The contributions of forest foods to sustainable diets

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More research, and greater use of traditional knowledge, will help fulfil the potential of forest foods as a valuable component of nutritious diets.

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Traditionally, policy-makers have focused on energy-rich staple crops such as wheat, rice and maize in the quest for national and global food security. However, many staple foods contain only low amounts of limiting micronutrients essential for human health and by themselves are insufficient to address the problem of "hidden hunger", or micronutrient deficiency (Pinstrup-Andersen, 2013; Miller and Welch, 2013). The challenge for policy-makers and other stakeholders is to promote food systems that are productive, nutritious, sustainable and culturally acceptable. The ultimate goal is to have a food system that ensures "sustainable diets", defined (in Burlingame and Dernini, 2012) as:

> *those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.*

Figure 1 shows some of the dimensions of sustainable diets. This article examines the contribution that forests and trees can make to some of these dimensions and proposes recommendations for optimizing that contribution.

***Previous page:** A woman prepares to transport **Landolphia** spp. fruits (mabongo) to be sold at the market in Yangambi, the Democratic Republic of the Congo. A number of wild indigenous fruit trees in sub-Saharan Africa have high vitamin and mineral contents, and increasing their production and consumption could increase the sustainability of diets in the region*

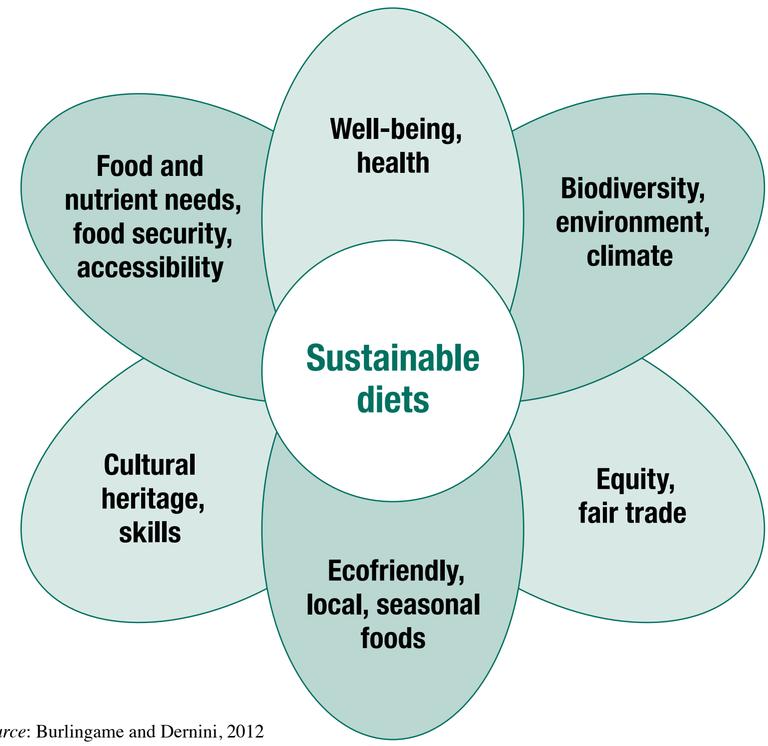
***Right:** Leaves of **Vitex doniana** and powder from baobab leaves (**Adansonia digitata**) at the market in Parakou, Benin*

FORESTS AND SUSTAINABLE DIETS

Use and nutrition of forest foods

Forest foods such as wild fruits, nuts, vegetables, mushrooms and animal products contribute in many ways to food security. While few communities worldwide rely on forest foods to provide their complete diet (Colfer, 2008), forest foods help maintain household nutrition in many communities, especially during lean seasons (complementing, for example, the seasonality of staple agricultural crops), in times of low agricultural production, during periods of climate-induced vulnerability, and when gaps in the availability of food occur due to other cyclical events (Kehlenbeck, Asaah and Jamnadass, 2013).

1
The many dimensions of a sustainable diet



Source: Burlingame and Dernini, 2012

The dietary quality of many forest foods is high. Many of the micronutrients provided by forest foods have important health and developmental functions, and their absence in diets therefore has important health implications (UNSCN, 2004). For example, vitamin A deficiency causes blindness in up to 500 000 children per year and is also associated with high rates of infection (e.g. diarrhoea, measles and respiratory-tract infections) because of its importance in the functioning of the immune system (Black, Morris and Bryce, 2003). Good dietary sources of vitamin A are green leafy vegetables and orange-coloured fruits and vegetables. Deficiencies in iron, zinc and vitamin B_{12} can impair growth, cognitive development and school performance in children, with lifelong implications for health and socio-economic success (UNSCN, 2004). The best dietary sources of these micronutrients are animal-sourced foods (meat).

Most animal foods, including those sourced from forests, are rich in highly bioavailable[1] iron, zinc and vitamin B_{12} (as well as protein and fat) (Nasi, Taber and Van Vliet, 2011; Murphy and Allen, 2003). Forests also provide diverse options for leafy vegetables, fruits and other plant foods important for the intake of vitamin A, iron, folate, niacin and calcium (Vinceti, Eyzaguirre and Johns, 2008). In one study in the United Republic of Tanzania,

[1] The commonly accepted definition of bioavailability is the proportion of a nutrient that is digested, absorbed and metabolized through normal pathways. It is not enough to know how much of a nutrient is present in a dietary supplement; the more important issue is how much of that present is bioavailable.

*A woman prepares gbedegbede (***Amaranthus dubius***), a leafy vegetable harvested in the wild in Kisangani, the Democratic Republic of the Congo. Green leafy vegetables are good dietary sources of vitamin A, an essential micronutrient for human health*

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children who consumed forest foods had more diverse and nutrient-dense diets than those who did not, and there was also greater tree cover in close proximity to their homes (Powell, Hall and Johns, 2011). Another study in the Democratic Republic of the Congo found the consumption of wild plant foods to be associated with a higher intake of vitamin A and calcium (Termote *et al*., 2012).

Even though the nature of much of the available evidence is circumstantial, a growing body of data indicates that increased agricultural and forest biodiversity leads to a more varied diet, which in turn improves human health (Johns and Eyzaguirre, 2006; Johnson, Jacob and Brown, 2013).

Wildlife resources. Wild meat, here defined as non-domesticated terrestrial mammals, birds, reptiles and amphibians harvested in the wild for food, is the main source of animal protein in many tropical forest regions, especially the Congo and Amazon basins (Arnold *et al*., 2011; Nasi, Taber and Van Vliet, 2011). A significant proportion of the wildlife biomass hunted by humans for food across the tropics, especially large-bodied primates, ungulates and rodents (average weight greater than 1 kg), is found in tropical forest ecosystems, with ungulates and sometimes rodents dominating the biomass in more open habitats (Robinson and Bennett, 2004). Edible insects are also important elements in the diet (Ndoye and Tieguhong, 2004; Termote *et al*., 2012; Kuyper, Vitta and Dewey, 2013; van Huis *et al*., 2013).

Animal-based foods supply many important micronutrients in much higher amounts or with higher bioavailability than most plant-based foods (Murphy and Allen, 2003). A recent study in a remote part of the eastern rainforest in Madagascar (where local communities rely heavily on local wildlife resources)

TABLE 1. Nutrient contents of selected African indigenous and exotic fruits per 100 g edible portion

Species	Energy (Kcal)	Protein (g)	Vitamin C (mg)	Vitamin A (RE*) (μg)	Iron (mg)	Calcium (mg)
Indigenous fruits						
Adansonia digitata L.	327	2.5	126–**509**	0.03–0.06	6.2	275
Dacryodes edulis	263	4.6	19	n.a.	0.8	43
Grewia tenax (Forrsk.) Fiori	n.a.	3.6	n.a.	n.a.	**7.4–20.8**	**610**
Irvingia gabonensis (kernels)	697	8.5	n.a.	n.a.	3.4	120
Sclerocarya birrea Hochst.	225	0.7	85–**319**	**0.035**	3.4	35
Tamarindus indica L.	275	**3.6**	11–20	0.01–0.06	3.1	192
Ziziphus mauritiana Lam.	184	0.4	3–14	0.07	0.8	23
Exotic fruits						
Guava *(Psidium guajava* L.*)*	68	2.6	**228.3**	0.031	0.3	18
Mango *(Mangifera indica* L.*)*	65	0.5	27.7	0.038	0.1	10
Orange *(Citrus sinensis (*L.*)* Osbeck)	47	0.9	53.0	0.008	0.1	40
Pawpaw *(Carica papaya* L.)	39	0.6	62.0	**0.135**	0.1	24

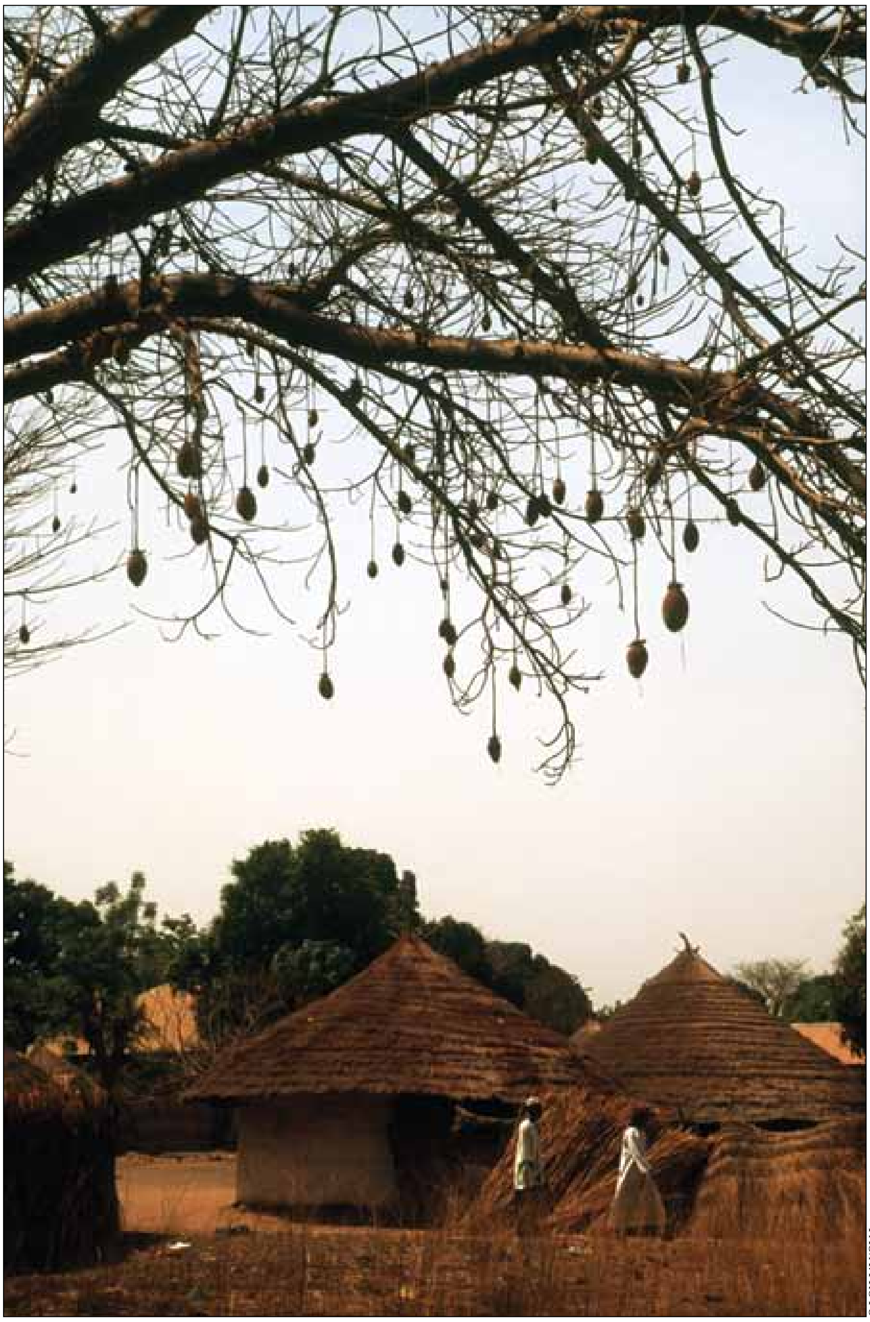
Notes: high values are shown in bold. *RE = retinol equivalents.
Sources: Kehlenbeck, Asaah and Jamnadass, 2013; Stadlmayr *et al*., 2013

estimated that the loss of wild meat from the diet of children, without substitution by other sources, would result in a 29 percent increase in children suffering from iron-deficiency anaemia (Golden *et al*., 2011).

The overexploitation of certain wild animal populations is leading to the depletion of populations of some species (Nasi, Taber and Van Vliet, 2011). The resultant decline in the availability of wild meat threatens the food security and livelihoods of forest communities (Heywood, 2013), especially those in which home consumption is more common than wild-meat trading.

Forest fruits in sub-Saharan Africa. Fruit consumption in sub-Saharan Africa has been estimated to fall considerably short of the recommended daily amount (Ruel, Minot and Smith, 2005). Kehlenbeck, Asaah and Jamnadass (2013) showed that a number of wild indigenous fruit trees have high vitamin and mineral contents (Table 1), with the potential to contribute year-round to the micronutrient supply of local communities, even during seasons of food shortages. For example, consuming 40–100 g of berries produced by *Grewia tenax* (a widespread, fruit-producing deciduous shrub) could supply almost 100 percent of the daily iron requirement of a child under the age of eight years. In addition to micronutrients, the high sugar content of fruits such as tamarind (*Tamarindus indica*) and baobab (*Adansonia digitata*) make them important sources of energy. The fruits of *Dacryodes edulis* and the seeds of *Irvingia gabonensis*, *Sclerocarya caffra* and *Ricinodendron rautanenii* all have higher fat contents than peanuts (Barany *et al*., 2004).

Until a decade ago, little research had been conducted on the range of intraspecific genetic variation behind the variable nutritive values and other properties of edible products from key tree species. Although data are still sparse, a recent review by Stadlmayr *et al*. (2013) of the nutrient composition of selected indigenous fruits in sub-Saharan Africa noted very high variability in nutrient content among naturally occurring populations of the same species. This offers the opportunity to select individual trees with the highest nutrient contents in their fruits for future domestication programmes. Similar genetic variability has been documented in non-cultivated indigenous vegetables in the United Republic of Tanzania with regard to iron, zinc and β-carotene (Msuya, Mamiro and Weinberger, 2009), and also in cereals (millet, sorghum, rice, wheat and fonio) in Mali analysed for iron, zinc, thiamine, riboflavin and niacin, with ecological and climatic conditions strongly affecting values (Barikmo, Ouattara and Oshaug, 2007).



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Fruit of the baobab tree (*Adansonia digitata*) hang ready to harvest near Basse, the Gambia. Baobab fruit are high in vitamin C

Berries from a jujube fruit tree (*Ziziphus zizyphus*) in Bangladesh. Jujube is a drought-resistant tree that produces a nutritious fruit that can be eaten fresh or dried. Over many generations, indigenous peoples have developed knowledge systems, practices and decision-making for the identification, preparation and sustainable management of wild foods in forests and on farms

Homegardens. Seminal work on the domestication of wild tree species was carried out in West Africa in order to boost food supply and cope with food insecurity during conflicts (Okafor, 1976). Domestication programmes are now being developed to bring wild tree species into cultivation and to integrate them into agroforestry systems (Leakey, 2012), including homegardens. Homegardens are common in the tropics and subtropics and can provide readily available, diverse food products and many ecosystem services (Kehlenbeck, Arifin and Maass, 2007). It has been estimated that around 1 billion people in the tropics obtain produce from homegardens supported by semi-subsistence agriculture (Heywood, 2013). Improving homegarden systems can be highly effective in improving micronutrient intake (Masset *et al*., 2012). Some studies have found that a child's nutritional status is associated with the presence of a homegarden and that the garden's biodiversity, rather than its size, is the most important factor (Jones *et al*., 2005).

Cultural importance of forest foods

A recent extensive review of indigenous food systems around the world, including in many forest regions, highlighted the cultural importance of traditional foods, many of which are wild or semi-domesticated (Kuhnlein, Erasmus and Spigelski, 2009; Kuhnlein *et al*., 2013). Over many generations, indigenous peoples have developed knowledge systems, practices and decision-making for the identification, preparation and sustainable management of wild foods in forests and on farms (Kuhnlein, Erasmus and Spigelski, 2009; Turner *et al*., 2011). In South Africa, most forest foods traded in local markets maintain a prime position in local cultures; in several cases, commercial substitutes for forest foods do not exist, and wild-harvested products are generally preferred even when alternative products can be found (Shackleton, Shanley and Ndoye, 2008).

CHALLENGES AND OPPORTUNITIES

The concept of sustainable diets is relatively new, and it has not yet been incorporated in forest management approaches. The following challenges must be met to strengthen the contribution of forest foods to sustainable diets.

Cultural challenges

One of the factors most likely to determine differences in the use and value of forest foods is ethnicity (Termote, Van Damme and Dhed'a Djailo, 2011). Traditional knowledge should therefore be taken into consideration when promoting nutritious forest foods as part of diets and in the selection of priority species for marketing and domestication (Shanley *et al*., 2011). Some indigenous wild foods, especially vegetables, may be perceived as old-fashioned or inferior (Chweya and Eyzaguirre, 1999), yet they can attract premium prices in urban markets (Chelang'a, Obare and Kimenju, 2013). Others, such as wild meat in parts of Africa, bestow cultural prestige (Lindsey *et al*., 2013).

The availability of and access to forest foods may decline due to physical shortages of the product as a consequence of deforestation, forest degradation and overexploitation, among other reasons. In many countries, changes in livelihood strategies, the processes of urbanization and globalization, and changes in diets have resulted in considerable changes in the consumption of indigenous wild foods (Pingali, 2007).

Research has shown that as former hunter–gatherer groups, such as the Baka and Kola Pygmies of Cameroon and the Tubu Punan of Borneo, became sedentary, they suffered many negative dietary, nutritional and epidemiological consequences (Dounias and Froment, 2011). Around the world, forest-based communities are abandoning traditional lifestyles and food regimes in exchange for diets higher in processed foods, salt, refined sugar and fat – a shift referred to as the nutrition transition (Popkin, 2004).

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"Soumbala" produced from seeds of Parkia biglobosa*, sold in a local market in Parakou, Benin. The availability of and access to forest foods may decline as a consequence of deforestation, forest degradation and overexploitation*

Sustainability of use of forest foods

Several threats could affect the capacity of forests and other tree-based systems to provide food and nutrients. The unsustainable harvesting of wild species has been documented in various contexts (Sundriyal and Sundriyal, 2004; Delvaux, Sinsin and Van Damme, 2010). It is increasingly accepted that the commercialization of non-wood forest products frequently leads to overharvesting and declining availability in the absence of sustainable forest management (Belcher, Ruiz-Perez and Achdiawan, 2005). A review of important fruit species in the local economy and diet near Iquitos, Peru, revealed that the availability of several of the most popular wild-harvested fruit species had decreased markedly (Vasquez and Gentry, 1989).

Subsets of species, usually referred to as "conflict-of-use" species, are valued for both wood and non-wood forest products (Guariguata *et al*., 2010). Research on the rates of extraction (for timber) of species that are valued locally for medicinal and food use (e.g. *Dipteryx odorata*, *Parahancornia fasciculata* and *Endopleura uchi*) carried out in logging frontiers in the Amazon Basin indicated that logging contributes to declining access (Shanley, 2012). Other reports have shown that 5 of the 12 most valuable fruit and medicinal species traded in eastern Amazonia are also valued timber species (Serra *et al*., 2010). In Cameroon, timber harvesting targets species that have edible fruits and oils; others host caterpillars that, at a certain time of the year, comprise 75 percent of the protein consumed by Baka Pygmies (Ndoye and Tieguhong, 2004). Conflicts between multiple uses have also been documented in Asia (Limberg *et al*., 2007). In West Africa, selected multipurpose trees that supply food, wood and medicines are maintained when woodland is cleared for traditional agriculture (Faye *et al*., 2010). However, useful trees and shrubs are now disappearing due to shortening fallow periods, conflicts over tenure, a drying climate, overbrowsing by livestock, and the absence of management practices to protect regeneration (Maranz, 2009).

For most wild-collected animal and plant species, little is known about the effects of harvesting on genetic diversity and the long-term survival of populations (for example, Sunderland, Besong and Ayeni, 2002, on *Gnetum* spp.). Detailed inventories of these wild species exist for only a few countries and species, and the literature is scattered.

The rise of food-based approaches

The overall health outcomes of a diet rich in multiple micronutrients and phytochemical and other components of food that regulate physiological functions are being increasingly recognized (Miller and Welch, 2013). This has led to a shift in focus in nutrition interventions towards improving overall dietary patterns and quality by increasing dietary diversity – defined as the number of unique foods or food categories consumed in a given period – and promoting the consumption of foods naturally rich in micronutrients or enriched through fortification[2] (Torheim *et al*., 2010; Fanzo *et al*., 2013).

Forest foods can play an important role in such interventions. The increasing focus on dietary diversity as an indicator of food security and a proxy for diet quality allows a quick, user-friendly, low-cost assessment of the whole diet (Kennedy, Ballard and Dop, 2011). Translating the findings into programmes is challenging, however, and researchers are investigating the best tools for evaluating diversity in diets and the nutritional outcomes (Ruel, 2003; Arimond *et al*., 2010; Masset *et al*., 2012). Many

[2] According to the definition used by the World Health Organization and FAO, fortification refers to the practice of deliberately increasing the content of essential micronutrients (i.e. vitamins and minerals, including trace elements) in a food, irrespective of whether the nutrients were originally in the food before processing, to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health.

interacting factors affect the content and bioavailability of micronutrients in human diets and there is a need to adopt a food-system approach that includes all the steps from forest/farm to plate, examining all aspects affecting the nutritional outcomes of a particular diet, from agricultural production systems to food-processing methods and consumer education strategies (Miller and Welch, 2013).

There is growing interest in the use of micronutrient-rich foods, including wild plant and animal foods, to supplement the diets of children who predominantly consume staple foods (Kuyper, Vitta and Dewey, 2013). Based on local availability and ease of access, underused complementary foods may be affordable and potentially more acceptable than some other options. An example is the fermented condiment known as *soumbala* obtained from the seeds of *Parkia biglobosa*, a west African tree species. A rich source of iron, *soumbala* is often used by families as a low-cost substitute for meat (Savadogo *et al*., 2011).

Increasing knowledge

Bringing about a change in attitude towards the consumption of traditional foods is a challenge because they are often considered inferior (see van Huis *et al*., 2013, for edible insects). Improved scientific knowledge of nutritional values, and greater documentation of indigenous knowledge, could lead to more conducive policies and a change in attitude towards forest foods (Kuhnlein, Erasmus and Spigelski, 2009; Kuhnlein *et al*., 2013).

In some cases, the consumption of micronutrient-rich foods has increased as a result of information dissemination and promotion, but nutrition interventions remain complicated by a lack of data on the nutrient content of lesser-known species and limited understanding of the dietary requirements for many micronutrients. There are also challenges in measuring habitual food intake due to the difficulty that study participants have in recalling exactly what they have eaten over a certain period of time, and also self-report bias, where participants tend to under-report behaviours they think researchers will consider inappropriate. The generation and use of better data on the nutrient composition of forest foods should be combined with research on ecology, management and (participatory) domestication so that appropriate, nutritionally rich species can be integrated into fields and homegardens (Pudasaini *et al*., 2013).

Adapting management of forests and trees to account for forest foods

Many traditional communities actively manage the wild resources they use. Where there is conflict over the use of multipurpose species that supply both timber and food products, forest management plans should be negotiated with timber companies and adapted to consider the interests of both local communities and timber companies (Ndoye and Tieguhong, 2004). Such an approach should be based on sound cost–benefit analyses that take into account the nutritional and cultural importance of forest foods in the diets of the most vulnerable: women and children.

Women in Parakou, Benin, gather for a focus group discussion about the food tree species commonly used in the diet during food shortage periods

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In Gulmi in western Nepal, a socially marginalized family poses in their homegarden, which is an essential source of nutritious foods, including several derived from trees. Homegardens are key elements in rural landscapes; they are important reservoirs of agricultural biodiversity and of the knowledge to make use of it, and they can also help empower women. Better approaches are needed to manage heterogeneous landscapes for nutrition-sensitive food-production systems

Women have a central role in ensuring food security and adequate nutrition (de Schutter, 2011), and interventions directed towards women are likely to have a particularly beneficial impact (Hoddinott, 1999). Supporting the role of women as producers and consumers of food would help remove barriers to improved nutrition, including the increased consumption of forest foods. A process led by FAO that reviewed guidance documents developed by several international organizations found that empowering women is a key principle in better linking agriculture and nutrition (Herforth, 2013).

Maintaining forest cover near villages and homes may be necessary if forest foods are to retain their place in diets. Nutritionally important indigenous trees can also be introduced to farming systems to produce traditional forest foods through processes of domestication that improve product quality and yield.

Access to forest foods

A lack of secure access rights and land tenure discourages many poor and marginalized communities from investing in more productive and sustainable land management and from protecting and planting key tree-food species. In many countries, local control and management of forests is still constrained by weak political and institutional arrangements and a lack of access by the poor to resources that can yield forest foods and income. Policies and programmes that enable local people to have a genuine role in decision-making are rare (Larson and Ribot, 2007).

Integrating forest biodiversity into complex landscapes

Landscape approaches can help reconcile conservation and development objectives (Sayer *et al*., 2013). In many places, fallow land and farm bushland areas are managed actively to protect and regenerate species that are valued by local communities. In the Brazilian Amazon, primary forests were found to sustainably provide more wild meat per unit area than secondary forests (Parry, Barlow and Peres, 2009), whereas the density of useful plant species was lower in mature forests than in secondary forests in the Bolivian Amazon (Toledo and Salick, 2006). In the Peruvian Amazon, Gavin (2004) found that fallow provided fewer useful species than secondary forest, but the total monetary value of the items obtained from fallow was higher. In the mixed landscapes of western Panama, Smith (2005) found that each land use made a unique contribution to providing access to different species of wild meat, highlighting the importance of diversified landscape approaches in both research and conservation.

RECOMMENDATIONS

To help optimize the role of forests and trees in sustainable diets, we recommend that policy-makers, land-use planners and land managers:

- seek innovative approaches to the management of heterogeneous landscapes to ensure that food-production systems are nutrition-sensitive, while minimizing their ecological footprint;
- prioritize research into and the development of nutritious forest foods, including the documentation and integration of indigenous knowledge, the analysis and documentation of the nutritional composition, digestibility and bioavailability of forest foods, the effect of storage and processing on the nutritional value of specific forest foods, and the potential for the domestication of important forest species and their integration into farming systems and product value chains;

- encourage research that examines the relative contribution of forest foods to local diets and nutrition;
- support research on governance and access to forests and forest products;
- support the development of nutrition-sensitive product value chains involving forest foods;
- study the ecological impacts and sustainability of harvesting the various forest species for food;
- ensure that extension services, schools, hospitals and health centres are aware of the benefits of, and promote, the consumption of nutritious forest foods in their programmes and interventions;
- promote the better integration of information and knowledge on nutritious forest foods and their conservation into national nutrition strategies and programmes by establishing policy platforms that bring together the environment, health, development, agriculture, forestry and other sectors with the aim of mainstreaming the use of forest foods in strategies addressing food security, nutrition, conservation and land-use planning and related policies.

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