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Agroforestry for food and nutritional security

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More than 1.2 billion people already practise agroforestry, and continued adoption will improve global food security.

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Agroforestry is a set of approaches to land management practised by more than 1.2 billion people worldwide involving the integration of trees with annual crop cultivation, livestock production and other farm activities. Agroforestry systems range from open parkland assemblages to dense imitations of tropical rainforests such as homegardens, to planted mixtures of only a few species. These systems can increase farm productivity when their various components occupy complementary niches and the associations between them are managed effectively (Steffan-Dewenter *et al*., 2007).

In this article we assess the role of agroforestry in supporting food and nutritional security. Many of the examples we present are from sub-Saharan Africa, where nine of the 20 nations with the highest burden of child undernutrition worldwide are located (Bryce *et al*., 2008). We discuss the challenges faced by agroforestry in supporting food and nutritional security, and we canvass opportunities to overcome these challenges.

Agroforesters in Kigoma, the United Republic of Tanzania, tend crops established as part of an FAO project to strengthen forest management and its contribution to sustainable development, land use and livelihoods

THE BENEFITS OF AGROFORESTRY SYSTEMS FOR FOOD AND NUTRITIONAL SECURITY

Agroforestry for food production

Solving the problem of food and nutritional security requires a range of interconnected agricultural approaches, including improvements in the productivity of staple crops, the biofortification of staple foods, and the cultivation of a wider variety of edible plants that provide fruits, nuts and vegetables for more diverse diets (Frison, Cherfas and Hodgkin, 2011). There is huge potential for the diversification of crop production in the great range of lesser-used indigenous foods found in forests and other wooded lands, which are often richer in micronutrients, fibre and protein than staple crops (Malézieux, 2013). Traditionally, such foods have been harvested in forests and woodlands, but the availability of these resources is declining due to deforestation and forest degradation (FAO, 2010), and cultivation could provide an alternative resource. The yield and quality of production can be increased through genetic improvement and on-farm management, making planting a potentially attractive option for growers. A combination of indigenous and exotic tree foods in agroforestry systems supports nutrition, the stability of production, and farmer income (Box 1).

1
Developing domestic markets for tree foods in sub-Saharan Africa

Exotic and indigenous fruits cultivated and managed in agroforestry systems are important in Africa. In Kenya, for example, a 2004 survey found that over 90 percent of the more than 900 households surveyed grew fruits, with at least one-quarter growing avocado (*Persea americana*) and mango (*Mangifera indica*). Over two-thirds of households that reported fruit production harvested at least four fruit species, while over half sold some fruit.

Nevertheless, the average consumption of fruit and vegetables in sub-Saharan Africa is significantly lower than the minimum recommended daily intake of 400 g per person. One reason for this is that poor households that have to buy food understandably focus on the purchase of staples such as maize and rice that provide relatively cheap sources of carbohydrate to meet basic energy needs, leaving only a small fraction of the family budget to spend on other, potentially more nutritious foods. Expenditure analysis shows, however, that as incomes increase, the purchase of fruit also increases. Domestic markets for fruit are predicted to grow in sub-Saharan Africa by about 5 percent per year over the next ten years. If production and delivery to consumers can be made more efficient, the potential is high for farmers to boost their incomes by meeting this demand.

***Source:* adapted from Jamnadass *et al.*, 2011**

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A smallholder farmer harvests fruit from one of the trees he has planted near his homestead. Fruit consumption in sub-Saharan Africa is often below the recommended daily minimum, but homegardens and other agroforestry configurations can increase fruit consumption as well as income for smallholders


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Maize grows under farmer-managed faidherbia natural regeneration

As well as directly providing edible products, trees in agroforestry systems support food production by giving shade and support to nutritious vegetable crops (Maliki *et al*., 2012; Susila *et al*., 2012). Many tree species also assist staple crops through soil-fertility improvement. This was demonstrated in an analysis of more than 90 peer-reviewed studies on the planting of nitrogen-fixing green fertilizers, including trees and shrubs, which found consistent evidence of benefits to maize yields in Africa, although the level of response varied by soil type and the technology used (Sileshi *et al*., 2008). As well as increasing average yields, the planting of trees as green fertilizers in southern Africa is able to stabilize crop production in drought years and improve the efficiency with which crops use rainwater (Sileshi *et al*., 2011; Sileshi, Debusho and Akinnifesi, 2012). This is important for food security in the context of climate change, which is increasing the incidence of drought in southern Africa.

Supporting the regeneration of natural tree and shrub vegetation in agroforestry systems can also provide significant benefits for staple crop yields. Farmer-managed natural regeneration of faidherbia (*Faidherbia albida*) and other leguminous trees in dryland agroforests (parklands) in semi-arid and subhumid Africa, for example, has been encouraged in Niger since 1985 by a policy shift that awarded tree tenure to farmers; it has led to the "re-greening" of approximately 5 million hectares (Sendzimir, Reij and Magnuszewski, 2011). Farmer-managed natural regeneration in the Sahel has led to improvements in sorghum and millet yields, and positive relationships have been observed with dietary diversity and household income (Place and Binam, 2013).

Agroforestry for incomes to support access to food

Market data on tree products derived from agroforestry systems are sparse, but information on export value is quantified for tree commodity crops such as palm oil (derived from oil palm, *Elaeis guineensis*), coffee (primarily from *Coffea arabica*), rubber (from *Hevea brasiliensis*), cocoa (from cacao, *Theobroma cacao*) and tea (primarily from *Camellia sinensis*). Each of these tree crops is grown to a significant extent by smallholders; in Indonesia in 2011, for example, the contribution of small farms to the country's total production area was estimated at 42 percent for palm oil, 96 percent for coffee, 85 percent for rubber, 94 percent for cocoa and 46 percent for tea (Government of Indonesia, 2013). Globally, the annual export value of these five commodities combined is tens of billions of United States dollars (FAO, 2013a) and there are opportunities to bring new tree commodities into cultivation (Box 2). Less clear is the proportion of commodity export value that accrues to smallholder cultivators, but production often constitutes a considerable proportion of farm takings and is used to support household food purchases.

There is a danger that the planting of commodities will result in the conversion of natural forest – which contains important local foods – to agricultural land, and a risk that food crops will be displaced from farmland in a trend towards the growing of large areas of monocultural crops (e.g. oil palm; Danielsen *et al*., 2009). Monocultures also reduce resilience to shocks such as droughts, floods and, often, the outbreak of pests and diseases. In addition, buying food using the income received from a single commodity crop can lead to food insecurity for farm households when payments are one-off, delayed or unpredictable in value.

Mixed agroforestry regimes – such as shade-coffee and shade-cocoa systems – can help avoid many such negative effects by combining tree commodities in diverse production systems with locally important food trees, staple crops, vegetables and edible fungi (Jagoret, Michel-Dounias and Malézieux, 2011; Jagoret *et al*., 2012; Sustainable Cocoa Initiative, 2013) that increase or at least do not decrease commodity yields and profitability (Clough *et al*., 2009). Such systems have often been practised traditionally and are now encouraged by some international purchasers of tree commodity crops through certification and other schemes (Millard, 2011).

Agroforestry, fuel and food

Woodfuel, mostly comprising firewood and charcoal, is crucial for the survival and well-being of perhaps 2 billion people, enabling them to cook food to make it palatable and safe for consumption (FAO, 2008). In sub-Saharan Africa, the use of woodfuel is still increasing rapidly; the charcoal industry there was worth about US$8 billion in 2007 (World Bank, 2011). The firewood and charcoal industries are important for food and nutritional security because they produce energy and generate

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Women sort allanblackia seeds for sale in the United Republic of Tanzania

2

Integrating markets and cultivation: the case of allanblackia

The seeds of allanblackia (*Allanblackia* spp.), found wild in the humid forests of central, eastern and western Africa, yield an edible oil with a potential global market of more than 100 000 tonnes annually, especially as a "hardstock" for the production of healthy margarines that are low in trans-fats. A private–public partnership known as Novella Africa is developing a sustainable allanblackia oil business that could be worth hundreds of millions of United States dollars annually to local farmers. Supply chains for seed have been established in Ghana, Nigeria and the United Republic of Tanzania based on harvesting by local communities in natural forests and from trees remaining in farmland after forest clearance. Volumes are currently small (in the hundreds of tonnes) and oil is being exported for food product development. At the same time, more allanblackia trees are being brought into cultivation by improving seed-handling, developing vegetative propagation methods and selecting superior genotypes. Tens of thousands of seedlings and clones have been distributed to smallholders. The integration of allanblackia into small-scale cocoa farms is being promoted to support more biodiverse and resilient agricultural landscapes. As allanblackia trees grow, cocoa trees provide the shade they need; when they have grown, they in turn will act as shade for cocoa. Cocoa and allanblackia provide harvests at different times of the year, and when the allanblackia trees have matured they will help diversify farmer incomes and distribute them throughout the year.

***Source:* adapted from Jamnadass *et al*., 2010**

income; their importance is likely to remain high for some time, despite efforts to promote "more modern" energy sources.

In poor households, firewood and charcoal are often burnt in open fires or on poorly functioning stoves, with substantial emissions of pollutants that damage human health and may lead to the premature deaths of more than 1 million people annually worldwide, the majority of them women (Bailis, Ezzati and Kammen, 2005; see article by Stoukal *et al.* in this edition). Fuel quality depends on the tree species being burnt; poor families may be forced to use species that were traditionally avoided because of their harmful smoke or that were maintained for other products, such as fruit (Brouwer, Hoorweg and van Liere, 1997).

Reduced access and increased prices have led to initiatives to promote the cultivation of woodfuel-producing tree species in agroforestry systems. Where agroforestry is practised by smallholders, less woodfuel needs to be purchased by them, there is less reliance on collecting from natural stands, and less time is involved in collection. This leaves more time for income-generating activities, especially for women, who are usually the major firewood collectors (Thorlakson and Neufeldt, 2012). Access to cooking-fuel provides people with more flexibility in what they eat, including foods with better nutritional profiles that require more energy to cook. The cultivation of woodlots allows the production of wood that is less harmful when burnt and has higher energy content.

Agroforestry, ecosystem services, climate change and food

Trees in agroforestry systems provide important ecosystem services, including soil, spring, stream and watershed protection, animal and plant biodiversity conservation, and carbon sequestration and storage, all of which ultimately improve food and nutritional security (Garrity, 2004). Individual farmers can be encouraged to preserve and reinforce these functions – which extend beyond their farms – by payments for ecosystem services (Roshetko, Lasco and Delos Angeles, 2007).

Appropriate combinations of crops, animals and trees in agroforestry systems can not only increase farm yields, they can promote ecological and social resilience to change because the various components of such systems, and the interactions between them, will respond in differing ways to disturbances (Steffan-Dewenter *et al*., 2007). A diversity of species and functions within integrated production systems is therefore a risk-reduction strategy, and agroforestry can make important contributions to both adaptation to, and the mitigation of, climate change (Thorlakson and Neufeldt, 2012).

CHALLENGES FOR AGROFORESTRY IN SUPPORTING FOOD AND NUTRITIONAL SECURITY

Policy constraints

Place *et al.* (2012) identified three key policy areas in which constraints need to be overcome for agroforestry to play a greater role in food and nutritional security. First, farmers need secure land and tree tenure. Where these are absent or contested, farmer involvement in tree-planting and management can be limited, but when they are assured, greater interest in agroforestry is stimulated. Land-tenure rights are particularly important for agroforestry compared with other agricultural practices because of the relatively long period that may be required to realize benefits from managing and cultivating trees.

Second, policies that determine how farmers obtain seeds, seedlings and clones of a wide range of tree species suitable for their various purposes are crucial (Lillesø *et al*., 2011). Current policies often slow the adoption of agroforestry: for example, providing extension services with funds to give free seeds to farmers discriminates against small-scale entrepreneurial seed and seedling suppliers (as well as reducing the perceived importance to growers of the seeds). Although well-intentioned (e.g. to protect intellectual property and stop the introduction of potentially invasive species), laws to control germplasm flows internationally have also slowed smallholder access to appropriate planting material by, for example, limiting the transfer to Africa of superior cultivars of fruit trees developed in other countries, in this case notably in Asia.

Third, many policy environments do not recognize agroforestry as an attractive investment in agriculture. For example, governments often subsidize the provision of artificial fertilizers to increase staple crop yields, which discourages the adoption of improved tree-based fallow technologies that could ultimately increase crop production more cost-effectively and sustainably. Another problem is the lack of attention given to tree products and services in data collection on farmer livelihoods and therefore the lack of properly quantified information on the value of trees grown in agroforestry systems in supporting food and nutritional security (FAO, 2013b).

Constraints in delivering tree products to markets

For many tree products, markets are poorly structured and lack coordination (Roshetko *et al*., 2007). This results in low and unstable returns to farmers and high prices for buyers of tree foods, which limits access and consumption. Problems often cited by producers include the absence of a collective bargaining system, poor transport infrastructure, and the involvement of multiple intermediaries in the supply chain, all of which act to reduce farm prices. For perishable goods such as fruit, such barriers also lead to high wastage along the supply chain and a failure to meet quality grades. Prevailing low returns mean that farmers struggle to afford inputs to improve their suboptimal farm management practices. Traders also face many problems, such as poor roads, corrupt officials and the high cost of collecting from geographically scattered producers (Jamnadass *et al*., 2011).

There has been underinvestment in the characterization of tree foods and the development of new tree cultivars that


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*Fruits of safou (***Dacryodes edulis***), a species undergoing participatory domestication in Cameroon, show some of the genetic variation that can be exploited to improve production*

have high yields and provide high-quality products under smallholder production conditions. Until recently, for example, scientists largely ignored the great potential for the genetic improvement of indigenous fruit trees (Jamnadass *et al.*, 2011). Insufficient work is being done to bring these indigenous species into cultivation in the tropics.

RECOMMENDATIONS

To strengthen the important and potentially crucial role of agroforestry in food and nutritional security, we recommend the following:

- Better quantification of the role of the products and services from trees grown in agroforestry systems in supporting the food and nutritional security of the rural poor, to allow more appropriate targeting of intervention options. Where possible, quantification should be done separately for men, women and children, small-scale farmers, the landless poor and local traders.
- Specific policies for the development of agroforestry, including more attention to ensuring smallholder tenure of trees and land, greater support for how farmers obtain tree-planting material, and wider acknowledgement of agroforestry as an agricultural investment option.
- Intensified research into tree domestication to provide planting material appropriate for smallholders, and further assessment of the complementarity and resilience of agroforestry systems in the face of climate change and other agricultural production challenges.

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