quarters of the farmers’ groups were primarily interested in producing seedlings for their own land, and once they had done this, they no longer remained active within their nurseries. As Usman puts it, “The desire to work together tended to diminish with time.” His nursery originally had nine members; now just three operate on a semi-independent basis. Indeed, this seems to be the pattern: group nurseries last for a few years, to be superseded by private nurseries, many of which are now flourishing. Much the same has happened in East Africa.

The success of group nurseries depends to a considerable extent on good relationships between members. However, when groups disband, this is not necessarily a sign of failure. Indeed, it may indicate success: the farmers have improved their skills in groups, but now choose to operate alone. Furthermore, smallholder farmers are often busy, and they may leave groups simply to focus on other priorities, not because they are dissatisfied with the group activities. Farmers who remain within groups, or privatize a former group nursery, tend to be those who have an interest in selling seedlings to the market on a commercial basis.

The Kenyan experience

For over a decade, Jonathan Muriuki has been involved in research on nursery development in Kenya. During the early years of research, Muriuki and his colleagues helped farmers’ groups set up small nurseries near Nairobi and further north, around Meru. Most were not a success. They tended to produce low-quality seedlings and were poorly managed. Partly because of this, and partly because the nurseries were not the main activity for many farmers’ groups, most didn’t last long. “However, we noticed that when these group nurseries got into the hands of individuals who wished to establish their own nursery businesses, they were much better managed,” recalls Muriuki.

The experience around Meru is instructive. Between 1997 and 2004, the World Agroforestry Centre worked with 62 nurseries, 35 of which were run by groups and 27 of which were private. By 2006, just two group nurseries remained, whereas 22 private nurseries were still functioning. Ten of these – including the one run by Mr and Mrs Magaju – have been very successful. A similar story can be told for the nurseries in and around Nairobi. As a result, the World Agroforestry Centre decided to focus its research and development on the private sector.

As in Aceh, nearly all the successful private nurseries in Kenya have benefited from intensive training, provided by the World Agroforestry Centre, its local partners or other organizations. As the nurseries have developed, most have tended to specialise in the most profitable species. This is understandable: *Grevillea* and eucalyptus make up 90% of the seedlings bought by farmers around Mt Kenya; the other 10% comprise some 80 species, many of them indigenous.



▲ Nurserymen such as these, in Laikipia, Kenya, have received training in the best methods of wild seed collection. However, they are the exception, rather than the rule.

Unfortunately, the relatively low demand for many indigenous trees means there is little incentive for nursery owners or seed collectors to abide by the guideline of gathering seeds from 30 high-quality mother trees. (See Box 1: The quality issue) Most continue to buy seeds from untrained collectors who are operating ‘informally’.



▲ Juja Tree Nursery, near Nairobi

Attempts by the World Agroforestry Centre to provide training for these collectors have largely failed. “It’s difficult for us to reach them, because they’re operating without a licence from the Kenya Forestry Seed Centre, which officially they require,” says Muriuki. “We would like to see these collectors being given more recognition – then it would be easier to work with them.”

The lack of improved seed orchards is also preventing many nurseries from acquiring and producing high-quality planting material. “There’s limited incentive for private businesses to invest in seed orchards for the smallholder sector, partly because it takes a long time to establish them and considerable effort to manage and protect them, and partly because genetic quality is insufficiently appreciated in the smallholder sector,” says Lillesø. As far as public-sector organizations are concerned, they simply don’t have the money to set up a network of seed orchards.

Of course, there would be a greater incentive for the private sector to get involved if there was an increase in demand for high-quality seeds from smallholders. The World Agroforestry Centre, FLD and the Kenya Forestry Seed Centre recently launched an interactive website whose aim is to provide knowledge on seed sources to potential customers. This, it is hoped, will help individuals and organizations to find high-quality planting material and stimulate the sale of seeds.

Governments in East Africa have shown little enthusiasm for supporting the small-scale, private-sector seed and nursery enterprises. A survey in Malawi identified 600 small-scale nurseries, most set up by NGOs. Of these, approximately half were run by groups, and half were individually owned. The government provided only limited, technical support to nurseries, while NGOs provided significant support to group nurseries and little to those which were individually owned. Lillesø describes the latter as belonging to “a neglected parallel system – undervalued and underfunded.”

The power of association

Some 20 years ago, the World Agroforestry Centre and its partners in East Africa began research on fodder trees. By 2006, over 205,000 smallholders were growing fodder trees as a source of protein for their dairy animals, significantly increasing milk yields and incomes. This research is described in another *Trees for Change* booklet – ‘Fodder for a Better Future’ – but elements of the story are relevant here.

Between 2005 and 2007, a communication process known as SCALE (System-wide Collaborative Action for Livelihoods and the Environment) revolutionised the way fodder trees were promoted. As a result, demand for seeds soared. The World Agroforestry Centre and its partners did their utmost to get commercial seed companies involved in tree seed production and sale. However, the companies considered the returns from the sale of perennial seeds – which farmers do not have to buy on an annual basis – too low to justify setting up a new line of business.

Nevertheless, a private seed sector began to emerge. This became increasingly influential after the formation of the Kenya Association of Tree Seed and Nursery Operators (KATRESNO).



▲ Julius Kangee, chairman of the Dairy Goat Association of Kenya, harvests seeds of the fodder tree *Trichandra* to sell to other farmers.

“The emergence of KATRESNO had a tremendous impact on the tree seed supply system in Kenya, and this quickly translated into more farmers using fodder trees,” says Charles Wambugu. Over an 11-month period, 47 seed dealers belonging to the Association sold over 3.8 tonnes of seeds, enough to supply over 38 million trees to around 120,000 farmers.

Although this trade is not subject to any certification system, the dealers have received training from the World Agroforestry Centre, the Kenya Forestry Seed Centre and other organizations, ensuring that they are well versed in the measures required to produce and distribute good-quality seeds and seedlings. The members of the association have good links to the market through research and extension systems within and outside Kenya. They have been able to import fodder-shrub seed from Uganda, Tanzania and Ethiopia, and export fodder-shrub seeds to Madagascar and Japan.

The World Agroforestry Centre also encouraged nursery owners in Nairobi and Meru to set up tree nursery network associations. An association in Nairobi, created in 2003, initially had 30 member nurseries. Subsequently, it split into three separate groups. These have provided many benefits, according to Samuel Njenga Kimani, who runs Juja Tree Nursery and acts as project manager for one of the associations. (See Box 2: Training matters) “We meet once a month, and we share knowledge and information,” he says. “I think this has helped to improve our businesses.” Muriuki agrees. “The associations have helped to make nursery owners less dependent on our advice and support,” he says, “and they’ve also improved the quality of the material they sell.”

Elsewhere, the World Agroforestry Centre and its partners were closely involved with a particularly successful association in the Philippines. Established by smallholder farmers in Mindanao, the Agroforestry Tree Seeds Association of Lantapan (ATSAL) received training on how to collect, process and market agroforestry tree seeds and seedlings. Subsequently, the association provided training to NGOs, local government departments, farmers and students on all aspects of seed production and nursery management. Before long, ATSAL informally created its own brand of products, which it was able to sell throughout the Philippines.



How it should be done: Kaguru Research Nursery, near Meru, is run by the World Agroforestry Centre.

Box 2: Training matters

In 1990, Samuel Kimani noticed that some of the fruit which he threw on the waste dump behind his grocer's shop had germinated. Initially, he gave the seedlings to customers, but soon he recognized a business opportunity: he began to put them in pots and sell them. Before long, he had developed a small nursery, but he was much troubled by theft. He sold his shop and rented a patch of land on the road between Nairobi and Thika. Here he and his wife established Juja Tree Nursery.

In 2002, the World Agroforestry Centre invited him to a workshop, where he learnt about nursery management. "After that, my business really took off," he recalls. "I began to do so many things differently. I learned how to get hold of the best seeds, how to improve the quality of my seedlings and how to graft fruit trees." At any one time there are 50,000 seedlings of some 70 species in the nursery and he employs 15 full-time staff.

The secret of success? "He's benefited from all the training he's had and his interactions with other nursery owners," says Sammy Carsan of the World Agroforestry Centre. "He's a very good manager, very dedicated and very enterprising, and he provides his customers with high-quality material at a price they can afford."



Juja Tree Nursery, on the road between Nairobi and Thika, is a significant employer of local labour.

Chapter 3: KENYA'S MANGOES – A MISSED OPPORTUNITY?

If you buy mango juice in a Kenyan supermarket, there's a good chance it will come from another country, despite the fact that Kenya has the ideal environment for growing many commercially desirable varieties. Indeed, Kenya could be a major exporter of mangoes, which could provide a significant source of income for tens of thousands of Kenyan farmers. However, lack of investment, lack of research and extension and the centralized fruit tree nursery systems are conspiring against the widespread adoption of high-yielding varieties.

Had it not been for a German development worker, Jürgen Griesbach, there would be fewer varieties of mango in Kenya. During the 1970s, Griesbach introduced dozens of improved exotic varieties, gathered during his travels in the Philippines, the United States and elsewhere. He established orchards and nurseries on prison farms, which had a plentiful supply of land and free labour. Later, the same varieties, and a few that were introduced afterwards, were raised at the stations managed by the Kenya Agricultural Research Institute (KARI). The nurseries of KARI and the prison farms now provide some of the best available seedlings.

"It is largely because of Griesbach's work that improved varieties of mango are now widely grown in Kenya," says Katja Kehlenbeck, a scientist with the World Agroforestry Centre, "but their



Nurseries run by the Kenya Agricultural Research Institute (KARI) provide some of the best available seedlings – but they could do more.

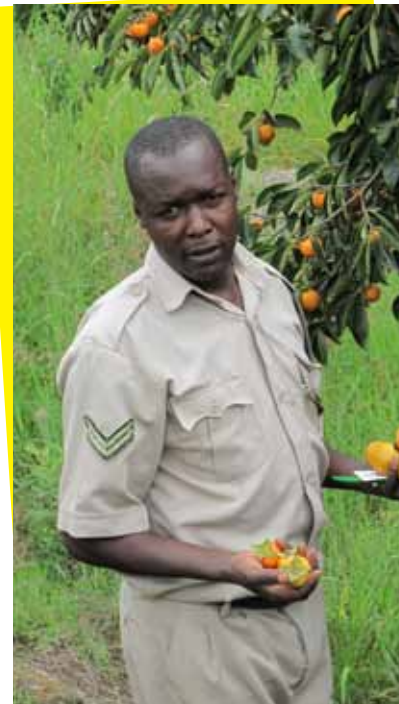
full potential has yet to be realized.” Indeed, many of the new varieties are virtually unknown in the coastal regions and in Western Kenya.

In 2010, Kehlenbeck and her colleague Emanuela Rohde conducted a mango variety survey, focusing on three KARI stations, five prison farms and some private farms. They found 50 varieties, and were struck by the remarkable lack of documented agronomic knowledge about most of these. Since the orchards were established in the 1970s, there has been no systematic research on the mangoes, or any attempt to develop new varieties, for example to find early- or late-bearing varieties which produce fruits outside the major harvesting season, during which half of the country’s crop goes to waste because of over-supply.

At KARI’s Thika research station in Central Kenya, the scientists identified 36 varieties in the mango mother block, but only five – the local varieties Apple and Ngowe, and the exotic varieties Kent, Van Dyke and Tommy Atkins – were being produced in significant quantities. The others were simply being ‘maintained.’ No records have been kept about their performance, their tolerance to pests and diseases or how to manage different varieties. As a result, farmers are not supplied with the most suitable planting material.

The prison nurseries also sell half a dozen varieties, but there is no incentive for them to produce large numbers of grafted mango seedlings or to improve their fruit and scion production through better management of the mother trees in their orchards. The money the nurseries make from selling grafted mango seedlings goes to prison headquarters, which is in no hurry to release the funds needed to buy fertilizers, pesticides, poly bags and other essential material for a good nursery. “When you take these difficulties into consideration, it’s surprising that the mango seedlings produced here are of such good quality,” says Rohde.

► *Prison farms have played a key role in making high-quality mango seedlings available to Kenya’s farmers. George Ojambra, nursery manager at Kamiti Prison, with persimmon fruit.*



Setting priorities

With the strong market demand for mangoes, there is a real incentive to develop new high-yielding varieties in Kenya and make them available to farmers, but that simply isn’t happening. “Much is known about mango biology and reproduction, and methods of propagation, yet little is being done to develop improved varieties,” says Ramni Jamnadass. And if mango is so neglected in Kenya, she says, what hope is there of developing improved varieties of other, less commercially valuable indigenous species like baobab, *Ziziphus* and tamarind? These, too, could improve the nutrition and incomes of smallholders in Kenya, particularly in the country’s drought-prone drylands. However, this won’t happen without a significant investment in new research.

At present, farmers in Central and Eastern Kenya can buy grafted mango seedlings of reasonable quality, though the choice of varieties is limited, from the prison farms and KARI. Farmers can also get good seedlings from 200 or so certified private nurseries. However, there are thousands of uncertified nurseries where there is no quality assurance, and in the more remote rural areas and in Western and coastal Kenya it is almost impossible for farmers to get grafted mango seedlings.

“I believe we could make mango serve as a model for other species by exploring the best ways of getting high-quality seedlings of the appropriate varieties to smallholders, especially those living in remote areas,” says Kehlenbeck.



► *More could be done to increase the variety of mango seedlings available to farmers in East Africa.*

There is an urgent need for long-term research to establish which varieties grow best in different agro-ecological zones. Kehlenbeck suggests that scientists need to monitor the performance and health of at least 20 varieties over a ten-year period in the potential mango-growing zones. She also believes that a network of farmer-managed rural resource centres with fruit tree nurseries, similar to those described in the next chapter, could play

a major role in developing high-quality fruit production, and alleviating poverty, in remote areas.

“Farmers in Kenya, and elsewhere in Africa, could also benefit from the introduction of new cultivars, already developed in other parts of the world,” says Ian Dawson, an Associate Scientist with the World Agroforestry Centre. “Our research suggests that a ‘south-south’ transfer could help to improve the planting material available to farmers in Africa and elsewhere, assuming the question of local delivery to farmers is addressed.”

The World Agroforestry Centre has been closely involved with the introduction to Africa of improved Asians cultivars of the fruit tree *Ziziphus mauritiana*, known as ber in English. *Ziziphus* is a native of both



◀ The introduction of Asian varieties of *Ziziphus mauritiana* to Africa's Sahelian region has helped to increase fruit yields.

sub-Saharan Africa and several countries in Asia. In the 1990s, cultivars from India and Thailand were brought to the Sahel, where their performance was compared with that of local varieties. The Asian cultivars flower and fruit just six months after grafting, compared to two to three years for local varieties. They also produce fruits which are 10 times the size of local types.

Undertaking the international exchange of plant material is a complicated procedure, and introduced varieties need to be tested against local varieties. This can be time-consuming and expensive. However, there is considerable potential for the south-south transfer of fruits such as mango, guava, tamarind, pomegranate, papaya, custard apple and jackfruit.

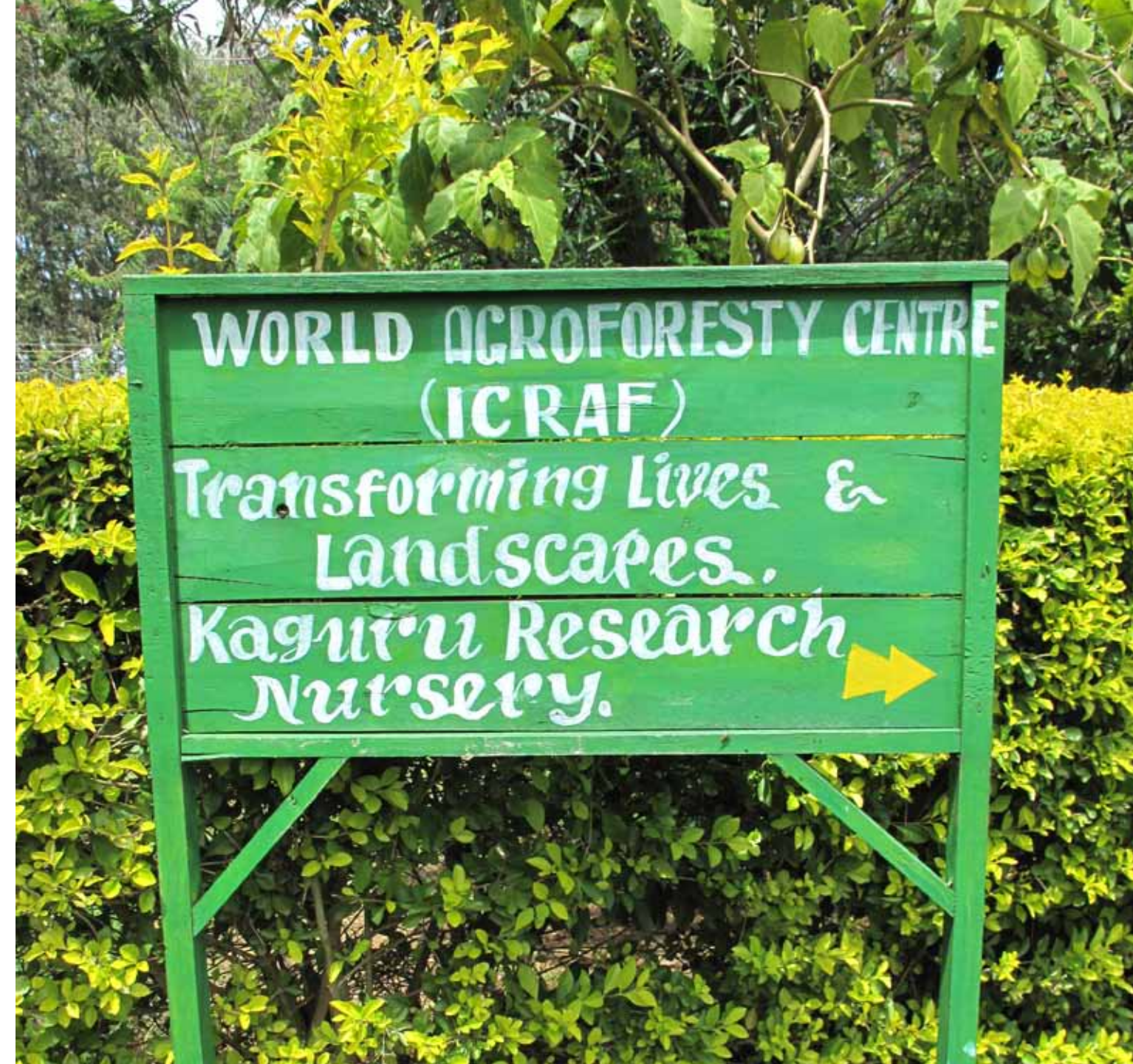
Box 3: The right tree in the right place

“Over much of Africa, farmers are planting tree seeds which aren’t adapted to their land and climate,” says FLD’s Jens-Peter Barnekow Lillesø. “You can’t just collect seeds from one place and expect to use them successfully in another, but that’s what happens for most agroforestry species.”

Ideally, scientists would establish whether a particular species will thrive in a particular area by planting it there and seeing what happens, but with over 80,000 tree species in the world this simply isn’t possible. However, FLD and the World Agroforestry Centre have come up with an alternative.

The Vegetation and Climate Change in East Africa (VECEA) project combined detailed vegetation maps drawn up by surveyors during colonial times with current knowledge about the flora in seven countries. “It wasn’t just a question of finding old maps, but finding old botanists too,” recalls Roeland Kindt, an ecologist at the World Agroforestry Centre. Once the maps had been digitized, the botanists populated them with tree species.

The maps enable farmers, tree seed centres and NGOs 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 has conducted a similar exercise for the entire continent, using an overlay on Google Earth.



Chapter 4: CENTRES OF EXCELLENCE

In 1998, scientists from the World Agroforestry Centre suggested to a small group of farmers in Njinikejem, in Cameroon's Northwest Region, that their modest tree nursery should be transformed into an enterprise which was larger in both scale and ambition.

"We were impressed by what they'd been doing," says tree scientist Ebenezer Asaah, "and we were keen to expand our tree domestication activities." Over the past decade, Asaah and his colleagues at the World Agroforestry Centre had developed superior varieties of indigenous fruit trees with the attributes farmers wanted: large, sweet fruit, grown on trees that mature quickly. Now it was time to make these varieties widely available to farmers.

The farmers' group in Njinikejem agreed to transform their nursery into a rural resource centre. Similar enterprises – there are now more than 15 rural resource centres in Cameroon – were established in other parts of the country. "The rural resource centres make science available to tens of thousands of people who live off the land," says Kuh Emmanuel, the coordinator of the Twantoh Mixed Farming Common Initiative Group (MIFACIG), the centre in Njinikejem.

Science for all

MIFACIG is beautifully laid out on a gently sloping hillside, with offices, a training hall, accommodation for visitors, orchards, vegetable gardens and tree nurseries. Farmers come here to receive training on a range of topics, from agroforestry to beekeeping, enhancing soil fertility to rearing pigs. In the meantime, scientists continue to work on the domestication of indigenous fruit trees.

► Bush mango seedlings for sale at a rural resource centre.



Thaddeus Salah is the leader of a farmers' group which runs a satellite nursery associated with one of Cameroon's most successful rural resource centres.

Once the centre was established, the number of farmers who wanted to get involved swiftly rose from around a dozen to over 40. Indeed, such was the demand for training that the decision was taken to establish satellite nurseries in the surrounding countryside. By 2009, there were 35 of these, serving over 2500 farmers. MIFACIG and the satellite nurseries are now serious commercial enterprises, as well as training and research centres.

The rural resource centres in Cameroon have been central to the success of Cameroon's Agricultural and Tree Products Program, which is managed by the World Agroforestry Centre. They have acted as hubs of information, providing farmers with new skills and knowledge, as well as high-quality seedlings. This has led to a significant increase in rural incomes and better land management.

Seeds of hope

Rural resource centres have also played a key role in developing what could become one of Africa's most valuable crops. Allanblackia, a tree whose range stretches from Liberia to Tanzania, has been used by villagers for centuries as a source of cooking oil and timber. However, it wasn't until the early years of this century that its true value was recognized. In 2000, Unilever discovered that Allanblackia oil has properties ideally suited to the manufacture of white spreads like margarine. The potential demand was huge, but there was a problem: there were nowhere near enough trees in the wild to satisfy demand.



▲ Allanblackia seeds being sorted at a collection centre in Tanzania.

A public-private partnership, the Novella Project, addressed this challenge by launching a multi-country tree domestication programme, initially focusing on Tanzania and Ghana. "Rural resource centres have played a very important role in the Allanblackia domestication programme," says scientist Daniel Ofori. "The centres act as nurseries and demonstration plots, where farmers can learn about the importance of using good-quality seedlings." This story, like that of the rural resource centres in Cameroon, has been told at length in another Trees for Change booklet.

Ramni Jamnadass believes that rural resource centres provide one model for the future. "My dream is that there should be a network of mother blocks with high-quality material and sufficient diversity across the country, so that even farmers in remote areas will have access to high-quality seeds and seedlings," she says.



► The researchers discovered that keeping Allanblackia seeds in black plastic bags encourages quicker germination.

Chapter 5: PLANNING FOR THE FUTURE

Jamnadass approvingly quotes a Welsh proverb, “A seed hidden in the heart of an apple is an orchard invisible.” And the quality of the orchard depends on the quality of the seed.

In many developing countries the existing systems for collecting and distributing tree seeds and seedlings have failed to provide smallholders with high-quality planting material. At the same time, the activities of some government agencies and NGOs have undermined the development of the private sector. What is needed, say scientists from the World Agroforestry Centre and FLD, is a commercially-oriented, decentralized system which provides farmers, even in remote areas, with high-quality seeds and seedlings at an affordable price.

A new certification system

The OECD certification system has proved unworkable in most developing countries, even though some have chosen to use it. Despite its good intentions, it has tended to be a barrier to developing and distributing high-quality seeds, rather than an instrument to promote the use of high-quality seeds and protect users from inferior germplasm.

FLD has proposed a classification scheme which reflects the different types of seeds sources used by farmers. In Kenya, for example, there are five different sources of planting material. These are farmland, where most seeds are currently collected, natural forests, seed orchards, plantations and places which provide material for vegetative propagation, such as cuttings for fruit trees. “For each of these sources there is an appropriate

▶ *Clonal eucalyptus seedlings in the nurseries of the Tree Biotechnology Programme Trust, Nairobi.*



Esther Gama with sweet granadilla, a fruit rich in vitamins, in Chiweshe, Zimbabwe.

system of collection and distribution, and it would be easy to set up rules for each,” says Lillesø. Not only would such a system provide a better guarantee of quality than the OECD certification system, it would encourage the participation of decentralized producers and distributors.

Rethinking the role of the state and civil society

Most national tree seed centres in the developing world have two roles: they operate commercially, selling seeds; and they advise government on legal aspects of seed supply. This creates a conflict of interest, as there is a danger that they will favour legislation which furthers their own commercial ends and discriminates against private-sector entrepreneurs.

National tree seed centres should become knowledge brokers, providing technical information to entrepreneurs and producers about every aspect of seed quality, production and procurement. They should play a prominent role in training nursery owners, seed collectors and others involved in seeds and seedlings supply. Governments also need to introduce affordable licensing systems which encourage the participation of small-scale collectors. At present, the high cost of licences acts as a deterrent and encourages many collectors to operate outside the law.

With relatively little effort, national tree seed centres could identify seed sources for immediate use that would improve the quality of seed available to smallholder farmers, and they could provide advice on establishing seed sources. The centres could also promote efficient distribution systems which link seed sellers to smallholders requiring better quality seeds. This will require efficient collaboration between the public and private sectors to ensure adequate returns on investments.



▲ A stand of forest managed as a seed orchard near Meru, Kenya.

Small-scale entrepreneurs are already important producers and distributors of high-quality seeds and seedlings in Kenya, Indonesia and the Philippines. They could play an even more prominent part in promoting high standards of agroforestry if disincentives – such as unfair competition from NGOs – were removed. NGOs should be encouraged to support the private sector, for example by providing business training to seed dealers and nurseries, and by buying seedlings from entrepreneurs. They should be discouraged from establishing and running their own nurseries and providing free or low-cost – and frequently poor quality – planting materials to farmers.

Farmers are reluctant to invest in high-quality planting material, such as grafted fruit seedlings, if they cannot see a market for their produce. Many NGOs have developed an interest in linking smallholders to markets, and they could play an important role here by helping to establish value chains for agroforestry products such as fresh fruits, nuts and oils.

The role of research

The measures described above – the introduction of a certification system appropriate to developing countries and new roles for the state, NGOs and entrepreneurs – will help to create a more sustainable, quality-assured distribution system. However, these reforms need to be accompanied by further research.

Our understanding of the factors which contribute to the success of seeds and seedlings systems remains partial. To give just one example, researchers at the World Agroforestry Centre and FLD assume that a



▶ Inside the Kenya Forestry Seed Centre.

number of factors influence the performance of nurseries. These include information about quality, access to good seed sources of a range of species, business knowledge about how to run a nursery, and knowledge about markets.

But which of these matters most? Indeed, are they all important? To answer these questions, scientists will need to take a large sample of nurseries – such as those around Mt Kenya or in the Indonesian provinces where Roshetko and his colleagues have been working – and provide them with different combinations of the various factors mentioned above. “At present, most nurseries are simply selling enough seeds to survive, and paying little attention to quality,” says Lillesø. “If we’re going to create an efficient, decentralized seeds and seedlings system, then we need to gain a much better understanding of precisely what is needed to create the best nurseries.”

The challenges facing agroforestry seed and seedlings systems are similar to those for crop-seed systems. In Africa, the Alliance for a Green Revolution in Africa (AGRA) has invested heavily in its Programme for Africa’s Seeds Systems (PASS). The primary objective of this US\$150 million initiative is to increase Africa’s capacity to breed, produce and disseminate high-quality seed of staple food crops such as maize, rice, cassava, sorghum and millet, and deliver new crop varieties to smallholders in an efficient and sustainable way.

“This is precisely the sort of investment needed to improve agroforestry planting material,” suggests Ramni Jamnadass. Without significant investment, we are unlikely to see a dramatic increase in the breeding, production and dissemination of high-quality seeds and seedlings of the many agroforestry species that have the potential to improve the livelihoods and incomes of smallholder farmers throughout the tropics.

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