2018 VOL 12 ISSUE 1

current conservation

The Critical Role of Agroforestry in Forest and Landscape Restoration

Authors: ***Rhett Harrison*** *and* ***Andrew Miccolis*** · *Illustrator:* ***Chaaya Prabhat***

Land degradation and poverty

Land degradation is one of the most conspicuous symptoms of planetary abuse. Picture a desolate expanse of bare soil and sparse struggling vegetation, or a naked slope gouged with raw gullies, or a forest smothered under a shroud of vines. The ecological integrity of these lands has been damaged through human mistreatment to such an extent that its capacity to support agriculture and supply ecosystem services has been completely undermined. The scale of land degradation is staggering. Globally there are over 2 billion hectares – an area equivalent to Mexico, USA and Canada combined – impacting an estimated 1 billion people, predominantly in the Global South. In sub-Saharan Africa, FAO has calculated that as much as 65% of arable land and 30% of grazing land are degraded. Meanwhile, to meet the demands of growing populations and increased affluence, global food production needs to increase by 70% or more by 2030.

Poverty and land degradation are intricately intertwined, as farmers without alternatives attempt to eke out an existence in fragile environments, often having to contend with poor soils, erratic rainfall, and inequitable and limited access to resources. Land degradation reduces agricultural yields and incomes, increases the vulnerability of rural populations to climate and economic shocks, and fuels involuntary migration, social and political marginalisation, and conflict. Moreover, in an attempt to supplement meager incomes, poor farmers invade forests to clear more land or to cut trees for timber and charcoal. Thus, poverty and land degradation are also major causes of deforestation, and hence important drivers of the global climate change and biodiversity crises.

Political momentum for forest and landscape restoration (FLR) was borne out of a recognition that to maintain global temperature rise at or below 2°C, we need to restore 300-400 million hectares (Mha) of forest by 2050. And, to achieve this, we simultaneously need to address the goals of reducing poverty and enhancing food security. Under the auspices of the Bonn Challenge, the global community has set a target of restoring 350 Mha by 2030 through FLR. While this is a very laudable political aspiration, there is a risk that in countries' rush to meet targets, authorities may advocate inappropriate and ultimately unsustainable interventions that fail to meet the needs of local populations. Agroforestry has a critical role to play in addressing this concern.

Multiple roles for agroforestry in restoration

In some parts of the tropics, marginal agricultural land is being abandoned as economically unprofitable, thereby releasing land for forest restoration without impinging on local people's productive use of the landscape. Implementation of relatively simple legal and policy instruments, including for example carbon credits, could consolidate these gains and expand the area available for restoration. However, much of the world's degraded land occurs in landscapes that are occupied by poor farmers who are dependent on the land and its natural resources for their livelihoods. In such situations, large-scale forest restoration is likely to be in conflict with development goals. Restoration instead needs to focus on restoring ecological functionality to multiuse landscapes, thereby improving the livelihoods of local people while simultaneously enhancing global goods and services, such as carbon sequestration and biodiversity conservation.

Trees on farmland provide many goods and services. Products include nutritious fruits and nuts for food, fodder for livestock, fuel for cooking, and timber for building. Trees also provide shade and shelter for crops, livestock and people, and habitat for pollinators and other beneficial organisms. Although often under appreciated, these ecosystem services can make a substantial contribution to farmers' livelihoods. For example, combining trees with grazing lands, so-called silvopastoral systems, can increase beef and dairy production by over 30% as a consequence of improved grass productivity and access to shade for livestock. Likewise, access to high quality pollination services increases coffee yields by over 20%. In farmers' fields, the judicious choice and placement of trees can improve soil health, increase water infiltration and reduce erosion. And, of course, trees sequester carbon, both in wood and in soils, and can substantially increase the value of agricultural landscapes for conservation. Although on a per area basis, the amount of carbon that can be sequestered through agroforestry is much lower than for mature forests, the size of the land area available means that agroforestry's potential for climate change mitigation is substantial. For example, it has been estimated that if all the possible agroforestry land in the EU were realised, it would offset one-third of the EU's greenhouse gas emissions. Globally, an amount of carbon equivalent to approximately 20 years' worth of deforestation is stored in agroforestry systems. Hence, most developing countries have identified agroforestry as a key strategy for meeting national commitments under the Paris Agreement.

Similarly, although agroforestry supports substantially lower biodiversity than forests, trees on farmland can provide a significant conservation benefit by creating a much more biodiversity-friendly matrix than one covered in arable or plantation monocultures, and thereby facilitate the movement of wildlife between forest patches. Improvements to soil management, food and nutritional security, and incomes also enhance the resilience of poor farmers. As farmers often fall back on destructive activities such as timber harvesting or charcoal production in times of need, improving their resilience can contribute to reduced deforestation and forest degradation.

In addition, agroforestry can provide viable forest restoration pathways in situations where restoration would otherwise be uneconomic. Natural regeneration provides the cheapest and most sustainable mode of forest restoration. However, when land is highly degraded – for example, very infertile or rapidly eroding soils – establishment of naturally seeded trees may be poor and recovery of vegetation slow. Or, if the target for restoration is far from seed sources, then the quality of vegetation arising from natural regeneration may be poor. However, the costs of land preparation and planting are often prohibitive unless there is an opportunity to recover costs. Agroforestry systems that combine natural regeneration or planting of native tree species with income generation through, for example, shade grown crops (e.g. coffee or cardamon), timber (e.g. Eucalyptus), non-timber forest products (e.g. rubber, mushrooms, fruits or firewood) or livestock grazing, can be used to transition degraded lands to natural forest. Using agroforestry in this way, as an interim step to ecological restoration of forests, may enable governments and landowners to substantially increase the scale of restoration they can consider.

Putting the "L" into FLR

The "L" in FLR speaks more to the process through which restoration should be implemented than it does to the scale of restoration. In essence, the landscape approach is one that involves inclusive, devolved decision-making to improve land-use planning and governance of common-pool resources. An essential element is the need to adopt systems thinking, so that the consequences of land management decisions at different scales are understood and acted upon.

Agroforestry by nature requires a systems perspective. At the field scale, agroforestry interventions aim to maximise multiple benefits, such as improving soil health and providing fuel wood, while minimising negative interactions between trees and crops. For example, *Faidherbia albida*, a widely promoted fertiliser tree in Africa, fixes nitrogen but its real benefit as an agroforestry tree comes from the fact that it drops its leaves in the early wet season, thereby adding nitrogen and organic matter to the soil and reducing light interception, just when the crops are growing most rapidly. At the farm scale, agroforestry contributes to economic diversification, as well as to food and nutritional security. In the developing world, many rural communities suffer seasonal hunger in the final months before harvest. Even relatively short periods of hunger can have a serious effect on a child's physical and mental development. However, the traditional practice of planting home gardens with fruit trees can be adapted, through careful species selection, so that there is a year-round production of nutritious fruit and nuts. Diversification at the farm scale is also insurance against pest outbreaks, and climate and economic uncertainty, and therefore increases resilience. Finally, agroforestry involves the integration of woods and forests into the farming system, including for example livestock grazing and the supply of non-timber forest products, such as honey, mushrooms and insects. Community level land use planning and management of these resources is essential to ensure people can continue to derive benefits. Thus, agroforestry brings with it a systems thinking that can be readily integrated into landscape approaches.

Agroforestry options for restoration: Three examples from around the world

The rubber tree is originally from the Brazilian Amazon and was introduced in plantations in Asia in the late 19th century. Almost immediately it was adopted by local farmers and incorporated into the swidden agricultural systems as a way of enriching fallows, so called jungle rubber. Rubber is in many respects an ideal smallholder crop: cultivation is low input and technically straightforward, latex tapping is labour-intensive and, as demonstrated by jungle rubber, it is easily incorporated into existing farming systems. Around the mid-20th century, rubber provided around 80% of agricultural incomes where it was grown in Indonesia. However, with the development of high yielding clones, which produce 2-3 times as much rubber, farmers began to adopt monoculture plantation management, as practiced by the large commercial firms. Often, this was perceived as improved management and promoted by government extension services. However, a sharp fall in rubber prices in the early 1980s led smallholders to experiment with intercropping. Many found that modern clones can be grown just as well when intercropped with timber or shade crops. Research has confirmed these findings and in addition shown that rubber agroforests can be used to restore impoverished soils invaded by *Imperata* grass. In North East Thailand, smallholders are rehabilitating highly degraded cassava fields with rubber agroforests. Rubber can be grown in anything from simple combinations with fruit trees (e.g. mangosteen) or shade crops (e.g. tea or cardamom) to multi-species systems incorporating high value timber species that mimic secondary forest regrowth. With the demand for rubber set to continue rising, rubber agroforestry offers options to rehabilitate ecosystem services over 5 Mha of monoculture plantations across South East Asia, as well as a strategy for restoring degraded lands elsewhere. At Hutan Harapan, an Ecosystem Restoration Concession in Sumatra, we are using rubber agroforestry as a tool for community development, to reduce land conflicts and avoid further deforestation. We can also expect greater interest of rubber companies in Africa, as land and labour become limiting in Asia, and proactively developing smallholder-managed rubber agroforestry systems would ensure that potential social and environmental benefits are realised.

The second example comes from the African dryland systems. In the early 1980s, much of the Sahel was a treeless wasteland. There were recurrent multi-year droughts, productivity had plummeted and most farmers were dependent on international aid for food. To combat desertification and restore ecosystem services, the international community invested millions in large-scale restoration efforts, planting huge numbers of seedlings of mostly exotic tree species that simply perished from neglect or were eaten by goats. Lack of farmer involvement meant they had little vested interest in the success of projects and most viewed the trees as competition for their crops. However, in the mid-1980s practitioners noticed that native trees were resprouting naturally from stumps and underground rootstocks, but were cut back each year by farmers clearing their fields. Through a couple of test projects, farmers were persuaded to allow some trees to regrow. The farmers were encouraged to select which trees they retained and to prune the stumps so that just one or a few stems grew from each stump. Almost overnight, the benefits were apparent and the results spread rapidly by word of mouth. Increased fuelwood availability provided additional income and reduced the burden on women, who previously had to walk miles in search of cooking fuel. Trees provided shade and leaves for dry season fodder, improving livestock productivity and generating manure for crops. Crops were protected from high winds, which in addition reduced soil erosion and improved soil health, with resultant increases in crop yields and incomes. Moreover, it has been estimated that the benefits in terms of asset creation, increased consumption of wild resources, health and psycho-social improvements are of even higher value than the increases in income and agricultural yields.

Over an approximately twenty year period, farmers have restored over 5 Mha of Sahel in Niger and neighbouring countries through Farmer Managed Natural Regeneration (FMNR). Largely through the work of NGOs, the technology is spreading throughout the arid to seasonally dry regions of sub-Saharan Africa. For example, it is practiced widely in both Ethiopia and Malawi today. Nonetheless, there is still scope for improving the technology and adapting it to new biomes. FMNR works because the re-sprouts from stumps and underground rootstocks are hardy and require little maintenance. However, species choice is strongly constrained by what's available in a farmer's field. Can we enrich FMNR with selected tree species to improve outcomes? For example, perhaps we could select (or plant) more multi-purpose trees, or those that compete less with crops for limited soil water, or that provide better quality fodder or nutritious fruit. Can we design species combinations based on functional traits to optimise outcomes?

The final example is from Peru. It has been repeatedly demonstrated that providing secure land tenure and resource access rights is an essential step to achieving sustainable natural resource management. In Peru, millions of hectares of national forest have been encroached, including much of the approximately 3.5 Mha of Amazonian forests managed by smallholders. This places huge numbers of poor people—the de facto land managers—at odds with the law. In an attempt to reconcile this reality with Peru's national forest laws, which preclude private ownership of forest lands and prohibit deforestation, in 2011, the government introduced an amendment to the forestry law to enable agroforestry concessions. The government now views agroforestry concessions as making a major contribution to the country's commitments under Latin America's 20x20 Restoration Initiative and the Paris Agreement. The concept is relatively straightforward – smallholders (who generally manage between 5 and 100 ha) receive a 40 year renewable concession license in return for maintaining remnant forest patches, establishing agroforestry on a minimum of 20% of the remaining area and practicing soil and water conservation measures. They can also qualify for various incentives aimed at increasing tree cover with native species. Social surveys indicate there is strong support for the concept and that it could enable restoration at scale, but researchers also warn that certain provisions will need to be made to ensure the scheme's success. Essential is a need to adopt a broad definition of agroforestry that includes long-rotation systems, such as fallow forests and small scale timber plantations.

Putting agroforestry into FLR

It has been estimated that 40% of the world's agricultural land (>1 B ha) has over 10% tree cover, although this substantially underestimates agroforestry's contribution as it omits systems defined as forests but still extensively used within food production systems. Agroforestry has also been recognised as the natural (or appropriate) way to farm in the tropics. Yet, it is one thing knowing that trees on agricultural land provide many goods and services, and another persuading farmers to plant trees. Agroforestry often does not receive the support from governments it warrants and there remains a strong tendency among farmers to eliminate trees from their farms. Indeed, for many, intensification is synonymous with the promotion of monoculture systems. How can we ensure that agroforestry contributes to FLR?

In part, agroforestry is overlooked because it is considered neither agriculture nor forestry and therefore falls outside the remit of institutional structures. A critical aspect to FLR is that it should be cross-sectoral, but nonetheless it helps if agroforestry is given a proper home, usually within the ministry or department of agriculture. A second related step is to develop a national strategy on agroforestry, such as for example in India. Critical here is consideration of land and tree tenure. Without long-term tenure, there is little incentive for farmers to grow trees. A final major constraint is the availability of planting material, which is a concern for FLR as a whole. It is essential that farmers can access high quality seeds and seedlings for the species they wish to plant at reasonable prices.

Nevertheless, even where farmers acknowledge the services trees provide, they may be unwilling to invest in planting, protecting and nurturing those trees unless there is a ready market for the products. Trees take several years to yield benefits and poor farmers often need more rapid returns on their investment, particularly if they consider it risky. There

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are of course many ways around these problems, such as providing structured markets or schemes for adding value, outgrowers schemes or PES schemes, but these need to planned and built into the FLR process.

Agroforestry has an important contribution to make to FLR, in particular through its role in sustainable agricultural intensification and poverty alleviation, but also through its often under-recognised potential for climate mitigation and biodiversity conservation. Realising these goals will require creating the appropriate enabling conditions so that farmers are eager, and not just willing, to invest in trees.

Further reading

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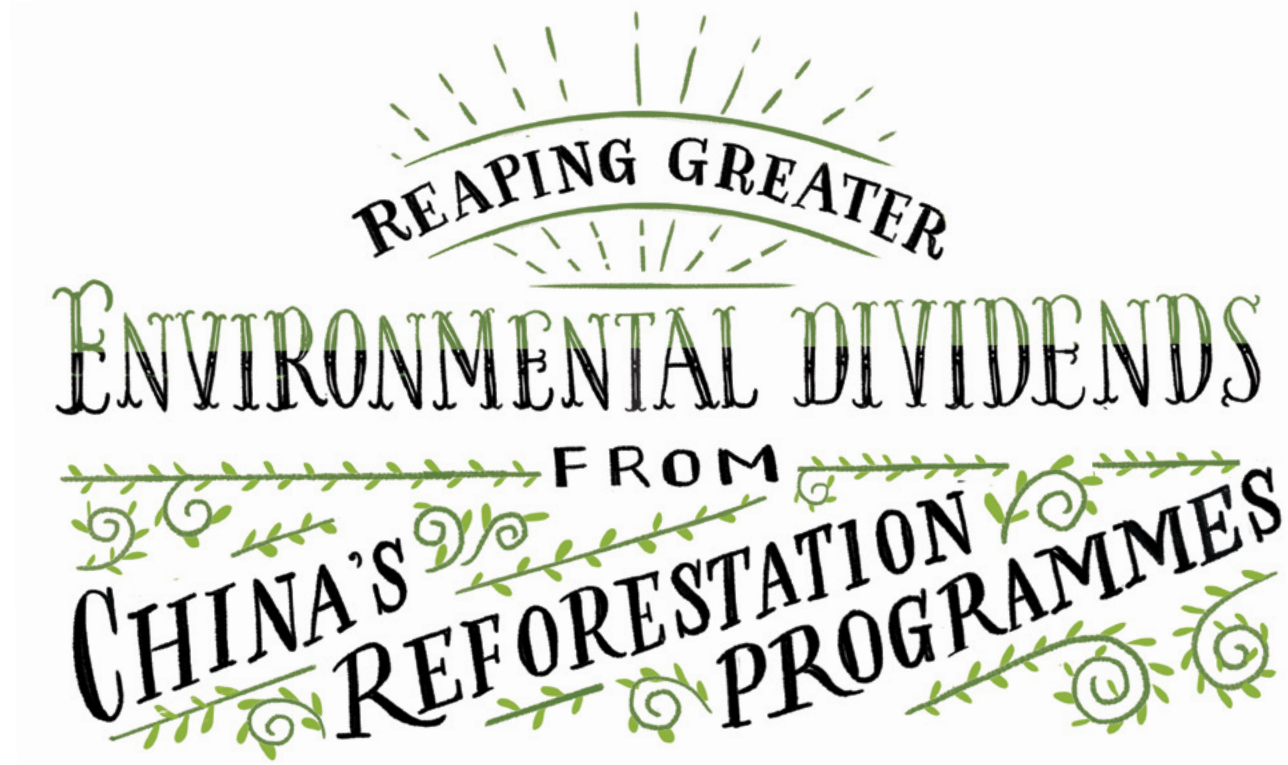
***Rhett D Harrison** is a landscape ecologist with the World Agroforestry Centre, based in Lusaka, Zambia. He has diverse research interests and has worked in over 20 tropical countries.*

***Chaaya Prabhat** is an independent illustrator and graphic designer currently based in Chennai, India. Her work usually involves a combination of illustration, design and hand-lettering which she is passionate about.*



Author: ***Fangyuan Hua*** · Illustratator: ***Megha Vishwanath***

Echoing a similar story the world over, native forests in China have historically suffered severe losses linked to the expansion of agriculture and production forestry. As the ultimate source of agricultural land in much of China, native forests gradually dwindled over thousands of years, before the shock of the Great Leap Forward at the end of the 1950's when remaining native forests were extensively cleared to harvest fuel wood and expand agriculture. Industrial logging of native forests was completely unregulated in China until the mid-1970's and continued well into the late 1990's (Richardson 1990). In the meantime, large-scale deforestation for plantations and particularly rubber plantations in tropical southern China, further exacerbated the destruction of native forests.

Recognising the deleterious environmental consequences of forest loss, the Chinese government has long embraced reforestation as a mitigation strategy. Since as early as the late 1950's, reforestation has been extensively implemented using manual planting and aerial seeding. However, it was not until the massive floods across the country in 1998 – widely attributed to unchecked deforestation – that systematic nationwide reforestation programs were put in place. The Natural Forest Protection Program (NFPP) and the Grain-for-Green Program (GFGP) are not only the largest in China, but are also among the world's biggest and most extensively funded.

The NFPP, in effect in 18 of mainland China's 31 provinces since 1998, was a direct response to the 1998 floods. Aimed at protecting native forests and safeguarding against floods, it employs a combination of logging bans, natural regeneration, and the establishment of plantations for alternative timber supply. The GFGP aims to curb soil erosion by providing incentives for households to retire and reforest croplands on slopes prone to erosion, thus replacing "grain" production with "green" forest cover. It was trialled in three provinces in 1999 and rolled out to 23 more provinces in 2000. Both programmes are currently ongoing and expected to last until at least 2020. Notably, both have a clear emphasis on the key ecosystem services provided by forest ecosystems.

This recent boost of state sponsorship for reforestation coincided with profound changes in rural China. Mass emigration to urban areas reduced the availability of rural labour, while remittance from urban or other non-farm jobs accounted for an increasing proportion of rural income. The demographic and economic changes across rural China are palpable, and among them is the increasing tendency of rural households to shift land use away from crop production, or any kind of production altogether. Tree stands or forests, requiring far less labour to manage than food crops, have come to be an appealing land use option. Recent reforestation in China has thus taken place under a highly favourable socio-economic context.

The combination of strong state sponsorship and conducive socio-economic context has afforded China's recent reforestation efforts sizeable success, at least as measured by the land area reforested. State Forestry Administration (SFA) reports that 84 million hectares of land in China were reforested* between 1999-2013—an area slightly larger than Sweden and Japan combined. Independent remote-sensing studies show that China's forest cover increased from 2000 to