

Realizing the economic benefits of agroforestry: experiences, lessons and challenges

Agroforestry is the set of land-use practices involving the deliberate combination of trees, agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence (Lundgren and Raintree, 1982). Cultivating trees in combination with crops and livestock is an ancient practice. However, several factors have contributed to a rising interest in agroforestry since the 1970s: the deteriorating economic situation in many parts of the developing world; increased tropical deforestation; degradation and scarcity of land because of population pressures; and growing interest in farming systems, intercropping and the environment (Nair, 1993). Most research on agroforestry has been conducted from the biophysical perspective, but socio-economic aspects are gaining attention (Mercer and Miller, 1998).

Main agroforestry practices include improved fallows, taungya (growing annual agricultural crops during the establishment of a forestry plantation), home gardens, alley cropping, growing multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, orchards or tree gardens, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and apiculture with trees (Nair, 1993; Sinclair, 1999).

EXAMPLES OF ECONOMIC BENEFITS OF AGROFORESTRY PRACTICES

Agroforestry practices differ considerably from country to country as farmers adapt to needs and circumstances. This section provides

a number of examples of the agroforestry strategies successfully employed by farmers in different situations.

Fodder

Farmers and pastoralists have long used fodder trees and shrubs to feed their livestock, but traditional practices tend to be extensive, with farmers lopping off branches or allowing their animals to browse. Integrating trees into systems where they can be planted close to each other and pruned or browsed intensively can help increase economic benefits.

In the highlands of central Kenya, for example, farmers plant fodder shrubs, especially *Calliandra calothyrsus* and *Leucaena trichandra*, to use as feed for their stall-fed dairy cows (Franzel, Wambugu and Tuwei, 2003). The farm-grown fodder increases milk production and can substitute for relatively expensive purchased dairy meal, thus increasing farmers' income. Fodder shrubs also conserve the soil, supply fuelwood and provide bee forage for honey production. Rather than cash outlays, farmers only need small amounts of land and labour to plant them. Some farmers also earn money by selling seeds.

In Cagayan de Oro, Philippines, a combination of improved fodder grasses and trees (*Gliricidia sepium*) has helped farmers increase income from livestock production, increase crop production and reduce farm labour, especially for herding and tethering (Bosma *et al.*, 2003).

Agroforestry systems for fodder are also profitable in developed countries. In the northern agricultural region of western Australia, tagasaste (*Chamaecytisus proliferus*) planted in alley farming and plantation systems has increased returns to

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Cultivating trees in combination with crops and livestock is an ancient practice, but interest in agroforestry has been rising since the 1970s, with socio-economic aspects now gaining attention

farmers whose cattle formerly grazed on annual grasses and legumes (Abadi *et al.*, 2003).

Soil fertility

With intensified agriculture and reduced fallowing periods, soil fertility has emerged as a key problem in many farming systems throughout the tropics. In several areas, researchers and farmers have developed improved tree fallows as one means to increase crop yields.

In Malawi and Zambia, for example, planting the shrubs *Tephrosia vogelii*, *Sesbania sesban*, *Gliricidia sepium* or *Cajanus cajan* in fallows for two years, cutting them back, then following them with two to three years of maize cultivation increased maize yields compared with planting continuous unfertilized maize (Franzel, Phiri and Kwesiga, 2002). Although fertilized maize was found to perform even better than improved fallows, the fallows strategy proved beneficial to farmers who could not afford fertilizer.

Another agroforestry practice for improving soil fertility is biomass transfer – the manual transfer of green manure to crops – which increases vegetable yields, extends the harvesting season and improves the quality of produce. In western Kenya, farmers who treated their vegetable plots with leaves from *Tithonia*

diversifolia hedges grown along field boundaries, together with small amounts of phosphorus fertilizer, doubled their returns to labour (Place *et al.*, 2002).

Timber and fuelwood

Agroforestry produces timber and fuelwood throughout the world. For example, intercropping of trees and crops is practised on 3 million hectares in China (Sen, 1991). Farmers intercrop *Paulownia* spp. (primarily *P. elongata*) with cereals over a wide expanse of the North China Plain. The tree is deep rooted, interferes little with crops and produces high-quality timber (Wu and Zhu, 1997). In Minquan County (Henan Province), 30 years after the introduction of agroforestry, two-thirds of the 46 000 ha of farmland were intercropped with trees of this genus. In one commune, *Paulownia* spp. accounted for 37 percent of farm income (Wu and Zhu, 1997). In addition to timber, these species provide excellent fuelwood, leaves for fodder and compost fertilizer and protection against wind erosion and evapotranspiration (Wu and Zhu, 1997).

In Tabora District, United Republic of Tanzania, about 1 000 tobacco farmers have started *Acacia crassiparva* woodlots to produce fuelwood for tobacco curing, intercropping the trees with maize during the first two years (Ramadhani, Otsyina and Franzel, 2002). Growing wood on farms prevents the felling of trees from the forest, reducing forest degradation and saving costs of transporting fuelwood.

In Uttar Pradesh, India, 30 000 farmers grow poplar (*Populus deltoides*) to sell to the match industry on woodlots that average 1.3 ha. Intercropping is common, especially in the first two to three years (Jain and Singh, 2000; Scherr, 2004).

In the United Kingdom, a range of timber/cereal and timber/pasture systems has been profitable to farmers. McAdam, Thomas and Willis (1999) found that ash trees intercropped with ryegrass pastures did not influence the pasture yields for the first 10 years of the 40-year rotation. Incentives to increase biodiversity in pastoral systems and the

Gum arabic husbandry

Through centuries of practice, gum producers in sub-Saharan Africa have devised a comprehensive protocol, from tree management to tapping, collecting, cleaning, sorting and marketing. Over the years they have learned that gum trees (*Acacia senegal*) are ripe for tapping after a dormant period following the rainy season and judge the best time for this activity by the shedding of leaves, a change in the colour of bark and, for experienced elders, by the smell of stripped bark. The first gum exudation takes place a few weeks after tapping and then is harvested in a series of pickings.

More than just providing a commercial product, gum trees supply a number of goods and services to farmers. Because of its deep tap roots and wide lateral root system – up to 40 percent of biomass may be underground – the tree is

highly valued as a soil stabilizer. In sandy areas, it assists in dune fixation, acts as a buffer against wind erosion and decreases water runoff. Its local value derives in part from the belief that, in traditional rotations, crops have higher yields after *A. senegal* fallow. The tree is also a source of fodder and browse, as well as fuelwood.

As a well-established activity, gum production has all the ingredients for growth and sustainability in place, including policies, legislation and institutional capacity for resource management, development and quality control (Chikamai, 1996).

uncertainty of meat prices versus timber prices further encourage farmers to practise agroforestry.

Environmental services: windbreaks, carbon sequestration and biodiversity

Studies of the environmental benefits of agroforestry are far fewer than those related to economic benefits, and studies seeking to monetize such benefits are almost non-existent. Available information indicates that agroforestry can provide a greater range of environmental benefits than conventional types of annual crop cultivation. For example, Murniati, Garrity and Gintings (2001) found that in areas adjacent to national parks in Sumatra, Indonesia, households with diversified farming systems, including mixed perennial gardens, depended much less on gathering forest products than did farms cultivating only wetland rice. Thus, tree felling and unsustainable hunting practices in the nearby parks were reduced. The findings suggest that promoting diversified farms with agroforestry in buffer zones can enhance forest integrity.

Windbreaks are one of the oldest agroforestry

systems in North America. In the Canadian prairies, more than 43 000 km of windbreaks have been planted since 1937, protecting 700 000 ha. In 1987, approximately 858 000 windbreaks in the United States, mostly in the north central and Great Plains areas, spanned 281 000 km and protected 546 000 ha (Williams *et al.*, 1997). Kort (1988) estimated the yield increase of crops sheltered from wind to be 8 percent for spring wheat, 12 percent for maize, 23 percent for winter wheat and 25 percent for barley. In addition, windbreaks improve crop water use and protect livestock and homesteads.

Several examples exist of private companies supporting agroforestry in exchange for carbon benefits. In the Scolel-Té pilot project in southern Mexico, 400 small-scale farmers in 20 communities are converting from swidden agriculture to agroforestry, either by intercropping timber trees with crops or by enriching fallow lands (de Jong, Tipper and Montoya-Gomez, 2000). The International Federation of Automobiles has purchased the resulting 17 000 tonnes of carbon offsets for US\$10 to \$12 per tonne of carbon. Sixty percent of the revenues have gone to farmers. However,

the question remains whether returns from agroforestry will be sufficient for farmers to maintain the practices once carbon payments have ended (de Jong, Tipper and Montoya-Gomez, 2000). Similarly, in the highlands of Ecuador, farmers participating in a carbon-trading project are planting mixed woodlots of pine, eucalyptus and indigenous species. Pine and eucalyptus are profitable, but the slow-growing indigenous species offer negative returns. This again puts into question the sustainability of carbon-trading tree projects involving activities that are not in themselves profitable (Smith and Scherr, 2002).

Gockowski, Nkamleu and Wendt (2001) compared the environmental benefits of the most prevalent cropping practices around Yaoundé, Cameroon: cocoa agroforests and food crops rotated with short or long fallows. Cocoa agroforests ranked first in carbon stocks, numbers of plant species and degree of plant biodiversity. They also ranked highest in terms of social profitability – the economic returns from society's perspective, not taking into account the effects of taxes, subsidies and distorted exchange rates. However, with regard to the most important criterion to farmers, net returns to labour, there was little difference among the alternatives.

MULTIPLE STAKEHOLDERS AND MULTIPLE CRITERIA FOR ASSESSING BENEFITS

Most economic analyses of agroforestry focus on benefits to farmers, yet many groups of stakeholders are interested in changes of land use. Tomich *et al.* (2001) used a matrix to assess how various land-use practices performed across different criteria important to six groups in Sumatra: the international community, hunter-gatherers, small-scale farmers, large-scale estates, absentee farmers and policy-makers. The results showed that while sound management of natural forests is most conducive to achieving carbon sequestration and biodiversity conservation (criteria important to the international community), rubber agroforests contribute to achieving these two objectives more than rubber or oil-palm monocultures and much more than

rice/fallow rotations or cassava. Table 9, an abridged version of the matrix, suggests that introducing cloned rubber into agroforests significantly raises labour use and profitability and can increase returns to farmers. Wider adoption of this approach has the potential to help balance competing objectives by addressing the concerns of policy-makers to generate income and employment; by meeting the interests of smallholders to earn profits; and by improving the environment (Tomich *et al.*, 2001).

Development agencies are increasingly targeting interventions towards poor and female farmers and want to know whether they are reaching these groups. In a review of 23 studies of factors affecting the adoption of agroforestry, Pattanayak *et al.* (2003) found that eight included gender as a variable. In five of these studies, male-headed households were found to be more likely to adopt agroforestry than female-headed households. However, these findings may reflect the access men have to resources and information rather than women's preferences. In central Kenya, women accounted for 60 percent of a sample of 2 600 farmers planting fodder trees (Franzel, Wambugu and Tuwei, 2003). A study in western Kenya showed that women used improved fallows and biomass transfer more frequently than men, who more often used mineral fertilizers (Figure 10) (Place *et al.*, 2004).

Pattanayak *et al.* (2003) found 12 studies that assessed the effect of wealth or income on adoption of agroforestry. The relationship was positive in six and insignificant in the other six. Data from western Kenya showed that poor and non-poor households were equally likely to use improved fallows and biomass transfer to increase soil fertility (Figure 11) (Place *et al.*, 2004).

LESSONS LEARNED, CHALLENGES AND OPPORTUNITIES

Much has been learned about how to promote agroforestry and increase benefits to farmers and others through research, extension and policy reform. Whereas this chapter has focused on success stories, failures have also provided important lessons. For example, the effectiveness of alley farming practices to improve soil fertility

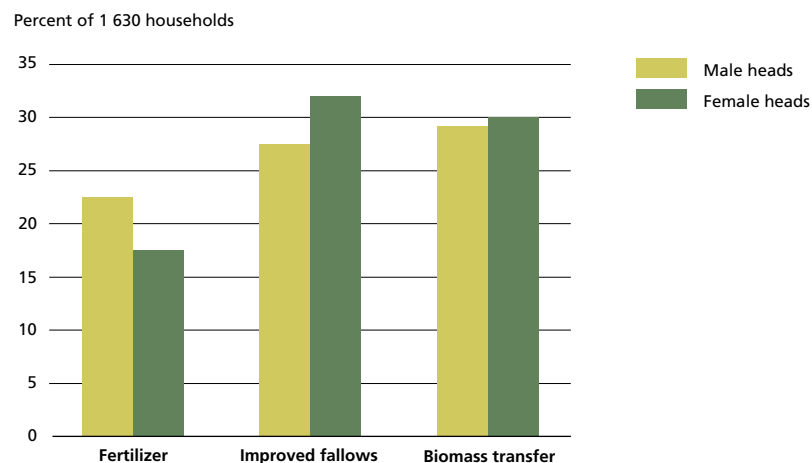
TABLE 9
Abridged matrix: how selected land-use practices perform across criteria important to different stakeholders in Sumatra, Indonesia

STAKEHOLDERS	International community	Agriculturists	National policy-makers	Smallholders		
CRITERIA	Global environmental quality	Plot level production sustainability	Social profitability	Employment	Production incentives	
MEASURED BY	Carbon sequestration: time averaged (Mg/ha)	Biodiversity: plant species per standard plot	Rating	Returns to land at social prices (Rp 1 000/ha)	Labour input (days/ha/year)	Returns to labour at private prices (Rp/day)
LAND USE						
Natural forest	254	120	1	0	0	0
Rubber agroforest	116	90	0.5	73	111	4 000
Rubber agroforest with clonal planting material	103	60	0.5	234–3 622	150	3 900–6 900
Upland rice/bush fallow	74	45	0.5	53–180	15–25	2 700–3 300
Continuous cassava degrading to <i>Imperata</i> spp.	39	15	0	315–603	98–104	3 895–4 515

Note: 1 Rupiah (Rp) = US\$0.00012 (2000).

Source: Adapted from Tomich *et al.*, 2001.

FIGURE 10
Use of soil fertility management options by gender of household head, western Kenya



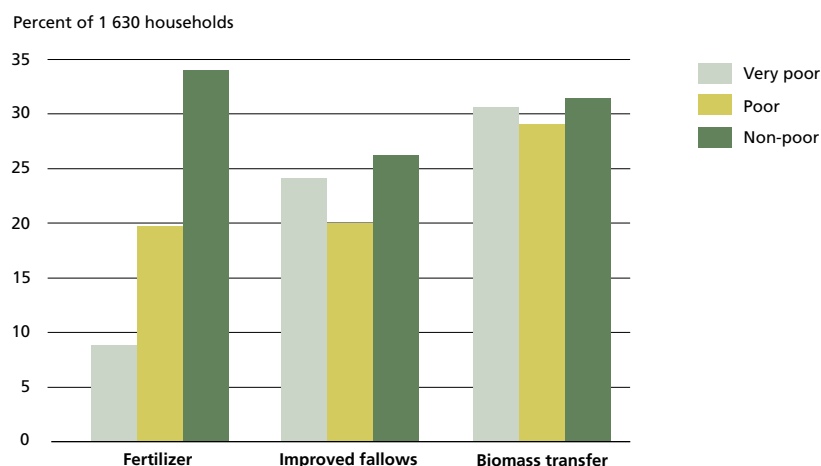
Source: Place *et al.*, 2004.

and crop yields helped refocus strategies on growing trees and crops in rotation rather than together. Some trees, such as *Leucaena leucocephala*, have become invasive in some areas, and this has helped researchers to recognize the importance of screening species.

Benefits of agroforestry

In a review of 56 agroforestry practices in 21 projects in Central America and the Caribbean, Current and Scherr (1995) found that 75 percent had positive net present values. In two-thirds of the cases, net present values and returns to labour

FIGURE 11
Use of soil fertility management options by household wealth class, western Kenya



Source: Place *et al.*, 2004.

were superior to those in alternative enterprises. In both developed and developing countries, however, agroforestry is not generally recognized as a science or a distinct practice and is rarely featured in development strategies (Garrett and Buck, 1997; Williams *et al.*, 1997). Policy-makers need to be informed about the benefits of agroforestry so that they can use it to support rural development and provide environmental services (Current and Scherr, 1995). In developing countries, local authorities and traditional leaders are in a good position to promote agroforestry.

Substitutes for purchased products. Many farmers appreciate agroforestry because it generates cash income through the sale of tree products. It also provides products that the farmer would otherwise have to purchase – an important consideration, given the lack of working capital in many farming systems. For example, farmers substitute nitrogen-fixing plants for mineral fertilizers, fodder shrubs for expensive dairy meal and home-grown timber and fuelwood for wood bought off the farm.

Enhanced diversity and reduced risk.

Agroforestry enhances diversity both in terms of plant biodiversity and enterprise diversity.

The latter decreases risk and allows farmers to reduce seasonal labour peaks, earn income throughout the year and accrue benefits at different times – over the short, medium and long term. Also, farmers often value trees because little effort is required to maintain them and they can be sold whenever cash is needed.

Complement to natural forest management.

Evidence suggests that where farmers have incentives to plant trees and have access to information and planting material, they depend less on neighbouring forests and are less likely to damage them. Sound policies and extension programmes, as well as effective forest management mechanisms, can significantly enhance the impact of agroforestry on forest protection.

Factors affecting performance

Adaptation to local conditions. Successful efforts to introduce agroforestry often combine modern science and traditional knowledge. Experience has also shown that individual preferences, adaptations and entrepreneurial skills make a big difference and that communities need help to document and spread innovations of farmers. To minimize risk,

Faidherbia albida agroforestry/agrosilvipastoral system

One of the most pronounced agroforestry and agrosilvipastoral systems in the gum belt of sub-Saharan Africa is the one that uses *Faidherbia albida*, a tree that attains enormous size in such areas as the foothills of Jebel Marra in Darfur, Sudan. Having learned the tree phenology over centuries, communities in Darfur fence and crop the entire areas under *F. albida* with staple (sorghum and millet) and cash crops (tomato and chilli, for example).

The tree sheds its leaves during the rainy season (July to October), allowing light over the entire crown to the bole. During winter and summer (November to June), the tree produces leaves and pods that cast a heavy shade. Livestock, particularly sheep and goats, visit the tree for crop residues, shade and pods. In so doing, they add animal manure to a soil already improved through nitrogen fixed by the *F. albida* root system and the decomposition of twigs and leaflets.

F. albida usually grows along seasonal water-courses with shallow water table and is irrigated from hand-dug wells. When felled in thinning operations or when the tree is wind thrown following root collar zone rot, the wood is used in carpentry and for utensils such as mortars, oil mills and shoe lasts.

Scientists and academics need to acknowledge that today's practices and terminology have their origins in traditional knowledge and that other sound and sustainable aspects of such knowledge should be recognized and taught at all levels. Investigating myths that surround *F. albida*, including those related to the shedding of its leaves during the rainy season, might also improve understanding of current systems.

farmers prefer to choose from different options to solve a problem rather than have to rely on a single approach (Franzel and Scherr, 2002).

Availability of information and training.

Farmers need more information and training for agroforestry relative to other agricultural activities, which limits the spread of some practices. When starting operations, they often lack skills to establish tree and shrub nurseries, pre-treat the seeds and carry out tree pruning activities. However, extension strategies, including field schools, exchange visits and farmer training, are effective ways of disseminating needed information.

Government and project support. Lack of financial credit is not a major constraint to adopting agroforestry practices because of the small size of farms and scale of operations, the incremental approach that farmers use to plant trees and the desire of most farmers to avoid risks. In many

instances, offering free inputs or paying farmers to plant trees encourages dependency and acts as a disincentive to planting when a project ends. Once farmers start planting on a small scale and see the benefits, they are usually able and willing to continue. On the other hand, government and project interventions are needed to promote tree planting, provide information and technical assistance and fill other gaps such as supplying tree seeds where they are not available. In most cases, however, credit or payments to farmers for planting trees are not required and may do more harm than good (Current and Scherr, 1995; Scherr and Franzel, 2002).

Linking farmers to markets. Assessing demand before planting trees is a critical first step in adopting agroforestry, as looking for a market only in times of surplus is problematic. It is also more advantageous to assist farmers to sell their produce locally before they attempt to enter a more competitive export market, and

to help them strengthen their links with the private sector as part of market development. In addition, training in entrepreneurship and business skills has proven highly beneficial to farmers, and farmer organizations can have an important role in assembling produce, bargaining collectively and reducing transaction costs.

Secure land tenure and exemptions from government ordinances. Farmers with insecure land rights are unable or unwilling to plant trees. However, formal land registration is not always necessary, as some traditional forms of tenure provide the security to plant trees (Place, 1995). A critical constraint, especially in semi-arid and arid zones, is that livestock often graze freely, feeding on or trampling newly planted trees. In some communities, restrictions now prevent this practice, and lessons need to be shared to address the problem elsewhere. In many countries, bans on cutting down trees are a disincentive for farmers to plant them. Therefore, mechanisms are needed to exempt trees on farms from such ordinances (Current and Scherr, 1995).

Decentralized, community-based germplasm strategies. The most successful approaches to supplying and distributing planting material are those involving community-based seed stands and nurseries managed by individual farmers or groups. Seed and nursery enterprises can also help to increase incomes. Efforts are needed to ensure the quality and diversity of planting material (Current and Scherr, 1995; Franzel, Cooper and Denning, 2001).

CONCLUSIONS

The proportion of trees on farms and in forests varies considerably among countries, but two trends seem almost universal in the tropics: the number of trees in forests is declining, and the number on farms is increasing. In a survey of 64 communities in Uganda, for example, the proportion of land under forest declined from 4 to 2 percent between 1960 and 1995, while that under agriculture increased from 57 to 70 percent. Interestingly, the proportion

First World Agroforestry Congress

Participants from 82 countries attended the first World Agroforestry Congress in Florida, United States, from 27 June to 2 July 2004. During discussions, they noted significant progress over the past 25 years in building a scientific foundation for agroforestry systems. Recognizing the links to the United Nations Millennium Development Goals, the congress called on countries, international organizations, the private sector and other partners to use the full potential of agroforestry:

- to increase household income;
- to promote gender equity;
- to empower women;
- to improve the health and welfare of people;
- to promote environmental sustainability.

Experts further noted the need to increase investments for research, technology development and extension so as to integrate agroforestry more fully with natural resource and watershed management. They also urged governments to highlight the role of agroforestry in poverty reduction strategies, to provide financial support and to develop policies that promote the adoption of associated practices.

of agricultural land under tree cover increased from 23 to 28 percent (Place, Ssentenza and Otsuka, 2001).

Agroforestry has made tremendous strides in recent years, but many challenges remain in terms of its wider application. It is necessary to identify and measure the range of benefits, given that they are not well documented. Moreover, additional research is required to quantify the benefits to various stakeholders, to deal with the variability in benefits, to assess the effects and trade-offs of different policies and to examine the impact of agroforestry practices on forest protection, particularly in the tropics. Determining which practices are most suited to particular groups, such as women

and poor people, is another area that warrants attention.

Many success stories appear to be confined to small areas. Thus, emphasis needs to be placed on ways to replicate these on a larger scale to reach more households. Other issues involve identifying policies, institutional innovations and extension strategies that facilitate the spread of agroforestry and increase economic benefits. With research and extension services declining throughout the tropics, ways to promote farmer experimentation and enhance farmer-to-farmer communication need to be found as well. Measures are required to overcome lack of planting materials (seeds, seedlings or cuttings) and lack of information.

Improving marketing and adding value to raw products are critical for enhancing the livelihoods of agroforestry farmers. In this regard, private sector contracting mechanisms should be extended to countries and commodities where they do not exist. More market analysis is also needed to assess how consumer preferences can be satisfied without simply increasing production. Community-based institutional mechanisms are needed to help farmers acquire information and business skills, market produce and promote quality. ♦

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