BRIEF

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# Contribution of forests and trees to food security and nutrition

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## Key messages

- Forests, trees and agroforestry play a key, often undervalued, role to support food security and nutrition (FSN), in its four dimensions (availability, access, utilization and stability).
- Forests, trees and agroforestry provide: (i) diverse and nutritious foods (such as nuts, oils, vegetables – leaves, flowers, roots –, fruits, bushmeat, fish, herbs, saps, mushrooms, tubers and insects), and feed for livestock; (ii) bioenergy for cooking and boiling water; (iii) income and employment (both formal and informal); and (iv) ecosystem services indispensable for agriculture and food production, now and in the future.
- All these contributions need to be better considered by policies aiming at strengthening food security and nutrition, towards SDG2.
- The contributions of forests and trees to FSN allow a broader and richer understanding of the notion of people's "forest dependence", with local to national and global dependences.
- Maximizing the contributions of forests, trees and agroforestry to FSN requires policy coherence and integrated landscape approaches.
- Agricultural policies need to better integrate the specificities of tree crops and the multiple benefits provided by the integration of trees in farming systems.

## Introduction

Because the expansion of agriculture (crop and livestock), and therefore food production, has been both historically and presently realized at the expense of forests, food security and forests are often perceived as antagonistic, and their relation characterized by inherent trade-offs. The reality, however, is much more complex, with forests and trees playing a key, yet largely unrecognized, role in sustaining food production

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and contributing to food security and nutrition (FSN) in its different dimensions. Conversely, because they impact on forests and trees, the considerable landscape changes driven by agricultural expansion also bring negative effects on the ecosystem services that sustain agricultural production itself, with potential impacts on the FSN status of local populations as well as on global food availability and food security (Sunderland et al. 2019). Devising landscape-scale solutions and integration to maximize forests and trees' contribution to FSN require closer collaboration between experts on FSN and experts on forests and trees, as well as stronger convergence between related policy sectors, especially in relation to determining land uses and food and nutrition policies (e.g., HLPE, 2017).

These issues are of renewed importance today: since 2014, after a decade of decline, the number of hungry people worldwide has been slowly rising, and in 2020 food insecurity has further increased because of the COVID-19 crisis (see Box 1).

## Box 1. State of food insecurity in 2020

Prior to the COVID-19 pandemic, in 2019 two billion people experienced hunger (undernourishment) or did not have regular access to sufficiently nutritious food (undernutrition). Almost 690 million people, or 8.9 percent of the global population, were undernourished. In 2019, 21.3 percent (144 million) of children under 5 years of age were stunted, 6.9 percent (47 million) wasted and 5.6 percent (38.3 million) overweight, and at least 340 million suffered from micronutrient deficiencies. The COVID-19 pandemic may have added an additional 83 to 132 million people to the ranks of the undernourished in 2020. Furthermore, adult obesity is on the rise in all regions. Only in Asia, and globally in high- and upper-middle-income countries, are there enough fruits and vegetables available for human consumption to be able to meet the FAO/WHO recommendation of consuming a minimum of 400 g/person/day (FAO and WHO, 2004a).

Source: FAO, IFAD, UNICEF, WFP and WHO (2020).

This paper synthetizes knowledge about the contributions of forests and trees to the four dimensions of FSN: availability, accessibility, utilization and stability. Its purpose is to facilitate the use of such knowledge to inform policy and decision making in forestry and FSN related areas, as well as actions meant to build back better in a post-pandemic world.

In recent years, many research publications and two major global reports (Vira et al. 2015; HLPE 2017) have drawn attention to the contributions of forests, trees and agroforestry to FSN. This has led to better recognition of these roles in international fora such as the United Nations Committee on World Food Security (CFS),[1] the FAO Committee on Forestry (COFO)[2] and the United Nations Forum on Forests (UNFF).[3]

Food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." (FAO 1996).[4] This definition is summarized in the statement "the four pillars of food security are availability, access, utilization, and stability" (WSFS 2009). Availability refers to the supply of food through production, distribution and exchange. Access covers physical access (proximity), social access, economical access (affordability) and consequent allocation of food. Utilization refers to the metabolism of food by individuals and the factors needed for individuals to make use of the foods they have access to (including for instance: energy for cooking, clean water, sanitation and health care). Stability refers to the constancy and resilience of the three previous pillars over time (FAO 2006).

The current definition of the concept of FSN, with its four dimensions (pillars), is the result of a gradual expansion of the understanding of what it takes for a population to be food secure in the long term. It reflects a progressive enlargement of the notion (Gitz and Meybeck 2011) and a change in focus, from availability, to access, utilization and stability. Diets and nutrition have been given more visibility in recent years, together with an emphasis on the impacts of political crises and the potential impacts of climate change, leading to linking the concept of FSN to the one of sustainability of food systems (HLPE 2014; Berry et al. 2015; Meybeck and Gitz 2017; Burlingame and Dernini 2019). These evolutions also call for an increased recognition of the significant contributions of forests and trees to the four dimensions of FSN.

1 See: http://www.fao.org/cfs/cfs-home/en/
2 See: http://www.fao.org/about/meetings/cofo/en/
3 See: https://www.un.org/esa/forests/forum/index.html
4 The definition of food security, first adopted during the World Food Summit (FAO 1996), was updated with the addition of the word "social" in the FAO State of Food Insecurity in the World (FAO 2001). This modification was integrated by the CFS in 2009.

Ecosystem services - Landscape of Mount Halimun Salak National Park, West Java.
Photo by Aulia Erlangga/CIFOR

This brief presents an overview of the multiple contributions of forests and trees to FSN. It considers the wide diversity of forests and other ecosystems with trees, including agricultural tree crops and agroforestry systems (HLPE 2017; FAO 2018). These cover a great variety of systems, such as diverse agroforestry systems, mosaic landscapes as well as agricultural tree plantations like oil palm, olive trees and orchards (fruit and nuts trees). All of these tree-based ecosystems provide major contributions to FSN, albeit to varying degrees.

Section 1 examines the broad ways by which forests and trees contribute to FSN. Section 2 assesses the contributions of forests and trees to the four dimensions of FSN. Section 3 considers the notion of forest dependence for FSN, and examines these contributions at various scales guided by the notion of forest dependence for FSN.

## 1 Four main contributions of forests and trees to FSN

Two major reports have played a considerable role in clarifying the multiple contributions of forests, trees and agroforestry to FSN and in raising awareness of their importance in both the forestry and food security communities. The fourth global assessment of the Global Forest Expert Panel (GFEP)[5] of the Collaborative Partnership on Forests (CPF), released at the UNFF in May 2015, focused on the role of forests, trees and landscapes for FSN (Vira et al. 2015). The High-Level Panel of Experts on Food Security and Nutrition (HLPE)[6] produced a report on sustainable forestry for FSN (HLPE 2017) to inform CFS debates at its 44th Plenary Session in October 2017.

The multiple contributions of forests and trees to FSN, whether direct or indirect, short, medium or long term, can be grouped under four main categories (HLPE 2017), represented as 1-4 in Figure 2:

- *direct provision of nutritious food*, such as nuts, oils, vegetables (leaves, flowers, roots), fruits, bushmeat, fish, herbs, saps, mushrooms, tubers and insects; and feed for livestock;
- *provision of woodfuel*[7] for cooking food and boiling water, which is critical in developing countries for preparing many nutrient-rich foods (such as legumes and meats) facilitating nutrient assimilation, improving food safety and reducing the risks of diarrhoea;

5 See: https://www.iufro.org/science/gfep/
6 See: http://www.fao.org/cfs/cfs-hlpe/en
7 Woodfuel is defined as all types of fuels originating directly or indirectly from woody biomass. The main types of woodfuel in less-developed regions of the world are fuelwood and charcoal.

- formal and informal employment and income generation in the forestry sector and through sales of wood and non-wood-forest products (NWFPs),[8] with significant differences by gender and social groups;
- *non-provisioning ecosystem services*[9] that sustain all food production and agriculture activities now and in the future.

## Direct provision of food and feed

Forests and trees provide a huge variety of food products including, edible plant-products (e.g., fruits and berries, nuts, leaves, flowers, roots, etc.) and animal-sourced foods (e.g., bushmeat, fish, honey, insects), as well as medicines and aromatic plants that support human health and well-being (Jamnadass et al. 2015; Sorrenti 2017; FAO 2020). The assessment of the full magnitude of the contribution of these to human diets is limited by a lack of accurate statistical information for non-wood forest products (NWFPs) (HLPE 2017; see also Box 2)

Many forest, tree and shrub species also provide an important source of feed, enabling farmers and local communities to maintain livestock production and strengthen the intake of meat and milk products in local diets. Leguminous, high-protein fodder trees and shrubs can significantly enhance milk yields without commensurately increasing production costs as would be the case with commercial feed (Wambugu et al. 2006; Franzel et al. 2014; Baudron et al. 2017). This makes an important contribution to FSN in vulnerable communities that otherwise have limited access to animal-source foods, due to their high prices (Headey et al. 2018).

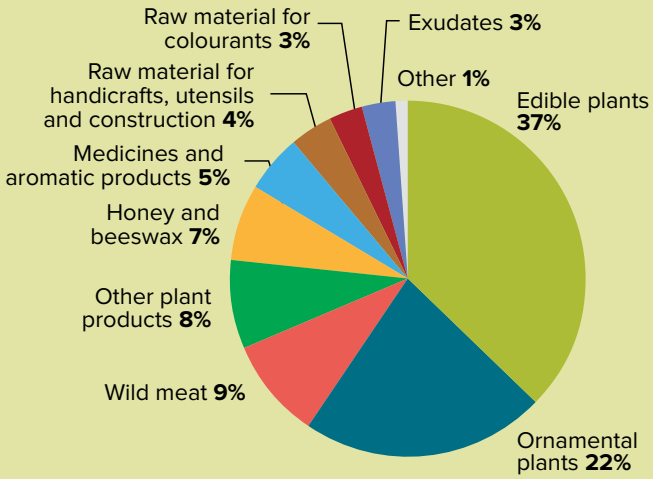
8 The term NWFP excludes all woody raw materials. Consequently, timber, chips, charcoal and fuelwood, as well as small woods such as tools, household equipment and carvings, are excluded. Non-timber forest products (NTFPs), in contrast, generally include fuelwood and small woods; this is the main difference between NWFPs and NTFPs.

9 The Millennium Ecosystem Assessment (MA 2005), distinguishes provisioning ecosystem services (e.g., food and feed, fibre and biomass, medicines, freshwater) from non-provisioning ecosystem services. This last category is further divided in three subcategories: regulating services (e.g., climate and water regulation, water, air quality, erosion control, pollination), supporting services (soil formation, photosynthesis, nutrient and water cycling), and cultural services (e.g., recreation, ecotourism, cultural heritage, spiritual and ethical values, existence values).

## Box 2. Non wood forest products (NWFPs)

At the global level, there is still no systematic framework to collect data on NWFPs because: (i) there is no universally agreed definition of NWFPs; (ii) hunting and gathering activities, often informal, are not easy to capture through formal statistics; and (iii) a huge number of forest products and species can be considered as NWFPs and should be included in such statistics (Sorrenti 2017; Muir et al. 2020). Moreover, as forest and farmland sources are often assessed differently by government forestry and agriculture departments, a proper synthesis of the overall value of tree products and services across these sources is hard to achieve (de Foresta et al. 2013).

The latest FAO Global Forest Resources Assessment (FRA2020: FAO 2020) represents the first global attempt at systematic data collection on NWFPs, including food products. It covers the NWFPs considered to be the most commercially important at the national level for 124 countries representing 73 percent of the world's forests. Plant products account for 80 percent of the global economic value of NWFPs collected, animal products for the remaining 20 percent. The most important categories are edible plants (37 percent), ornamental plants (22 percent), wild meat (9 percent), honey and beeswax (7 percent) and medicinal and aromatic plants (5 percent) (FAO 2020).




Note: Numbers may not sum to the totals indicated and percentages may not tally to 100 due to rounding.

**Figure 1. Non-wood forest products categories as a proportion of total reported economic value, 2015.**

Woman collecting fuelwood - Yangbi, DRC.
Photo by Axel Fassio/CIFOR

## Bioenergy

In many developing countries, woodfuel is often the main or only source of energy for cooking and boiling water available and accessible to poor people in rural areas, especially in Africa where it represents 27 percent of the total primary energy supply (FAO 2014a). FAO (2014a) estimated that some 2.4 billion people, including two-thirds of households in Africa, are using woodfuel as their main source of energy for cooking, while 764 million people use woodfuel to boil and sterilize water, of which 644 million are in Asia. However, overharvesting puts fuelwood resources at risk in many places and increases the time needed to collect fuelwood. Even in countries with moderate fuelwood scarcity, people, mostly women, have been reported to walk up to 10 km to gather wood (Wan et al. 2011) notwithstanding the concomitant health impacts of fuelwood burning in enclosed rural kitchens (FAO 2014a; HLPE 2017).

## Employment and income

Forests and trees also contribute indirectly to FSN through employment and income generation. In many places, forest- and tree-related jobs and activities, both formal and informal, can represent an important, if not the main source of livelihoods for many people, especially vulnerable people (poor, smallholder, women, or indigenous communities), living in rural areas in developing countries. In Zambia for instance, forest-related activities, both formal and informal, represent more than a million jobs for a total population of about 13 million, and over 80 percent of rural Zambian households depend heavily on natural resources for their livelihoods (Turpie et al. 2015). Based on data from the Poverty and Environment Network (PEN),[10] Angelsen et al. (2014) calculated that, on average, about 22 percent of rural household income is derived from forest products and environmental resources, often equivalent or higher than the income derived from agriculture. PEN data also showed that dependence on forest products tends to increase in lower income groups (Angelsen et al. 2014; Wunder et al. 2014).

## Non-provisioning ecosystem services

Forests and trees deliver a number of non-provisioning ecosystem services, essential for agriculture, food production, human health and well-being, and sustainable development (Richardson 2010; Foli et al. 2014; HLPE 2017; Prabhu et al. 2015; Reed et al. 2017; Rosenstock et al. 2019). This includes: (i) ecosystem services critical for current food production, such as local climate and water regulation, pest control, pollination or nutrient cycling, as well as (ii) ecosystem services supporting the stability and sustainability of food production in the long term, such as climate change mitigation and adaptation, soil formation and erosion control or biodiversity conservation. These ecosystem services can be provided, to different extents, by a wide diversity of tree-based ecosystems, from agroforestry systems to natural forests.

Beyond their immediate contribution to FSN, health and livelihoods, forests, trees and related activities, such as hunting and gathering, are also a significant part of the cultural and spiritual identity of many societies, including but not limited to indigenous peoples and forest-dependent communities, not only in the tropics but also in temperate and boreal forests of North America and Europe (MacKay and Campbell 2004; Kuhnlein et al. 2009; Willebrand 2009; Konijnendijk 2010; Fischer et al. 2013; Whyte 2013). Some wild traditional food species are “cultural keystone species”. The cultural value adds up to economic value, with for instance emigrants willing to pay more to consume traditional foods from their homelands (Ndam et al. 2001; Garibaldi and Turner 2004; Van Damme and Termote 2008; LaCerva 2016).

10 PEN is a collaborative effort launched in 2004 and led by the Center for International Forestry Research (CIFOR). This project generated the largest and most comprehensive pantropical database on forests and poverty, including comparable socioeconomic and environmental information collected from 8,301 households, in 333 villages in 24 developing countries. See: https://www2.cifor.org/pen/about/ (accessed in August 2020).

## 2 Contributions of forests and trees to the four dimensions of FSN

This section details how forests and trees contribute to each one of the four dimensions of FSN (availability, access, utilization and stability). These contributions mobilize the four above-mentioned main categories (see Figure 2).

### Availability

Food/FSN availability results both from direct and indirect contributions of forests and trees (see categories 1 and 4 in Figure 2).

First, forests and trees directly provide a wide variety of plant- and animal-sourced foods, which may represent an essential part of the diet for many people living in or near forests and more broadly in rural areas (see below: Utilization) and contribute to balanced diets for the global population. The most consumed wild and forest food species are fruits, vegetables, mushrooms and animal-source foods such as fish, animals, birds and insects – all of particular importance to nutrition (Powell et al. 2015). The quantity, frequency and type of forest food used varies greatly from one place to the next (Powell et al. 2015; Rowland et al. 2016): from occasional supplementation to a very high level of dependence. The diversity of plant species in tree-based systems and the differences in their fruiting phenology help ensure all year-round food availability, including availability of particular micronutrients, such as vitamins (Vira et al. 2015; McMullin et al. 2019). Forests and trees, used as a reserve of fodder, can support livestock production and increase animal-sourced food consumption among poor rural communities living in or near forests.

Forest foods, traded in local, national and international markets, also contribute to global food availability and to FSN of much wider populations, including people living far from forests, even in urban areas (WHO/CBD

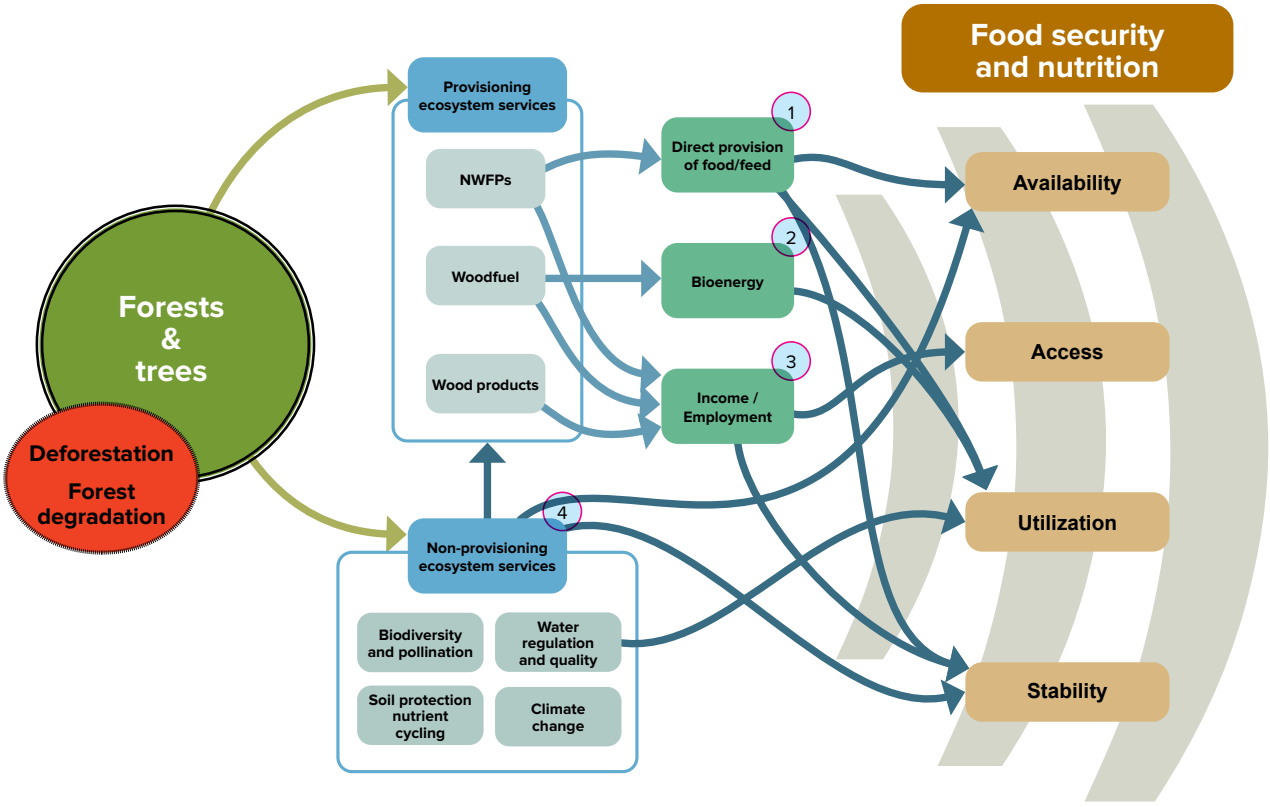



**Figure 2. Multiple contributions of forests and trees to the four dimensions of FSN.**

Source: Adapted from HLPE (2017).

*Amanita caesarea*, commonly known as Caesar's mushroom (Russia).
Photo by Nikolay Kashpor/CC BY 4.0

2015; LaCerva 2016). Almost 4.6 million metric tons of bushmeat are extracted annually from the Congo Basin, out of which around 6 percent are consumed in urban areas, where bushmeat is considered "high-status food" (Nasi et al. 2011; van Vliet et al. 2015; HLPE 2017). Many non-tree but originally forest species, such as peanuts (*Arachis hypogea*), various species of beans (*Phaseolus spp.*), cassava (*Manihot esculenta*), banana (e.g., *Musa Acuminata*), pineapple (*Ananas comosus*), cashew (*Anacardium occidentale*), maracujá (*Passiflora edulis*) and peach-palm (*Bactris gasipaes*), have been domesticated and became widely traded commodities (HLPE 2017), and forests are still reservoirs of genetic diversity for these species (FAO 2014b). All nuts[11] and more than half of all fruits (in metric tons) produced worldwide grow on trees (Powell et al. 2013a).

The indirect pathway to availability results from the fact that forests and trees provide ecosystem services that critically support agriculture. Forest and tree root systems, transporting deeper water and nutrient resources close to the soil surface and making them accessible for other crops, enhance agricultural productivity (Jose 2009; FAO 2010; CIE 2011). They contribute to regulating surface and groundwater flows, mitigating flood risk, reducing water runoff by facilitating water infiltration in soils, and enhancing water quality (Bradshaw et al. 2007; FAO 2013; Miura et al. 2015; Ellison et al. 2017). Forests and trees play a critical role in the provision of adequate water supply (quantity and quality) for human consumption, agriculture irrigation, or alimentation of lakes and rivers on which inland fisheries depend, all essential for FSN (Carignan and Steedman 2011; FAO 2013).

Forests and trees also shelter a range of auxiliary species, including pollinators and natural pest enemies, which provide multiple benefits for availability at different scales, particularly in smallholder agricultural systems with no or little agrochemical use (Bale et al. 2008; Garibaldi et al. 2011; Karp et al. 2013; Foli et al. 2014; Reed et al. 2017). Beside water provision, pollination is probably one of the most important ecosystem services for global food production. An estimated 86 percent of all flowering plant species depend, for their reproduction, on animal pollinators, mostly insects (Ollerton et al. 2011). Fruit, vegetable or seed production from 87 of the world's most important food crops, representing 35 percent of global food production, depend to some extent upon animal pollination, (Klein et al. 2007). Large-scale land conversion to specialized and intensive monoculture systems, excessive pesticide application, as well as emerging predators and diseases (e.g., Asian hornet or varroa) have been associated with the recent massive decline of domesticated honey bee populations and

11 Groundnuts (peanuts) are not considered nuts.

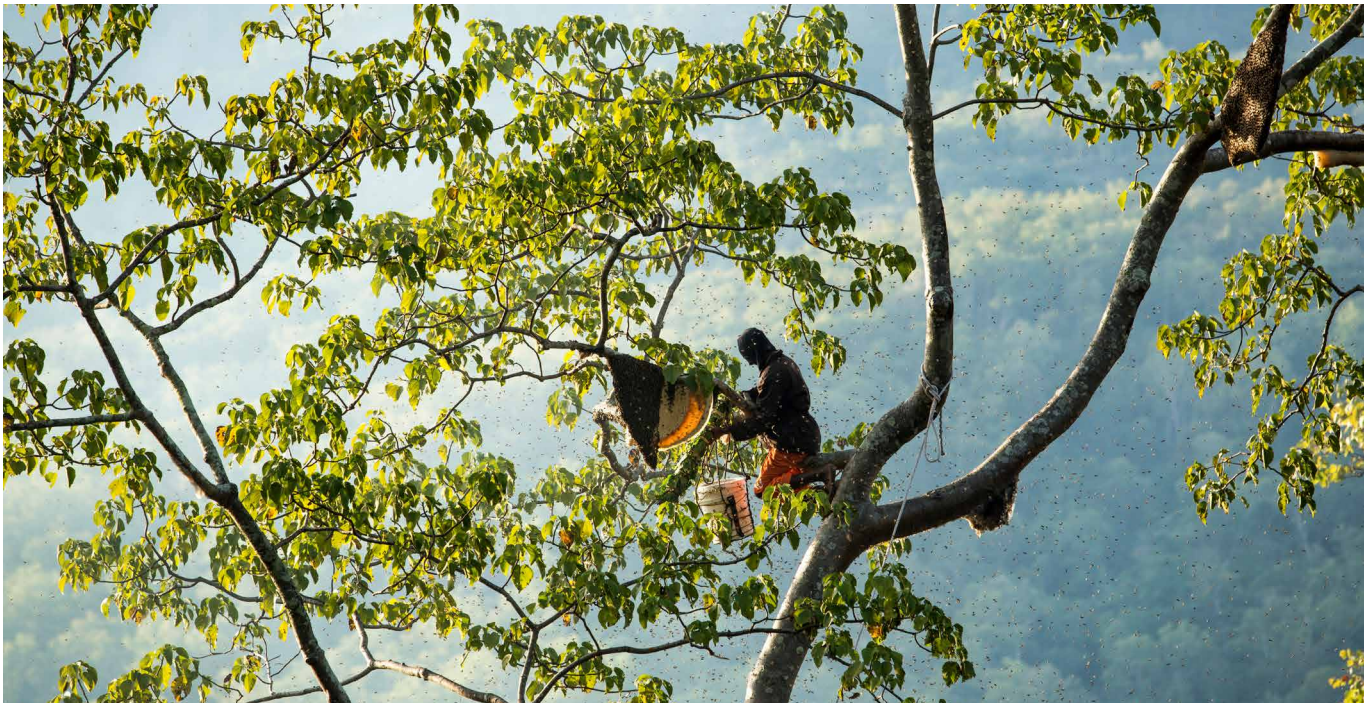
the increase of colonies collapse disorder (CDD) (Klein et al. 2014; IPBES 2016; HLPE 2017). This raised a renewed interest in native wild bees and wild pollinators able to sustain crop yields (Aizen et al. 2009; Garibaldi et al. 2011, 2013; IPBES 2016). Numerous studies have demonstrated strong relationships, both in tropical and temperate ecosystems, between proximity of forest, forest strips and fragments; bee abundance and pollination rates; and agricultural productivity (Hawkins 1965; De Marco and Coelho 2004; Ricketts 2004; Blanche et al. 2006; Chacoff and Aizen 2006; Taki et al. 2007; Ricketts et al. 2008; Aizen et al. 2009; Arthur et al. 2010; Garibaldi et al. 2011; Watson et al. 2011; Freitas et al. 2014; Bailey et al. 2014; Kormann et al. 2016). Warming temperatures in a changing climate, impacting the seasonal development cycle of plants and animals, can cause temporal mismatches threatening plant-pollinator associations or beneficial predator-prey relationships (Fitter and Fitter 2002; Laws 2017; IPBES 2018).

Forests and trees, through their impact on GHG emissions, evapotranspiration, albedo and surface roughness, contribute to climate regulation, affecting temperature, wind and rainfall regimes locally and at larger scales (Ellison et al. 2017; Jia et al. 2019), thus impacting agricultural productivity and food availability. Deforestation reduces or interrupts soil-atmosphere moisture fluxes, impacts water circulation in the atmosphere and can generate “downwind” water shortages. For instance, current deforestation in the Amazon Basin is threatening the existence of the “flying river”, i.e., a low-level jet of atmospheric water vapour flux driven by winds, representing a water flux bigger than the one of the Amazon River, largely responsible for precipitation and freshwater supply in Southeast Latin America (Marengo et al. 2004; Nobre 2014; HLPE 2015).

## Access

Contribution of forests and trees to FSN access is mainly linked to their function of income and employment generation (see category 3 in Figure 2).

Forests and trees provide means of subsistence, employment and income to millions of people, making an essential contribution to their FSN status. This contribution is not well covered overall by official statistics. First, because a large share of the economic benefits and employment generated by forests and trees is not accounted for in the forest sector but in other economic sectors from agriculture to industry and services (tourism). Second, because the biggest component of such employment is informal and thus



Honey hunter from the Molo community harvesting honey in the forest. West Timor, Indonesia.
Photo by Nanang Sujana/CIFOR

Timber transformation is an important source of employment in Cameroon.
Photo by Mokhamad Edliadi/CIFOR

not well assessed nor included in national reporting systems (Agrawal et al. 2013; Whiteman et al. 2015; HLPE 2017). Third, because studies on employment do not adequately capture the realities of livelihoods depending on multiple means of subsistence. For all these reasons the contribution of forests and trees to economic access to food at the global level is largely underestimated.

In 2011, at the global level the formal forest sector[12] employed around 13.2 million people in full-time equivalents (FTE, i.e., 0.4 percent of the global workforce) and generated a gross value added (GVA) of USD 606 billion (0.9 percent of the world gross domestic product - GDP) (FAO 2014a). However, the largest parts of income and employment generated by products and services derived from forests and trees are not included in these figures because they are accounted for in other economic sectors: agriculture (tree crops, fruits and nuts); industries (e.g., construction, furniture manufacture, paper and chemical industries, logistics and packaging); or services (ecotourism, recreation activities or payment for ecosystem services).

12 i.e., forestry and logging, sawnwood and wood-based panel production, pulp and paper production.

Many forest-dependent communities around the world, including poor rural communities, indigenous people or ethnic minorities, smallholder farmers and pastoralists, rely heavily on informal forest-related activities, such as hunting, gathering or fuelwood collection, as important sources of livelihoods. FAO (2014) estimated that, when considering both formal and informal sectors, the 2011 forest sector GVA increased to almost USD 730 billion, including USD 33 billion from informal production for construction or energy and USD 88 billion from NWFP collection. Agrawal et al. (2013) estimated that the informal forest sector employed 40-60 million people. According to FAO (2014), in 2011, the forest sector contributed directly to the livelihoods of 83.3 million people worldwide: not only the abovementioned 13.2 million people employed in the formal sector, but also 29 million forest owners (families and individuals), and at least 41 million FTE in the informal sector. In addition, 841 million people are engaged part-time (on average 5 percent) in fuelwood collection and charcoal production for urban markets and many millions more collect fuelwood or forest foods for sale in rural markets or for their own subsistence' (FAO 2014a).

Brazilian Nuts - Brazil.
Photo by Neil Palmer/CIAT

According to FAOSTAT,[13] in 2016, the six main tree crops (oil palm, coconut, cocoa, rubber, coffee and olive trees) covered 74 million ha globally and generated a gross production value of USD 136.7 billion. Coffee production alone employs 25 million people globally, the majority of whom are smallholders in developing countries.[14] The cocoa sector is an important source of livelihoods, providing revenue for 40 to 50 million people in 2012, mostly in developing countries (Houston and Wyer 2012). These commodities contribute to the livelihoods of numerous smallholders and are also at the origin of important processing industries that employ many people, particularly women, often in small enterprises in rural areas.

13 See: http://www.fao.org/faostat/en/#data/QC and http://www.fao.org/faostat/en/#data/QV (accessed in August 2020)

14 See International Coffee Organization (www.ico.org) (accessed in August 2020).

The collection of forest products, for sale or subsistence, can provide an essential source of livelihoods for women, who have limited access to many alternative opportunities more easily available to men, and for their entire household (Sunderland et al. 2014; HLPE 2017). For instance, according to a report by UNEP (2014), the collection, processing and marketing of oil-rich nuts from shea trees (*Vitellaria paradoxa*) naturally grown in forests, represented about 80 percent of income for over 4 million women in West Africa. FAO (2014) suggests that women play a smaller role in the formal sector (where they represented only 24 percent of the total workforce in 2011) and in full-time income and are more often engaged in part-time activities including fuelwood or NWFP collection for subsistence. FAO (2014) found that women represent only 4 million out of the 41 million people engaged in full-time woodfuel production activity, but account for the vast majority (706 out of 841 million) of the people engaged in part-time activities of woodfuel collection.

Prior to the COVID-19 crisis, tourism was an increasing source of income for forested areas. In many parts of the world, from tropical to temperate and boreal zones, hunting and ecotourism are growing economic activities. In some parts of the boreal zone, hunting tourism is a mature market, contributing significantly to local economies (Fischer et al. 2013; MacKay and Campbell 2004; Willebrand 2009). In Norway, hunting of moose has been valued at USD 70 to 90 million annually (Storaas et al. 2001). In Finland, Norway and Sweden, non-market valuation studies show that the value of hunting can be divided into a meat-based part and a recreation-based part (Fredman et al. 2008). In the tropics, Costa Rica promotes its biodiversity and ecotourism with great success. In 2016, the tourism sector in Costa Rica represented 7.2 percent of total employment, estimated to be 28 percent when including indirect jobs (OECD 2018).

The contributions of forests and trees to the access dimension of FSN depend also on access rights to forests and tree products. Protecting access and use rights to land, trees and other natural resources is critical for the FSN of many forest-dependent communities, especially the most vulnerable (FAO 2005; HLPE 2017; Sunderland and Vasquez 2020). Any single parcel or landscape is subject to a complex web of multiple access and use rights, that can be held by different stakeholders, simultaneously or successively (Fortmann and Bruce 1988; Bruce 1999; Fuys and Dohrn 2010). Land ownership, for instance, does not automatically imply ownership of the trees grown upon it (Castro 1983; Fortmann and Riddell 1984; FAO 1989).

Olive trees on Thassos, Greece.
Photo by Petr Pakandl/CC BY-SA 2.5

In Morocco for instance, argan trees (*Argania spinosa*) remain state property, even when they grow on private land (Biermayr-Jenzano et al. 2014). Such complex webs of rights are often a cause of conflicts between different rights holders (Bruce 1999). In Morocco, conflicts are frequent around argan trees, between nomadic camel and goat herders with grazing rights and local residents with the right to harvest argan fruit (Biermayr-Jenzano et al. 2014). In cases of conflict, specific attention must be paid to the needs and rights of the most vulnerable and food insecure people and communities, considering that populations with customary *de facto* access and use rights are generally more vulnerable than private landowners or communities with formalized *de jure* rights over forests and natural resources (RRI 2012; HLPE 2017).

## Utilization (and nutritious diets)

Forests and trees contribute in multiple ways to better food utilization and nutritious diets (through categories 1, 2 and 4 in Figure 2).

Nutrient-rich foods from forests and trees make an essential contribution to dietary quality and diversity and, hence, to human health (Vinceti et al. 2008; Powell et al. 2013b, 2015; HLPE 2017; Ickowitz et al. 2014, 2016; Herrero et al. 2017; Rasolofoson et al. 2018; Rasmussen et al. 2020; Baudron et al. 2019).

Fruits and nuts are among the most nutrient-dense foods, but they are under-consumed in many countries. Fruits and vegetables are under-consumed in all regions of the world, except for China, Japan and South Korea (Berners-Lee et al. 2018). Indigenous tree fruits can contain up to five times more vitamin C than oranges[15] (McMullin et al. 2020). According to Vira et al. (2015), consuming only 10 to 20 g of baobab fruit pulp, or a glass of its juice (made with the pulp), can cover a child's daily vitamin C requirement. Edible leaves from trees and shrubs are also important sources of protein, iron, calcium, folate, vitamin A and vitamin C, all key nutrients often lacking in a staple-based diet (Latham 1997; FAO and WHO 2004b; Kehlenbeck and Jamnadass 2014).

15 Vitamin C concentrations in orange, mtikiza fruit (*Sorindeia madagascariensis*), marula fruit (*Sclerocarya birrea*) and baobab fruit (*Adansonia digitata*) amount respectively to 53, 107, 160 and 273 mg per 100g of edible portion (EP) (McMullin et al. 2020).

Animal-sourced foods (ASFs) from forests, including bushmeat, honey, fish and insects, make an important contribution to nutrition, not only as a source of protein but also of highly bio-available micronutrients (Murphy and Allen 2003, Headey et al. 2018). In regions with high prevalence of micronutrient deficiencies, even modest amounts of ASFs can make a difference for the nutritional status and cognitive development of children (Neuman et al. 2007). In many forest-dependent communities where people have few alternative sources of protein and income, wild fish and bushmeat can become the main source of animal protein, cheaper than any domesticated meat. Forests often support significant fish consumption (Lo et al. 2019, 2020). For instance, da Silva and Begossi (2009) found that, in the Rio Negro region of the Brazilian Amazon, fish caught in flooded forests and forest rivers amounted to 70 percent of animal protein in the diet, excluding other aquatic species such as turtles. Hence, forest degradation and overexploitation of wildlife might have severe impacts for the FSN and health of many forest-dependent people (Fa et al. 2002; Golden et al. 2011; van Vliet et al. 2015; HLPE 2017). The relations between trade in wild meat, wet markets and bushmeat's role in diets and rural livelihoods, have reappeared again as part of discussions over the origins of COVID-19 (McNamara et al. 2020). Lack of access to wild meat because of trade bans could result in hunger and malnutrition for local and indigenous communities (Nasi and Fa 2020), while not necessarily improving the ecological status of endangered species.

Rowland et al. (2016), in a study across 37 sites in 24 tropical countries, based on data from 7,569 households in the PEN database, found that over half of the households surveyed consumed forest foods, and that forests provided up to 15 percent of the fruits and vegetables needed to meet dietary recommendations. Despite their low to moderate contribution to energy intake, wild foods can represent up to 36 percent of total vitamin A and 20 percent of iron in the diet in Gabon (Blaney et al. 2009), or 31 and 19 percent respectively in Tanzania (Powell et al. 2013c).

Livestock-based livelihood system (dependent on fodder tree, Khejri) in Churu District, Rajasthan.
Photo by V.P. Singh/World Agroforestry

Market in the village of Minwoho, Lekié, Center Region, Cameroon.
Photo by Ollivier Girard/CIFOR

The direct contribution of forest and tree foods to nutritious diets is generally grossly undervalued for multiple reasons. The first one is the under-representation of forest and tree products in terms of global food. The second one is the use of metrics focusing on energy/calory supply, that is wildly disproportionate to the real nutritional contribution of forest and tree products. Using energy-based metrics, FAO (2014) estimated that forest foods represented 0.6 percent of global food supply. A second bias is that global numbers hide critical contributions of forests and tree foods to nutritious diets, especially in populations living in proximity to forests (Food Secure Canada 2008; Powell et al. 2015; Rowland et al. 2016; HLPE 2017). Countries need to improve data collection on forest foods consumption and their contribution to diets (Sorrenti 2017; FAO 2020), as well as on tree foods.

For numerous households, woodfuel is the only available source of energy to cook food and boil water; a major contribution of forests and trees to the utilization dimension of FSN (FAO 2014a; Herrera et al. 2017; HLPE 2017). Cooking and boiling water are instrumental to food safety. Cooking also improves the bioavailability of numerous micronutrients. Lack of woodfuel might reduce dietary quality and diversity, leading to omission of meals or exclusion of foods (such as beans) requiring longer cooking times (Brouwer et al. 1996,1997; Wan et al. 2011). Access to woodfuel thus contributes to preventing food and water-borne illness and improving nutritional status. However, the use of woodfuel on open fires or traditional stoves also generates respiratory illnesses, particularly for women and children, which, in turn, impacts their nutritional status (Kiraz et al. 2003; Wan et al. 2011; Po et al. 2011; FAO 2014a; HLPE 2017).

Water quality, a major determinant of good nutrition, is strongly enhanced by forest protection of streams and vegetative coverage of hillsides subject to erosion. FAO (2013) estimates that at least one-third of the world's largest cities draw a significant proportion of their drinking water from forested areas.

## Stability

Stability is a particular dimension of FSN insofar as it concerns the stability of the other three components/pillars (availability, utilization and access). The contribution of forests and trees to stability is linked to categories 1, 3 and 4 in Figure 2. These three categories in fact cover various ways by which forests and trees play a critical role in improving resilience[16] at global, landscape, community and household levels, to various risks that can impact FSN, including climate change.

First, at household level, forests and trees provide complementary or alternative sources of food, feed, income and employment, thus playing an important role as a safety net during drought or lean seasons, as well as during periods of crises and conflicts, in particular for the most vulnerable populations (Humphry et al. 1993; Angelsen and Wunder 2003; Shackleton and Shackleton 2004; McSweeney 2004; Keller et al. 2006; Karjalainen et al. 2010; Mulenga et al. 2012; Sunderland et al. 2013; Powell et al. 2013c, 2015; Blackie et al. 2014; Wunder et al. 2014; HLPE 2017). Diversification of agroecosystems strengthens resilience to both economic and environmental shocks (Powell et al. 2015; HLPE 2016; Rahman et al. 2013; FAO 2016). For instance, a wider diversity of fruit tree species in agroforestry systems can help prevent or limit seasonal shortages in fruit supply (Jamnadass et al. 2011; Vinceti et al. 2013; McMullin et al. 2019).

Second, at ecosystem/landscape level, forests and trees provide many ecosystem services able to enhance food systems' resilience and support the stability of food production in that ecosystem in the long term. Forest and tree root systems and canopy cover help protect soils against erosion from wind and water, particularly in areas of steep slopes and heavy rainfall, and against desertification (Khalil 1983; Petrov and Lobovikov 2012; Gitz et al. 2020). Forests and trees also contribute to soil formation, enhancing soil organic matter accumulation. In turn, soil organic matter improves soil structural stability, further reducing vulnerability to wind and water erosion. It buffers soil pH and facilitates nutrient and water circulation in soils, thus supporting soil biodiversity, health and fertility (Kimble et al. 2007; IPBES 2018; FAO and ITPS 2015; Miccolis et al. 2019: Olsson et al. 2019).

16 Defined as the capacity to prevent, mitigate or cope with risk, and recover from shocks (Gitz and Meybeck 2012).

Third, forests and trees are instrumental for climate change adaptation. They play a key role in climate (temperature, wind and rainfall) regulation, in flood control and water supply regulation (quantity and quality), in coastal protection against sea level rise, as well as in pest control. All these functions will be essential for increasing the resilience of food production systems to increased climate variability and intensified extreme climatic events (Pramova et al. 2012; FAO 2016; HLPE 2017). The deep and extensive root systems of trees make them more tolerant than annual crops to weather-related shocks, including droughts, winds and heatwaves, allowing them to produce food when other food sources are not available (Jamnadass et al. 2011; Kehlenbeck et al. 2013). This calls for better integration of forests and trees in adaptation strategies aiming at enhancing FSN, as well as for additional measures to increase adaptive capacity and support adaptive management of forests; particularly relevant in an uncertain future (Robledo and Forner 2005; Seppälä et al. 2009; FAO 2017; Meybeck et al. 2019, 2020). Because of their capacity to store carbon in soils and biomass, forests and trees are and will also be critical for climate change mitigation (Griscom et al. 2017; Fuss et al. 2018; IPCC 2018; Hepburn et al. 2019; Roe et al. 2019; Jia et al. 2019).

Fourth, the biodiversity harboured in forest- and tree-based systems, including wild relatives of agricultural crops or wild pollinators, is critical for global food production in the long term (Bélanger and Piling 2019). The world's forests are estimated to contain 80 percent of terrestrial biomass and to host more than half of all known terrestrial, plant and animal species (Shvidenko et al. 2005; Aerts and Honnay 2011). Primary forests in particular are irreplaceable pools for biodiversity conservation. In the Brazilian Amazon, 25 percent of species and nearly 60 percent of tree and liana genera are unique to primary forests (Barlow et al. 2007). Domestication of indigenous trees or wild forest species holds huge potential for food production, job creation and income generation (Vira et al. 2015) and supports the conservation of important genetic resources outside of threatened forests (Jamnadass et al. 2011). Further research efforts are needed to better understand and harness this potential, which could beneficially build upon the traditional and indigenous knowledge of local communities (Jamnadass et al. 2011; Gyau et al. 2012).

## 3 Relations between the concept of "Dependence of people on forests and trees" and the contributions of forests and trees to FSN

Newton et al. (2016) note that despite the long history and widespread use of the term "forest dependent", there are substantial divergences about to whom it refers. The analysis of the uses and definitions of "forest dependence" by different authors led them to conclude that a universal definition would be untenable. Forest dependence should be defined in relation to a specific use or function.

The contributions of forests and trees to FSN and their variations by regions, social groups, households and even within households can help to further enrich (through FSN dimensions) the concept of a given group's "dependence on forests and trees". And by means of consequence, this leads to a better understanding of the concept of forest dependence, and to better cover the diversity of "forest-(and tree-) dependent" people.

To integrate the different contributions of forests and trees to FSN, into the notion of forest dependence, we start from the categories suggested by Fisher et al. (1997), driven by an economic dependence perspective, and that started with people/populations living in or in proximity to forests. We then include populations that benefit from/depend on the contribution of forest and tree ecosystem services to agriculture, from the employment generated by processing industries and from the contribution to diets and good nutrition (utilization dimension of FSN). The latter includes, in particular the consumption of woodfuel as well as of fruits, nuts and other forest and tree products including by urban populations (HLPE 2017; FAO and CIFOR 2019).

This leads to the following classification of types of forest dependence (that are not exclusive) :

a. People living in and around natural forests, or on the forest frontier, including indigenous peoples or minority ethnic groups, often living as hunter-gatherers or shifting cultivators, and who are heavily or exclusively dependent on forest resources (timber, food, feed, woodfuel, fibre and medicines) for their subsistence.

Aerial view of the Amazon rainforest, near Manaus, the capital of the Brazilian state of Amazonas, Brazil.
Photo by Neil Palmer/CIAT

b. People living in proximity to forests, usually involved in agricultural practices either within or outside the forest, who regularly use forest products as complementary sources of subsistence (food, feed and/or income).
c. People engaged in agricultural and agroforestry systems that are heavily dependent on the provisioning and non-provisioning ecosystem services provided by forests and trees.
d. People depending on forest- and tree-related commercial activities (such as hunting and gathering, forestry and logging, forest industries, production and transformation of tree commodities, recreation activities or ecotourism) as a source of employment and cash income.
e. People depending on woodfuel for cooking and boiling water.
f. People depending on forests for clean water.
g. Worldwide population regularly consuming forest and tree products (fruits, nuts and others) and benefitting, directly or indirectly, from forest and tree ecosystem services that sustain agriculture and food production (e.g., pollination or water provision or genetic resources in crop wild relatives).

Newton et al. (2020) estimate that 1.6 billion people lived within 5 km of a forest in 2012, two thirds of them in tropical and low- or middle-income countries. Even if they do not all have access rights to forests, they are benefitting from them in various ways for their FSN. It is a coincidence that this number is close to the estimate for forest-dependent people of 1 to 1.7 billion (Chao 2012; HLPE 2017) summing up indigenous peoples, rural communities, smallholder farmers and employees of forest-based enterprises. Neither figure however fully covers the range of people depending on forests and trees – to various extents – for their livelihoods (category d above), or for clean water, woodfuel or forest and tree products providing essential nutrients (categories e to g above). The contributions of forests and trees to FSN and different categories of forest-dependent people can be inscribed in concentric circles, from households of local forest dwellers (category a) to the entire global population (category g). Globally, the closer people are to the forest, the stronger their "dependence on forests". But, as evidenced in this paper, forest dependence and contributions of forests and trees to FSN can also be significant at the landscape, national and even global level, with differences according to types of contributions and contexts (see Figure 3).

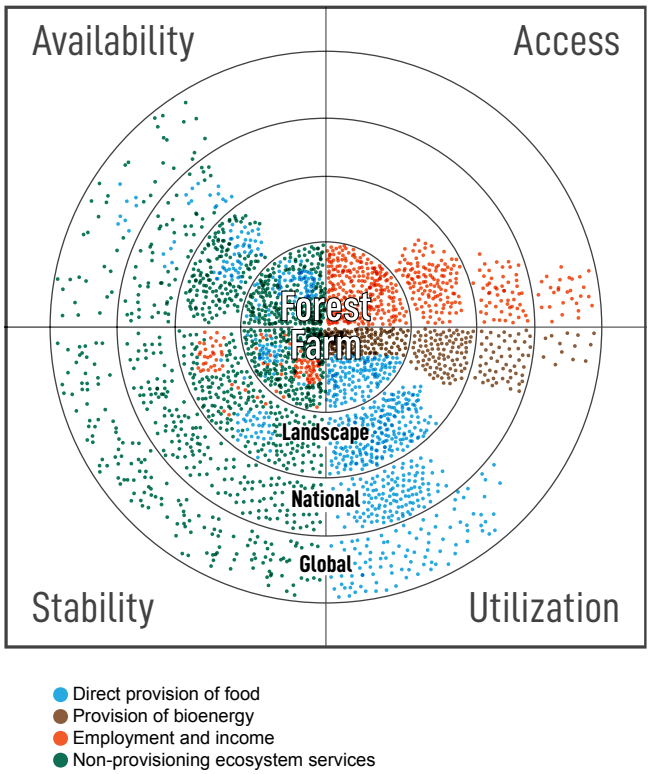



**Figure 3. Schematic representation of the multiple contributions of forests and trees to the four dimensions of FSN from local to global scales.**

Figure 3 provides a schematic view of the various contributions of forests, trees and agroforestry to the four dimensions of FSN at 4 concentric scales through points density. The density of dots is meant to be illustrative of the strength of the various contributions (with different colours for the different categories of contributions) in diverse contexts and at the different scales.

## Conclusions and recommendations

Forest- and tree-based ecosystems, in their diversity, contribute directly and indirectly to FSN at different spatial and temporal scales, through four main categories: direct provision of food and feed; provision of bioenergy for cooking and boiling water; provision of income and employment (both formal and informal); and provision of ecosystem services indispensable for agriculture and food production. Each of these categories impacts different dimensions of FSN through several pathways, constituting a varied set of important different contributions. These contributions need to be

appropriately assessed and considered in the design of policies and measures that influence land use and forest and tree management to avoid negative consequences on FSN and maximize positive impacts. There is otherwise a major risk that policies will be based on the criteria that are most easily available (such as income or calories), ignoring other criteria for which information is scarce or that are important for social groups that have less voice in political debates. In so doing there would be a major risk of policies having undesired detrimental effects on food security and nutrition, social equity and environmental sustainability.

Appropriate metrics are needed, at different scales, to better inform decision makers about the contributions of forests and trees to FSN. This need is recognized at the global level; the Global Core Set of indicators developed by UNFF includes an indicator on the contributions of forests and trees to FSN (Indicator 14, see Box 3). This GCS indicator represents a first attempt to develop such metrics, based on national data already available in reliable global databases. It needs to be complemented by more locally appropriate information. To the extent possible, such metrics should build upon data disaggregated by gender, age and other relevant social parameters (HLPE 2017; CFS 2017).

Further research, including large-scale and long-term research projects, would be needed to better understand and enhance these multiple contributions (Reed et al. 2017, HLPE 2017; CFS 2017), as well as to make explicit the associated synergies and trade-offs between contributions at diverse geographical and temporal scales. For instance, developing wood production can increase income for forest employees (e.g., category d), but may reduce the diversity of products collected and thus have detrimental consequences on diets of local communities (e.g., categories a and b).

Policy coherence should be strengthened, across sectors (e.g., forestry, agriculture, environment, land planning, trade, education, health, etc.) and across spatial and temporal scales, to enhance the multiple contributions of forests and trees to FSN and sustainable development, strengthen resilience at landscape, community and household levels, preserve biodiversity and sustainably manage ecosystems, and address the challenges associated with climate change. In particular, policy and decision makers should adopt integrated landscape approaches for sustainable forest management, land-use planning and adaptive land management, which consider forests and trees as key components of broader, multifunctional, nutrition-

## Box 3. Contributions of forests and trees to FSN: What global metrics?

The CPF (2019) initiated in 2016 a joint attempt to develop a concise Global Core Set (GCS) of 21 forest-related indicators to measure the contributions of sustainable forest management to the 2030 Agenda for Sustainable Development (UN 2015), the United Nations Strategic Plan for Forests 2030 (UNDESA 2019) and other international agreements. GCS Indicator 14, "contributions of forests and trees to FSN," relates to Global Forest Goal 2 (Target 2.3).[17]

As these contributions are very different in nature and benefit different groups of stakeholders at different scales, it is impossible to include them all in one single indicator. Therefore, a set of sub-indicators has been proposed, using data already available at the national level:

- *Fruit consumption per capita*, based on FAOSTAT Food Balance Sheets (FBS);
- *Nut consumption per capita*, based on FBS;
- *Woodfuel consumption per capita*, based on FAOSTAT[18] data;
- *Employment provided by forests and trees*, building upon ILOSTAT[19] data and other appropriate reliable sources.

This set of quite readily available sub-indicators could be complemented by an additional indicator to better assess the importance of ecosystem services provided by forests and trees to farming systems. Among the options proposed are:

- *Percentage of farming households having part of their livelihood coming from forests and trees.*
- *Forest proximity.*

Source: CPF (2019).

17 "The contribution of forests and trees to food security is significantly increased" (UNDESA 2019).

18 See: http://www.fao.org/faostat/en/#home

19 See: https://ilostat.ilo.org/

sensitive landscapes (Reed et al. 2020). Such an integrated, cross-sectoral and multi-scale land and forest governance process should seek to maintain and enhance the ecosystem services provided by forests and trees without compromising the rights of local forest-dependent populations to access and use forest foods and forest resources, enabling them to realize their right to adequate food. As a consequence, full and effective participation to decision making of all relevant stakeholders, particularly the most vulnerable (women, indigenous peoples, smallholder farmers and pastoralists, forest dwellers and forest-dependent communities) should be ensured, enabling them to protect and fulfil their rights, views, cultures, traditional knowledge and practices (HLPE 2017; CFS 2017). Agricultural policies that are often focused on staple crops need to better integrate the specificities of tree crops and the multiple benefits provided by the integration of trees in farming systems. A particularly promising development is the adoption of agroforestry policies in India and Nepal with others in preparation in several countries.

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