Food and Agriculture Organization of the United Nations

FORESTS FOR FOOD

Nourishing people, sustaining the planet

LANDSCAPE ALLIANCE

CIFOR & ICRAF in action

CPF Collaborative Partnership on Forests

FORESTS FOR FOOD

Nourishing people, sustaining the planet

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2 Forest foods make substantial contributions to diets in some forest-dependent communities – up to 80 percent of total protein intake and nearly half (by weight) of total food consumed. Although largely invisible in national statistics, these contributions strengthen resilience within sustainable agrifood systems.

3 Forests are essential for rural livelihoods and access to food. More than 5 billion people depend to some extent on forests for their livelihoods. In many rural areas, forests contribute up to 20 percent of household income, enabling access to nutritious and diverse diets – especially for the poorest households.

4 Forests and trees support agriculture and food production systems. They play a vital role in agricultural resilience by hosting pollinators (supporting 35 percent of crop production), maintaining soil health, retaining water, providing fodder and shade for livestock, and protecting crops from climate extremes. In times of conflict, crop failure and economic disruption, forests provide food and income that help households survive and adapt.

5 Forests and trees provide essential energy for cooking and water safety. An estimated 1.8 billion people rely mainly on woodfuel (fuelwood plus charcoal) for cooking, and about 410 million people use mainly woodfuel to treat/sterilize water by boiling, both of which are crucial for food safety, nutrient absorption and overall health.

6 Forests offer medicinal resources that support food utilization. More than 1 billion people use medicinal plants from forests, including treatments for diseases such as childhood diarrhoea that impair nutrient uptake and health.

7 Forests ensure access to clean water for food security and nutrition. Forested watersheds supply freshwater to more than 85 percent of major cities, and sustainable forest management can improve water quality for 1.7 billion urban dwellers, supporting agricultural production, food safety and healthy diets.

8 Forests help buffer climate-related risks to food systems. By serving as carbon sinks, mitigating soil erosion, floods and droughts, reducing temperatures, retaining moisture and acting as windbreaks, forests and trees on farms are crucial for reducing climate-related food insecurity.

9 Cross-sectoral policy coordination is essential for food security and nutrition. Greater recognition of the role of forests in food security and nutrition can drive policy coherence across the agriculture, food and forest sectors, thereby reducing trade-offs and enabling more integrated land-use planning to deliver mutually reinforcing outcomes for agriculture and forestry.

10 Clear and secure tenure rights are key. Tenure security supports sustainable management and access to forest resources, including forest food. Effective legal frameworks are needed, drawing on instruments such as the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security.

11 Strong forest institutions and inclusive governance are vital for food security and nutrition. Effective forest governance requires institutional capacity, gender equity, stakeholder engagement (including women, Indigenous Peoples and local communities), and transparency in decision-making. Partnerships among government, civil society and business should be fostered.

Foreword

Forests and trees are vital resources for ensuring sustainability, productivity and resilience of our agrifood systems. This global report, developed jointly with the Landscape Alliance, shows that, in addition to Sustainable Development Goal (SDG) 15 (life on land), forests are indispensable for achieving SDG 1 – no poverty and SDG 2 – zero hunger.

Too often, however, the crucial role of forests and trees in food security and nutrition is underestimated. Synthesizing the latest global evidence to address this knowledge gap, this report highlights opportunities to strengthen data and knowledge, improve policy coherence, promote cross-sectoral action, and ensure sustainable forest management for resilient agrifood systems.

Globally, people use more than 50 000 wild forest-based species, including at least 10 000 directly as foods. These forest foods complement staple crops, enhance dietary diversity and supply essential micronutrients and protein for functional foods. In some countries, forest foods supply 20 percent of dietary protein – and as much as 80 percent in remote forest-dependent communities.

Forests are more than a direct source of food. An estimated 1.8 billion people rely on wood fuel from forests for cooking and water sterilization, which is crucial for food safety, healthy diets and overall nutrition. Forests and trees also support agricultural production by supplying ecosystem services such as water and soil conservation and pollination, by serving as windbreaks and providing shade, and by strengthening resilience to climate and economic shocks.

More than 5 billion people depend to some extent on forests for their livelihoods. In many rural areas, forests contribute up to 20 percent of household income, enabling greater access to healthy and diverse diets – especially for the poorest households.

Enhancing the role of forests and forest foods is vital for implementing the FAO Strategic Framework 2022–31 and its Four Betters – better production, better nutrition, a better environment and a better life, leaving no one behind. FAO supports Members in achieving this ambition through the FAO Forestry Roadmap: From Vision to Action 2024–2031.

As highlighted in the report, forests and trees are largely absent from traditional food security and nutrition policies and broader agrifood system planning. This is due in part to a lack of globally agreed definitions and methodologies for obtaining data on forest foods and the role of forest ecosystem services, and because of fragmentated policy approaches.

Countries and partners are called upon to strengthen cross-sectoral policy coherence and collaboration, invest in improving data and evidence on forest–food linkages, and harness innovation to unlock the full potential of forests and trees for food security and functional components, without exacerbating deforestation and biodiversity loss.

By working together and fully integrating forests into national, regional and global strategies, we can build agrifood systems that are more efficient, more inclusive, more resilient and more sustainable. We must do so – because conserving and sustainably managing forests is fundamental to nourishing people, sustaining the planet and improving the well-being of present and future generations.

Qu Dongyu

FAO Director-General

Why this report?

Forests contribute to food security and nutrition in many ways but are rarely viewed through this lens. Their role is often underestimated, insufficiently documented and inadequately reflected in policies, investment decisions and public discourse. Data on forest foods and their nutritional contributions, as well as on wood energy and the broader role of forest ecosystem services, are fragmented, limiting the visibility of forests in strategies on food security, nutrition and agrifood systems.

At the same time, the world faces growing challenges. Hunger and malnutrition persist, climate change is affecting food production, biodiversity continues to decline, and pressure on land and natural resources is increasing. Addressing these interconnected challenges requires a better understanding of how forests contribute to food security, nutrition and resilient agrifood systems.

This report, which brings together evidence from around the world, was developed jointly by the Food and Agriculture Organization of the United Nations (FAO) and the Landscape Alliance to address the knowledge gap on the role of forests in food security and nutrition and in supporting sustainable agrifood systems.

The report examines the multiple ways in which forests contribute to food security and nutrition, with a particular emphasis on forest foods because they are among the least visible and least well-documented components of food systems. Recognition of their importance is growing, but definitions, methodologies and data are fragmented, limiting understanding of their nutritional, economic, social and cultural contributions. The report seeks to strengthen the evidence base on forest foods while also highlighting the broader role of forests and trees in supporting food security and nutrition through ecosystem services, livelihoods, energy provision and the resilience of agrifood systems.

The report also reviews policy experiences and international initiatives, identifies challenges and opportunities, and presents recommendations for strengthening the integration of forests into food security and nutrition strategies. It stresses the importance of policy coherence and cross-sectoral collaboration across the forest, agriculture, food security, nutrition, health and environmental sectors.

Ultimately, the report seeks to contribute to a shift in perspective, from seeing forests primarily as environmental assets towards recognizing them as fundamental components of sustainable, resilient and nutritious food systems. By making these connections more visible, we hope to support informed decision-making, increase collaboration across sectors, and ensure that forests and trees continue to make their vital contributions to food security and nutrition for all.

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Abbreviations

AFOLU	agriculture, forestry and other land uses
ANEF	National Agency for Water and Forests (Morocco)
CFS	Committee on World Food Security
CNY	Chinese yuan
COP	Conference of the Parties
EPF	Ecological Products of Forests (China)
EPVR	ecological product value realization (China)
FACT	Forest, Agriculture and Commodity Trade
FAO	Food and Agriculture Organization of the United Nations
FSN	food security and nutrition
g	gram(s)
GDP	gross domestic product
GFG	Global Forest Goal
ha	hectare(s)
IUCN	International Union for Conservation of Nature
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
MAD	Morocco dirham(s)
MGAP	Ministry of Livestock, Agriculture and Fisheries (Uruguay)
NPR	Nepalese rupee(s)
NWFP	non-wood forest product
PEN	Poverty and Environment Network
REDD+	reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SDG	Sustainable Development Goal
SMFEs	Small and medium-sized forest enterprises
TRY	Turkish lira
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar(s)

Executive summary

Forests and trees play multifaceted roles in ensuring food security, enhancing nutrition, sustaining livelihoods and contributing to broader development goals. They provide food, fuel, income and employment, support soil fertility, protect water resources and offer habitats for biodiversity, including vital pollinators. They are key for the survival of forest-dependent communities – particularly Indigenous Peoples – and contribute to climate-change mitigation by storing carbon.

Nevertheless, the vital contributions of forests and trees to food security and nutrition (FSN) are underestimated and insufficiently recognized. More integrated and inclusive approaches are needed to elevate forests and trees in national FSN strategies and policies and achieve Sustainable Development Goal 2 (zero hunger), especially among people living close to forests or who depend directly on forest ecosystems for their livelihoods and sustenance.

Harnessing the full contributions of forests to food security requires a comprehensive and adaptive definition that encompasses all relevant products derived from forest ecosystems. Such a definition, which is lacking at the global level, would support the development of evidence-based policies, strategies and legal frameworks for ensuring that everyone, everywhere, can access sufficient, safe and nutritious food at all times.

Global overview of food security and nutrition

Forest foods – fruit, nuts, tubers, mushrooms, edible insects and wild meat – are essential sources of nutrients for forest-dependent communities, complementing those obtained from conventional agriculture and aquaculture. More than 50 000 wild species, many from forests, are used for food and medicine, including at least 10 000 species used directly as food.

Forest plants and animals are rich in protein, vitamins and minerals, which are all important components of healthy diets. Forest products and services also generate employment for millions of people, enabling better access to food and nutrition and improving livelihoods in surrounding communities through consumption and investment. Forests provide as much as 20 percent of rural incomes in some areas, enabling greater access to nutritious food and diverse diets, particularly among the poorest households.

For around one-quarter of the global population, woodfuel is essential for cooking or water sterilization, or both. Reliable access to woodfuel enables proper cooking, which is vital for nutrient absorption and overall health. Forests also provide medicinal plants, on which more than 1 billion people rely for healthcare, including treatments for diseases such as childhood diarrhoea that impair nutrient uptake and health. These are especially important in rural and forest-dependent communities.

Forest ecosystem services support sustainable agriculture, livestock and fisheries by regulating water, protecting soil, cycling nutrients, providing habitat and enabling pollination and pest control. They sustain biodiversity as a vital gene pool for food and medicinal crops, including wild relatives of domesticated plants and livestock, whose genetic diversity is essential for adapting to shocks and climate change. In periods of food shortages and during economic downturns, forests act as safety nets by providing incomes and wild foods.

Forests supply nearby farmers with agricultural inputs (e.g. fodder and feed for livestock; fibre for rope fencing, packaging and other uses; and organic matter for enriching soils) that help reduce costs and limit the negative ecological impacts of producing and transporting such inputs from elsewhere.

The role of forest foods tends to change with dietary shifts as part of the "nutrition transition" – a broad pattern in which populations move from traditional, often plant-based diets towards diets higher in processed foods, sugars, fats and animal products, typically as incomes rise and urbanization increases. Wild forest foods can play an important nutritional role in the early stages of this transition, contributing to dietary diversity and to the intake of macronutrients and micronutrients, particularly in rural areas. People tend to rely less directly on forest foods in the middle stages of the transition as they increase their consumption of packaged and processed foods and as tastes change towards a more homogenous "global diet"; nevertheless, forests may continue to act as nutritional safety nets and income sources through the sale of forest products. In later stages of the transition, health concerns linked to processed diets and the use of agrochemicals become more prominent, increasing demand for more "natural" foods, including forest foods.

Although the nutritional transition described above is a general pattern, it is neither linear nor universal. Not all populations move through this process, and those that do may experience the stages in diverse ways shaped by local economies, cultures, ecologies and food environments. Forest foods also complement agricultural foods by helping diversify and enhance the nutritional quality of rural and urban diets.

In certain regions, particular forest foods continued to be valued and consumed, irrespective of the nutrition transition – such as açaí in the Amazon region; wild berries in Canada and the Scandinavian countries; and forest ferns in Indonesia.

Despite their contributions to food security and nutrition, forest resources are being depleted in some regions. An estimated 10.9 million ha per year of the world's forests were deforested in the decade to 2025, driven by poverty, weak governance, limited capacity and a lack of secure forest tenure for local communities, among other factors. More positively, the annual rate of net forest loss declined from 10.7 million ha in the period 1990–2000 to 4.12 million ha in 2015–2025.

The loss of biodiversity due to deforestation and forest degradation can lead to reduced agricultural productivity and the diminished availability of nutritious food. Conversely, greater recognition and valuation of the benefits of biodiversity can foster sustainable farming that supports both food production and biodiversity conservation. Countries can reduce deforestation and enhance

ecosystem resilience by adopting agricultural practices that support biodiversity, such as agroforestry and integrated pest management. Recognizing and valuing biodiversity in forest management strengthens the natural services on which agriculture depends, thus helping safeguard food production and thus FSN.

Contribution of forest foods to food security, nutrition and culture

Moderate or severe food insecurity affected 58.9 percent of the population in **Africa** in 2024, more than double the global average of 28 percent, but to some extent this was mitigated by the consumption of forest foods. Some people in Africa derive as much as 80 percent of their daily protein needs from wild meat sourced from forests. In the Congo Basin, the consumption of wild meat has been estimated at 5 million tonnes per year, compared with up to 1.3 million tonnes per year in the Amazon Basin.

Eighty percent of the 41 studies reviewed in this report for Africa found positive linkages between the consumption of forest foods and FSN. The consumption of wild meat is especially important: although its role in providing rural households with nutritional benefits is widely recognized, its importance varies among urban residents. Wild forest fruits are important sources of micronutrients in Africa, and they are vital for high-quality diets in many rural areas. The consumption of about 200 g of five specific forest fruits by young people in Gabon can provide up to 100 percent of their daily nutrient requirements for energy, vitamins C and E, iron, magnesium and zinc.

Wild green leafy vegetables and forest fruits are major contributors to FSN in Africa due to their nutrient density and richness in important micronutrients. Many rural communities and Indigenous Peoples rely on wild freshwater fish for protein and other essential nutrients. Research has established that important linkages exist between freshwater fish from rivers and the surrounding forests.

Some parts of the **Americas** use wild meat more for recreation than sustenance. An estimated 16.2 million hunters in the United States of America and 1.3 million hunters in Canada contribute to wild-meat harvests. Although big game such as white-tailed deer provides the most biomass, ducks and pigeons are the most frequently harvested animals. In some other parts of the Americas, wild meat plays a crucial role in FSN, with studies showing that people who eat more wild foods from forests experience greater food security, such as more months with sufficient food. In addition to wild meat, a wide variety of edible forest foods such as Brazil nuts and açaí berries contribute significantly to diets and nutrition in forest-dependent communities. Aquatic resources in some areas are fundamental for food security for forest-dwelling communities – particularly in the Amazon, where fish account for 44 percent of total consumed food mass. Wild meat obtained in forests in the Americas are a crucial source of protein and vital micronutrients, such as iron and zinc.

In **Asia**, which is home to more than half the world's population, an estimated 418 million people were severely food-insecure in 2024 and an additional 682 million were moderately food-insecure.

Asia has the largest number of wild forest species used for food, with many studies shows the crucial links between forests and food security and nutrition. In rural Cambodia, more than 80 percent of households consume wild meat at least once a year. India's 104 million Indigenous Peoples are the country's predominant users of wild forest foods – consuming hundreds and possibly thousands of species.

In India, young children living in areas with high forest cover have higher dietary diversity and lower stunting rates than children living in areas with less forest cover, controlling for other factors. Studies show that the consumption of wild foods (mostly from forests) is associated with higher dietary diversity scores among women.

Hunting in many of Asia's forests has reached unsustainable levels in the last 30–40 years, driven by increased demand from urban areas for wild meat, coupled with increased forest access and technological advances in hunting equipment.

In **Europe**, economic and social shifts (e.g. in herbicide use, supermarket shopping, land use and culinary habits) have led to a decline in wild-food consumption and a loss of traditional knowledge. Despite this, a survey in 28 European countries found that 90 percent of Europeans consumed at least one forest food in a year. Fifteen percent ate game meat more than once a month and more than one-third reported eating some game meat every year. Wild foods have historically been integral to diets in Europe and, despite an overall decline in wild-food consumption, many traditional dishes still incorporate wild ingredients. Wild plants are eaten fresh, cooked or brewed and used in sweets, teas, seasonings and garnishes. Mushrooms and wild fruits and berries are widely foraged and consumed. Walnuts, sweet chestnuts, pine nuts and beechnuts are consumed and collected throughout the region.

Compared with the other regions, a lower diversity of forest species is used for human food in **Oceania**. Of the animal classes, birds have – by far – the highest number of forest species used for food, which is unique among the regions. Despite the increasing transition towards imported and processed foods, forest and marine resources remain important for dietary diversity, complementing agricultural staples and serving as emergency food sources and safety nets. The contribution of wild-pig meat to diets varies across Oceania, from 5–15 percent in Fiji to 10–30 percent in Vanuatu. Wild-pig meat is particularly important in rural and remote areas, where it often supplements or replaces domestic meat. Forest foods are deeply woven into the cultural fabric of societies in the region; many forest plants and animals feature prominently in traditional stories, rituals, ceremonies and gift-giving customs.

Policy and legal frameworks and international initiatives

To help ensure food security and nutrition globally and maintain ecosystem services, the world's agrifood systems must be capable of sustainably producing more diverse and nutritious foods and other products without precipitating forest or biodiversity loss. This requires efficient and

sustainable resource use and intensification and the integration of landscape perspectives into agriculture and forestry.

The Committee on World Food Security produced the Policy Recommendations on Sustainable Forestry for Food Security and Nutrition in 2017 with the aim of strengthening the contributions of sustainable forest and tree management to food security and nutrition. Six of the recommendations address the integration of agricultural and forest management policies. The utility of these recommendations is seen in the progress made by five countries (China, the Dominican Republic, Morocco, Türkiye and Uruguay, used as case studies in the report) in managing forests to ensure their contributions to the four levels of food security (availability, access, utilization and stability), in line with the recommendations.

Exports from low- and middle-income economies now account for more than one-third of global agrifood trade, creating economic growth and job creation in these countries but placing natural resources at risk. Countries and companies could establish supply-chain regulations that address deforestation and forest degradation to mitigate harm and maintain the crucial connections between agriculture and forestry.

The world's agrifood systems must be capable of sustainably producing more diverse and nutritious foods and other products without exacerbating deforestation and biodiversity loss. Doing this will require increasingly efficient and sustainable resource use alongside the integration of landscape perspectives into agriculture and forestry. Opportunities exist to boost coordination and to benefit both agriculture and forestry, amplifying the latter's role in ensuring FSN globally.

Recommendations

To fully realize the value of forests for FSN, the following actions are suggested.

Policy

- **Adopt context-specific and integrated policies** that address the primary drivers of deforestation and promote sustainable land-use planning, with inclusive stakeholder collaboration for better food security and nutrition outcomes.
- **Strengthen and harmonize legal and policy frameworks** to secure land tenure, ensure equitable access to resources, and maintain coherence across land, environmental, wildlife and forest policies and legal frameworks.
- **Avoid forest conversion** that undermines biodiversity, food security, nutrition and long-term sustainability.

Management

- **Promote the sustainable management and use of forest foods** and diverse production systems – including agroforestry, agroecology and climate-smart agriculture – to enhance diets, livelihoods and ecosystem health.
- **Promote participatory and inclusive approaches** that mainstream gender equality and youth

engagement in decision-making processes.

- **Increase public investment and mobilize diverse funding sources** for sustainable agriculture and forest management initiatives.
- **Apply robust social and environmental safeguards** to protect communities and ecosystems from adverse impacts that could worsen food insecurity.

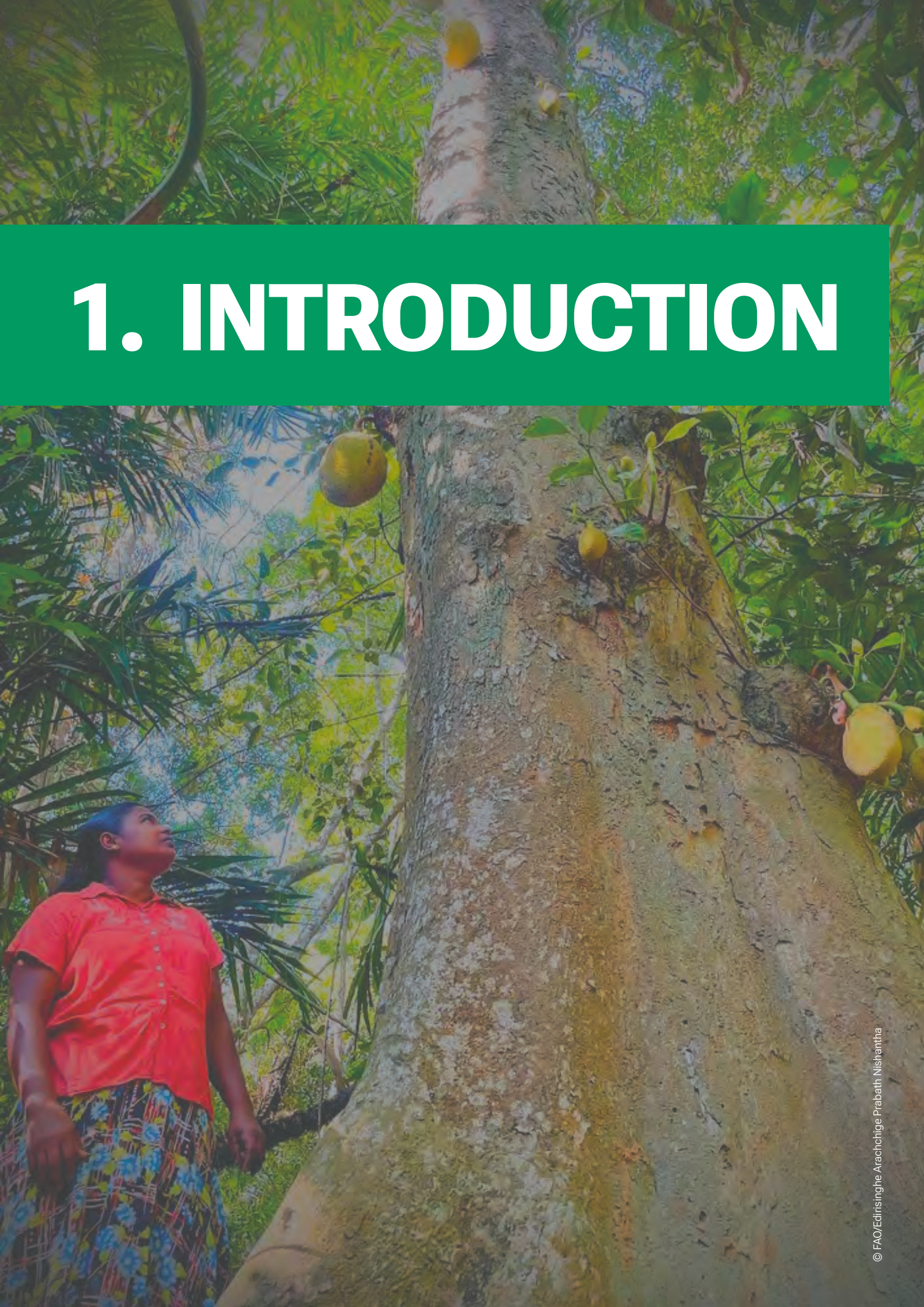
Information

- **Strengthen forest-food data systems** by establishing consistent and globally representative methodologies, investing in primary data collection, harmonizing datasets on forest foods, and building national capacities to better inform policies.
- **Strengthen investment in research and technology** to improve understanding of the biological and ecological processes that determine forest food availability, address constraints to their sustainable harvesting, and enhance processing methods, thereby maximizing their contributions to diversified and nutritious diets.

Governance

- **Build institutional and human capacity** through education, training and interdisciplinary research to support sustainable forest and food-system governance.
- **Foster multisectoral partnerships** among governments, civil society and the private sector to advance sustainable land management and food security goals.
- **Ensure coordinated and cross-sectoral action** at all levels to sustain the vital contributions of forests to FSN.

1. INTRODUCTION



KEY POINTS

- Despite progress in some regions, an estimated 638 million to 720 million people around the world face chronic hunger and limited access to nutritious food – challenges exacerbated by conflicts, climate change, economic instability and disease outbreaks.
- Although their importance is often undervalued, forests, trees and agroforestry systems provide crucial support for the four dimensions of food security and nutrition.
- Forests, and trees grown in agroforestry systems, are excellent sources of diverse and nutritious foods and livestock feed, and they provide formal and informal employment and incomes for many. Woodfuel is important for boiling water and cooking, and the water-regulation and pollination services provided by forests are indispensable for agricultural food production.
- Harnessing the full contributions of forests to food security and nutrition requires a comprehensive and adaptable definition that encompasses all relevant products derived from forest ecosystems. Such a definition is lacking at the global level, however.
- Achieving food security and adequate nutrition for all requires integrated action across agriculture, forestry, health, education, the environment and social protection. Evidence-based policies, strategies and legal frameworks, coordinated across sectors, are essential for ensuring that everyone, everywhere, can access sufficient, safe and nutritious food at all times.

Background

Food security refers to the availability, accessibility and affordability of sufficient, safe and nutritious food that meets an individual's dietary needs for an active and healthy life. Achieving positive food security and nutrition (FSN) outcomes depends on both the physical supply of food and the socioeconomic and cultural factors that influence how food is produced, distributed and consumed (see Box 1 for a definition of food security).

Box 1.
Defining food security

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: (1) availability; (2) access; (3) utilization; and (4) stability.

Source: FAO. 1996. Report of the World Food Summit. In: *FAO. World Food Summit.* https://www.fao.org/4/w3548e/w3548e00.htm

FSN is a crucial issue on the global, regional and national agendas, closely aligned with Sustainable Development Goal (SDG) 2 to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture". Achieving FSN requires integrated actions across sectors such as agriculture, forestry, health, education, the environment and social protection. Despite the progress made in some regions, millions of people around the world still face chronic hunger, malnutrition and limited access to nutritious food, with these challenges exacerbated by conflicts, climatic change, economic instability and outbreaks of diseases. Coordinated efforts, evidence-based policies and inclusive strategies are essential for ensuring access to sufficient safe and nutritious food for all.

Forests occupy one-third of the Earth's land area and are estimated to hold the majority of terrestrial biodiversity, with 75–80 percent of the species of some groups – such as amphibians and birds – found in forests (FAO, 2020a). Forests and trees play vital roles in food security, nutrition and livelihoods through the provision of food, fuel, employment and cash income (Jagger *et al.*, 2022). Globally, about 50 000 wild species are used for food, energy, materials, medicine and other purposes. This includes an estimated 7 500 wild fish, 31 100 plants (including 7 400 tree species), and various species of fungi, invertebrates and terrestrial vertebrates (IPBES, 2022a).

Forests provide a wide range of foods – including fruit, nuts, leaves, wild meat, mushrooms, tubers and insects – that supplement diets, enhance nutritional dietary diversity and provide vital nutrients. Globally, an estimated 3.5 billion rural people in developing countries (45 percent of the global population) rely on wild species for their livelihoods (IPBES, 2022a). In addition to their economic,

nutritional and ecological contributions, forests hold significant cultural importance, serving as vital spaces for spiritual practices, cultural traditions and community identity among many Indigenous Peoples and local communities. Spending time in forests has been found to have psychological benefits, such as reduced stress and lower anxiety (Bratman *et al.*, 2015; Vermeesch *et al.*, 2024).

Between 638 million and 720 million people worldwide experienced hunger in 2024 (FAO, 2025b). Many were in low- or middle-income countries, where numerous communities rely on nearby forests for food and livelihoods (Newton *et al.*, 2022).

In 2019, an estimated 3.27 billion people living outside urban areas – approximately 75 percent of the global non-urban population and 42 percent of the total global population – were located within 1 km of a forest that was at least 1 ha in size. When the distance from forest is extended to 5 km, the number of people increases to 4.17 billion, representing 95 percent of the global non-urban population and 54 percent of the total global population (Newton *et al.*, 2022).

Forests contribute to soil fertility in farming systems, support biodiversity and protect watersheds and watercourses, ensuring reliable access to clean water. In arid and semi-arid areas, rangeland trees provide essential browse for livestock, forming a crucial resource for pastoralist communities.

Forests and trees thus play a multifaceted role in supporting livelihoods, ecosystem services and broader development goals, although the full scope of their contributions to FSN is insufficiently recognized. Despite their importance, forests are often undervalued in policy discussions. This disconnect underscores the need for more integrated and inclusive approaches that elevate forests in national strategies.

A woman in the Democratic Republic of the Congo sustainably harvests mfumbwa leaves from a wild forest vine native to Central Africa, helping to conserve the resource for future generations.

Purpose and methodology

This report examines the relationship between forests and FSN using a methodology based on literature reviews and the synthesis of existing data to assess the contributions of forests to FSN, as described in detail in the annex. Data for estimating the number of species of forest foods consumed in the various regions were extracted from the International Union for Conservation of Nature (IUCN) Red List for those species that:

- have been assessed on the IUCN Red List (i.e. that have a profile);
- were stated to occur in forests; and
- were listed as consumed for human food.

It was not possible to systematically collect information on the diverse contributions of wild foods to FSN for all countries. Instead, for each region, expert elicitation was used and literature reviews conducted.

The main source of information on woodfuel use for cooking was the World Health Organization's Household Energy Database of nationally representative household surveys. This database, accessed for this report in February 2024, contains more than 1 600 surveys conducted in 171 countries between 1960 and 2022.

The country case studies were developed via interviews with key stakeholders, who were identified in collaboration with national governments and FAO Country Offices. Each interview was conducted based on a list of guiding questions relevant to six recommendations made by the Committee on World Food Security in 2017 aimed at strengthening the contributions of sustainable forest and tree management to FSN and contributing to the realization of the right to adequate food for all. In addition to stakeholder interviews, country case studies used reviews of literature recommended by stakeholders and others involved in the process.

Scope and structure

Forests, trees and agroforestry systems are crucial for supporting the four dimensions of food security, although their importance is often undervalued (Gitz *et al.*, 2021). Forests are excellent sources of diverse and nutritious foods and livestock feed and provide both formal and informal employment (and incomes) for many. Forest woodfuel and other bioenergy sources are used for boiling water and cooking, and the water regulation and pollination services provided by forest ecosystems are indispensable components of agricultural food production.

Although the analysis in this report emphasizes rural, forest-adjacent and forest-dependent populations, it also addresses the growing importance of forest-origin foods in urban and peri-urban

areas through both market-based and informal value chains. The following forest foods are covered: fruit; leaves and herbs; seeds and nuts; mushrooms; insects; roots and tubers; wild meat; and fish from rivers and mangrove forests.

Understanding the transformative role of forest foods in achieving food security requires clear and consistent definitions, but both the literature and countries and organizations – such as FAO, the European Union, non-governmental organizations, forestry ministries and academia – are variable in how they define "forest foods" (Box 2; see also Box 32 on Chinese definitions related to forest foods). The absence of an agreed definition and list of products restricts assessments of the contributions of forest foods to food security and nutrition.

A woman returns from harvesting forest produce, including nutrient-rich leaves, near the village of Minwoho, Lekié, Center Region, Cameroon

Box 2
Transforming food security: the imperative to define forest foods

Inconsistent definitions and terminologies limit the collection of data and therefore understanding of the contributions of forests to food security and nutrition. Terms are often used interchangeably and inconsistently, posing a significant obstacle to measuring the impacts of forest foods on dietary diversity and overall nutrition. Relevant terms are discussed below.

- **Non-wood forest products.** FAO defines non-wood forest products (NWFPs) as tangible goods sourced from forests, such as fruit, mushrooms and honey;[i] thus, this definition excludes fish and other products harvested on agricultural lands and in agroforestry systems. As a basis for global assessments, it provides a good starting point for understanding the contributions of NWFPs to food security and nutrition but falls short of capturing the full value. Issues that complicate efforts to develop a comprehensive definition of NWFPs include whether to include non-industrial timber and other wood products; whether the products are gathered in the wild or derived from domesticated systems; the scale of production; and the ownership and distribution of benefits.[ii]
- **Non-wood goods.** According to the European Union, forests and other wooded lands are an important source of "non-wood goods, such as foods and materials. Cork, Christmas trees, chestnuts, fruit, mushrooms, wild meat and honey represent traditional non-wood goods". This definition acknowledges the economic value of these resources, but its application is inconsistent across the Member States of the European Union; moreover, it may overlook vital local products.[iii]
- **Wild and forest foods.** The tremendous diversity of wild foods and forest foods, and of the contexts in which they occur, presents great challenges to the definition of these terms. Fruit from scattered trees in tropical regions, wild herbs gathered at forest fringes, game meat, and edible insects are all examples of this complexity. Although some countries embrace the concept of forest foods, there is no internationally accepted definition or comprehensive list, limiting the creation of reliable inventories.[iv]

In many communities, forest foods are more than dietary supplements – they provide vital nutrients and increase dietary diversity and are essential, therefore, for enhancing dietary quality. To fully harness the contributions of forests to food security and nutrition, a framework definition of forest foods is needed that covers all relevant products. It should:

- establish a clear, comprehensive definition of forest foods;
- capture the full spectrum of forest-derived foods (encompassing products from natural forests, planted

forests, trees, agroforestry systems, riparian environments, mangroves, and other related ecosystems), acknowledging local terminologies and practices;

- enable the development of replicable data collection methodologies across regions for accurate assessments of the nutritional and economic impacts of forest foods; and
- champion evidence-based policies that promote the sustainable use of forest foods, ultimately enhancing food security and empowering communities.

Countries have a crucial role to play by embedding data collection on forest foods into their food security agendas. Recognizing the contributions of forest foods can transform approaches to food security and nutrition, which, in turn, will contribute to attainment of Sustainable Development Goal 2 (zero hunger). The full potential of forest foods can be leveraged only with a clear operational definition encompassing the variety and richness of forest foods. This is a call to action for communities, policymakers and stakeholders to establish a clear operational definition of forest foods and thus help realize the full potential of forest foods.

Sources: [i] FAO. 2025. *Terms and definitions*. Forest Resources Assessment 2025. Rome. https://openknowledge.fao.org/server/api/core/bitstreams/a6e225da-4a31-4e06-818d-ca3aeadfd635/content; [ii] Ahenkan, A. & Boon, E. 2011. Non-timber forest products (NTFPs): clearing the confusion in semantics. *Journal of Human Ecology*, 33(1); [iii] Forest Europe. 2020. *State of Europe's Forests 2020*. Ministerial Conference on the Protection of Forests in Europe. https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf; [iv] Albrecht, S. & Wiek, A. 2021. Food forests: their services and sustainability. *Journal of Agriculture, Food Systems, and Community Development*, 1–15. https://doi.org/10.5304/jafscd.2021.103.014; Delgado, T.S., McCall, M.K. & López-Binnqüist, C. 2023. Non-timber forest products: small matters, big significance, and the complexity of reaching a workable definition for sustainability. *Small-scale Forestry*, 22(1): 37–68. https://doi.org/10.1007/s11842-022-09517-9; Rowland, D., Ickowitz, A., Powell, B., Nasi, R. & Sunderland, T. 2017. Forest foods and healthy diets: quantifying the contributions. *Environmental Conservation*, 44(2): 102–114. https://doi.org/10.1017/S0376892916000151; WHO, FAO & UNICEF. 2024. *Guidance for monitoring healthy diets globally*. Geneva, World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), and United Nations Children's Fund (UNICEF). https://iris.who.int/bitstream/handle/10665/377755/9789240094383-eng.pdf?sequence=1

2. GLOBAL OVERVIEW OF FOOD SECURITY AND NUTRITION

KEY MESSAGES

- Forest foods – fruit, nuts, tubers, mushrooms, leaves, edible insects and wild meat – are essential sources of nutrients for forest-dependent communities, complementing those obtained from conventional agriculture and aquaculture. More than 50 000 wild species are used for food and medicine, including at least 10 000 species used directly as food.
- Forests support as much as 20 percent of rural incomes in some areas, enabling greater access to nutritious foods and diverse diets, particularly among the poorest households.
- Forests and trees outside forests contribute to food utilization by providing woodfuel for cooking and water sterilization. An estimated 23 percent of the global population (about 1.8 billion people) relied on woodfuel as their primary energy source for cooking in 2022, compared with 35 percent (2.5 billion people) in 2011.
- Reduced access to woodfuel due to deforestation and forest degradation can affect food security and nutrition by limiting the ability of households to cook food and increasing the time spent gathering woodfuel and the cost of purchasing it.
- Forests provide ecosystem services such as carbon and water regulation, soil protection, nutrient circulation, biodiversity conservation, pest control and pollination that underpin agricultural productivity and sustainability and therefore food security and nutrition.
- Despite their contributions to food security and nutrition, forest resources are being depleted in some regions. The deforestation rate globally was estimated at 10.9 million ha per year in the decade to 2025, driven by poverty, weak governance, limited capacity and a lack of secure forest tenure for local communities, among other factors. More positively, the annual rate of net forest loss (that is, the rate of deforestation, less the rate of forest expansion) declined from 10.7 million ha in the period 1990–2000 to 4.12 million ha in 2015–2025.
- The loss of biodiversity due to deforestation and forest degradation can lead to reduced agricultural productivity and the diminished availability of nutritious food. Conversely, greater recognition and valuation of the benefits of biodiversity can foster sustainable farming that supports both food production and biodiversity conservation.
- Sustainable land management is key to realizing the benefits of ecosystem services. Indigenous and local knowledge can be invaluable assets for sustainability.

Current and future challenges

High food prices, a global economic crisis, high energy prices, climate change and the impacts of the COVID-19 pandemic have negatively affected the food security of millions of people worldwide.

The global population is expected to grow by nearly 1 billion people by 2050, to more than 9 billion, and dietary patterns are also changing. According to some estimates, agricultural production could need to double to keep pace with increasing food consumption (Alexandratos and Bruinsma, 2012; Ray *et al.*, 2013; Tilman *et al.*, 2011), necessitating a transformation of food systems (Bahar *et al.*, 2020; Ickowitz *et al.*, 2022).

As of 2023, four crops supplied nearly half of humanity's energy intake, with wheat and rice alone accounting for 35 percent (FAO, 2025c). Reducing this dependence on a few calorie-rich but often nutrient-poor staples and sustainably meeting future demand for nutrition will require a shift towards more diverse and nutritious food systems. It will also involve sustainable land management and careful attention to existing natural resources, such as forests and rangelands. The biodiversity loss and desertification that would result from the loss or degradation of forest and tree resources would reduce the overall productive capacity of ecosystems, hamper water availability and limit access to woodfuel, which is still the main energy source for many communities; moreover, many cultures continue to prefer it for cooking certain dishes. Recognition of the fundamental role of forests in FSN will encourage the more widespread uptake of sustainable forest management, which is also necessary to ensure resilience in both natural and agricultural systems in the face of climate change.

The full recognition of the contributions made by forests to global FSN is hampered by a lack of data and a paucity of metrics, including accurate and comprehensive indicators. The diversity of forest foods complicates efforts to collect and analyse data and hinders the drawing of comparisons between different parts of the world. FSN is inherently a multidimensional construct, making it challenging to identify a singular metric that comprehensively captures its complexity. Moreover, the absence of a universally accepted definition and classification system distinguishing between wild and farmed non-wood forest products (NWFPs) obscures the role played by forests in securing and maintaining FSN. Addressing the lack of robust data on forests and food security requires the development and adoption of globally representative methodologies; investment in primary data collection; harmonized datasets; and greater data-collection capacity in countries.

Impacts of the COVID-19 pandemic

Although forests – and the communities who rely on them – exhibited considerable resilience, the COVID-19 pandemic (2020–2023) had great economic, social and environmental impacts. Household incomes declined and food was less available. In many rural areas, people relied on forests and forest products for subsistence (e.g. plants and wildlife for food), in some cases resulting in overharvesting. In general, periods of duress can lead people to increase woodfuel production, convert forests to agriculture, and engage in other informal and even illegal economic activities, leading to deforestation and biodiversity loss (FAO, 2025d).

Forests are important sources of pharmaceuticals: according to some estimates, as much as 60 percent of medicinal plant products is harvested in the wild (FAO, 2020b). Sustainably managed forests serve as barriers to zoonotic diseases (e.g. the human immunodeficiency virus, Ebola and COVID-19). Zoonoses – infectious diseases that can be passed from animals to humans – constitute roughly three-quarters of emerging infectious diseases, making their prevention a vital component of public-health strategies (FAO, 2020a). The deforestation and biodiversity loss caused by efforts among forest communities to survive the pandemic contributed to the spread of diseases (FAO, 2025d).

Agricultural production was hampered during the pandemic by reduced access to labour, seeds, agrichemicals and knowledge. Incomes were reduced by difficulties in accessing local, national and international markets, which also experienced high price volatility (FAO, 2022a). Informal employment, tourism, remittances and other key off-farm income sources were disrupted. The global rolling back of social and environmental safeguards increased the ability of large industries to overexploit forest resources (FAO, 2022a).

The COVID-19 pandemic had severe health impacts in forest communities. For example, pandemic response measures reduced access to health services, which were already sparse in rural areas, and many forest-dwelling communities of Indigenous Peoples experienced higher fatality rates during the pandemic (FAO, 2022a). The pandemic exacerbated food security challenges in forest communities, which led to additional health concerns.

The role of forests and trees in food security and nutrition

Forests hold most of the planet's terrestrial biodiversity (FAO, 2020a). By providing nutritious food, income, employment, energy and ecosystem services, forests and trees outside forests[1] are linked closely to the four dimensions of food security (availability, access, utilization and stability; see Box 1).

Forest plants and animals, which are rich in protein, vitamins and minerals, are important dietary components for millions of people. The income that people derive from forest products and services provides them with better access to food and nutrition. In many parts of the world, woodfuel is a crucial source of energy for cooking, which is the primary means of ensuring proper nutrient absorption.[2]

Forest ecosystem services support agricultural, livestock and fishery production through water regulation, soil protection, nutrient circulation, pest control and pollination. Ensuring the diversity needed for adequate diet quality requires maintenance of the gene pool for food and medicinal crops provided by forests. When food is in short supply or in the face of economic, social and political shocks, forests provide a safety net as a source of income and wild foods. By helping in the mitigation of, and adaptation to, climate change, forests help obviate climate-related food insecurity (FAO and UNEP, 2020).

Even though forests support FSN in myriad ways, they continue to be depleted in some regions. Deforestation was estimated to have occurred at a rate of 10.9 million ha per year between 2015 and 2025 (FAO, 2025a), due to factors such as conversion to other land uses, fire, and pest outbreaks. Important underlying causes include poverty, weak governance, limited capacity, and a lack of secure forest tenure for local communities (see Box 3 for a discussion of forest rights). The annual rate of net forest loss declined from 10.7 million ha in the 1990s to 4.12 million ha in 2015–2025 (FAO, 2025a), with deforestation offset to some extent by afforestation. Deforestation diminishes the availability of forest foods, and associated biodiversity loss can reduce agricultural productivity and thus the overall supply of nutritious food (FAO and UNEP, 2020). Reduced access to woodfuel may also affect food security and nutrition by reducing the capacity of households to cook food and by increasing the time required to gather woodfuel (and thus reducing the time available to earn income or produce and gather food) (FAO, 2017).

[1] The term "trees outside forests" encompasses agroforestry systems, other trees on farms, and trees in non-forested rural and urban landscapes (FAO, 2013a).

[2] See the appendix for detailed information on woodfuel use for cooking and sterilizing.

Box 3
Estimating forest ownership: updated data and expanded definitions

A review of data on forest ownership for some countries produced the following estimates, using a broad definition of "forest owners" that includes individuals with use rights, effective control or customary rights – groups that are often excluded in traditional assessments.

- In China, 101 million people are considered "forest owners" due to their significant use rights and control over forest resources, even though the state is the nominal owner of the land.[i]
- In India, 2.30 million people are recognized as forest owners through land rights granted under the Forest Rights Act, 2006.[ii]
- The Philippines recognizes 1.22 million individuals as forest owners because they hold "certificates of ancestral domain title", with control over forest resources within ancestral domains.[iii]
- The forest management approach in Viet Nam includes the transfer of woodlands to community ownership, with about 1.4 million individuals recognized accordingly as forest owners.[iv]
- The United States of America has approximately 11.2 million family forest owners,[v] and Canada has an estimated 455 000 private forest owners.[vi]
- Colombia has an estimated 30 000 owners of forest plantations.[vii]

Overall, an estimated 71 percent of the world's forests are publicly owned, 24 percent are privately owned, and the remainder is under other or unknown ownership.[viii]

Note: Data collection methodologies vary across countries, reflecting their specific recording practices. The measurement periods also differ, and the precise relationship between ownership counts and the actual area of forest controlled is often unclear.

Sources: [i] Liu, J., Dong, J., Long, H., Xu, T. & Putzel, L. 2020. Private vs. community management responses to de-collectivization: illustrative cases from China. *International Journal of the Commons*, 14(1), 445–464. https://doi.org/10.5334/ijc.971. [ii] Jahan, I. 2023. India's landmark law to empower Indigenous forest-dwellers to sustainably access and use forest resources. *Inequality Portal*. https://www.sdg16.plus/policies/indias-landmark-law-to-empower-indigenous-forest-dwellers-to-sustainably-access-and-use-forest-resources/#policy-reference-18. [iii] Domingo, S. & Manejar, A. 2020. *Review of Indigenous Peoples policy and institutional grounding*. https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidsdps2020.pdf. [iv] World Economic Forum. 2024. *Vietnam: from quantity to quality*. Forests for Climate, World Economic Forum. https://www.weforum.org/publications/forests-for-climate-scaling-up-forest-conservation-to-reach-net-zero/?utm_source. [v] Butler, B.J., Butler, S.M. & Floress, K. 2023. Studies of family forest owners in the USA: a systematic review of literature from 2000 through 2019. *Small-scale Forestry*, 22: 1–35. https://doi.org/10.1007/s11842-022-09529-5. [vi] Canadian Forest Owners. 2024. *CFO members*. https://www.forestowners.ca/members/; [vii] World Bank. 2017. *Colombia: Programmatic Forest Country Note*. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/892731545423859022/colombia-programmatic-forest-country-note. [viii] FAO. 2025. *Global Forest Resources Assessment 2025*. Rome. https://doi.org/10.4060/cd6709en

Food availability

Food availability is the extent to which food is physically present (actually or potentially). Forests and trees outside forests contribute to availability by providing wild foods (such as nuts, fruit, wild meat, edible insects, edible plants and inland fisheries), livestock and fodder.

It has been estimated that up to 5.76 billion people across socioeconomic groups and geographic regions use NWFPs (Shackleton and De Vos, 2022); some studies indicate that, in developing countries, these households have the lowest incomes (Angelsen *et al.*, 2014). Around the world, people use roughly 50 000 wild species for various purposes, including food and medicine, at least 10 000 of which are used directly as food (IPBES, 2022a).

There exists a vast diversity of other forest products that often rely on less-formal marketing channels and are not captured in databases such as FAOSTAT.[3] Forest foods are crucial for communities seeking healthier food options, and they have a major impact on global food diversity. For some communities, forests foods are crucial because of their high nutritional value[4] (See Box 4 for an example).

People living close to forests often rely on forests for dietary items such as rodents and other mammals, as well as insects, birds, bird eggs and fish; these forest foods constitute at least 20 percent of the animal protein in rural diets in at least 60 countries (FAO, 2016a). Studies suggest that, where forest food consumption is high, the proportion of meat and fish in diets coming from forests can be greater than that from domestic livestock and aquaculture; in areas where forest food consumption is highest, the proportion of fruit and vegetables consumed from forests can be greater than that from agriculture (Rowland *et al.*, 2017).

Box 4
Fish: a dietary staple and potential anaemia buffer in the Amazon

A study of children living near the Amazon River in central Brazil found that fish consumption was strongly correlated with higher haemoglobin levels, especially among the most vulnerable rural children. The consumption of wild meat was also positively correlated with haemoglobin in this group, but fish was consumed far more frequently (up to 6.4 days per week, on average) and likely played a more significant role in providing essential nutrients to combat anaemia. This highlights the importance of ensuring consistent access to fish as part of broader strategies for addressing nutritional deficiencies in this region.

Source: Carignano Torres, P., Morsello, C., Orellana, J.D.Y. *et al.* 2022. Wildmeat consumption and child health in Amazonia. *Scientific Reports,* 12, 5213 (2022). https://doi.org/10.1038/s41598-022-09260-3

[3] FAOSTAT, maintained by FAO, is the world's largest statistical database on food and agriculture. It provides free access to data related to agriculture, food security and nutrition for over 245 countries, covering information from 1961 to the present.

[4] The nutritional value of forest foods is linked directly to the utilization dimension of food security. This is further elaborated on in Chapter 3.

Although numbers are difficult to estimate (Van Huis *et al.*, 2022), insects are part of the traditional diets of at least hundreds of millions of people worldwide (Box 5), with more than 1 900 insect species known to be used as food (Omuse *et al.*, 2024). The value of edible insects is more than their nutritional value; for example, it is much more environmentally friendly to produce protein from the yellow mealworm (*Tenebrio molitor*) than from cattle.[5]

Forests and trees outside forests provide fodder for livestock via browse plants and animal feed. For example, an estimated 75 percent of tree species in tropical Africa is used as browse by livestock such as sheep, goats, cattle, camels and donkeys (FAO, 1991). Worldwide, an estimated 30–40 million pastoralists use forests for fodder and as rangelands for billions of cattle, goats and sheep (FAO, 1996a). Fodder contributes to food availability because the livestock it feeds is a source of meat and dairy and can increase the productivity of farming by providing draught power and manure.

Many forest ecosystem services – such as those related to hydrological services, pollination, biological pest control, climate regulation, nutrient cycling and soil formation – support and increase agricultural yields. Around 24 percent of global agricultural land has greater than 10 percent tree cover and can be considered agroforestry (FAO, 2022b). Trees in agroforestry systems can increase production and resilience by enhancing soil fertility, regulating microclimates, providing food and income, and supporting shade-dependent crops such as coffee and cacao, although benefits vary depending on species composition, management practices and other factors. Silvopastoral systems – a form of agroforestry – can help increase the productivity of livestock production while preventing erosion, enhancing biodiversity and benefiting soil health, hydrological regulation and carbon sequestration (Chará *et al.*, 2019).

Food availability can change over time, such as due to what is sometimes called the nutrition transition, a process in which urbanization, economic growth and technological changes bring about shifts from traditional foods to diets higher in fats, sugars, animal products and processed foods, and potentially away again from these (Box 6).

Box 5
Insects on the menu: a look at eating habits in the Lao People's Democratic Republic

According to a national survey in 2015, 97 percent of adults (sample size = 1 059 individuals) in the Lao People's Democratic Republic consume insects primarily harvested in forests and rural areas, favouring weaver ant eggs, short-tailed crickets, crickets, grasshoppers and cicadas. Insect consumption has decreased, however, due to reduced availability (84 percent of respondents) and lifestyle changes (5.5 percent); this has particularly affected women who sell wild-harvested insects (to earn an average of USD 6 per day). Despite the decline, insects remain a significant part of diets in the country; people value them for their nutritional content (82 percent of respondents considered them a complete meal) and cultural importance, highlighting the need for sustainable harvesting and farming practices to ensure future access to this vital food source.

Source: Carignano Torres, P., Morsello, C., Orellana, J.D.Y. *et al.* 2022. Wildmeat consumption and child health in Amazonia. *Scientific Reports*, 12, 5213 (2022). https://doi.org/10.1038/s41598-022-09260-3

[5] Farming edible insects for food and feed can reduce pressure on resources such as land, soils, water and energy compared with the production of other sources of an equivalent quantity of animal protein (Van Huis *et al.*, 2013).

Box 6
The nutrition transition

The role of forests changes as population groups move through the nutrition transition – a process driven by urbanization, economic growth and technological changes that describes shifts from traditional diets high in grains and fibre to diets higher in fats, sugars, animal products and processed foods, and potentially away again from these (see Table A). Although by no means universal, this transition is a process observed in many parts of the world over the last century.

In rural areas, particularly in the earlier stages of the nutrition transition, wild forest foods are essential sources of food security and nutrition. They often complement subsistence agriculture and provide affordable, nutrient-rich options that are integral to local diets. Additionally, low value-added forest-based income earned from activities such as the gathering of non-wood forest products and the small-scale harvesting of wild meat provides rural people with buffers against economic shocks and increase resilience.

Even when rural populations become more integrated into the modern economy and their diets shift towards more processed and packaged foods, forests may continue to provide them with nutrient-dense, minimally processed foods that contribute to healthier eating. Moreover, forest-based enterprises may evolve to include value addition, thereby generating higher incomes and fostering local economic development.

The nutrition transition typically advances faster in urban contexts, with diets shifting towards more processed, energy-dense foods and away from traditional diets that rely on forest-sourced foods. Despite this, forest foods may continue to supply urban markets with fresh, low-processed forest foods such as fruit, nuts, mushrooms and fish, which become increasingly valued for their health benefits and contributions to dietary diversity. Urban consumers also benefit indirectly from forests through the provision of ecosystem services that support overall well-being, including air-quality regulation, green spaces for recreation, and cultural values linked to forest heritage. Forests contribute to active lifestyles through the provision of green spaces and ecosystem services that enhance physical and mental health.

In summary, forests play a dynamic and multifaceted role throughout the nutrition transition, depending on the needs and contexts of rural and urban populations. This highlights the importance of integrating forest conservation and sustainable forest management into policies aimed at improving nutrition, health and livelihoods in diverse settings.

Table A. The nutrition transition

Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
• Diet comprises diverse wild plants and animals • Water is the predominant drink • Work is labour-intensive	• There is a shift to monoculture agriculture • Cereals dominate the diet • Water is the predominant drink • Work is labour-intensive	• The diet shifts towards starchy, low-variety, low-fat, high-fibre foods • Water is the predominant drink • Work is labour-intensive work but there is more leisure	• There is increased fat, sugar and processed foods in the diet • Consumption increases of sugary beverages and juices • There is a shift in technology of work and leisure • Sedentariness is high	• There is a shift from ultra-processed to minimally processed foods • Water and low-calorie beverages are favoured • Sedentariness is replaced by purposeful increases in activity

Source: Popkin, B.M. & Ng, S.W. 2022. The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. *Obesity Reviews*, 23(1). https://doi.org/10.1111/obr.13366

Access to food

The access dimension of food security considers whether households and individuals have sufficient access to food. Forests and trees outside forests contribute to economic access by providing income sources (e.g. the sale of timber, fuelwood, charcoal and non-wood forest products) and employment in forest enterprises. In some parts of the world, forests provide around 20 percent of rural incomes, enabling access to nutritious food and diverse diets, particularly among the poorest households (see, for example, Shackleton *et al*., 2007; Angelsen *et al*., 2014).

The formal and informal forest sectors are important sources of employment and income. The formal sector generated an estimated 42 million jobs globally in 2022 (FAO, 2025a). It contributed more than USD 661 billion to global gross domestic product (GDP) in 2015 – and USD 1.523 trillion when indirect and induced effects are included (Li *et al.*, 2022). Numbers tend to be underestimated in the informal sector (i.e. non-commercial, subsistence or unregulated and unreported small-scale enterprises) due to a lack of data;[6] nevertheless, a study of the informal sectors in 56 countries estimated that 7.7 million people were employed in 2017–2019, accounting for 77 percent of total forest-related employment in those countries (Lippe *et al.*, 2022).

Small and medium-sized forest enterprises (SMFEs) account for as much as 80–90 percent of forestry enterprises in developing countries and represent more than half of all forest-sector employment (Macqueen and Mayers, 2006). More than 20 million people worldwide are employed by SMFEs, generating roughly USD 130 billion annually (FAO and UNEP, 2020).

SMFEs provide forest-related livelihoods in local communities, thus boosting food security and nutrition. A lack of local capacity, as well as bureaucratic regulation and tenure insecurity, can limit their potential. Moreover, the benefits generated by SMFEs are often captured by local elites with the political and financial means to acquire land and forest permits.

According to the most recent available data, NWFP removals totalled USD 88 billion worldwide in 2011, with plant-based NWFPs contributing the majority (USD 77 billion) (FAO, 2014). Despite the limited availability of gender-disaggregated data, studies suggest that rural women play a central role in the sustainable harvesting of NWFPs and the collection of woodfuel and are strongly reliant on the returns they generate from their sale (FAO, 2013b; HLPE, 2017) (Box 7).

There is potential for growth in the forest sector. For example, the production of açaí berries in Amazonian forests is a USD 7 billion industry, with projected annual growth of 6.9 percent through to 2030 (Prophecy Market Insights, 2024). Although the cash contribution of many forest products to household incomes may not be large, it is crucial for the livelihoods, food security and nutritional intake of many millions of people (see Box 8 for an example).

[6] The global figures mask large differences among countries and generally underestimate the real contributions of forests to national incomes because they do not integrate the value-added of wood products that accrue in the industrial sector or the contributions of forests to tourism and recreation (HLPE, 2017).

Box 7
Sustainable forestry through gender equality: a case study from Nepal

Nepal made significant progress in community forest management between 2013 and 2022 thanks to its commitment to gender balance. By 2020, 35 percent of forested land was managed by community forest user groups.

The FAO-hosted Forest and Farm Facility supported community forest user groups in 25 community forests managed predominantly by women. It fostered the development of successful enterprises, such as a women's handicraft cooperative generating NPR 25 000 (USD 180) per month for 12 women. Overall, the work has highlighted the importance of gender equity in achieving sustainable forest management and economic development.

Source: Adhikara, S. Undated. Women's livelihood support through natural resource management: a case study from Nepal's Forest and Farm Facility. FAO Nepal. https://www.dropbox.com/scl/fo/orkgum094muq9kmq5xbrl/h?rlkey=338fz26ueyl1nta9uifmazrnn&e=2&dl=0, Forest Food workshop Asia Pacific – Presentations #12

Box 8
The vital role of artisanal fishing in communities in the Colombian Amazon

Artisanal fishing is a cornerstone of the economy in riverside communities in the Amazon, including Puerto Nariño, in the Amazonas department of Colombia, where an estimated 78 percent of household income in 23 families is derived from the exploitation of natural resources. Twenty-four percent of this income comes exclusively from artisanal fishing. Eighty-one percent of the protein consumed by households is obtained from fish, underlining the essential role of fishing in ensuring food security and sustaining the livelihoods of these communities.

The intricate relationship between the local people and their aquatic environment reflects economic reliance and a deep-rooted cultural connection, making the conservation of aquatic resources vital for the community's continued survival and identity.

Source: Trujillo Osorio, C. & Flórez Laiseca, A. M. 2016. Economic contribution of the traditional fishing to the economy of the riverside communities of the Colombian Amazon. *Revista de Investigación Agraria y Ambiental*, 105–121. https://www.cabidigitallibrary.org/doi/full/10.5555/20173230881

Food utilization

The utilization dimension of food security addresses whether individuals are maximizing their consumption of adequate nutrition and energy. Forests and trees outside forests contribute by providing woodfuel for cooking and water sterilization, nutrients (particularly protein-rich forest foods) and herbal medicines.

Villagers harvest *Phallus indusiatus*, an edible fungus, in a bamboo forest in Xiashai village, Guangdong Province, China. Economic activities using bamboo forests help local farmers improve their lives

For adequate nutrient absorption, food must be cooked properly. An estimated 23 percent of the global population – roughly 1.8 billion people – relied on woodfuel as their primary energy source for cooking in 2022.[7] This was a substantial decrease from 2011, when around 2.5 billion people (35 percent of the global population) depended on this energy source.

The reduction in the number of people using woodfuel between 2011 and 2022 coincided with a period of significant economic growth globally that enabled many people to gain greater access to alternative household energy services. In both China and India, the number of people using woodfuel as their primary source of energy for cooking fell by about 300 million over the period, and there were also substantial declines in Indonesia, Myanmar and Viet Nam. In contrast, the number of people using woodfuel increased in many countries in Africa – from 730 million in 2011 to 900 million in 2022 – due largely to population growth. Seven percent of the population in the Americas – about 70 million people – were reliant on woodfuel as their main source of energy for cooking in 2022. In Asia, the percentage of people relying primarily on woodfuel dropped from 37 percent (1.6 billion people) in 2011 to 18 percent (840 million people) in 2022. Two percent of the population in Europe (17 million people) used woodfuel as their main source of energy for cooking in 2022, compared with 25 percent of the population of Oceania (11 million people). In general, reliance on woodfuel was much higher in rural areas, with an estimated 40 percent of rural dwellers worldwide (comprising 78 percent in Africa, 65 percent in Oceania, 30 percent in Asia, and 24 percent in the Americas) using woodfuel for cooking compared with 10 percent in urban areas.

[7] More than half of world wood production is consumed as woodfuel, and one-third of this is estimated to be harvested unsustainably due to unregulated forest access, contributing to forest degradation (Jin, 2017).

The percentage of urban dwellers using mainly woodfuel for cooking was below 5 percent in 2022 in all regions except Africa, where it was 42 percent.

An estimated 410 million people worldwide mainly used wood energy to sterilize their water via boiling in 2022 – substantially fewer than the 760 million people reported in 2014 (FAO, 2014). Many households use woodfuel to preserve food, such as by smoking and drying, an essential part of food security because it enables the continued supply of food in non-productive periods.

The burning of woodfuel in houses can have negative impacts on human health due to air pollution,[8] although good-quality stove systems can reduce this risk. When produced sustainably and used efficiently, however, woodfuel is an effective and affordable source of energy for cooking, food preservation and water sterilization. In many countries, it is likely to remain an essential resource for household food security and nutrition.

Forests and their often-rich biodiversity contribute to the utilization component of food security and nutrition. Wild foods often contain high levels of key micronutrients, and most of the global supply of vitamin A, vitamin C and calcium, and much of the supply of folic acid, comes from crops pollinated by animals and insects (Powell *et al.*, 2013a). Wild forest foods are crucial components of diets commonly consumed by rural food-insecure people, and they add variety to predominantly staple diets (Box 9). In some communities with high levels of forest-food use, consumption of such foods is sufficient to meet minimum dietary guidelines for fruit, vegetables and animal-source foods (Rowland *et al.*, 2015).

Box 9
Nourishing the community: the nutritional power of non-wood forest products in the Democratic Republic of the Congo

A study near the Kahuzi-Biega National Park in eastern Democratic Republic of the Congo found that non-wood forest products (NWFPs) contributed 23.3 percent of household incomes (second only to agriculture). These incomes were dedicated primarily to purchasing food; on average they purchased 29.0 percent of household food.

Despite challenges such as low market prices, short shelf life, high taxation in urban areas, seasonality, scarcity and price control, NWFPs were found to be crucial components of local diets, providing essential nutritional diversity and resilience in a region with significant poverty and food insecurity. The study identified at least 55 NWFPs used as foods, such as black nightshade (*Solanum nigrum*), termite mushrooms (*Termitomyces robustus*) and black pepper (*Piper nigrum*) (all valuable sources of protein), providing essential nutrients that are often deficient in the diets of impoverished populations. Sustainable practices and improved market access are vital for the full realization of the nutritional and economic potential of forest resources.

Source: Mondo, J.M., Chuma, G.B., Muke, M.B., Fadhili, B.B., Kihye, J.B., Matiti, H.M. & Sibomana, C.I. *et al.* 2024. Utilization of non-timber forest products as alternative sources of food and income in the highland regions of the Kahuzi-Biega National Park, eastern Democratic Republic of Congo. *Trees, Forests and People*, 16: 100547. https://doi.org/10.1016/j.tfp.2024.100547

[8] The inefficient combustion of biomass for cooking can cause smoke pollution. Cooking with solid fuels is responsible for 25 percent of black carbon emissions globally and as much as 60–80 percent in some countries in Africa and Asia (United States Environmental Protection Agency, 2014).

Forest fruits are rich in minerals and vitamins, and seeds and nuts harvested in forests contribute calories, oil and protein to diets. Edible roots and tubers are sources of carbohydrates, and mushrooms provide important nutrients such as potassium, selenium and vitamins. Wild leaves, either fresh or dried, are among the most widely consumed forest products. They serve as rich sources of protein and micronutrients – vitamin A, calcium and iron, among others – that are commonly deficient in the diets of nutritionally vulnerable communities.

There are strong links between forest cover and dietary quality. For example, a study in Africa found that children living in areas with higher tree cover have been shown to have more diverse and nutritious diets; fruit and vegetable consumption increased with tree cover to a peak of 45 percent tree cover, after which it declined (Ickowitz *et al.*, 2014).

Many trees provide more than one source of food. For example, in addition to edible pods, flowers and seeds, the leaves of moringa (*Moringa oleifera*) are rich in vitamin B, vitamin C, beta-carotene of vitamin A, magnesium, iron and protein. They also contain phenolics and flavonoids that provide antioxidant, anticarcinogenic, immunomodulatory, antidiabetic, antiatherogenic and hepatoprotective properties. Five grams of leaf powder from these trees can meet 80 percent of the vitamin A intake requirements of children under three years old.

The baobab (*Adansonia digitata*) is another tropical tree used for both fruit and leaves, and it is a staple food source for many people in African drylands. Baobab contains naturally dehydrated fruit pulp that is five times as rich in vitamin C as oranges while also providing vitamins A, B1, B2 and B6. A daily consumption of 10–20 g of baobab fruit pulp can fulfil a child's vitamin C intake requirement, and the leaves are high in calcium, iron and protein.

Forest foods are especially important (both nutritionally and culturally) in Indigenous communities. In 22 countries in Asia and Africa, including both industrialized and developing countries, Indigenous communities use an average of 120 wild foods per community (Bharucha and Pretty, 2010). As components of both traditional medicine and prescription drugs, NWFPs provide medicinal resources for a wide array of ailments.[9] For example, at least 1 billion people worldwide[10] use herbal remedies to treat diarrhoea in children (FAO, 2014).

The value of forest foods as a nutritional and medicinal resource is not limited to developing countries. In 2021, a statistically representative survey of more than 17 000 respondents in 28 European countries found that 90 percent of households consumed NWFPs and approximately 25 percent collected them (Lovrić *et al.*, 2021).

[9] Medical plants are used both as part of traditional medicine (e.g. herbal medicines, manual and spiritual therapies and acupuncture) and as ingredients in up to one-quarter of all prescription drugs (Farnsworth *et al.*, 1985).

[10] Not including people in Europe and North America.

Stability of food security

The stability dimension of food security is about how food security changes over time. The incomes generated and wild foods produced by forests serve as safety nets during seasonal shortages and in times of famine, crop failure and economic, social and political shocks. Harvesting forest food helps people cope with periods of food insecurity – especially vulnerable households living in or near forests. Forest products are frequently available for extended periods, including during "hungry" or "lean" seasons. They help people meet their nutritional requirements when traditional agricultural products are seasonally unavailable, stocks have run out, or money is in short supply (Miller *et al*., 2021).

In addition to providing coping measures for short-term instability (which can lead to *acute* food insecurity), forests perform ecosystem services that help ensure medium- to long-term stability (which can prevent *chronic* food insecurity). The crucial role of forests in maintaining biodiversity

A woman in Timor-Leste journeys to the local market, a handmade basket brimming with glossy betel nuts balanced expertly on her head. Betel nut contributes both to local diets and to household incomes, supporting rural livelihoods

as a gene pool for food and medicinal crops – thereby promoting long-term high-quality diets and providing services for sustainable agricultural, livestock and fishery production – cannot be ensured without healthy forest ecosystem services.

For example, forests provide habitat for many pollinators, which are essential for sustainable food production and the regeneration of forest plants. Eighty-seven of the world's leading food crops – representing 35 percent of global food production – depend on animal pollination (HLPE, 2017). "Green" water accounts for approximately 60 percent of global precipitation, and "blue" water makes up 40 percent (Douville *et al.*, 2021).[11] Nearly half (about 45 percent) of the rain that falls on land originates in the land (with the rest originating in oceans) (De Petrillo *et al.*, 2024).

Forests are essential for climate-change mitigation and adaptation: for example, they were net sinks of atmospheric carbon dioxide between 1990 and 2025 (FAO, 2025e). They play a crucial role in reducing climate-related food insecurity, such as by minimizing the potential for agricultural losses from extreme weather events such as droughts and floods.

Contribution to sustainable agriculture

Forest and agricultural production systems often overlap (sometimes completely, in agroforestry systems). Plant and animal biodiversity is much higher in forests than in agricultural areas, with positive impacts on the productivity and resilience of nearby agricultural production systems (Duffy, Godwin and Cardinale, 2017) and thus on FSN (HLPE, 2017). A high diversity of species around

This cocoa agroforestry plantation in the Centre Region of Cameroon combines cocoa production with diverse tree cover to support sustainable land management and agricultural productivity

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[11] Green water is the water supply for all non-irrigated vegetation, including forests and woodlands, grasslands and rain-fed crops, and blue water is accessible for use via lakes, reservoirs, streams and aquifers (FAO, 1996b).

agricultural production systems strengthens the provision of essential ecosystem services (FAO, 2019), boosting climate regulation and enhancing nutrient cycling, soil health, fertility and stability, and water purification (Millennium Ecosystem Assessment, 2005). Strategically located shelterbelts of trees can enhance agricultural production substantially (Box 10).

Box 10
Shelterbelts in the Russian Federation

Forests enhance soil fertility in agricultural landscapes by increasing humus content and biophilic elements, improving the structure and water stability of soil aggregates, activating microbiological processes and reducing the content of toxic salts.

The total length of large state-owned forest shelterbelts in the Russian Federation is greater than 5 300 km, with an estimated 2.1 million ha planted from the 1950s to the 1970s. Today, average grain yields are 18–23 percent higher in areas protected by forest shelterbelts than in unprotected fields, industrial crop yields are 20–26 percent higher and forage crop yields are 29–41 percent higher. The 1.2 million ha of shelterbelts that now exist in the country provide an estimated 12 million tonnes of additional agricultural production (in grain equivalent).

Sources: Turusov, V. & Konovalova, E. 2026. Состояние и пути повышения роли агролесомелиоративного комплекса в земледелии [The state and ways of increasing the role of agroforestry in agriculture]. [Cited 12 February 2026]. https://vrnikc.ru/news/sostoyanie-i-puti-povysheniya-roli-agrolesomeliorativnogo-kompleksa-v-zemledelii/; Ministry of Science and Higher Education of the Russian Federation. 2020. СТРАТЕГИЯ РАЗВИТИЯ ЗАЩИТНОГО ЛЕСОРАЗВЕДЕНИЯ В РОССИЙСКОЙ ФЕДЕРАЦИИ НА ПЕРИОД ДО 2025 ГОДА [Strategy for the development of protective forestation in the Russian Federation to 2025]. https://vfanc.ru/wp-content/uploads/2023/04/strategiya-razvitiya-zlr18-2.pdf

Forests help regulate the water cycle in ways that directly sustain agricultural production. Through evapotranspiration, forests recycle moisture and contribute to downwind rainfall, thus benefiting rainfed agriculture. Many agricultural regions depend on forests located far beyond national borders for a significant share of annual precipitation: globally, it has been estimated that agricultural areas in 155 countries depend on forests in other countries for up to 40 percent of annual rainfall (FAO *et al.*, 2025b). In Africa, the Congo rainforest recycles more than 40 percent of its moisture locally and contributes more than 10 percent of precipitation to some distant agricultural zones in Africa (FAO *et al.*, 2025b). In addition to influencing rainfall, forests regulate water quantity, quality and timing by supporting freshwater supply, mitigating floods and droughts, and improving water filtration (see Box 11 for an example from Switzerland). Despite their importance for agricultural productivity and rural livelihoods, these services are often undervalued and poorly monitored.

As habitat for wildlife and insects, forests support agricultural production through crop pollination and the control of pests and diseases. Forests are a reservoir of wild ancestral or relative species of livestock and crop varieties that have been domesticated and bred for high yields and which can be highly homogeneous and vulnerable to shocks and climatic change. Wild species continuously evolve and diversify under natural, diverse and sometimes extreme conditions and are therefore a source of adaptation for the future of domestic species if they crossbreed with wild species.

Box 11
Forest contributions to food security and nutrition in Switzerland

Forests, which cover 31 percent of the land area in Switzerland, underpin food security by sustaining the ecological conditions necessary for stable agricultural production. By supporting stable production and a diversity of agricultural outputs, forests contribute to dietary diversity, nutrition and human health. Forests deliver four essential ecosystem services for sustainable food production:

1. **Protection against natural hazards.** Forests protect farmland, infrastructure and livestock from hazards such as rockfalls, landslides, avalanches and wind, particularly in alpine regions, helping safeguard the 50–56 percent of food that Switzerland produces domestically and reducing the need for costly engineered protection.[i,ii,iii,iv]
2. **Soil and water regulation.** Forests reduce erosion, regulate water flows and support soil fertility in adjacent farmland, helping maintain agricultural productivity and keeping soil loss well below critical thresholds.[v,vi]
3. **Climate regulation and carbon storage.** The agriculture sector and agricultural soils in Switzerland are net carbon-dioxide emitters, with soils losing around 500 000 tonnes of carbon dioxide per year; in contrast, agroforestry systems, which cover 8–12 percent of Swiss agricultural land, significantly increase carbon storage and help regulate the climate.[vii,viii,ix,x]
4. **Biodiversity and pollination support.** Swiss forests host roughly 40 percent of species present in the country, providing biodiversity that supports natural pest control and the pollination of key crops, such as oilseed rape.[xi,xii]

The Government of Switzerland reinforces these contributions through direct payments for biodiversity-promoting agricultural landscape elements such as hedgerows, fruit trees, forest edges and wooded pastures and by providing incentives for agroforestry under the country's Agricultural Policy 2022+.

Sources: [i] Bianchi, E., Accastello, C., Trappmann, D., Blanc, S. & Brun, F. 2018. The economic evaluation of forest protection service against rockfall: a review of experiences and approaches. *Ecological Economics*, 154: 409–418. https://doi.org/10.1016/j.ecolecon.2018.08.021; [ii] Sergiacomi, C., Floris, A., Clementel, F. & Paletto, A. 2024. The economic value of the protective functions of mountain forests: a case study in the Italian Alps. *Journal of Sustainable Forestry*, 43(6–10): 153–173. https://doi.org/10.1080/10549811.2025.2451438; [iii] Swiss Federal Authorities. 2023. Agriculture. In: *About Switzerland*. https://www.aboutswitzerland.eda.admin.ch/en/economy-agriculture; [iv] Swiss Federal Authorities. 2025. Domestic production as a proportion of total consumption. In: *Federal Statistical Office*. https://www.bfs.admin.ch/asset/en/36187582; [v] Baskent, E.Z. & Yılmaz, Ü.S. 2026. Quantifying and integrating ecosystem services in forest management planning. *Ecosystem Services*, 77: 101809. https://doi.org/10.1016/j.ecoser.2025.101809; [vi] Prasuhn, V., Hutchings, C., Gilgen, A. & Blaser, S. 2023. How do different arable crops affect erosion risk? In: *Agrarforschung Schweiz*. [Cited 4 February 2026]. https://www.agrarforschungschweiz.ch/en/2023/07/how-do-different-arable-crops-affect-erosion-risk/; [vii] Pestalozzi, G. 2024. How disturbances influence carbon sequestration in forest soils. In: *Swiss Federal Institute for Forest, Snow and Landscape Research WSL*. [Cited 4 February 2026]. https://www.wsl.ch/en/news/how-disturbances-influence-carbon-sequestration-in-forest-soils/; [viii] Roberti, G., Herzog, F., Jäger, M. & Kay, S. 2025. Temperate agroforestry for tree carbon storage in Switzerland: 10 years of biophysical and social monitoring. *Climate Smart Agriculture*, 2(2): 100055. https://doi.org/10.1016/j.csag.2025.100055; [ix] Herzog, F., Szerencsits, E., Roces-Díaz, J.V. & Kay, S. 2018. Agroforestry in Switzerland – A non-cap European country. Paper presented at the 4th European Agroforestry Conference, Nijmegen, the Netherlands; [x] Federal Office for the Environment. 2025. *Climate services in forest management and wood use in Switzerland: Key findings and conclusions of the KWHS study for the Swiss forest and timber sector*. Bern. https://www.bafu.admin.ch/dam/en/sd-web/Sy4re9VSsfLu/en_UW_2511_KWHS.pdf; [xi] European Commission. 2017. Quantification of ecological services for sustainable agriculture | FP7. In: *CORDIS - EU research results*. [Cited 4 February 2026]. https://cordis.europa.eu/project/id/311879/reporting; [xii] WSL News. 2025. Forest Report 2025: Swiss forests under pressure to adapt. In: *Swiss Federal Institute for Forest, Snow and Landscape Research WSL*. [Cited 4 February 2026]. https://www.wsl.ch/en/news/forest-report-2025-swiss-forests-under-pressure-to-adapt/

Nearby forests also provide farmers with agricultural inputs such as food, fodder, fibre and organic matter, thereby reducing the costs and negative externalities associated with the production and transportation of such inputs from more distant locations.

Forests help moderate temperatures, providing cooling benefits that are increasingly important in the face of climate change. Forests reduce local temperatures through evapotranspiration and other biophysical processes. Forest clearance, in contrast, can lead to temperature rises of several degrees, increasing heat stress for crops, livestock and rural workers. A study in Brazil found that the conversion of forest to farmland reduced evapotranspiration by about 30 percent, increasing temperatures at the local level (FAO *et al.*, 2025b). This increased temperature can, in turn, reduce soil moisture, exacerbate drought conditions and diminish labour productivity during growing seasons. It has been estimated that, between 2001 and 2020, tropical deforestation contributed to around 28 000 additional heat-related deaths annually (FAO *et al.*, 2025b). The physical work capacity of manual agricultural labourers in growing seasons is estimated to have declined by as much as 14 percent in half the world's cropland regions due to increasing temperatures (FAO *et al.*, 2025b). Conserving and restoring forest cover can contribute to environmental sustainability, improved public health and the resilience of agricultural labour.

Forest biodiversity is under pressure on many fronts, however, posing a serious threat to the sustainability of food production systems. Agricultural transformation in the late twentieth century relied on large-scale intensification using high levels of inputs; in many countries, that approach has

Women workers weed and clean around cacao trees in a plantation in Brazil. Cocoa has a high food value, containing as much as 20 percent proteins

resulted in severe environmental impacts. Cropland expansion and livestock grazing are significant contributors to deforestation (FAO, 2022b), with associated negative impacts on biodiversity. The benefits of biodiversity to agriculture are not always recognized and valued, which can lead to biodiversity-negative land management decisions and further biodiversity loss.

Sustainable agricultural management practices are key to realizing the benefits of forest ecosystem services and reducing the disservices associated with agricultural activities (Power, 2010), including in mountain regions (Box 12). Indigenous and local knowledge can be an invaluable asset in sustainable land management (IPBES, 2019). Maximizing provisioning services from agroecosystems can result in trade-offs with other ecosystem services, but integrated management can substantially reduce or even eliminate these trade-offs.

Agroforestry is an optimized system for linking agriculture and forest and tree biodiversity, whether organized as trees in agricultural landscapes or as farms in forest landscapes (Udawatta, Rankoth and Jose, 2019). Interactions may take place at the stand level (where agricultural and forest products grow together) or at the level of the farm or landscape. Sustainable management, and mainstreaming the role of biodiversity, is essential – both to reduce the negative impacts on biodiversity and to ensure sustainable agricultural production and future FSN.

Box 12
Mountains: key players in sustainable food systems

Mountains cover 27 percent of the Earth's land and host 1.2 billion people (about 15 percent of the global population), mostly in rural areas of developing countries. Half the rural mountain population living in developing countries was estimated to be food-insecure in 2017.

Mountains host about half the world's biodiversity hotspots, are home to vital genetic resources for crops and livestock, and provide key ecosystem services such as water regulation, climate stability, and downstream food and water security. Mountains may be considered the world's "water towers" because they provide freshwater to billions of people living in highlands and surrounding lowlands. For example, the Hindu Kush Himalaya is estimated to provide freshwater to about 2 billion people.

Mountain runoff supports two-thirds of irrigated agriculture, linking mountains directly to global food production. Sustainable agrifood systems in mountains can foster enterprises, tourism and renewable energy, but climate change and ecosystem degradation threaten their role in food security and sustainable development.

Sources: Romeo, R., Grita, F., Parisi, F. & Russo, L. 2020. *Vulnerability of mountain peoples to food insecurity: updated data and analysis of drivers*. Rome, FAO and United Nations Convention to Combat Desertification. https://doi.org/10.4060/cb2409en; Wester, P., Mishra, A., Mukherji, A. & Shrestha, A.B. 2019. *The Hindu Kush Himalaya assessment: Mountains, climate change, sustainability and people*. Kathmandu, International Centre for Integrated Mountain Development. https://doi.org/10.1007/978-3-319-92288-1

3. OVERVIEW OF THE CONTRIBUTIONS OF FOREST FOODS TO FOOD SECURITY AND NUTRITION, BY REGION

KEY MESSAGES

- Africa has the highest rates of food insecurity in the world, with 58.9 percent of the population experiencing moderate or severe food insecurity – more than double the global average. Studies show that forest foods reduce food insecurity, provide crucial nutrients and increase dietary diversity.
- Some people in Africa derive as much as 80 percent of their daily protein needs from wild meat sourced from forests. In the Congo Basin, the consumption of wild meat has been estimated at 5 million tonnes per year, compared with up to 1.3 million tonnes per year in the Amazon Basin.
- Wild forest fruits are important sources of micronutrients in Africa, and they are vital for high-quality diets in many rural areas. The consumption of about 200 g of five specific forest fruits by young people in Gabon provide up to 100 percent of their daily nutrient requirements for energy, vitamins C and E, iron, magnesium and zinc.
- In Nigeria, bitter kola, breadfruit, bush mango, kola nut, African blackberry, African star apple and African bush pear are collected frequently in forests and offer significant contributions to food security.
- The Americas host a vast diversity of forest ecosystems that are crucial for food security and nutrition. Many Indigenous Peoples and local communities depend on forests for subsistence and livelihoods, maintaining traditional practices and food systems that support both nourishment and cultural heritage. Wild fruit such as that of the Mauritian palm are particularly important because they provide macronutrients and essential micronutrients, such as beta-carotene, a precursor to vitamin A, which is vital for vision and immune function.
- Aquatic resources are a fundamental aspect of the food security of forest-dwelling communities across the Americas, particularly in the Amazon, where fish account for 44 percent of total consumed food mass and serve as the predominant source of dietary protein (78 percent) and fat (66 percent) and also contribute significantly to dietary energy (31 percent). Studies in the Amazon (as well as in Africa) have found linkages between aquatic foods and forests.
- Asia is home to more than half the world's population and has the highest number of food-insecure people. Asia also has the largest number of wild forest species used for food, with many studies shows the crucial links between forests and food security and nutrition.
- In rural Cambodia, more than 80 percent of households consume wild meat at least once a year. India's 104 million Indigenous Peoples are the country's predominant users of wild forest foods – consuming hundreds and possibly thousands of wild food species.

- Despite an overall decline in wild-food consumption and a loss of traditional knowledge, a survey in 28 European countries found that 90 percent of Europeans eat forest foods. Fifteen percent of consumers reported eating game meat more than once a month and more than one-third indicated that they ate game meat every year.
- Despite rising consumption of imported and processed foods, forest and marine resources remain vital in Oceania for dietary diversity and emergency food and as safety nets, with reliance on forest food highest among rural Melanesian communities. Agroforestry is widespread, especially in Micronesia, where land-area constraints mean that the line between forests and agricultural areas is often blurred.
- In New Guinea, tropical rainforests are crucial for food security and meeting the dietary needs of local communities. Sago, derived from the sago palm, is a staple food for many, especially in lowland areas.
- The contribution of wild-pig meat to diets varies across Oceania, from 5–15 percent in Fiji to 10–30 percent in Vanuatu and rural Papua New Guinea. Wild-pig meat is particularly important in rural and remote areas, where it often supplements or replaces domestic meat.

Two farmers in Côte d'Ivoire work on their agroforestry cocoa plot, where cocoa is cultivated alongside other plant species

© FAO/Candida Villa-Lobos

Background

There is no universal definition of forest food. In its Specification of Forest Food Certification Technology, China defines forest food as edible forest products that are collected, cultivated or raised in line with the principle of sustainable management in well-managed forests that are raw, free from pollution, healthy, and safe (see Box 32). In Africa (e.g. Cameroon) and the Americas (e.g. Brazil), some researchers also consider freshwater fish from forested landscapes and marine fish from mangrove systems as forest food because many such species depend on forests for habitat structure, food, nutrition and protection from predators. In this report, forest foods are defined as wild foods sourced from forests (where "wild" means that the foods are neither cultivated nor domesticated).

In regions where forest foods likely make the most important contributions to FSN, most of the species consumed are not traded in formal markets. Rather, they are collected and consumed directly by households or traded in informal markets, both of which increase the challenge of capturing the magnitude of their use.

Forest foods are consumed widely, but little systematic information has been captured at the national or global levels about consumption quantity; information on the species consumed is also scant in many parts of the world (FAO, 2019). The lack of systematic data makes it difficult to estimate the magnitude of the contributions of forest foods to FSN. This chapter summarizes the existing evidence in the five major global regions[12] and the contributions of forests foods to other facets of well-being (e.g. recreation, culture and culinary practices).

[12] This chapter is organized by United Nations regions. The International Union for Conservation of Nature (IUCN) Red List characterizes species distribution based on biogeographic realms, which do not coincide perfectly with the United Nations regions. Here, therefore, for each United Nations region, IUCN estimates are reported for the biogeographic realms with the largest overlap based on forest cover. This approach allows the comparison of similar ecosystems and landscapes in different countries and contexts.

Africa

Overview

Africa has the highest rates of food insecurity in the world, with 58.9 percent of the population experiencing moderate or severe food insecurity[13] – more than double the global average (28–29 percent) (FAO *et al.*, 2025a). It is estimated that nearly 22 percent of the forest cover in tropical Africa has been lost since 1900 (Aleman, Jarzyna and Staver, 2017). Numerous case studies in Africa show that forest foods help mitigate food insecurity by providing critical nutrients and closing food gaps in lean seasons, although no comprehensive data for any country in the region have been published quantifying this importance.

According to IUCN (2024), 1 088 forest species are documented as being used for food in the Afrotropics (a biogeographic realm covering sub-Saharan Africa, Madagascar and the southern Arabian Peninsula), comprising 559 species of animals, 518 species of plants, 11 species of fungi (an underestimate by at least an order of magnitude; Sileshi, Tibuhwa and Mlambo, 2023) and one insect species (also clearly a vast underestimate; Omuse *et al.*, 2024) (Figure 1).

Bushmeat is sold in a local market in Ebolowa, Cameroon. Wild meat is an important resource in rural and biodiversity-rich areas, where it supports nutrition and household income

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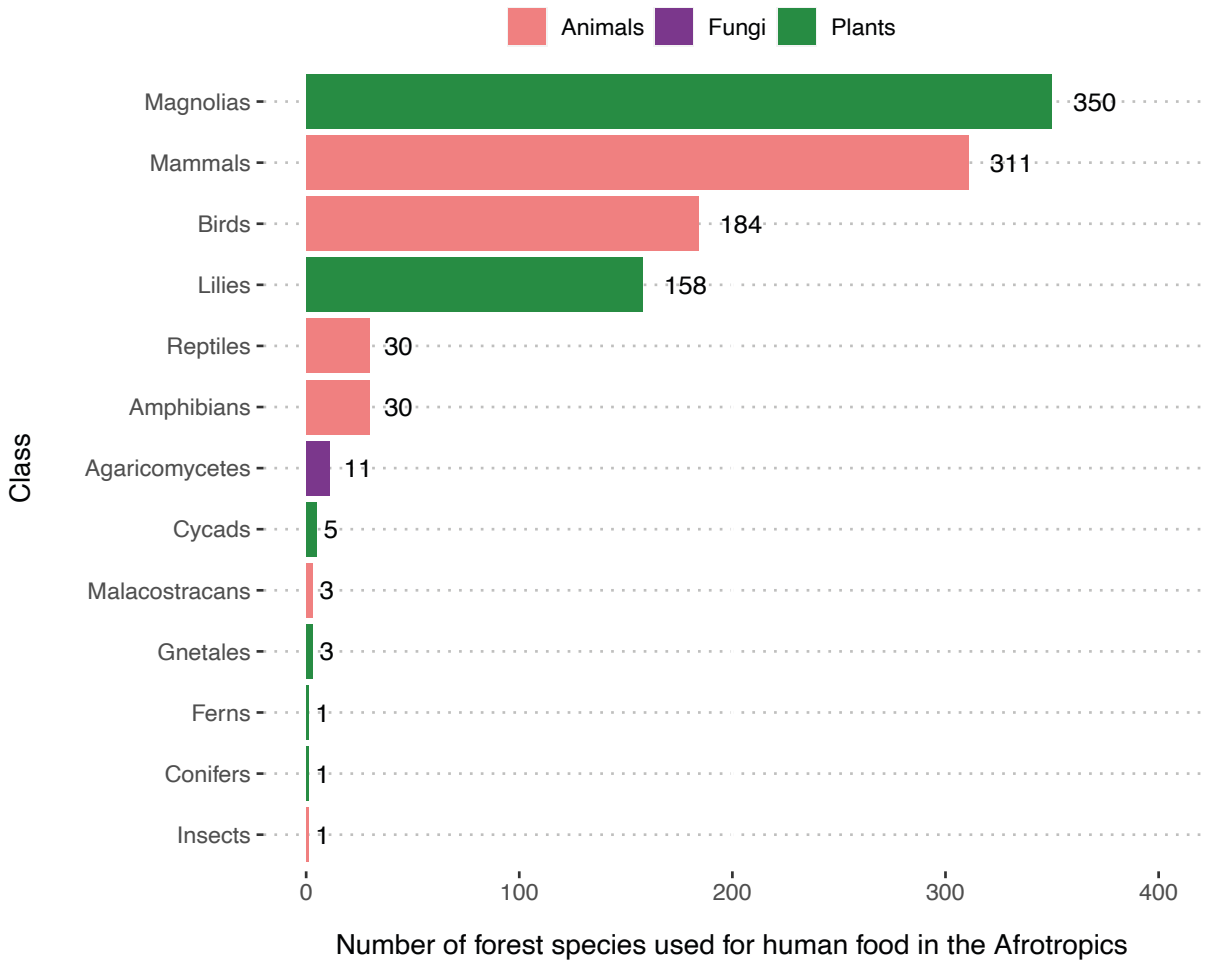
[13] Moderate food insecurity describes a situation in which people are forced to decrease the quality and/or quantity of the food they consume. People experiencing severe food insecurity typically have run out of food or have gone one day (or more) without eating (FAO, 2025f).

Figure 1.

Number of forest species used for human food in the Afrotropics, by taxonomic group, as listed on the IUCN Red List



Note: This figure does not include species that have not been assessed on the IUCN Red List and is therefore likely to vastly underestimate numbers for some taxonomic groups.
Source: IUCN. 2024. *The IUCN Red List of Threatened Species*. Version 2024-1. https://www.iucnredlist.org

Children look for frogs in Sibi village near Boromo, Burkina Faso. For many rural households facing food insecurity, wild meat is an important source of nutrition and dietary diversity

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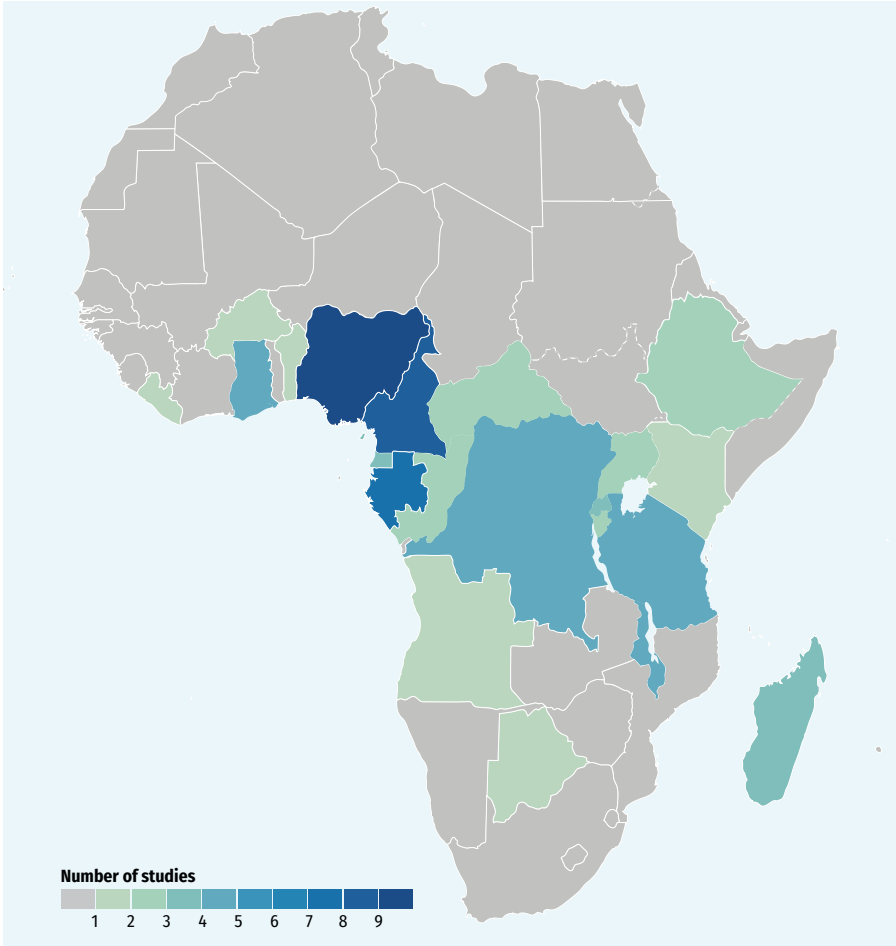
Contribution of forest foods to food security and nutrition

Africa is the best-studied region for the linkages between forest-food consumption and FSN. This section synthesizes findings from 41 studies (all in sub-Saharan Africa) in 23 countries published between 1993 and 2024 (Figure 2).

Figure 2.
Distribution of studies in the period 1993–2024 in the African region on linkages between forest foods and food security and nutrition, by country



Note: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.
Source: Authors' own elaboration. Visualization created in Datawrapper

Eighty percent of the studies found positive linkages between the consumption of forest foods and FSN, and 20 percent showed mixed linkages. None of the studies found exclusively negative linkages.

Forest foods contribute to FSN in various ways. Nearly half (49 percent) of the publications included in the review found that people who eat more forest foods have higher food security. Thirty-nine percent of papers showed a positive association between the consumption of forest foods and dietary diversity – often measured by the minimum dietary diversity index (FAO and FHI 360, 2016) – and 34 percent found positive linkages between forest foods and macronutrient or micronutrient

intake (e.g. folate, iron, protein, vitamin A and zinc). Twenty-four percent of papers showed that forest foods contributed positively to various anthropometric outcomes related to FSN (e.g. height for age, weight for age, level of anaemia and body mass index).

Wild fruit. Wild forest fruits are important sources of micronutrients in Africa, contributing to dietary quality in many rural areas (see Box 13 for an example in Zambia). A study in Gabon on the nutritional content of five forest fruits (*Afrostyrax lepidophyllus*, *Gambeya lacourtiana, Panda longifolia*, *P. oleosa* and *Poga oleosa*) found that children aged 1–3 years could obtain 20–100 percent of their daily nutrient requirements for energy, vitamins C and E, iron, magnesium and zinc if they consumed about 200 g of these five fruits (Fungo *et al.*, 2019).

A study in Enugu State, Nigeria, found that bitter kola (*Garcinia kola*), breadfruit (*Treculia africana*), bush mango (*Irvingia gabonensis*), kola nut (*Cola nitida*), African blackberry (*Dalium guinese*), African star apple (*Chrysophyllum albidum*) and African bush pear (*Dacryodes edulis*) were the most frequently collected forest products; these fruits contributed significantly to the food security of respondents (n=120) (Chiebonam, Achike and Onah, 2020).

Box 13
Wild-food collection in Zambia

A 2019 study by the Center for International Forestry Research, in collaboration with the Food and Agriculture Organization of the United Nations, surveyed the collection and consumption of wild foods in Zambia. A total of 209 households across five districts were asked about the wild foods they had collected and consumed in the previous year. The study found high participation rates in wild-food collection and consumption, particularly for fruit and vegetables. Almost all households (99 percent) collected wild fruit, 92 percent collected leafy vegetables, and 88 percent collected mushrooms. The harvesting of wild fish and insects was also important in some households.

These wild foods made enormous contributions to local diets; for example, wild fruit contributed about five months of annual recommended fruit intake. The study reported quantities collected of 14 wild fruit species, with wild loquat (*Uapaca kirkiana*) the most commonly collected, followed by money orange (*Strychnos cocculoides*) and Mobola plum (*Parinari curatellifolia*). Households collected and consumed an average of 122.5 kg of wild fruit, or approximately 29.8 kg per person, in 2019.

The study set the groundwork for a nationally representative survey in Zambia using similar methods, carried out in 2021 in a partnership between the Center for International Forestry Research, the Zambian Statistics Agency and the Zambian Forestry Department. This was the first nationally representative survey of wild-food collection carried out in Africa. A report sharing the results of the study is in preparation.

Sources: Steel, E.A., Bwembelo, L., Mulani, A., Siamutondo, A.L.M., Banda, P., Gumbo, D., Moombe, K. & Ickowitz, A. 2022. Wild foods from forests: quantities collected across Zambia. *People and Nature*, 4(5): 1159–1175. https://doi.org/10.1002/pan3.10367; Ickowitz, A., Bwembelo, L., Mulani, A., Siamutondo, A.L.M., Banda, P., Gumbo, D., Moombe, K.B. & Steel, E.A. 2021. *Collection and consumption of wild forest fruits in rural Zambia*. Center for International Forestry Research. https://doi.org/10.17528/cifor/008086

The relationship between the consumption of forest fruit and forest density is not linear. For example, Friant *et al.* (2019) compared inner-forest communities in Nigeria with forest-edge communities and found that the quantity of fruit rich in vitamin A (mostly wild mangoes) collected in forests was significantly higher for people living at the edge of the forest. This was explained partly by the higher degree of market access among forest-edge communities, enabling more commercial collection of wild forest fruit and thereby higher opportunistic consumption of the fruit.

Wild meat. In Africa, wild animals (often referred to in Africa as bushmeat; see Ingram *et al*., 2021) are a key source of food and income for rural forest communities and also for residents of growing provincial towns in which the domestic meat supply is not yet established (Coad *et al.*, 2019; Fa *et al.*, 2015; Gils *et al.*, 2019; Golden *et al.*, 2011; Vega *et al.*, 2013). A recent regional meta-analysis of hunting offtakes in West and Central Africa, using data from the WILDMEAT database covering 83 sites (Ingram *et al.*, 2025), found that more than 140 species in 33 orders were hunted, with 93 percent of the hunted biomass comprising mammals. On average, 57 percent of hunter offtakes were sold (Ingram *et al.*, 2025), with much of this wild meat heading for large urban centres in which wild meat is generally consumed as a luxury and for its cultural and social value (Ingram *et al.*, 2021).

Forest wildlife is a significant source of wild meat, with an estimated 5 million tonnes of wild meat consumed annually in the Congo Basin. Wild meat provides up to 80 percent of the daily protein needs of local people in the Amazon Basin, where an estimated 1.3 million tonnes of wild meat is eaten per year (FAO, 2022c).

Analyses of household consumption rates at 252 forested sites in Central Africa (Bessone *et al*., 2026) highlight the importance of wild meat for rural forest communities. On average, rural village households consumed 56 g of wild meat per person per day (for each adult male equivalent), amounting to 20 percent of the recommended daily protein intake (see Box 14 for a discussion of the dietary value of wild meat). The contribution to recommended protein intake in urban areas was less but still substantial, at 13 percent for residents of towns and 6 percent for city residents (Bessone *et al*., 2026).

Case studies also indicate the importance of wild meat for food security in West and Central Africa. A study of 195 households in the vicinity of the main protected forest in Sao Tome and Principe found that wild meat accounted for more than half of total protein intake (Carvalho *et al.*, 2015). A study in six communities near the Cross River National Park in Nigeria showed that wild-meat consumption was positively associated with higher food security status (Friant *et al.*, 2020). It found that 48 wild vertebrate animals from forests were used for food and that the consumption of rodents was the main predictor of increased food security status.

Wild meat can act as a safety net for households in times of shock, such as when crops fail or when access to employment or alternative food sources is already low or diminishes (Jambiya, Milledge and Mtango, 2007; McNamara *et al.*, 2020; Torres-Vitolas *et al.*, 2019). This was demonstrated recently in Nigeria, where rural forest communities were found to hunt and consume more wild meat during the COVID-19 pandemic in response to declines in alternative sources of food (Emogor *et al.*, 2024).

Indigenous Peoples such as the Baka in Cameroon face challenges related to hunting and wild-meat consumption due to shifting livelihoods and evolving constraints on land access. Traditionally, the Baka have relied on hunting, gathering and small-scale fishing as part of their semi-nomadic lifestyle, allowing them to maintain deep ecological knowledge of forest ecosystems (Dounias, 2016). Increasing pressures from extractive industries (logging and mining), restrictions imposed by conservation spaces and, in some areas, agricultural expansion have significantly restricted their mobility and access to forest resources (Leclerc, 2012). The transition towards a more sedentary existence has led to greater dependence on market-based food systems, often resulting in reduced dietary diversity and increased food insecurity (Ichikawa, 2004).

Wild meat is generally a luxury good in Kumasi, an urban area in southern Ghana (McNamara, Fa and Ntiamoa-Baidu, 2019), with more than 40 species sold in Kumasi's wild-meat markets (McNamara *et al.*, 2015). Long-term (1978–2004) studies of these markets suggest that overhunting and land-use change have led to significant increases in the proportion of rodents sold, as well as an increase in market catchment, both of which suggest ecological depletion (McNamara *et al.*, 2015). A 2019 study of wild-meat markets in northern Ghana found that frog species made up 80 percent of sales (by number of individuals sold), mainly to local consumers; ungulates were still the most frequently traded taxa by weight (52 percent) and were more likely to be part of longer trade chains, supplying Kumasi and other markets in southern Ghana (Sackey *et al.*, 2023). The implication is that the urban consumption of wild meat as a luxury good can put pressure on the availability of wild meat for rural consumers, for whom it is a key component of the diet.

Hunting remains important for the diet, identity and cultural knowledge of the Baka people. Game meat provides essential protein and micronutrients that complement those contained in gathered plant foods and cultivated crops (Fa *et al.*, 2021). Shifts in land tenure and resource governance, particularly in areas where national conservation policies have imposed restrictions on traditional hunting practices, are challenging the sustainability of this food system (Pyhälä, 2012). For example, the establishment of protected areas such as the Boumba Bek and Nki national parks in southeastern Cameroon has led to restrictions on traditional hunting grounds, limiting the ability of Baka communities to hunt legally (Riddell, 2013). These restrictions, often enforced without adequate consultation, contribute to conflicts between conservation authorities and local communities, raising concerns about the long-term viability of Indigenous food systems (Lewis, 2000).

Box 14
Challenges in assessing the dietary importance of wild meat in Madagascar

Effective rights-based wildlife management depends on understanding the role of wild meat in local diets. Assessments are difficult, however, especially near protected areas or involving protected species, due to legal sensitivities and methodological challenges. Thus, wild meat often remains a hidden part of local food systems. For example, concerns have arisen that the method of direct questioning underreports wild-meat consumption in areas such as Makira Natural Park in Madagascar, where lemurs and fossas are protected.

Under the Sustainable Wildlife Management Programme,[a] a study using the unmatched-count technique – an indirect method – found that 53 percent of households had eaten lemur meat and 24 percent had consumed fossa in the past year. These rates were more than three and twelve times higher, respectively, than those obtained from direct questioning. One explanation of the apparent underreporting via the latter method is that the fear of sanctions leads people to understate their wild-meat consumption.

Although wild meat is an important source of protein in remote communities, its nutritional role is poorly documented. Low reported consumption doesn't mean low dietary significance or minimal ecological impact (especially for small, vulnerable species like lemurs). Patterns also vary with season, food insecurity, cultural norms and the availability of alternatives. Some lemurs are protected by *fady* (taboos), while others are hunted for food or to protect crops.

The disconnect between unsustainable hunting and continued dietary reliance presents a complex challenge. Conservation strategies must be grounded in a deeper understanding of wild-meat use in broader food systems.

Note: [a] The Sustainable Wildlife Management Programme, which operates in 16 countries, is funded by the European Union and implemented by the Food and Agriculture Organization of the United Nations, the Landscape Alliance, the Wildlife Conservation Society and the French Agricultural Research Centre for International Development.

Source: Spira, C., Raveloarison, R., Cournarie, M., Strindberg, S., O'Brien, T. & Wieland, M. 2021. Assessing the prevalence of protected species consumption by rural communities in Makira Natural Park, Madagascar, through the unmatched count technique. *Conservation Science and Practice*, 3(7): e441. https://doi.org/10.1111/csp2.441

Although wild-meat research in Africa has focused on West and Central Africa (Van Velden, Wilson and Biggs, 2018), research conducted in forested regions in East and Southern Africa suggests that wild meat is still an important resource for rural communities there, too. A review in South Africa (Martins and Shackleton, 2019) identified three studies of wild-meat use in forested and thicketed regions (Table 1) showing that wild meat is hunted and consumed, albeit probably at lower levels that in West and Central African forests. In the United Republic of Tanzania, Barnett, ed. (2000) suggested that wild meat was becoming increasingly important as a source of protein and cash income, and hunting studies in villages in the Udzungwa mountains (Nielsen, 2006) found that wild meat was consumed in 22 percent of the meat-containing meals of the 125 hunters who participated in the study, with 10 percent of the catch sold. A study among 305 children in southern Madagascar found that the consumption of wild forest animals was correlated positively with height-for-age score (Iannotti *et al.*, 2024), with the authors suggesting that wild-animal-source foods – combined with wild leafy greens and tree fruit – could be leveraged to bridge periods of food insecurity (Box 15).

Table 1.
Wild-meat consumption in sites in Southern Africa

Province and area	Site/village	Biome	Percentage of households using wild meat	Comment	Reference
Eastern Cape, Wild Coast	Cwebe	Forest	8	Mean use was 210 kg per year per user household; 11 spp.	Shackleton, S., Shanley, P. & Ndoye, O. 2007. Invisible but viable: recognising local markets for non-timber forest products. *International Forestry Review*, 9(3): 697–712. https://doi.org/10.1505/ifor.9.3.697
	Ntubeni	Forest	50		
Eastern Cape, Wavecrest-Kobonqaba	Nombanjana	Forest	92 percent of men and 86 percent of boys	Widespread consumption, mostly by adolescent boys for tradition and sport rather than the need for meat. Eight percent of adult men hunted	White, R. 2004. People and forest fauna: a case study from coastal dune forest in the Transkei region of the Eastern Cape. In: *Indigenous forests and woodlands in South Africa: Policy, people and practice*. University Of KwaZulu-Natal Press.
	Nxaxo	Forest	75 percent of males		
Eastern Cape, Kat River Valley	Fairbairn	Thicket	39	Mean consumption was 28–259 kg per household per year across all households (users and non-users)	Shackleton, C., Shackleton, S., Ntshudu, M. & Ntzebeza, J. 2002. The role and value of savanna non-timber forest products to rural households in the Kat River Valley, South Africa. *Journal of Tropical Forest Products*, 8: 45–65.
	Ntilini	Thicket	28		
	Tidbury	Thicket	47		

Source: Martins, V. & Shackleton, C.M. 2019. Bushmeat use is widespread but under-researched in rural communities of South Africa. *Global Ecology and Conservation*, 17: e00583. https://doi.org/10.1016/j.gecco.2019.e00583

Wild meat has been an important source of food for African communities for millennia. Growing human populations, however, combined with increasing habitat loss, access to forest areas and to better hunting technologies (such as wire snares, light-emitting-diode torches, and guns), and demand for wild meat by urban communities are putting many wildlife populations – and, in turn, rural food security – under threat (Coad *et al.*, 2019). Bessone *et al.* (2026) estimated that wild-meat consumption in Central African forests increased by 51 percent between 2000 and 2022, from 0.73 million tonnes to 1.10 million tonnes, driven largely by increases in the number of consumers (rather than by changes in individual consumption patterns). The United Nations expects Africa's population to increase from 1.5 billion in 2024 to more than 3 billion in 2070 (United Nations, 2024), which, in the absence of significant changes in consumption patterns, could further increase demand for wild meat.

Box 15
Nutritional contributions of wild meat in Central Africa to the diets of young children

The inadequate intake of nutrients in children can retard physical growth, impair cognitive development and result in weakened immune systems; therefore, the consumption of nutrient-rich foods is especially important for young children. Animal-source foods (e.g. meat, fish, eggs and dairy) are rich in protein, minerals and vitamin B12, but, for many poor households in the tropics, these foods are difficult to access because they tend to be expensive. In many forested areas, income-poor communities obtain such foods for their children by hunting and fishing.

A study by Ickowitz *et al.* in four rural communities in Cameroon and the Democratic Republic of the Congo found that wild meat and local fish comprised an average of 74 percent (during the rainy season) and 61 percent (during the dry season) of the animal-source foods consumed by children under five years of age across the sites. Given that children in Central Africa experience high rates of malnutrition, this contribution is nutritionally important. For the children in the study who consumed these foods, wild meat and local fish contributed (on average) 23 percent of protein intake, 11 percent of iron intake, 14 percent of zinc intake and 57 percent of vitamin B12 intake across sites and seasons.

The study also found that, although wealth was associated with higher consumption of domestic meat for children, there was no statistically significant association between wealth and the consumption of wild meat or local freshwater fish. Thus, these wild foods act as a dietary equalizer, ensuring that even households experiencing income poverty can feed their children nutrient-rich animal foods. This has important policy relevance because proposals to replace wild meat with domestic meat could, if successful, be harmful to the diets of poorer households.

Source: Ickowitz, A., Pratama, M.F., Rahmah, M., Tata, C.Y., Tang, E.N., Ngondi, J.L. & Mirindi, V.B. 2024. The importance of wild meat and freshwater fish for children's nutritional intake in the Congo Basin. *People and Nature*, pan3.10759. https://doi.org/10.1002/pan3.10759

Ingram *et al*. (2025) found that the proportion of a hunter's catch that is sold rose from 34 percent in 1991 to 74 percent in 2020, with a corresponding rise in the proportion of the offtake obtained from gun hunting, suggesting an increase in the commercial trade of wild meat. The ratio of rodents to ungulates in the catch – a tested measure of ecological depletion – rose from 2.5 to 17.1 over the same period. An estimated 31 percent of mammals, birds, reptiles and amphibians are under threat of extinction in the region due to unsustainable hunting (Bessone *et al*., 2026; IUCN, 2024).

Wild vegetables. Wild green leafy vegetables are major contributors to FSN in Africa (Box 16) due to their density and richness in important micronutrients, such as vitamin A and iron (Blaney, Beaudry and Latham, 2009; Garekae, Lepetu and Thakadu, 2020; Olaniyi, Akintonde and Adetumbi, 2013; Powell *et al.*, 2013b). Multiple studies across the continent have explored the nutritional importance of wild green leafy vegetables that grow in forests (e.g. Bvenura and Afolayan, 2015; Chiebonam, Achike and Onah, 2020; Sagali, Mang'enya and Huang, 2023). A study among 120 women living around the Lama forest in southern Benin found that the consumption of wild green leafy vegetables contributed to higher dietary diversity among consumers of wild foods (Boedecker *et al.*, 2014).

A study among 220 households in the green famine belt of Ethiopia found that wild forest vegetables (including leaves, shoots and flowers) were the most collected and consumed group of wild foods and that they were important for ensuring household resilience in the face of food insecurity (Guyu and Muluneh, 2015). Although forests host an abundance of wild edible plants, wild vegetables are often collected in and around agricultural fields on forest fringes (Powell *et al.*, 2015). In some cases, this is due to imposed restrictions and a lack of access to forest resources. As a strategy for overcoming barriers to legal access, people sometimes transplant wild plants from forests into their near surroundings, such as homegardens and agricultural fields (Joshi, Siwakoti and Kehlenbeck, 2015; Msuya, Mdnolwa and Kapinga, 2008; Olesen *et al.*, 2024b; Zeitler *et al.*, 2024). The produce of such plants cannot be considered forest food; nevertheless, this use of wildlings shows that forests can contribute indirectly to the higher availability of nutrient-rich vegetables in surrounding landscapes (Johnson, 2002).

Box 16
Importance of *Gnetum africanum* in Central Africa

Gnetum africanum is a liana that grows in forests in Central and West Africa. Its leaves are consumed as a vegetable in Cameroon, the Congo, the Democratic Republic of the Congo, Gabon, Equatorial Guinea and Nigeria. In Cameroon, the plant is used in a popular dish known as *eru* comprising the leaves of *Gnetum africanum*, meat or fish, red palm oil, and seasonings, and some people also add groundnuts. *Eru* is considered one of the national dishes of Cameroon and is especially popular in the western and central parts of the country. The plant is rich in minerals, fibre and antioxidants and is believed to have many health benefits. A study in the Democratic Republic of the Congo found that consumption of *Gnetum africanum* leaves was associated with a lower incidence of diabetic retinopathy,[i] and a study in Cameroon found that consumption was associated with higher haemoglobin levels and a lower incidence of anaemia in women of reproductive age.[ii]

Sources: [i] Moise, M.-M., Benjamin, L.-M., Etienne, M., Thierry, G., Ndembe Dalida, K., Doris, T.M. & Samy, W.M. 2012. Intake of *Gnetum Africanum* and *Dacryodes edulis*, imbalance of oxidant/antioxidant status and prevalence of diabetic retinopathy in Central Africans. *PLoS ONE*, 7(12): e49411. https://doi.org/10.1371/journal.pone.0049411; [ii] Yengo Tata, C., Ickowitz, A., Powell, B. & Colecraft, E.K. 2019. Dietary intake, forest foods, and anemia in Southwest Cameroon. *PLoS ONE*, 14(4): e0215281. https://doi.org/10.1371/journal.pone.0215281

Fish and other aquatic animals. Fish and other aquatic animals from forested areas contribute to FSN in Africa through various mechanisms, particularly in inland and riverine communities, where wild fish contribute significantly to dietary protein and essential micronutrient intakes (Obiero *et al.*, 2019; Ickowitz *et al.*, 2024). Many Indigenous communities depend on local aquatic ecosystems for their subsistence, with fish providing not only protein but also vital micronutrients that are crucial for health and well-being (Béné *et al.*, 2016). Forests have been shown to play important roles in protecting and sustaining aquatic ecosystems. In Nigeria, the density of forest cover around rivers

was found to be significantly positively correlated with the consumption of fresh fish in nearby local communities (Lo, Narulita and Ickowitz, 2019). Small dried fish are a notable source of protein and nutrients in Africa (Wessels *et al.*, 2023). In the United Republic of Tanzania, people's intake of protein and vitamin A was found to be positively related to the level of surrounding tree cover, most likely driven by higher consumption of small dried fish (Olesen *et al*., 2024b). The availability of fish has been shown to be linked to lower wild-meat consumption in rural Ghana, and lower fish availability was correlated with wildlife declines (Brashares *et al.*, 2004).

Nuts and seeds. Many forest nuts and seeds are nutrient-dense, with substantial potential to improve dietary quality. For example, the fruit of bush mango (*Irvingia gabonensis*) is known for its high vitamin A content, and the kernels are also rich in fat. The seeds of African pears (*Dacryodes edulis*) contain significant amounts of oil and protein (Leakey and Tchoundjeu, 2001). Studies have shown that the domestication and commercialization of forest nuts and seeds can improve agricultural productivity (e.g. through soil enhancement) while conserving biodiversity (Weston *et al.*, 2015). In addition, the integration of forest foods into farming systems in forest-adjacent communities can increase climate resilience by diversifying agriculture and income sources (Mazur and Stakhanov, 2008).

Honey. Although the nutritional value of honey is limited, it has medicinal value related to its anti-inflammatory, antioxidant and antibacterial qualities. It is widely collected worldwide for direct consumption and sale. It can contribute to food security directly – mostly by providing energy – and indirectly through the generation of income used to purchase more nutrient-rich foods. In a study in Zambia's Miombo woodlands, forest beekeepers who sold honey were more likely than non-beekeepers to report having sufficient food (Lowore, 2020). In South Africa, a study linked participation in wild-honey collection among rural women with reduced food insecurity and higher dietary diversity and incomes (Taruvinga *et al.*, 2023).

Foraging for wild honey has been associated with destructive practices that can threaten forest ecosystems. In Mozambique, honey-gathering led to illegal tree-felling and damaged the overall health of woodlands (Ribeiro *et al.*, 2019). Sustainable practices and non-destructive harvesting techniques are essential for maintaining both honey production and forest health.

Mushrooms. African forests host an abundance of wild edible mushrooms. Although the IUCN Red List has data for only 11 species, Sileshi, Tibuhwa and Mlambo (2023) documented 480 species of wild edible fungi on the continent, with more than half found in forests (Sileshi, Tibuhwa and Mlambo, 2023). Mushrooms are low in fat and rich in protein and fibre, and they are also valuable sources of antioxidants (Degreef *et al.*, 2016; Panda *et al.*, 2024). Forest mushrooms contribute to ecosystem services such as nutrient recycling and soil enhancement, which, in turn, supports the productivity of surrounding agriculture and thereby improves local food production (Sileshi, Tibuhwa and Mlambo, 2023). The collection and consumption of mushrooms are linked to traditional knowledge, and forest-sourced mushrooms, therefore, serve as important means for improving diets and protecting cultural heritage (Cunningham and Yang, 2012; Fongnzossie *et al.*, 2020).

Insects. According to Omuse *et al.* (2024), more than 464 species of edible insects have been reported in Africa; not all are found in forests, however, and Omuse *et al*. did not provide information on ecological zones. A study in various provinces in Zambia found that 65 percent of households reported collecting insects in forests in the previous year (Steel *et al.*, 2022).

Insects are rich in protein, fats and fibre and can help enhance FSN. Studies across Africa show that edible insects are used to overcome periods of food shortages and strengthen resilience among rural communities during drought and other climatic shocks (Hlongwane, Slotow and Munyai, 2020) by providing a readily accessible food source (Borgerson *et al.*, 2021).

Wild roots and tubers. African forests host many varieties of edible roots and tubers (e.g. bush yams), which are commonly consumed by households engaged in the collection of forest products (Amadu and Miller, 2024). They are important dietary supplements during food shortages (Fongnzossie *et al.*, 2020; Kugedera *et al.*, 2024). In Burkina Faso, indigenous roots and tubers have been shown to serve as a safety net by mitigating food scarcity and also to support people's dietary diversity (Vinceti *et al.*, 2022). Research in the Eastern Arc Mountains in the United Republic of Tanzania found that wild forest roots and tubers were highly valued food items that were preferred over exotic species, underscoring their importance in local cuisine and diets (Msuya, Kideghesho and Mosha, 2010).

Other contributions of forest foods

Income opportunities. In addition to the direct contributions of forest foods to FSN, their collection is also often linked to incomes (Box 17), providing indirect benefits to people's diets by increasing their purchasing power (Friant *et al.*, 2019; Meyer, 2023; Sawadogo, 2023), assuming that people spend their incomes on healthy food (Ickowitz *et al.*, 2019). A study in Senegal's Boundou region found that the recent commodification of wild baobab (*Adansonia digitata L.*) has been an essential adaptation strategy for people to overcome climate shocks and the newly enforced prohibition on hunting in protected areas (Owolodun and Merten, 2023). The study showed that cash earned from the sale of wild baobab improved people's food security.

Box 17
Results from Poverty Environment Network data

The Poverty and Environment Network (PEN), a collaborative research project, was designed mainly to investigate the relative contributions of agricultural, forest and non-forest environmental income to rural households in developing countries.

The PEN surveyed 8 313 households in 333 villages living in or adjacent to forested landscapes at 58 sites in 25 tropical countries. Surveys were carried out over a 12-month period for each site between 2004 and 2010. The data on non-wood forest products included food and other products – fuelwood, charcoal, resin, fibre, fodder and medicinal plants.

Incomes from forest foods contributed an average of 6.5 percent to total household income across all sites and 5.13 percent to incomes in Africa.[i] The data showed that the direct consumption of forest food was important, although to varying degrees, at all sites. More than half the surveyed households collected forest foods for their own consumption. For the top quartile of forest-food-consuming households, these foods made an appreciable contribution to diets, with forest fruit and vegetables contributing 15 percent of the recommended amounts of fruit and vegetables in the global sample and 21 percent at the African sites.[ii] The contributions of meat and fish from forests to diets was even more striking: using a reference quantity of 425 g of animal-source foods per week, one study found that meat and fish from forests contributed an average of 106 percent of the reference quantity to the top quartile of consumers and 178 percent at the African sites.[ii]

Sources: [i] Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C. & Wunder, S. 2014a. Environmental income and rural livelihoods: a global-comparative analysis. *World Development*, 64: S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006; [ii] Rowland, D., Ickowitz, A., Powell, B., Nasi, R. & Sunderland, T. 2017. Forest foods and healthy diets: quantifying the contributions. *Environmental Conservation*, 44(2): 102–114. https://doi.org/10.1017/S0376892916000151

Recreation, spirituality and culture. In addition to contributing to FSN, forest foods play important roles in local cultural identity and social well-being (Johns and Maundu, 2006; Kuhnlein, eds., *et al.*, 2009). In South Africa, for example, forest foods hold a central place in the local cuisine and are often favoured over commercial alternatives (Shackleton, Shanley and Ndoye, 2007).

In the Congo Basin, certain wild-food items are highly valued for their flavour and for the sense of comfort and happiness they provide. Wild meat holds considerable cultural importance that transcends its nutritional benefits, influencing social practices, rituals and community identity and strengthening social bonds (Brashares *et al.*, 2011; Chausson *et al.*, 2019; Tadie and Fischer, 2013; Valeri, 2000; Van Vliet and Mbazza, 2011; Wilkie *et al.*, 2016). Some species, such as snakes and turtles, are subject to food taboos, especially for women, because they are believed to affect fertility and child behaviour (Dounias and Ichikawa, 2017; Maykondo *et al.*, 2022). Many cultures have totem animals that cannot be hunted or eaten, such as the leopard for the Bretuo clan in Ghana (Ntiamoa-Baidu, 1997) and the pouvi in Gabon (Walters *et al.*, 2015).

Many fungi and plants also play important cultural roles. In Tshopo Province in the Democratic Republic of the Congo, several species of wild mushroom are connected to myths and beliefs, with women holding key cultural knowledge (Milenge Kamalebo *et al.*, 2018). The Ngando people, known for their ethnomycological expertise, use fungi extensively in their culture.

Despite a huge diversity of social practices, traditions and rituals, similar examples of the cultural significance of forest foods are found across Africa.

The Americas

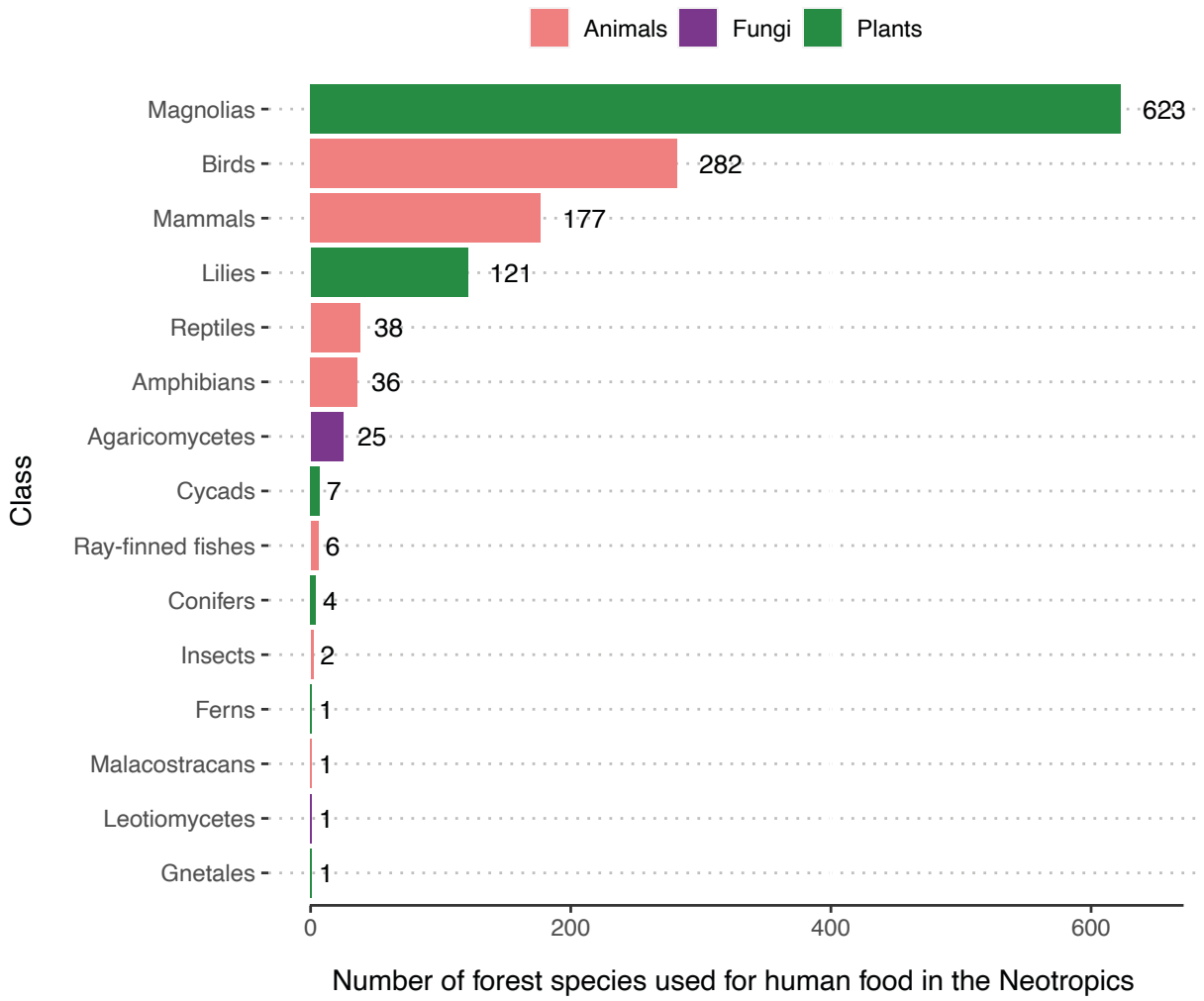
The Americas comprise a vast diversity of forest ecosystems that are crucial for ensuring FSN. The subsistence, livelihoods and cultures of many Indigenous Peoples and local communities are deeply rooted in forests.

In this report, the Americas are divided into two subregions: 1) Canada and the United States of America; and 2) Latin America (including Mexico) and the Caribbean. Mention is also made below of the Neotropics, also known as the Neotropical realm, a biogeographic realm that encompasses much of South America, Central America and the Caribbean and parts of the southern United States. This region is characterized by its rich biodiversity and varied ecosystems, including tropical rainforests, savannas and coastal areas.

Canada and the United States are home to some of the world's largest temperate and boreal forests, which provide foods such as wild berries, mushrooms and wild meat. Latin America and the Caribbean are among the most forest-rich regions on the planet. This subregion includes the Amazon, which is the world's largest tropical rainforest.

According to IUCN (2024), 1 325 forest species in the Neotropics are documented as being used for food (Figure 3). Plants represent the most diverse group, with 757 known forest species used as food. Animals are the second-most diverse group, with 542 species used as food, comprising birds (282 species), mammals (177), reptiles (38), amphibians (36), ray-finned fish (6), insects (2) and malacostracans (1). Twenty-six fungi species in the region have been documented as being consumed as food by humans.

Figure 3.
Number of forest species reported as being used for human food in the Neotropics, by taxonomic group, as listed on the IUCN Red List



Note: Does not include species that have not been assessed on the IUCN Red List and is therefore likely to greatly underestimate the number of forest species used for human food for some taxonomic groups.
Source: IUCN. 2024. *The IUCN Red List of Threatened Species*. Version 2024-1. https://www.iucnredlist.org.

Contributions of forest foods to food security and nutrition

The linkages between forest food consumption and FSN in the Americas have been explored in eight studies conducted in five countries – Brazil, Colombia, Ecuador, Jamaica and Peru – published between 2008 and 2021 (no study was found for Canada or the United States) (Figure 4). Positive linkages were reported in seven of the studies, with forest foods indicated to significantly contribute to dietary diversity, improved nutrient intake and food security. One study reported mixed outcomes (in Jamaica), finding that forest foods were an important safety net but were insufficient to fully address food security challenges. No studies reported exclusively negative outcomes.

Forest foods contribute to FSN in various ways. Four of the eight publications mentioned above indicated that higher consumption of wild forest foods was associated with improved food security. Three studies found a positive association between forest food consumption and higher dietary diversity, often using dietary diversity indices. Two studies reported positive linkages between forest foods and macronutrient and micronutrient intake, such as protein, vitamin A and iron. One study observed that forest foods contributed to positive anthropometric outcomes such as body mass index, height for age and levels of anaemia.

Figure 4.
Distribution of studies on linkages between the acquisition, collection and consumption of forest foods and food security and nutrition in the Americas, 2008–2021

Note: Refer to the disclaimer on the copyright page for the names and boundaries used in this map.
Source: Authors' own elaboration. Visualization created in Datawrapper

The studies illustrate the diverse ways in which well-managed forest systems contribute to food security. Nunes *et al.* (2019) demonstrated that wild meat is a vital nutritional resource for Amazonian communities with limited financial means, where household incomes are often insufficient to purchase domestic meat. Box 18 presents an example from Mexico, where forest ecosystems are used widely for cattle. Forest foods can also serve as alternative income *sources:* as reported by Andrieu, Blundo-Canto and Cruz-Garcia (2019) in the Ucayali region of Peru, families rely on forest ecosystem services for direct access to food and also to generate incomes for purchasing other food items. Given natural fluctuations inherent in traditional food systems, the

diversity of foods in forests also helps guarantee the system's resilience. In their study of seasonal changes in the Amazon, Tregidgo *et al.* (2020) found that fish catch rates declined by 73 percent during the flood season, significantly compromising food supply. In such situations, other forest foods, particularly wild meat, become a crucial safety net for communities, ensuring food stability in periods of scarcity.

Box 18
Forest ecosystems: a solid base for beef production in Mexico

Through their role in beef production, forest ecosystems are a crucial but often overlooked foundation of food security and nutrition in Mexico. Forest lands provide essential forage for breeding cattle that supply calves to the national meat system, supporting both domestic beef availability and rural livelihoods. Of Mexico's 109 million ha used for livestock, most are forest ecosystems (scrublands and dry forests) in which cattle feed on native grasses and tree leaves and fruits. Grazing on these forest lands produces an estimated 7.9 million calves annually, contributing significantly to the national beef supply and generating economic value equivalent to 60 percent of the cattle-breeding subsector's gross domestic product.

This forest–livestock linkage underpins protein availability and income for food systems, particularly in extensive production regions. However, the same system threatens its own food base, with livestock expansion accounting for nearly three-quarters (73.3 percent) of the country's deforestation; moreover, overgrazing degrades millions of hectares of forest forage.

Strategies for strengthening food security and nutrition include the regulation of grazing on forest lands, promoting silvopastoral restoration, designing compensation mechanisms in which large meat producers contribute to sustaining the calf supply, investing in payments for ecosystem services and productive restoration for forage, and promoting deforestation-free meat supply chains.

Sources: Mexican Meat Council (COMECARNE). 2024. Compendio Estadístico 2024 [Statistical Compendium 2024]. In: Consejo Mexicano de la Carne. https://comecarne.org/compendio-estadistico-2024; Ministry of Agriculture and Rural Development (SADER). 2025. Panorama Agroalimentario 2025 [Agrifood Panorama 2025]. In: *Dirección General del Servicio de Información Agroalimentaria y Pesquera*. https://nube.agricultura.gob.mx/panorama_dgsiap; National Forestry Commission (CONAFOR). 2020. *Inventario Nacional Forestal y de Suelos 2015–2020* [National Forest and Soil Inventory 2015–2020]. In: Gobierno de México. https://snmf.cnf.gob.mx/principaleindicadoresforestalesciclo-2015-2020; Ministry of Environment and Natural Resources (SEMARNAT). 2018. Coeficientes de agostadero por tipo de vegetación 2018 [Range coefficients by vegetation type 2018]. In: *SEMARNAT*. https://apps1.semarnat.gob.mx:8443/dgeia/compendio_2018/dgeiawf.semarnat.gob.mx_8080/ibi_apps/WFServletbe33.html; National Institute of Statistics and Geography (INEGI). 2026. Banco de Información Económica [Economic Information Bank]. In: *INEGI*. https://www.inegi.org.mx/app/indicadores/?tm=3

Wild meat. Wild meat from forests serves as a crucial source of protein and micronutrients, such as iron and zinc, in the Americas (Roche *et al.*, 2008). In Latin America and the Caribbean, wild-meat consumption is deeply embedded in food systems, supporting food security, cultural practices and rural economies. Campesino hunters – small-scale rural farmers who rely on hunting for subsistence and trade – harvest a wide range of species, with 799 species documented in 17 countries (Petriello and Stronza, 2020). The most consumed species are rodents and ungulates, particularly collared peccary (*Dicotyles tajacu*), lowland paca (*Cuniculus paca*), nine-banded armadillo (*Dasypus novemcinctus*) and white-lipped peccary (*Tayassu pecari*). Rural and Indigenous communities in the Amazon consume an estimated 1.2 million tonnes of wild meat annually (Nasi, Taber and Van Vliet,

2011).

The urban wild meat trade also plays a significant role, often operating in informal or illegal markets. In central Amazonia, 10 691 tonnes of wild meat are consumed annually in 62 urban centres, generating USD 35.1 million in revenue (El Bizri *et al.*, 2020). Immigrants from rural areas initially retain higher consumption rates of wild meat, although their intake decreases over time, signalling a transition from wild to domesticated meats (Chaves *et al.*, 2024). Vulnerable species such as manatees (*Trichechus inunguis*), tortoises (*Chelonoidis* spp.) and river turtles (*Podocnemis* spp.) are more frequently consumed by wealthier households; poorer households tend to rely on wild meat as a safety net during food insecurity (Chaves, Carignano Torres and Parry, 2023).

Wild-meat consumption has nutritional implications, particularly in remote communities where alternative protein sources are scarce. In rural Amazonian households, wild meat is vital for reducing child stunting and iron deficiency – vulnerable children who consume wild meat have higher haemoglobin levels than they otherwise would (Carignano Torres *et al.*, 2022).

Wild meat is a significant food source in Canada and the United States. Although hunting in these countries is often framed as a recreational activity, many hunters prioritize wild-meat acquisition over sport, with more than 25 percent of Canadian hunters and 52 percent of big-game hunters in the United States state of Oregon hunting primarily for food (Shrestha and Burns, 2012; Conference Board of Canada, 2019). For many rural and Indigenous communities, hunting is essential for protein, cultural identity and economic resilience, particularly in remote areas such as northern Canada and Alaska, where store-bought meat is expensive.

An estimated 1.3 million hunters in Canada and 16.2 million hunters in the United States contribute to wild meat harvests (Conference Board of Canada, 2019; United States Fish & Wildlife Service, 2023). The Wild Harvest Initiative estimated that, between 2014 and 2019, Canadian hunters harvested an annual average of 4 million animals, producing 23 000 tonnes of wild meat – equivalent to 138 million meals per year (Conservation Visions, 2019). The United States has significantly larger wild-meat harvests, with 61 million animals hunted annually, yielding 241 000 tonnes of wild meat – enough for 1.42 billion meals per year (Conservation Visions, 2019). Although big game such as white-tailed deer (*Odocoileus virginianus*) provides the most biomass, ducks and pigeons are the most frequently harvested animals, with the annual take at more than 11 million and 15 million animals, respectively. Recent estimates indicate that 9.9 million animals are harvested annually in forested landscapes in the United States, producing 68 000 tonnes of wild meat – equivalent to 437 million servings (Chamberlain *et al.*, 2025).

The sustainability of wild-meat use in the Americas varies according to ecological, socioeconomic and climatic factors. Overexploitation risks are considered low in Canada and the United States due to strict hunting regulations through permits, quotas, season limits and monitoring programmes. The North American model of wildlife conservation involving regulated hunting and habitat management has historically ensured that species such as elk, mule deer, wild turkeys and pronghorn antelope have recovered from past declines (Mahoney and Jackson, 2013).

In Latin America and the Caribbean, large-scale studies have shown that hunting and habitat loss

have resulted in local extinctions of up to 70 percent of mammal species in heavily disturbed areas (Bogoni, Ferraz and Peres, 2022). In sustainable-use protected areas in the Brazilian Amazon, studies using camera traps have shown that hunting affects wildlife populations within a 5 km radius of human settlements, diminishing the overall abundance of hunted species by (on average) 32 percent (Sampaio *et al.*, 2023). Studies on community-based wildlife management suggest, however, that subsistence hunting can remain sustainable when properly regulated because source–sink dynamics allow some terrestrial species to persist under moderate hunting pressure in remote areas with low population density. A study in two large Amazonian extractive reserves found that hunted composition and catch-per-unit-effort for all target species was constant over five consecutive years (De Paula *et al.*, 2022). In the Tamshiyacu-Tahuayo Regional Community Reserve in the Peruvian Amazon, the wildlife management plan was effective in maintaining or increasing populations of highly hunted species: reductions in the harvest rates of vulnerable species such as tapir (*Tapirus terrestris*) and primates kept catch-per-unit-effort and densities for most targeted species constant or increasing (Bodmer *et al.*, 2023). Species such as collared peccary (*Dicotyles tajacu*) and white-lipped peccary (*Tayassu pecari*) were hunted at less than 15 percent of their production capacity (Mahabale *et al.*, 2025). Thus, hunting can be sustainable given effective local governance, particularly in forests with minimal human disturbance.

In the Amazon, hunting in flooded forests and aquatic ecosystems presents greater sustainability challenges due to seasonal congregations of species, which make them more vulnerable to overharvesting (Antunes *et al.*, 2016). Historical data indicate that, although terrestrial species showed greater resilience to the pelt trade in the twentieth century, aquatic and semiaquatic species such as manatees (*Trichechus inunguis*), caimans and giant otters (*Pteronura brasiliensis*) suffered severe population declines due to the higher accessibility of rivers and congregations of such species in dry periods (Antunes *et al.*, 2016). Recent studies confirm this pattern. In Loreto, Peru, hunting in whitewater forests (*várzeas*) is less sustainable due to annual flooding, which reduces populations of deer, peccaries and large rodents (Bodmer *et al.*, 2023). In the Amazon River floodplain, fish yields are tied to forest cover, a strong argument for protecting floodplain forests to maintain the food, income and livelihood security provided by large river–floodplain fisheries (Castello *et al.*, 2018).

Climate change is reshaping wildlife distribution and posing another challenge to hunting sustainability. Extreme flood and drought frequency in the Western Amazon has risen sharply in the last two decades, leading to habitat loss and shifts in species abundance (Bodmer *et al.*, 2018). Populations of terrestrial species decreased by more than 95 percent between 2009 and 2015, affected especially by consecutive years of extreme floods (Bodmer *et al.*, 2018). The numbers of white-lipped peccary, collared peccary, red brocket deer (*Mazama americana*), black agouti (*Dasyprocta fuliginosa*), paca (*Cuniculus paca*), giant anteaters (*Myrmecophaga trydactila*) and nine-banded armadillo (*Dasypus novemcinctus*) declined dramatically: in 2009, overall density was 5.18 individuals per km^2; in 2015, no terrestrial mammals were sighted on transects or in camera-trap surveys (Bodmer *et al.*, 2018). These ecological changes have direct consequences for the sustainability of forest foods as fishing becomes a priority in local communities and hunting

pressure potentially shifts to arboreal species such as birds and primates. Such findings highlight the need for adaptive wildlife management strategies that account for shifting population dynamics, particularly in ecosystems that are more vulnerable to the effects of climate change.

Wild vegetables and mushrooms. Scientific studies of wild edible vegetables in the Americas have documented numerous species traditionally consumed for their nutritional and medicinal benefits. In the Zongolica region of Mexico, Indigenous communities consume 15 species of quelites (wild leafy greens), primarily during the rainy season, drawing on traditional knowledge; this makes a substantial contribution to food security (Díaz-José *et al.*, 2019). In the Gran Chaco region, spanning Argentina, Paraguay and the Plurinational State of Bolivia, Scarpa (2009) identified 179 species of native wild edible plants, 17 of which were harvested by Indigenous groups for their edible leaves, with some species cultivated despite their wild origins.

In Brazil, research has documented approximately 133 wild edible mushroom species (Carvalho *et al.*, 2024). Although urban populations primarily consume non-native cultivated species, such as *Agaricus bisporus*, *Lentinula edodes* and *Pleurotus ostreatus*, Indigenous communities maintain mycophilic traditions and a broader diversity of mushroom consumption. For example, the Yanomami people in the Amazon rainforest, on the border with Venezuela, integrate mushrooms of *Lentinus bertieri*, *Pleurotu djamor, P. neostrigosus*, *P. strigellus* and *P. velutinus* into their diets (Sanuma *et al.*, 2016). Historical ethnomycological studies document the consumption of *Fistulina* spp. by the Tucano Indigenous group in Brazil and Colombia and *Polyporus sapurema*, known as "Indian bread", among various Indigenous groups (Goés-Neto and Bandeira, 2001).

Wild fruit. Wild fruits are crucial for maintaining food security among many forest-dwelling populations, providing both macronutrients and essential micronutrients. A prime example is the buriti (*Mauritia flexuosa*), also known as Mauritian palm, which contains high levels of beta-carotene, a precursor to vitamin A that is essential for vision and immune function (Roche *et al.*, 2008).

Other palm species, such as peach palm (*Bactris gasipaes*) and forest açaí (*Euterpe precatoria*), are also important sources of fruit that provide dietary fats and fat-soluble vitamins. Such fruits are particularly important in floodplain areas because they provide a stable nutrient supply during flooded seasons, when other food sources may be scarce (Tregidgo *et al.*, 2020). Other highly valued wild fruits include açaí (*Euterpe oleracea*), camu-camu (*Myrciaria dubia*), bacaba (*Oenocarpus bacaba*), and cupuaçu (*Theobroma grandiflorum*), known for their antioxidant content, vitamin C and fibre. Açaí has transitioned from a subsistence food to a global commodity.

A nationwide study in Brazil found that wild foods such as Mauritian palm, pequi (*Caryocar* spp.) and tucumã (*Astrocaryum aculeatum*) are consumed even by urban residents, demonstrating the interconnectedness of food systems and the broad contribution of wild fruits to nutritional security (Gomes *et al.*, 2023).

In Canada, the commercial wild blueberry harvest has surpassed cultivated blueberry production for the past few years, beginning in 2021 (Agriculture and Agri-Food Canada, 2023). The gathering of wild berries is an essential cultural practice among many Indigenous and rural communities in Canada and the United States, often occurring within informal economies and therefore difficult

to quantify.

Wild roots and tubers. Wild roots and tubers are fundamental to food security for forest-dwelling communities in the Americas by serving as reliable sources of carbohydrates and energy (Campbell *et al.*, 2021). In Latin America and the Caribbean, commonly consumed species include cassava/manioc (*Manihot esculenta*), yam (*Dioscorea* spp.) and taro/dasheen (*Colocasia esculenta*). Some of these species may be harvested in the wild, but others are cultivated, a distinction that is blurred because both wild and domesticated plants contribute to overall consumption in the region. Certain native tubers, such as maca (*Lepidium peruvianum*), are particularly rich in micronutrients such as iron and vitamin A (Roche *et al.*, 2008). White tubers and roots, primarily manioc, form a dietary cornerstone in Amazonian communities (Tregidgo *et al.*, 2023), with *farinha* (manioc flour) accounting for 26 percent of total food mass consumed and serving as the primary source of dietary energy (48 percent) and carbohydrates (80 percent). Other tubers, such as purple and white yams, contribute to dietary diversity in the Amazon. Seasonal variations shape consumption patterns, particularly between *várzea* (floodplain) and *terra firme* (upland) communities. *Farinha* consumption declines in *várzea* areas during high-water seasons due to flooded croplands but is maintained or even increased in *terra firme* communities. Beyond sustenance, the harvesting and preparation of wild tubers draw on intricate traditional knowledge systems passed down through centuries (Campbell *et al.*, 2021). This is exemplified in the complex processing of cassava – a potentially toxic root that can be transformed into multiple food products using traditional methods. The transmission of this cultural knowledge ensures the effective use of forest resources while preserving Indigenous heritage.

Fish and other aquatic animals. Aquatic resources are fundamental to food security for forest-dwelling communities across the Americas. This is particularly the case in the Amazon (Sirén and Machoa, 2008) (Box 19), where fish account for 44 percent of total consumed food mass and serve as the predominant source of protein (78 percent) and fat (66 percent) while contributing significantly to dietary energy (31 percent) (Tregidgo *et al.*, 2023). Commonly consumed species include *Prochilodus* spp. (*bocachico*), which is particularly prevalent in Colombia and other Amazonian countries, *Pseudoplatystoma fasciatum* (*surubi*) and *Colossoma* spp. (*cachama*). Beyond their macronutrient contributions, aquatic foods provide essential micronutrients such as calcium, phosphorus and omega-3 fatty acids, which are vital for overall health. Different fish species offer different nutrient profiles, with some providing higher levels of zinc and iron and others more omega-3 fatty acids (Heilpern *et al.*, 2021). The estimated annual fish catch in the Amazon Basin is 422 000–473 000 tonnes in live weight, with a significant proportion of this unrecorded due to informal fishing (Sirén and Valbo-Jørgensen, 2022). Consumption varies greatly, in the range of 7–550 g per person per day, depending on the ecosystem and human impacts in the area (e.g. the presence of hydroelectric dams) (Begossi *et al.*, 2019).

In North America, freshwater ecosystems are tied closely to forests, with forest management practices influencing water flows, riparian habitats and aquatic biodiversity through activities such as dam construction, timber extraction and lakeside development (Giacomazzo *et al.*, 2020). There are about 3 million and 39.9 million non-commercial anglers in Canada and the United

States, respectively (Conference Board of Canada, 2019; United States Fish and Wildlife Service, 2023). In the United States, Lynch *et al.* (2024) estimated the nationwide freshwater fish harvest at 90 000 tonnes annually, providing 0.71 kg of consumable wild fish per fisher. Recent declines in fish biodiversity and availability in North America (Jelks *et al*., 2008; Brain and Prosser, 2022) may have important implications for food security and dietary quality among Indigenous and other resource-dependent communities, where fish remain an important source of traditional foods and key nutrients (Brockington *et al*., 2023).

Other foods. Forest-dependent communities in the Americas derive substantial nutritional benefits from other, often-overlooked forest foods, particularly insects and nuts (Box 20). Insects are a significant source of protein and essential fats. The *suri* (beetle larvae) in Peru exemplifies the nutritional contributions of insects to traditional diets, offering a sustainable alternative to conventional protein sources through seasonal harvesting practices (Roche *et al.*, 2008). The Amazonian (or Brazil) nut (*Bertholletia excelsa*) is a nutrient-dense food source, providing essential micronutrients and fatty acids – most notably selenium, a mineral commonly deficient in conventional diets. Beyond its nutritional value, the sustainable harvest of Amazonian nuts creates vital economic opportunities for forest communities, establishing a crucial link between biodiversity conservation and local livelihood sustainability (Nunes *et al.*, 2019).

Forests in the Americas are substantial sources of food biodiversity, with a wide assortment of edible wild animals, plants, fish, nuts and insects used by local communities. They have considerable potential to further enhance food security and nutritional diversity throughout the region.

Other contributions of forest foods

Recreation, spirituality and culture. In Latin America and the Caribbean, hunting for sport is a complex interaction between cultural traditions and wildlife management strategies. It often overlaps with subsistence practices that are deeply embedded in rural traditions. Despite increasing urbanization, many urban dwellers retain strong ties to rural areas, sustaining hunting as a cultural practice (El Bizri *et al.*, 2015). In Brazil, sport hunting has been de facto prohibited since 1967 but persists illegally, particularly targeting large mammals and birds. An analysis of social media data between 2018 and 2020 documented more than 2 000 posts depicting the hunting of 4 658 animals from 157 species across all Brazilian biomes that were consumed after the hunts (El Bizri *et al.*, 2024). Some countries – such as Guyana, Suriname, Trinidad and Tobago, and Uruguay – have regulated sport-hunting frameworks with defined hunting seasons, quotas and permissible species, including game birds and large rodents such as agoutis and pacas. Wildlife management units in Mexico integrate sport hunting into conservation and rural development strategies with the aim of achieving economic benefits, reducing poaching, and promoting sustainable wildlife use. Nevertheless, challenges persist, such as regulatory enforcement gaps and introductions of invasive species (Weber, García-Marmolejo and Reyna-Hurtado, 2006).

In Canada and the United States, sport hunting serves as both a recreational activity and a wildlife management tool. The United States enforces strict federal and state regulations, with mechanisms like the Pittman-Robertson Act funding conservation efforts through taxes on hunting equipment (Heffelfinger, Geist and Wishart, 2013). Deer hunting, for example, helps mitigate overpopulation and thereby reduce ecological imbalances and agricultural damage (Mahoney and Jackson, 2013). Canada has a similar approach, with provincial regulations managing species such as moose and deer, especially in areas with declining natural predators. In Alaska and the northern territories of Canada, Indigenous communities blend traditional hunting practices with sport hunting, reflecting a holistic conservation approach (Arnett and Southwick, 2015). Beyond its ecological role, sport hunting contributes significantly to the economy, generating billions annually through licences, tourism and equipment sales. In 2022, hunting-related expenditures in the United States reached USD 45.2 billion, supporting conservation programmes and rural economies (United States Fish & Wildlife Service, 2023).

Forests have long been associated with physical and spiritual healing, particularly through the use of entheogens – substances that induce altered states of consciousness – often used in religious and shamanic contexts (Lévi-Strauss, 1993). A striking example is the long-standing use of psilocybe mushrooms, also known in some Western cultures as "magic mushrooms" and, among Indigenous cultures such as the Aztecs and Mazatecs, as *teonanacatl* (Estrada, 1989). Mushrooms can grow in diverse environments, but forests provide ideal conditions due to their consistent humidity, shade and abundant organic matter, which support the decomposition processes crucial for nutrient cycling and forest health (Garibay-Orijel *et al.*, 2009). The ecological adaptation of psilocybe mushrooms to forest ecosystems has facilitated their enduring use in traditional spiritual and medicinal practices. For centuries, they have been integral to religious and shamanic ceremonies,

Box 19

Fishing giants among the trees: the role of the giant arapaima as a food and income source in Amazonia

Amazon's flooded forests, covering 3–4 percent of the biome, are highly productive environments that provide essential feeding and breeding grounds for fish species that are central to local diets.[i] Among these, the giant arapaima (*Arapaima gigas*), the world's largest scaled freshwater fish, plays a crucial nutritional, economic and cultural role in the Amazon. Growing up to 3 m in length and weighing over 200 kg, it has long been a key resource for food security and income generation for Indigenous and riverine communities.[ii] Its high-protein, boneless meat (19.25–21.81 g protein per 100 g meat) is widely consumed, with traditional salting and drying methods ensuring its preservation in remote areas without refrigeration.[iii]

Overfishing in the twentieth century led to drastic declines in giant arapaima populations, with some regions experiencing local extinctions. By the 1980s, commercial exploitation had wiped out the species in many areas, prompting fishing bans in some countries, although illegal harvesting continued.[iv]

Community-based management initiatives were introduced that integrated traditional ecological knowledge with scientific conservation strategies and enabled local fishers to participate actively in resource protection. These efforts have led to remarkable population recoveries, with numbers increasing thirty-fold in the Juruá River Basin after one decade. Protected lakes – where fishing is restricted to replenish arapaima populations during the flooded season – have been found to contain, on average, 304.8 giant arapaima per lake, compared with 9.2 in open-access, unprotected lakes.[v]

These community-based management approaches have generated significant economic benefits, with Amazonian villages earning an average annual revenue of USD 10 601 and individual households making USD 1 046.6 per year from sustainable giant arapaima sales.[v] In addition, sustainable fisheries contribute to gender equity, with 77 percent of women in co-managed areas earning income from fisheries, compared with just 8 percent in non-managed areas.[vi]

A key factor in the success of arapaima conservation has been local ecological knowledge, particularly among traditional fishers, who have developed effective fish-counting techniques over generations that are the basis of management effectiveness. The case of the giant arapaima illustrates how the sustainable management of key species can serve as a focal point for community-driven conservation, balancing biodiversity protection with nutritional and economic benefits.

Sources: [i] Saint-Paul, U., Zuanon, J., Correa, M.A.V., García, M., Fabré, N.N., Berger, U. & Junk, W.J. 2000. Fish communities in central Amazonian white- and blackwater floodplains. *Environmental Biology of Fishes*, 57(3): 235–250. https://doi.org/10.1023/A:1007699130333; [ii] Campos-Silva, J.V. & Peres, C.A. 2016. Community-based management induces rapid recovery of a high-value tropical freshwater fishery. *Scientific Reports*, 6(1): 34745. https://doi.org/10.1038/srep34745; [iii] Pino-Hernández, E., De Carvalho Júnior, R.N., Barata Alves, R.C., Peixoto Joele, M.R.S., Da Silva E Silva, N., Costa Da Silva, E.V. & Henriques Lourenço, L.D.F. 2020. Evaluation of muscle cuts of pirarucu (*Arapaima gigas*) and sous vide product characterization and quality parameters. *International Journal of Gastronomy and Food Science*, 20: 100200. https://doi.org/10.1016/j.ijgfs.2020.100200; [iv] Farias, I.P., Hrbek, T., Brinkmann, H., Sampaio, I. & Meyer, A. 2003. Characterization and isolation of DNA microsatellite primers for *Arapaima gigas*, an economically important but severely over-exploited fish species of the Amazon basin. *Molecular Ecology Notes*, 3(1): 128–130. https://doi.org/10.1046/j.1471-8286.2003.00375.x; [v] Campos-Silva, J.V. & Peres, C.A. 2016. Community-based management induces rapid recovery of a high-value tropical freshwater fishery. *Scientific Reports*, 6(1): 34745. https://doi.org/10.1038/srep34745; [vi] Freitas, C.T., Espírito-Santo, H.M.V., Campos-Silva, J.V., Peres, C.A. & Lopes, P.F.M. 2020. Resource co-management as a step towards gender equity in fisheries. *Ecological Economics*, 176: 106709. https://doi.org/10.1016/j.ecolecon.2020.106709

Box 20
Tree legumes: nutritional powerhouses from climate-resilient dry forests in the Americas

Dry tropical forests in the Americas, including the semi-arid Caatinga in Brazil, are facing escalating threats from climate change. In these vulnerable ecosystems, tree legumes (*Fabaceae*), also known as pulses, are crucial resources for food and nutrition. The seeds and pods of tree legumes are exceptionally rich in protein.[i] Moreover, the inherent resilience of tree legumes in arid and semi-arid conditions makes them indispensable for nutritional security, especially in drought-prone regions.

Tree legumes are nutritional powerhouses, owing primarily to the protein concentrated in their seeds. In an assessment of 14 wild legume species in the Caatinga, seed crude protein ranged from about 11 percent to 50 percent on a dry-weight basis;[i] because the seeds carry little water (about 7–16 percent moisture), this corresponds to approximately 20–45 percent protein on a fresh-weight basis for most species. These levels are higher than the protein found in commonly eaten leafy greens (about 1–4 percent of fresh weight, e.g. lettuce 1.4 percent, spinach 2.9 percent, kale 4.0 percent) and in tubers and roots (about 1–2 percent, e.g. cassava 1.4 percent, sweet potato 1.6 percent, potato 2.2 percent), all expressed on the same fresh-weight basis (USDA, 2019).[ii] This protein is crucial for combating malnutrition, particularly in vulnerable communities in dry forest regions. In the Caatinga, for example, rural communities consume at least 19 native species of legumes. One of these, *Dioclea grandiflora* (*mucunã*), contains about 30.9 g of protein per 100 g in its seeds, thus supplying 62 percent of the recommended daily intake of protein; *Libidia ferrea* (*jucá*) seeds contain an impressive 42.7 g of protein per 100 g, which is nearly 85 percent of the recommended daily intake.[iii] *Hymenaea courbaril* (*jatobá*) seeds contribute 431 kcal per 100 g, which is 22 percent of the daily caloric need, making it a valuable food source in energy-deficient diets.[i] Ethnobotanical studies indicate that these species are consumed in various forms, including as fresh fruit and in seed-based flours and porridge-like preparations.[iv]

Tree legumes are adapted to water stress and high temperatures and are thus resilient to drought. They improve soil fertility through nitrogen fixation, which also supports food security and nutrition.[v] They are rich in bioactive compounds, which enhances their health benefits.[vi] Like many other legumes, however, they contain antinutritional factors such as tannins, phytic acid and lectins that can limit nutrient bioavailability.[vii] Effective processing methods are essential to mitigate these factors and ensure safe consumption. Commonly used preparation techniques include soaking, cooking and fermentation.

Sources: [i] Carvalho, A.F.U., Farias, D.F., Da Rocha-Bezerra, L.C.B., De Sousa, N.M., Cavalheiro, M.G., Fernandes, G.S., Brasil, I.C.F. *et al*. 2011. Preliminary assessment of the nutritional composition of underexploited wild legumes from semi-arid Caatinga and moist forest environments of northeastern Brazil. *Journal of Food Composition and Analysis*, 24(4–5): 487–493. https://doi.org/10.1016/j.jfca.2011.01.013; [ii] US Department of Agriculture, Agricultural Research Service. 2019. *FoodData Central*. https://fdc.nal.usda.gov/; [iii] Jacob, M.C.M., Araújo De Medeiros, M.F. & Albuquerque, U.P. 2020. Biodiverse food plants in the semiarid region of Brazil have unknown potential: a systematic review. *PLoS ONE*, 15(5): e0230936. https://doi.org/10.1371/journal.pone.0230936; [iv] Cruz, M.P., Medeiros, P.M., Sarmiento-Combariza, I., Peroni, N. & Albuquerque, U.P. 2014. "I eat the manofê so it is not forgotten": local perceptions and consumption of native wild edible plants from seasonal dry forests in Brazil. *Journal of Ethnobiology and Ethnomedicine*, 10(1): 45. https://doi.org/10.1186/1746-4269-10-45; Do Nascimento, V.T., Vasconcelos, M.A.D.S., Maciel, M.I.S. & Albuquerque, U.P. 2012. Famine foods of Brazil's seasonal dry forests: ethnobotanical and nutritional aspects. *Economic Botany*, 66(1): 22–34. https://doi.org/10.1007/s12231-012-9187-2; Nunes, A.V., Peres, C.A., Constantino, P. de A.L., Santos, B.A. & Fischer, E. 2019. Irreplaceable socioeconomic value of wild meat extraction to local food security in rural Amazonia. *Biological Conservation*, 236: 171–179. https://doi.org/10.1016/j.biocon.2019.05.010; [v] Dubeux Junior, J.C.B., Muir, J.P., Apolinário, V.X.D.O., Nair, P.K.R., Lira, M.D.A. & Sollenberger, L.E. 2017. Tree legumes: an underexploited resource in warm-climate silvopastures. *Revista Brasileira de Zootecnia*, 46(8): 689–703. https://doi.org/10.1590/s1806-92902017000800010; [vi] Jacob, M.C.M., Da Silva-Maia, J.K., Albuquerque, U.P. & Pereira, F.D.O. 2022. Culture matters: a systematic review of antioxidant potential of tree legumes in the semiarid region of Brazil and local processing techniques as a driver of bioaccessibility. *PLoS ONE*, 17(3): e0264950. https://doi.org/10.1371/journal.pone.0264950; [vii] Salim, R., Nehvi, I.B., Mir, R.A., Tyagi, A., Ali, S. & Bhat, O.M. 2023. A review on anti-nutritional factors: unraveling the natural gateways to human health. *Frontiers in Nutrition*, 10: 1215873. https://doi.org/10.3389/fnut.2023.1215873

where their psychoactive properties are believed to bring participants closer to the divine (Schultes, Hofmann and Rätsch, 2001).

The psychoactive compound psilocybin mimics serotonin in the brain, binding to specific receptors and inducing profound experiences that influence mental health, spirituality and self-reflection (Nichols, 2016). Some scholars propose that the use of psilocybe mushrooms may have influenced early human consciousness by enhancing cognitive processes and self-awareness, potentially contributing to human evolution (Arce and Winkelman, 2021). Modern research highlights the therapeutic potential of psilocybin in treating mental health conditions such as depression and anxiety, offering transformative experiences that promote emotional healing (Winkelman and Sessa, eds., 2019). Thus, psilocybe mushrooms exemplify how forest-sourced foods can profoundly affect human health, spirituality and cognition, demonstrating their multifaceted significance across generations and cultures.

Forest foods play a significant role in strengthening identity and belonging in human communities (Box 21). Food is deeply intertwined with culture, and the gathering, preparation and consumption of forest foods serve as expressions of cultural heritage and continuity (Jacob, 2021). For Indigenous and rural communities, forest foods are not just sources of sustenance but also symbols of tradition, representing ancestral knowledge passed down the generations. This connection fosters a sense of community and reinforces cultural identity. A vivid example is the Yanomami people of the Amazon rainforest, whose deep connection to forest-sourced mushrooms extends beyond nutrition to cultural significance (Sanuma *et al.*, 2016). In 2016, the Yanomami launched a bilingual recipe book in their language and Portuguese that showcased their rich culinary traditions (Sanuma *et al.*, 2016). The book describes culturally significant mushroom preparation methods, often involving collective participation that strengthens social ties. Mushroom harvesting and preparation are deeply connected to the Yanomami people's ecological knowledge, reinforcing their bond with the land and passing down traditions through collective food practices.

Hunting culture promotes a "self-sufficient lifestyle", with some hunters distributing excess meat within their communities, which serves to reinforce social networks and food-sharing traditions (Conservation Visions, 2019). This is especially the case in the United States, where it is illegal to sell hunted meat. Thus, hunters often share their game meat with others in their communities or via programmes that provide food for the poor and elderly.

Box 21
How forest foods can foster sustainable development: the Brazilian school feeding programme

The Brazilian School Feeding Programme (Programa Nacional de Alimentação Escolar) exemplifies how forest foods can enhance school nutrition, support local economies and promote sustainable practices.[i] Indigenous Peoples and local communities have historically faced significant barriers to selling their products to the programme.[ii] As a result, schools in remote areas often rely on processed foods, even when local communities have the capacity to supply fresh, nutritious alternatives. Bureaucratic challenges such as formal registration requirements, legal contracts and compliance with health and safety standards are difficult for small-scale Indigenous and traditional farmers to meet. Many of these producers have also been excluded from CadÚnico, the country's social registry for public services, and lack access to information on procurement opportunities.

The Catrapoa initiative, coordinated by the Federal Prosecutor's Office, was launched in the state of Amazonas to better enable the use of local foods in the programme.[iii] The initiative simplified the procurement process and reduced bureaucratic hurdles to enable traditional and Indigenous communities to sell forest-sourced foods directly to schools. This has enabled schools to incorporate a wider variety of fresh, locally sourced foods into their meals, such as açaí, Brazil nuts, manioc and a variety of fish. The initiative improved the nutritional quality of school meals and promoted cultural integration by providing children with foods aligned with their local traditions.

Building on the success of Catrapoa in Amazonas, the Catrapovos Brasil initiative was launched to expand the model nationwide.[iv] The goal is to scale up access to nutritious, culturally relevant forest foods in schools across Brazil by enabling Indigenous and traditional communities to participate fully in public procurement. The initiative amplifies the impact of Catrapoa, aiming to provide children across Brazil with nutritious food that is integrated into their cultural heritage. It also has the potential to empower local communities by strengthening their economies and encouraging sustainable forest management, thus ensuring that the benefits of forest foods are also available to future generations.

Sources: [i] Government of Brazil. 2024. *Programa Nacional de Alimentação Escolar* [National School Feeding Programme]. https://www.gov.br/mec/pt-br/centrais-de-conteudo/publicacoes/institucionais/pnae; [ii] Tregidgo, D., Da Silva Maia, J.K., Barros Da Silva, E., Cardoso Lopes, J., Larrosa Oler, J.R., De Freitas Viana, F.M., Rigo, N. *et al*. 2023. Como inserir mais sociobiodiversidade na alimentação escolar na Amazônia brasileira? [How to include more sociobiodiversity in school meals in the Brazilian Amazon?]. *Ethnobiology and Conservation*, 12. https://doi.org/10.15451/ec2023-09-12.21-1-7; [iii] Ministério da Agricultura Pecuária e Abastecimento [Ministry of Agriculture, Livestock and Food Supply]. 2020. Alimentação escolar indígena e de comunidades tradicionais [School meals for indigenous and traditional communities]. In: *Agricultura familiar: boas práticas replicáveis de comercialização de produtos da sociobiodiversidade e agroecologia* [Family farming: replicable good practices for marketing sociobiodiversity and agroecology products]. https://www.mpf.mp.br/atuacao/ccr6/documentos-e-publicacoes/guia-alimentacao-indigena-e-comunidades-tradicionais.pdf; [iv] Ministério Público Federal. 2022. Mesa de Diálogo Permanente Catrapovos [Caprapovos Permanent Dialogue Table]. https://www.mpf.mp.br/atuacao/ccr6/catrapovos-brasil?utm_source

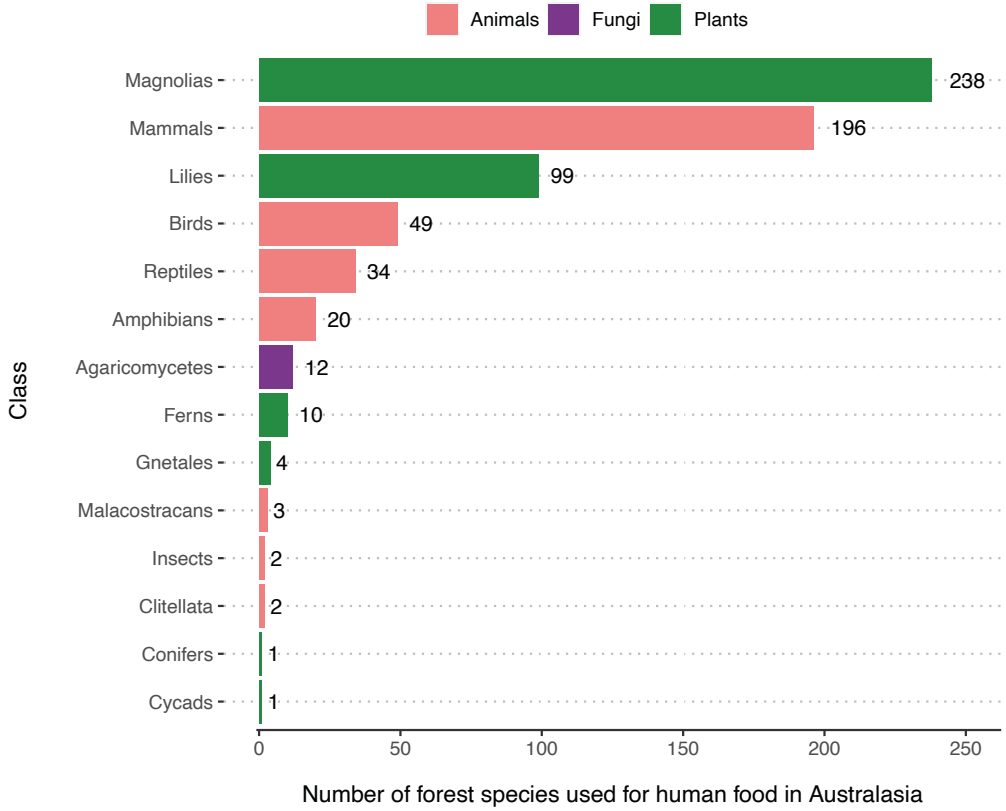
Asia

Overview

The Asia region spans the largest landmass globally, both from north to south and from east to west, making it highly diverse in ecosystems as well as cultures. It is home to more than half the world's population and has the largest number of people suffering from food insecurity (FAO, 2025g). An estimated 418 million people were severely food-insecure in Asia in 2024, an additional 682 million were moderately food-insecure (FAO *et al.*, 2025a),[14] and 323 million people were undernourished (FAO *et al.*, 2025a).

Asia spans three biogeographic realms – Indomalaya, the Palearctic and Australasia. The vast differences in ecology between these realms are accompanied by tremendous differences in income levels and cultures. According to IUCN data, 2 075 unique forest species are used for food in the Indomalayan realm; among the world's biogeographic realms, this is the greatest diversity of forest species reported to be used for human food. Indomalaya has the largest area of forests in Asia and is therefore the focus of Figure 5.

Figure 5.
Number of forest species used for human food in the Indomalayan realm, by taxonomic group, as listed on the IUCN Red List



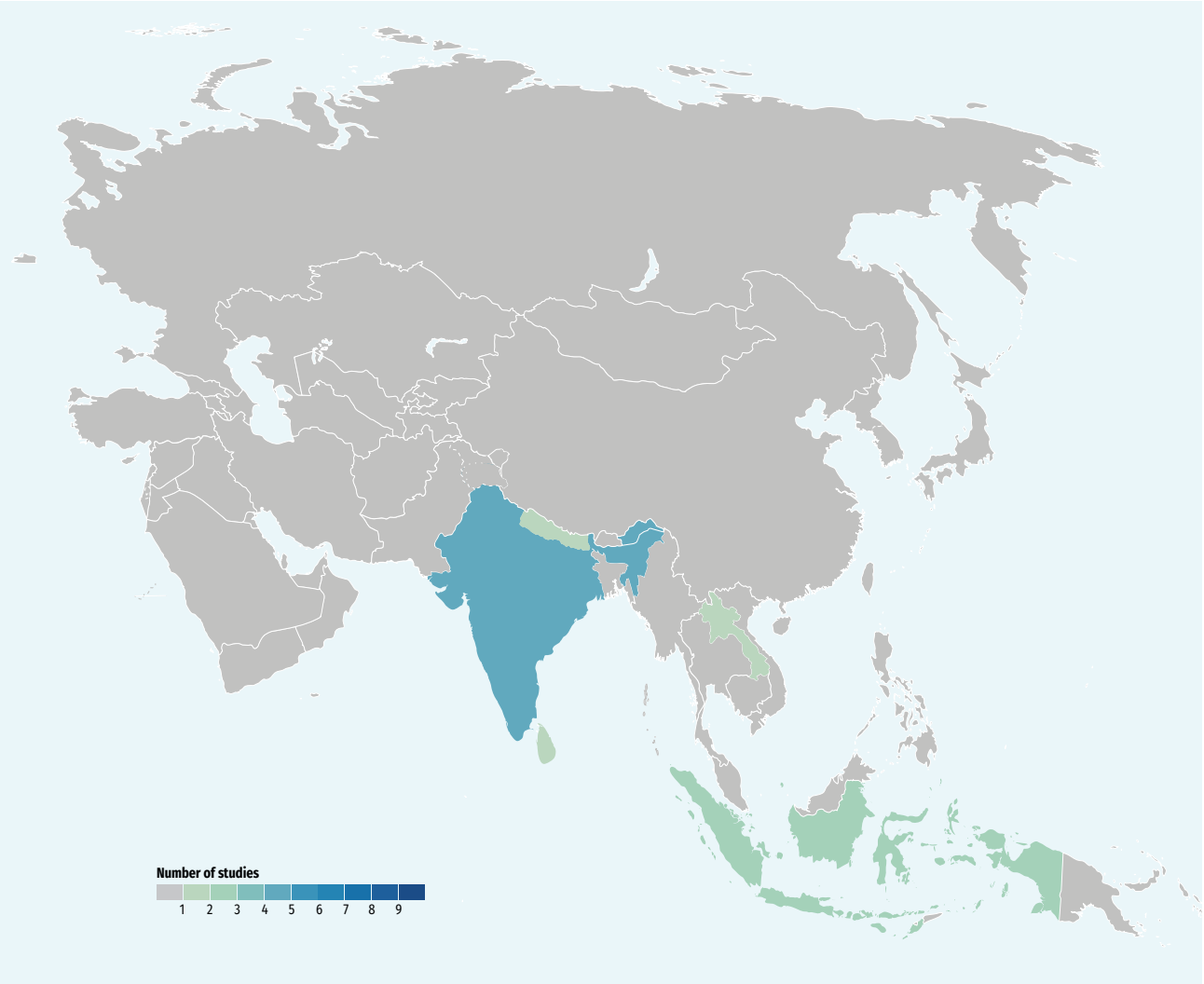
Note: This figure does not include species that have not been assessed on the IUCN Red List and is therefore likely to vastly underestimate the number of forest species used for human food for some taxonomic groups.
Source: IUCN. 2024. *The IUCN Red List of Threatened Species*. Version 2024-1. https://www.iucnredlist.org.

[14] The FAO Food Insecurity Experience Scale (https://www.fao.org/in-action/voices-of-the-hungry) measures the severity of food insecurity, on a scale from mild to severe. People with mild food insecurity might worry about their ability to obtain food. Moderate food insecurity encompasses such actions as compromising the quality and variety of food and reducing food quantities or skipping meals. People experiencing severe food insecurity have typically run out of food or gone without eating for a day or more.

Contribution of forest foods to food security and nutrition

Although more people in Asia experience food insecurity than in any other region (FAO *et al.*, 2025a), and more wild forest species are used for food (based on IUCN data), fewer published studies were found for this report that examine links between forest foods and FSN indicators than in Africa and the Americas. This may be because the literature search was conducted only in English. Nine studies in Asia met the inclusion criteria, of which four are in India (Figure 6). Eight of the nine studies reported positive associations between forests and FSN indicators, and one showed mixed effects.

Figure 6.
Distribution of studies published between 2007 and 2024 on linkages between consumption of forest foods and indicators of food and/or nutrition security in Asia



Note: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
Source: Authors' own elaboration. Visualization created in Datawrapper

The studies reported links between a range of indicators of FSN, with some reporting on more than one link. Five focused on links between forest foods and dietary diversity, with all finding positive associations. Four examined links between forest foods and food security, with one finding negative effects and the others finding positive associations. Two of the studies linked forests to better nutritional outcomes, including a healthier body mass index and a lower probability of child stunting and wasting.

A national survey in India found that young children living in areas with higher forest cover had higher dietary diversity and lower stunting rates than children living in areas with less forest cover, controlling for other factors (Milbank, 2023). Another study in eastern India found that the consumption of wild foods (mostly from forests) was associated with higher dietary diversity scores among women, particularly during the lean season (Cheek *et al.*, 2023). A study in two villages close to Vientiane in the Lao People's Democratic Republic found that 71 percent of respondents had eaten at least one forest food in the previous week and that forest foods increased dietary diversity for about half the respondents (Jendresen and Rasmussen, 2022). A study in Indonesia found that children in Central Sulawesi Province living close to areas with more forest consumed vitamin-A-rich fruit and vegetables, including green leafy vegetables, more frequently than other children in the dataset, controlling for other factors (Ickowitz *et al.*, 2016).

A study comparing three groups of Punan Indigenous Peoples in Borneo, Indonesia, found that those who remained more remote and closer to the forest consumed more forest foods and enjoyed a more diversified diet and healthier body mass index (Dounias *et al.*, 2007).

A study in Karnataka, India, found a positive relationship between the use of forest foods and food security among the Soliga Indigenous Peoples (Balasubramanian, 2021) (Box 22); nevertheless, forest regulations that reduce forest access for tribal peoples were weakening this relationship. A study in Nepal found that forest foods had direct importance and also generated income that was then spent on food for the household (Adhikari, Ojha and Bhattarai, 2016). The same study pointed to another indirect contribution of forest foods to human diets through the provision of food for livestock. In Nepal and parts of India (Balasubramanian, 2021; Hegde and Enters, 2000; Karki *et al.*, 2018), rural households graze their cattle and smaller ruminants in forests and collect fodder to feed them. In their study of two villages in west-central Nepal, Adhikari, Ojha and Bhattarai (2016) found that the cattle and other ruminants in these villages were fed solely on these forest-based resources; given that livestock provided villages with one-third of their incomes, the forest can be said to have contributed to a substantial portion of these incomes, as well as to the dairy products they consumed directly from their cattle.

A study in West Bengal, India, by Chand and Behera (2023) found a negative relationship between forest food use and FSN indicators, with households that earned more income from forest food sales more food-insecure than other households. The authors hypothesized that households relying on the sale of collected forest food tended to have little or no agricultural land for food production. Moreover, households who lived close to the forest suffered from crop damage caused by forest animals, with about 39 percent of households in the study area experiencing some crop loss.

Box 22
Tree cover, wild foods and dietary diversity in India

Although most of the studies investigating links between forests and diets are from Africa, India – with its vast areas of forest and the world's highest number of undernourished children – is a particularly important country for such linkages.

A study by Milbank (2023) used data from the country's National Family Health Survey 2019/2020 and remote-sensing data on tree cover to explore the relationship between forest cover and nutritional outcomes for children under five. The study used several models to estimate relationships between tree cover (which is used as a proxy for forest) and nutritional outcomes for children of different ages, controlling for potential confounding variables. It found a positive association between tree cover and dietary diversity in infants and young children aged 6–23 months. The study also found that areas with higher tree-cover densities were associated with a lower likelihood of stunting and wasting in children under five. Although studies such as this cannot show the reason behind these associations, one strong possibility offered to explain the finding is that households living near forests are able to source wild foods that are often nutrient-dense and provide important dietary diversity.

Although Milbank (2023) did not examine the causal pathways between tree cover and nutritional outcomes, a second study by Cheek *et al.* (2023) used primary data to explore the association between wild foods and nutritional outcomes directly, but at a smaller scale, in two districts in West Bengal, India. The study collected monthly data from women on what foods they had eaten in the previous 24 hours and where the foods had come from. It used a statistical technique to "match" the women who had consumed wild foods (from both forests and other common lands) with women who had not but who were otherwise similar in certain characteristics. The study compared the dietary diversity of the women in June and July, a lean season, when less agricultural food was available and when wild-food collection was highest. It found that women who consumed wild foods had statistically significant more dietary diversity than those who did not consume wild foods. The consumption of wild green leafy vegetables such as *chakwar* (*Senna obtusifolia*), jute leaf (*Corchorus olitorius*) and *khokari* (*Acalypha indica*), which are high in micronutrients such as vitamin A and iron, was the main reason behind this result. Because dietary diversity is an important proxy for healthy diets, the study showed that wild foods in these areas of India enabled women to have healthier diets.

Sources: Cheek, J.Z., Lambrecht, N.J., Den Braber, B., Akanchha, N., Govindarajulu, D., Jones, A.D., Chhatre, A. & Rasmussen, L.V. 2023. Wild foods contribute to women's higher dietary diversity in India. *Nature Food*, 4(6): 476–482. https://doi.org/10.1038/s43016-023-00766-1; Milbank, C. 2023. Associating dietary quality and forest cover in India. *Forest Policy and Economics*, 156: 103055. https://doi.org/10.1016/j.forpol.2023.103055

Wild meat. Historically, rural forest communities in Asia have consumed wild meat as a key part of their diets (see Box 23 for an example from Indonesia). The importance of wild meat to FSN is often discussed in relation to rural subsistence use, but urban communities across Asia are also major consumers. This high urban demand has influenced hunting trends and contributed to declines in wild animal populations in many areas, with implications for the FSN of rural communities that rely on wild meat for subsistence.

A 2007 review of hunting studies suggested that 160 mammal species are hunted across Asia (Corlett, 2007). The number is likely to be much higher, however, with a meta-analysis of 143

hunting studies in India (Velho, Karanth and Laurance, 2012) identifying 114 hunted mammal species for India alone.

Hunting in most Asian forests is thought to have reached unsustainable levels in the last 30–40 years, driven by increased demand for wild meat in urban areas and facilitated by increased access to forests (through habitat fragmentation and improvements in transport infrastructure) and technological advances in hunting equipment (Gray *et al.*, 2018; Harrison *et al.*, 2016). As a result, most local consumption of wild meat comes from small, fast-reproducing species such as monitor lizards, rodents (e.g. bamboo rats and porcupines) and small ungulate species (e.g. muntjak, chevrotain and mouse deer) (Aiyadurai, Singh and Milner-Gulland, 2010; Coad *et al.*, 2019; Harrison *et al.*, 2016). Larger and rarer species are also targeted by commercial hunters, mainly to supply the urban and international wildlife trade (Coad *et al.*, 2019; Ingram *et al.*, 2021). Given their fecundity and wide distribution, wild pigs are now generally the predominant form of large-bodied mammal hunted for personal consumption in Asian forests (Aiyadurai, Singh and Milner-Gulland, 2010; Harrison *et al.*, 2016; Milner-Gulland and Clayton, 2002).

Recent surveys in Asia suggest that the number of people consuming wild meat over the course of a year is still high in some countries. For example, household surveys conducted in rural areas of Cambodia's Eastern Plains (Ibbett *et al.*, 2021) and Cardamom Mountains (Coad *et al.*, 2019) suggest that more than 80 percent of households consume wild meat at least once a year. A survey of rural households in 23 tropical countries found that 24 percent of surveyed households in rural communities in Asia hunted for wild meat, with high variation among countries (from a low of zero percent at an Indian site to a high of 83 percent at a Cambodian site) (Nielsen *et al.*, 2018, supp. mat.). In Sulawesi, Indonesia, Latinne *et al.* (2020) found wild meat to be routinely available in 73 percent of surveyed markets and supermarkets (Box 23). Although Neilsen *et al.* (2018) found no hunting households at the Indian site in their survey, a meta-analysis of hunting studies in India (Velho, Karanth and Laurance, 2012) reported hunting across 23 of the 28 states (with no data available for the remaining states); hunting was thought to be particularly intense in the remote Indo-Myanmar and Eastern Himalaya hotspot complex of northeastern India.

Rural communities in Asia are believed to have less access to wild meat than forest communities in Africa and South America (Spencer *et al.*, 2025), possibly due to sharp declines in availability (Gray *et al.*, 2018). Alvard (2000) estimated the consumption of wild meat in Sulawesi, Indonesia, at 38 g per person per day, but more recent estimates of the amounts of wild meat consumed and the contribution of wild meat to FSN are lacking in Asia. This has been highlighted as a priority for further research (Ingram *et al.*, 2021).

The wild-meat trade in Asia became a focus of global attention after the outbreak of the COVID-19 virus, with many of the first cases of this disease linked to a market in Wuhan, China, where wild meat was sold. The exact origin of the virus is still debated, but the association of the market with the earliest documented cases contributed to heightened concerns about the risks of zoonotic diseases linked to the trade of wild animals. At the height of the pandemic, China and Viet Nam banned the trade and consumption of wild meat for food.

Box 23
Trends in wild-meat consumption in Sulawesi, Indonesia

In North Sulawesi, the Christian communities of the Minahasa region consume wild meat as a food for special occasions, especially during festivals such as Christmas, New Year, Thanksgiving and Easter. Due to the wide availability of domestic meats and the parity between the prices of wild and domestic meats, wild meat is not generally consumed as a daily necessity. The most frequently consumed animals in Sulawesi are fruit bats, large rats and Sulawesi warty pigs, together accounting for 93 percent of species observed in market surveys conducted from 2011 to 2019.[i] All these are unprotected species in Indonesia. In 2019, an estimated 319 tonnes of bats, 419 tonnes of wild pigs and 72 tonnes of snakes were sold in Sulawesi markets.[ii] Protected species, including the Sulawesi crested black macaque and saltwater crocodile, are also sold for consumption.

Islam is the predominant religion across the rest of the island, and Muslim communities rarely consume wild meat. However, the demand for wild meat in North Sulawesi, coupled with upgrades to road networks, has driven hunting activity across the island, and traders in North Sulawesi are now supplied by hunters hundreds of kilometres away.

The demand for wild meat has already led to local extinctions of some species (such as flying foxes) in the north of the Island. Long-term market surveys have identified that the volume of wild meat sold in traditional markets in North Sulawesi fell by 99 percent from 2011 to 2018. The reason for this is unclear, but it could be a combination of declining wildlife populations due to overhunting, alongside changes in consumer preferences and increased awareness of the impacts of hunting by consumers.[i,ii]

Sources: [i] Bailey, C., Hilser, H., Siwi, Y., Lawe, Z., Waterman, J., Loffeld, T.A.C., Sampson, H. *et al*. 2022. Trends in the bushmeat market trade in North Sulawesi and conservation implications. *Animal Conservation*, 25(1): 4–14. https://doi.org/10.1111/acv.12723; [ii] Latinne, A., Saputro, S., Kalengkongan, J., Kowel, C.L., Gaghiwu, L., Ransaleleh, T.A., Nangoy, M.J. *et al*. 2020. Characterizing and quantifying the wildlife trade network in Sulawesi, Indonesia. *Global Ecology and Conservation*, 21: e00887. https://doi.org/10.1016/j.gecco.2019.e00887

Wild fish. Two broad types of forest systems contribute to fisheries that supply aquatic animals for human food. First, inland freshwater forest systems enhance freshwater fisheries through allochthonous inputs, such as leaf litter, terrestrial invertebrates, and nutrient subsidies (Lo *et al*., 2021). Second, coastal mangrove forests support marine and estuarine fisheries by providing habitat complexity, detrital food pathways, and essential nursery grounds for species consumed by humans (Nagelkerken *et al*., 2008).

Evidence from Asian floodplain systems indicates that hydrological connectivity and seasonal inundation of forested floodplains regulate fish production and assemblage structure (Ly *et al*., 2024), although studies explicitly quantifying forest-cover effects on fish biomass are limited compared with research in other regions. Some research in Asia highlights the crucial role of mangroves in supplying fish and other aquatic animals that are critical for food and nutrition, particularly in coastal areas. National data from Indonesia show that coastal populations living near

dense mangrove forests consume significantly more fish and other aquatic animals than those living in areas with less forest cover (Ickowitz *et al*., 2023) (Box 24). Other case-study evidence from the western region of Indonesia confirms that these mangrove-associated foods contribute significantly to dietary quality, providing essential protein and critical micronutrients such as iron, zinc and omega-3 fatty acids (Middleton *et al*., 2025).

Box 24
Mangrove forests and fish consumption in Indonesia

Mangrove forests are coastal ecosystems characterized by trees and shrubs that thrive in brackish or saline water, especially where freshwater from rivers or streams mixes with seawater. These unique forests have received global attention for the large amounts of carbon they store, above and below ground. In addition, they protect coastlines from storms and flooding and reduce coastal erosion.

Mangroves also benefit fisheries because their root systems serve as nurseries and feeding grounds for fish. Using national data from more than 100 000 households in Indonesia, which has the world's largest area of mangrove forests, Ickowitz *et al*. (2023) found that coastal households living in proximity to high-density mangrove forests consumed 28 percent more wild fish and other aquatic animals (e.g. shrimps and molluscs) than other coastal households. This important but not highly visible contribution of mangroves to the food security and nutrition of coastal communities is an additional compelling reason for mangrove conservation.

Source: Ickowitz, A., Lo, M.G.Y., Nurhasan, M., Maulana, A.M. & Brown, B.M. 2023. Quantifying the contribution of mangroves to local fish consumption in Indonesia: a cross-sectional spatial analysis. *The Lancet Planetary Health*, 7(10): e819–e830. https://doi.org/10.1016/S2542-5196(23)00196-1

Wild vegetables. A study among the Lawa and Karen ethnic minorities in northern Thailand found that 65 percent of wild plant foods consumed by both groups were classified as vegetables, with a preference for young shoots and leaves (Punchay *et al.*, 2020). This preference for wild vegetables and particularly young shoots and leaves has also been found in other Asian countries, including China, the Lao People's Democratic Republic, Japan and the Republic of Korea (Kang *et al.*, 2012; Osawa, 2024).

Foragers in Japan prize fern shoots (Osawa, 2024), which are also popular in Indonesia, Malaysia and the Philippines, not exclusively in Indigenous communities. In a study among Han Chinese near a forest reserve in central China, more than 50 percent of those surveyed reported collecting young shoots or leaves, with more than half the vegetables collected in forest (Kang *et al.*, 2012). There was a strong preference among respondents for vegetables over other types of wild foods, such as fruit and mushrooms.

Mushrooms. Christensen *et al.* (2008) found that 228 species of wild fungi are consumed in Nepal, with the vast majority (201) from forests. The species of mushroom and attitudes toward mushroom-eating differed among regions and ethnic groups. Mushrooms were viewed as "poor man's meat" in lowland forest areas and as "prestigious" and culturally valued foods in mountainous areas (Christensen *et al.*, 2008).

Some forests are managed actively for mushroom production in China and Japan (Piras and Santoro, 2023). The Qingyuan forest-mushroom system, *susten*, is still practised in China's Zhexiang Province. Developed in the twelfth century, *susten* involves the active management of shiitake mushrooms in forests through various means, such as the cutting of a limited percentage of trees, the cracking of stumps to favour access by shiitake spores, and covering the stumps with leaves and branches to protect mushroom spores from sunlight. This highly successful system produces shiitake mushrooms for consumption and sale.

Other contributions of forest foods

Forest foods as medicine. In many communities in Asia, wild foods serve as both food and medicine. This is the case for several types of mushrooms, particularly in East Asia. There is evidence that many mushrooms have antimicrobial, antiviral and immune-modulating properties (Das *et al.*, 2023). Some types of forest mushroom, such as *Ganoderma lucidum* (commonly known as *reishi*), have been used in traditional medicine in China and Japan for thousands of years (Loyd *et al.*, 2018). Recent scientific studies have confirmed the presence of bioactive compounds that have antitumour and immune-enhancing properties (Liu *et al.*, 2024).

Several fungal species are used as both foods and medicines in the Kashmir Valley in the Western Himalayas of India. *Portulaca oleracea* is given to postpartum mothers to boost immunity, *Taraxacum officinale* is believed to improve circulation, and the fruit of *Viburnum grandiflorum* is taken for joint ailments.

Traditional medicine using wildlife products is deeply ingrained in many Asian cultures and is particularly common in China and southeast Asia (Lee *et al.*, 2014). In a survey of wild-meat hunting and use in the Cardamom Mountains, Coad *et al.* (2019) recorded 38 hunted species, of which 16 were consumed as medicine (in addition to their use as meat). Among those were slow loris (which is grated into rice wine to create a general medicinal tonic); porcupine (eating the stomach of the porcupine is thought to benefit pregnant women); and mouse deer (the meat of which is eaten to resolve issues after childbirth).

In Viet Nam, traditional-medicine market surveys conducted in 2008 identified 30 mammal species in the north and 58 in the south that were traded for medicinal use, generally as gels and dried powders or soaked in rice wine (Nguyen and Nguyen, 2008). In the Lao People's Democratic Republic, the high demand for medicinal wildlife products from neighbouring China and Viet Nam is a key driver of unsustainable hunting. Traded species include pangolin (the scales of which are used to treat various conditions, including cancer) and sun bears and Asiatic black bears (the bile of which is mixed with whisky as a tonic to reduce fatigue; see Davis and Glikman, 2020).

In India, about 15–20 percent of Ayurvedic medicines are based on animal-derived substances (Payyappallimana, 1998). In Assam state, household surveys conducted in 2015 in villages surrounding the Gibbon Wildlife Sanctuary (Borah and Prasad, 2017) identified 44 species of animals used to treat 40 disease conditions.

The illegal cross-border trade of wildlife for traditional medicine is highly lucrative, supplying key markets in China and, increasingly, Viet Nam (Jiao and Lee, 2022; TRAFFIC, 2023). Although its true scale is unknown due to its clandestine nature, global wildlife crime is estimated to generate billions of United States dollars annually (UNODC, 2020). Southeast Asia plays a central role as both a source and transit region for illegal wildlife trade. Seizure data provides a proxy for scale (although capturing only a fraction of actual flows). In 2019, for example, Wenzhou customs authorities in China seized a shipment of 23 000 kg of pangolin scales that had originated in Nigeria and were transported via Busan in the Republic of Korea and Shanghai, China. The pangolin scales were found concealed among slices of ginger (USAID, 2020).

Recreation, spirituality and culture. In Asia, many forest foods and non-foods are connected to the traditional management of cultural forests (Piras and Santoro, 2023). For many of Asia's Indigenous Peoples, wild foods, including those from forests, are important components of diets and cultures. In a study of wild-food use among the Karen people, the largest ethnic minority in Thailand, and of the neighbouring Lawa ethnic group, Punchay *et al.* (2020) found a combined use of 124 wild plant foods, with 96 of these species used by both groups.

The approximately 104 million Indigenous People in India (IWGIA, 2024) are the country's predominant users of wild forest foods. Considering the vast size of the country and the huge numbers of Indigenous People, hundreds and perhaps even thousands of wild foods are consumed (Mallick *et al.*, 2020). Some of the better-known are wild rice, moringa, bamboo shoots, weaver ants, jamun fruit (*Syzygium cumini*), Indian cherry (*Antidesma aciduma*), wild date palm (*Ericybe paniculata*), various mushrooms and flowers, fish and wild meat (Bose, 2020; Mahapatra and Panda, 2012; Mallick *et al.*, 2020). These foods are important for both nutritional and cultural reasons. Foraging and hunting have often traditionally been done in groups, and the large quantities brought home have made it logical to share and eat collectively. For many Indigenous Peoples, eating habits have changed as they have transitioned towards farming, but wild foods brought home are still often shared, thus maintaining this important cultural feature (Bose, 2020).

Many of the ethnic minorities living in mountainous and forested areas in China regularly consume wild foods, and hunting and foraging for mushrooms and wild plants are key aspects of their cultural identity (Liu, Huang and Bin, 2023; Turini, 2021; Wang *et al.*, 2020). Many other Chinese people, including in urban areas, value wild foods because they are seen as more nutritious and less polluted than cultivated foods; many such foods also have long histories in Chinese cuisine (Wu, Hou and Wen, 2018). The consumption of wild foods is often incorporated into tourism (Liu, Huang and Bin, 2023), with people with access to wild foods selling them to restaurants catering to tourists (Wu, Hou and Wen, 2018).

In Japan, various wild foods have cultural significance and are used for rituals, ceremonies and other special occasions. The consumption of wild foods seems to have followed a similar trajectory to Europe, with widespread use as a famine and seasonal food until the twentieth century, after which it declined. There has been a resurgence of interest in Japan in foraging as a recreational activity in recent years, especially for vegetables, and it is now also an important part of local tourism in some regions. Another cultural role of wild food plants in Japan is in the form of gift-giving, and foraging for them is important for shaping perceptions of nature and community (Osawa, 2024).

There is widespread concern among scientists and in communities over the loss of botanical knowledge and ancient ecological narratives held by Indigenous Peoples and other communities with long traditions of wild-food collection (Hassan *et al.*, 2024; Pawera *et al.*, 2020). For example, older people in India's Kashmir Valley (Hassan *et al.*, 2024) and Indonesia's Papua Province (Nurhasan *et al.*, 2022) have lamented the loss of knowledge about traditional wild foods among youth.

Hunting for wild meat remains an important subsistence activity in remote villages of Papua New Guinea's Bismarck Highlands, contributing to household food security and protein intake

Europe

Overview

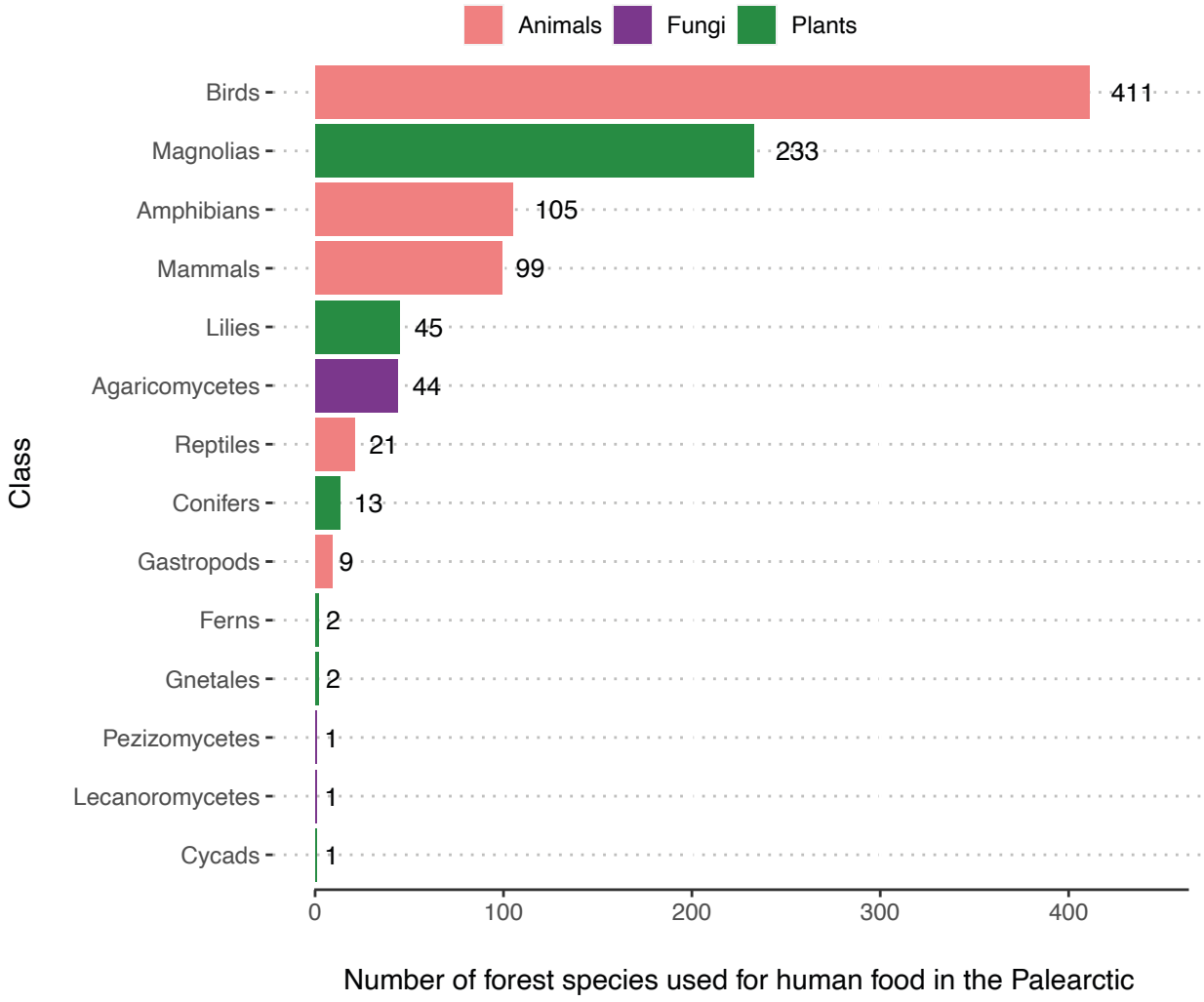
Wild forest foods have long been integral to European cuisine and culture. Many traditional dishes incorporate wild ingredients (Turner *et al.*, 2011a), and hunting and gathering have provided FSN during crises (Stryamets *et al.*, 2015). Practices such as preserving berries and mushrooms for winter consumption have been fundamental for FSN, particularly in colder regions in eastern and northern Europe, and an important traditional and cultural activity (Sõukand *et al.*, 2015; Stryamets *et al.*, 2015; Tardío, Pardo-De-Santayana and Morales, 2006). Wild plants and mushrooms have also been valued as remedies for specific ailments and for boosting general health (Tardío, Pardo-De-Santayana and Morales, 2006).

Economic and social shifts (e.g. herbicide use, supermarket shopping and changes in land use and culinary habits), however, have led to a decline in wild-food consumption in Europe (Łuczaj *et al.*, 2012; Łuczaj and Pieroni, 2016; Stryamets *et al.*, 2015) and a loss of traditional knowledge (Pieroni and Quave, 2006). Wild foods are now often used for non-essential products such as garnishes, seasonings, condiments and colourants (Tardío, Pascual and Morales, 2005). Practices once essential for nutrition in Europe are now primarily recreational, such as hunting deer and boar (Ljung *et al.*, 2012; Scillitani, Monaco and Toso, 2010) and foraging for wild plants and mushrooms, although they persist among older rural people (Pieroni and Quave, 2006) and Indigenous Peoples like the Sámi and Nenet (Evseev *et al.*, 2019; Roturier and Roué, 2009). Recently, some wild foods have experienced a revival, driven by interest in traditional practices, tourism and culinary innovation (Łuczaj *et al.*, 2012; Madej *et al.*, 2014).

According to the IUCN Red List (IUCN, 2024), 987 documented forest species in Europe are used for food. Birds represent the most diverse group, with 411 recognized species (Figure 7).

A literature review of wild-food use in European countries (Schulp, Thuiller and Verburg, 2014) across all habitats reported the consumption of 152 species of mushrooms and 592 species of vascular plants (the IUCN Red List includes 44 species of fungi and 296 species of vascular plants in forests). Schulp, Thuiller and Verburg (2014) also reported that 97 game species are hunted in the European Union, of which 34 (26 bird species and 12 mammals) are consumed as food. This is much lower than the number of bird and mammal species reported in the IUCN Red List as used for human consumption.

Figure 7.
Number of forest species used for human food in the Palearctic realm, by taxonomic group, as listed on the IUCN Red List



Note: This figure does not include species that have not been assessed on the IUCN Red List and is therefore likely to vastly underestimate the number of forest species used for human food for some taxonomic groups.
Source: IUCN. 2024. *The IUCN Red List of Threatened Species*. Version 2024-1. https://www.iucnredlist.org.

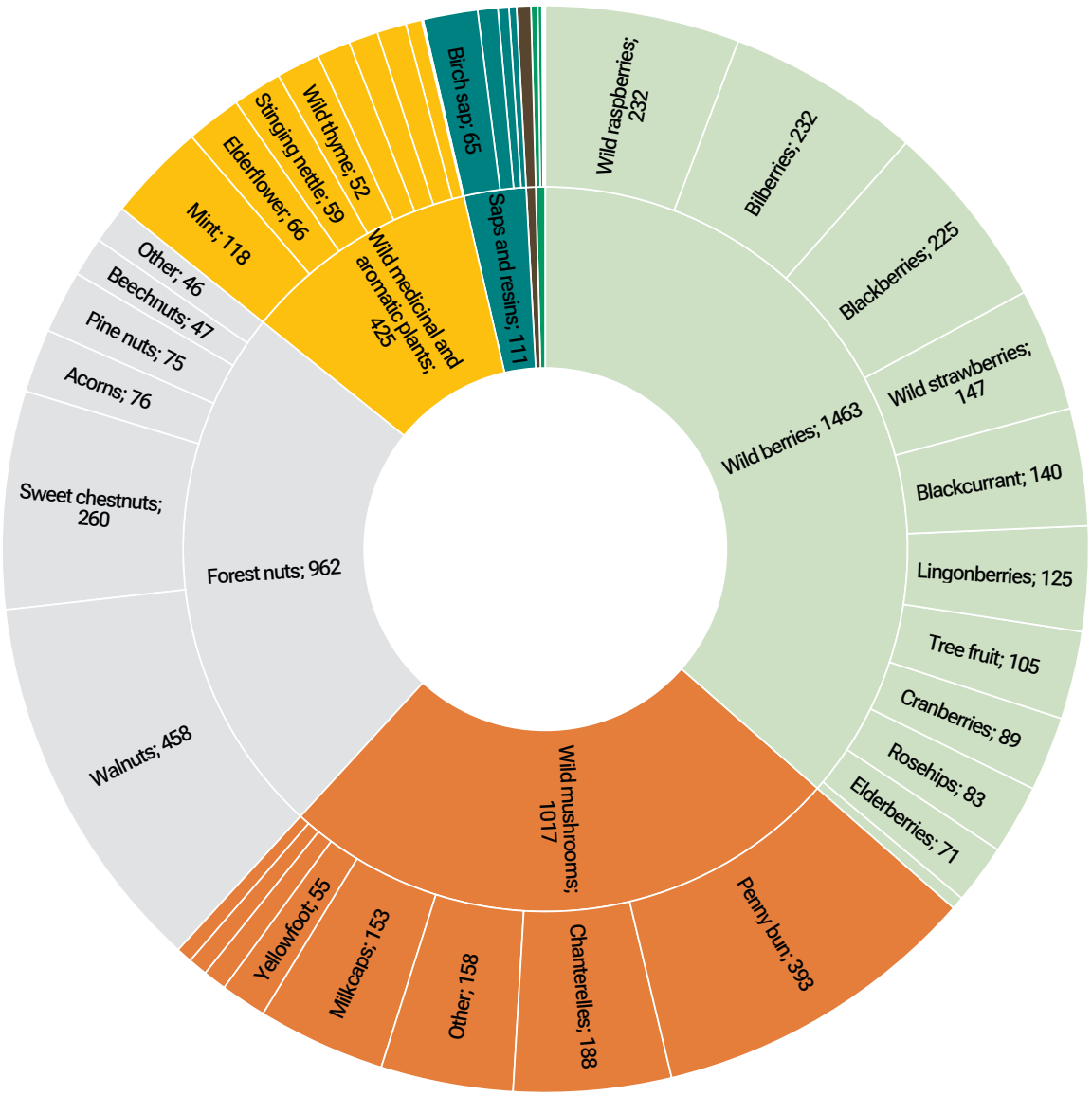
Contribution of forest foods to food security and nutrition

The contribution of forest foods to FSN is poorly studied in Europe: of the 63 studies identified globally in this systematic review, none for Europe met the inclusion criteria. This does not mean that wild foods play no role in FSN in Europe; rather, it means that research has not explicitly used measures of food security or nutrition. The literature refers to the use of wild foods in Europe in times of food scarcity in the nineteenth and twentieth centuries, providing a food-supply safety net (Łuczaj *et al.*, 2012). Today, however, the role of wild foods has transitioned from nutritionally vital in many parts of Europe to a more recreational, cultural and culinary significance.

Despite a paucity of information on the nutritional contributions of wild foods, some regional data are available on the prevalence of wild-food use. For example, a representative Europe-wide survey covering 17 346 respondents in 28 European countries was conducted in 2016 on the consumption and collection of NWFPs (excluding wild animals) (Lovrić *et al.*, 2020). It found that 90 percent of households consumed NWFPs and one-quarter collected them, with higher rates of consumption and collection in eastern Europe. The majority of wild plant food collection in Europe was by recreational harvesters (83 percent), followed by hobby harvesters (15 percent). Just 2 percent of harvesters were considered "professional" (i.e. with the objective of earning income from sale) (Lovrić *et al.*, 2021). Nuts were the most frequently reported NWFP type consumed (71 percent of households), followed by berries (60 percent) and mushrooms (47 percent). Of the 26 percent of households that collected NWFPs, berries represented 36 percent of the overall collected weight, followed by mushrooms (25 percent) and nuts (24 percent) (Figure 8).

Figure 8.

Collected weight of non-wood forest products in Europe, by product and product group, in one year

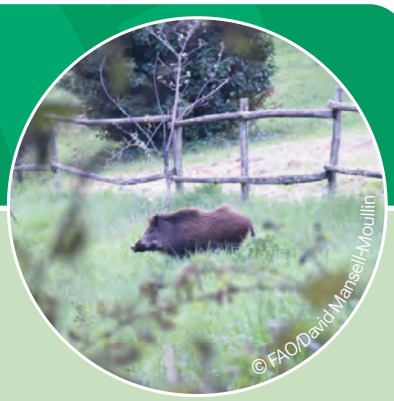


Note: Values are in thousands of tonnes.
Source: Reproduced from Lovrić, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P.J. & Mavsar, R. 2021. Collection and consumption of non-wood forest products in Europe. *Forestry*, 94(5): 757–770. https://doi.org/10.1093/forestry/cpab018

Wild meat and fish. Consumption rates of wild animals (game) across Europe are generally low (Niewiadomska *et al.*, 2020). Available estimates include 0.08 kg per person per year in Poland (Kwiecińska *et al.*, 2017), 0.4 kg per person per year in Germany (Damm, 2021), 0.55 kg per person per year in Croatia (Tolušić *et al.*, 2006), 0.56 kg per person per year in Slovakia (Reinken, 1998), and 1.1 kg per person per year in Czechia (Reinken, 1998). An estimated 15 percent of European consumers eat game meat more than once a month, and more than one-third have reported eating some game meat every year (Tomasevic *et al.*, 2018). The five main food game species are wild boar (*Sus scrofa*) (Box 25), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), hare (*Lepus europaeus*) and ring-necked pheasant (*Phasianus colchicus*), of which wild boar and red deer are the major species due to their wide distribution and high abundance (Needham *et al.*, 2023). Hunting is an important rural tradition (Ljung *et al*., 2012), with wild meat eaten as a traditional food and delicacy.

Although fish is a key component of European diets, wild freshwater fish likely represent a small proportion of this consumption. In 2021, the freshwater fish catch in the European Union was reported at 140 579 tonnes, which was 1.8 percent of the total fish catch (European Parliament, 2025). It is not possible to determine the proportion of this catch obtained from water bodies in forest habitats, and data on wild-fish consumption are lacking. Freshwater species fished in rivers in forest areas include trout, grayling, pike, perch, chub, barbel, bream and roach.

Box 25
Wild-pig hunting in Europe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Wild pigs (*Sus scrofus*), thought to have originated in Asia, have colonized much of the world and are now one of the planet's most widely distributed terrestrial mammal species.[i] It is identified as one of the top 100 "worst invasive alien species"[ii] and a threat to 672 taxa in 54 countries.[iii]

In medieval times, wild pigs (often called boar) were hunted in Europe for sport and prestige, often by nobility. Despite being highly adaptable to different habitats and capable of rapid reproduction, wild pigs were hunted to near-extinction in many parts of Europe in the seventeenth and eighteenth centuries as their forest habitats were converted to agriculture. They were thought to have been extirpated in the United Kingdom of Great Britain and Northern Ireland by the end of the seventeenth century, but farm escapes enabled the population to re-establish and numbers have increased since the 1960s.[iv]

Today, wild pigs are hunted by registered sports hunters, mostly by gun. At least 2.2 million wild pigs were harvested in 18 European countries in 2012, but populations continue to rise as the number of hunters in Europe declines.[v] Wild pigs have been reported in urban areas, such as Barcelona and Rome, coming into conflict with people and even resulting in nightly curfews, which have made international headlines.[vi]

Sources: [i] Risch, D.R., Ringma, J. & Price, M.R. 2021. The global impact of wild pigs (*Sus scrofa*) on terrestrial biodiversity. *Scientific Reports*, 11(1): 13256. https://doi.org/10.1038/s41598-021-92691-1; [ii] Lowe, S. M., Browne, M., Boudjelas, S. & De Poorter, M. *100 of the world's worst invasive alien species: A selection from the Global Invasive Species Database.* IUCN Invasive Species Specialist Group. First published as lift-out in *Aliens*, 12 (2000); [iii] Risch, D.R., Ringma, J. & Price, M.R. 2021. The global impact of wild pigs (*Sus scrofa*) on terrestrial biodiversity. *Scientific Reports*, 11(1): 13256. https://doi.org/10.1038/s41598-021-92691-1; [iv] Wilson, C.J. 2003. Distribution and status of feral wild boar *Sus scrofa* in Dorset, southern England. *Mammal Review*, 33(3–4): 302–307. https://doi.org/10.1046/j.1365-2907.2003.00016.x; [v] Massei, G., Kindberg, J., Licoppe, A., Gačić, D., Šprem, N., Kamler, J., Baubet, E. *et al*. 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. *Pest Management Science*, 71(4): 492–500. https://doi.org/10.1002/ps.3965; [vi] Giuffrida, A. 2022. Rome residents impose curfew after spate of wild boar attacks. *The Guardian*, 3 May 2022. [Cited 3 April 2025]. https://www.theguardian.com/world/2022/may/03/rome-residents-curfew-wild-boar-attacks

Wild plants and fungi. Wild plants and plant parts have long been used as food in Europe and remain part of traditional cuisines. Although mostly non-essential today, many wild plants are still eaten fresh, cooked or brewed as sweets, teas, seasonings and garnishes (Martínez-Jaúregui, Arenas and Herruzo, 2011; Tardío, Pardo-De-Santayana and Morales, 2006). Some wild plants have high commercial value, such as truffles (*Tuber* spp.) (Čejka, Trnka and Büntgen, 2023), mushrooms (Sucholas *et al.*, 2021) and cranberries (Bakkegaard, 2014).

Commonly foraged wild vegetables in the Mediterranean region include asparagus (*Asparagus acutifolius*) and fennel (*Foeniculum vulgare*), as well as herbs such as chicory (*Cichorium* spp.) and garlic (*Allium ursinum*), eaten cooked or raw (Leonti *et al.*, 2006; Łuczaj *et al.*, 2012, 2013; Wong, 2023). Such wild plants are key ingredients in traditional dishes, such as Italian *pistic*, a special dish in which more than 60 herbs are boiled and then sauteed together (Turner *et al.*, 2011b). Wild plants used as garnishes, seasonings or condiments include bay laurel (*Laurus nobilis*), fennel, oregano (*Origanum heracleoticum*) (Pardo-de-Santayana *et al.*, 2007; Pieroni *et al.*, 2005; Reyes-García *et al.*, 2015), and the roots of horseradish (*Armoracia rusticana*) and liquorice (*Glycyrrhiza glabra*). Wild herbs enhance or preserve foods, such as Spanish thyme (*Thymus zygis*), used with olives, and fennel, used with dried figs (Tardío, Pascual and Morales, 2005). Other commonly foraged plants include bladder campion (*Silene vulgaris*), black bryony (*Tamus communis*) and water blinks (*Montia fontana*) (Łuczaj *et al.*, 2012).

Some wild-plant products have waned in popularity. Birch sap was once used across Europe in drinks, syrups, confectionery and medicinal ointments (Svanberg *et al.*, 2012). A fermented drink made with cornflower (*Centaurea cyanus*) was consumed extensively in Poland but is no longer popular (Łuczaj and Szymański, 2007).

Teas made using forest herbs are consumed widely in Europe. Sõukand *et al.* (2013) identified 142 taxa used for this purpose in 29 areas in Europe. Plants from the Lamiaceae and Asteraceae families are especially popular in southern Europe (Idolo, Motti and Mazzoleni, 2010; Sõukand *et al.*, 2013; Tardío, Pascual and Morales, 2005), with their shoots, stems and roots cooked and consumed (Leonti *et al.*, 2006). Other important plant taxa include mint (*Mentha* spp.), lindens (*Tilia* spp.), thyme (*Thymus* spp.), oregano (*Origanum* spp.) and chamomile (*Matricaria* spp.) (Leonti *et al.*, 2006; Sõukand *et al.*, 2013). *Thymus* spp. and *Mentha* spp. are important for herbal teas in the Balkan countries of Albania, Bosnia and Herzegovina and North Macedonia (Alrhmoun, Sulaiman and Pieroni, 2024).

The gathering of wild mushrooms for personal use and sale is widespread in Europe, including penny bun (*Boletus edulis*), saffron milkcap (*Lactarius deliciosus*), Caesar's mushroom (*Amanita caesarea*), chanterelle (*Cantharellus cibarius*), morels (*Morchella* spp.) and king trumpet (*Pleurotus eringii*) (De Frutos *et al.*, 2019; Pieroni *et al.*, 2005; Turner *et al.*, 2011b) (Box 26). Wild mushrooms are dried, salted or pickled for winter in Poland, the Russian Federation and Sweden (Aramilev, 2009; Sõukand *et al.*, 2015; Stryamets *et al.*, 2015). Truffle foraging is a major industry in France, Italy and Spain (Reyna and Garcia-Barreda, 2014); the Italian white truffle (*Tuber magnatumone*) is one of the world's most expensive foods, and the United Nations Educational, Scientific and Cultural Organization recognizes its harvesting as a cultural heritage practice, with knowledge traditionally passed from father to son (Graziosi, Hall and Zambonelli, 2022).

Box 26
A wild-food revival in Europe

Despite a general decline in wild forest foods in Europe due to shifting lifestyles, there is renewed interest in some such foods and a resurgence in their production and consumption. Juniper beer, for example, once popular in Poland before declining in the twentieth century, has regained popularity since the 1990s as a regional specialty – aimed at tourists – in the Kurpie region.[i] This resurgence has boosted commercial production and helped preserve cultural practices and identities, as well as traditional knowledge regarding wild-food consumption.[ii]

Interest in wild foods has also grown among culinary leaders, with well-regarded chefs across Europe incorporating wild forest products in their restaurant menus.[iii] Luczaj *et al.* noted, however, that this culinary trend may vary over time and may be limited to culinary elites.[iv] Expanding a renewed interest in wild foods to a broader audience could help preserve traditional ecological knowledge and cultural practices.

Sources: [i] Madej, T., Pirożnikow, E., Dumanowski, J. & Łuczaj, Ł. 2014. Juniper beer in Poland: the story of the revival of a traditional beverage. *Journal of Ethnobiology*, 34(1): 84–103. https://doi.org/10.2993/0278-0771-34.1.84; [ii] Sõukand, R., Pieroni, A., Biró, M., Dénes, A., Dogan, Y., Hajdari, A., Kalle, R. *et al*. 2015. An ethnobotanical perspective on traditional fermented plant foods and beverages in Eastern Europe. *Journal of Ethnopharmacology*, 170: 284–296. https://doi.org/10.1016/j.jep.2015.05.018 ; [iii] Łuczaj, Ł., Pieroni, A., Tardío, J., Pardo-de-Santayana, M., Sõukand, R., Svanberg, I. & Kalle, R. 2012. Wild food plant use in 21st century Europe: the disappearance of old traditions and the search for new cuisines involving wild edibles. *Acta Societatis Botanicorum Poloniae*, 81(4): 359–370. https://doi.org/10.5586/asbp.2012.031; [iv] Łuczaj, Ł., Pieroni, A., Tardío, J., Pardo-de-Santayana, M., Sõukand, R., Svanberg, I. & Kalle, R. 2012. Wild food plant use in 21st century Europe: the disappearance of old traditions and the search for new cuisines involving wild edibles. *Acta Societatis Botanicorum Poloniae*, 81(4): 359–370. https://pdfs.semanticscholar.org/0b77/d919d082216fa32e8b133bcae5dd9bd708a1.pdf?utm_source

Wild fruit. Wild fruit and berries – raw, cooked or made into jams, juices and teas and often used as garnishes and flavourings – are widely foraged and consumed in Europe. In the Russian Federation, for example, wild berries such as bilberries, blackberries, cowberries, cranberries, raspberries and strawberries are used to add colour to soft and alcoholic drinks such as kvass, lemonade and fruit morse (Shikov *et al.*, 2017). These fruits have high commercial and nutritional value (Bakkegaard, 2014; Stryamets *et al.*, 2015).

Preserving wild fruits and berries as jams for consumption during winter is a longstanding practice that continues today, albeit less commonly than in the past. The practice is most common in northern Europe where winters are colder; in the Russian Federation and Sweden, for example, jams, juices and marmalades are made using bilberries, cowberries and cranberries (Stryamets *et al.*, 2015). In Spain, blackberries, European blueberries (*Vaccinium myrtillus*) and elderberries (*Sambucus nigra*) are commonly made into jams and preserves for year-round consumption. In Spain, fruit from blackthorn (*Prunus spinosa*, also known as sloe gin), sour cherry (*Prunus cerasus*) and the strawberry tree (*Arbutus unedo*) are used to produce liqueurs (Reyes-García *et al.*, 2015; Tardío, Pardo-De-Santayana and Morales, 2006). In Poland, it is popular to make liqueurs using

rose hip (*Rosa canina*), hawthorn berries (*Crataegus* spp.) and blackthorn (Kasper-Pakosz, Pietras and Łuczaj, 2016). Raspberries are a particularly important wild berry in eastern Europe (Sõukand *et al.*, 2013).

Other foods. Insects – such as cockchafers (*Melolontha*) as famine food – may have been consumed in Europe historically (Svanberg and Berggren, 2021). A reluctance or phobia exists today, however, on the use of insects as food, with none of the surveys of wild-food use in Europe identified for this report mentioning wild-insect consumption.

Nuts such as walnut, sweet chestnut, pine nut and beechnut are key NWFPs collected and consumed in Europe (Lovrić *et al.*, 2021).

Other contributions of forest foods

Forest foods as medicine. Wild forest foods have traditionally been valued in Europe for their medicinal and nutritional benefits, with the two benefits inextricably linked (Hadjichambis *et al.*, 2008; Tardío, Pardo-De-Santayana and Morales, 2006). Wild forest foods are consumed to treat specific ailments and to promote general health and well-being. Herbal teas and liqueurs made using wild plants and berries remain popular as digestifs and health infusions, and leaves, berries and herbs continue to be used in salves, ointments and infusions (Kasper-Pakosz, Pietras and Łuczaj, 2016; Lovrić *et al.*, 2020; Pardo-de-Santayana, Tardío and Morales, 2005; Shikov *et al.*, 2017; Stryamets *et al.*, 2015). Examples include *Malva sylvestris*, which is used to treat respiratory and digestive issues (Idolo, Motti and Mazzoleni, 2010; Scherrer, Motti and Weckerle, 2005), and *Urtica* spp. (nettles, used in traditional recipes), which have longstanding roles in Italian folk medicine (Idolo, Motti and Mazzoleni, 2010). Market surveys in Poland indicate the continued popularity of wild fruit as food and in the production of medicines and alcohol; there is renewed interest in species such as rose hip (*Rosa canina*), hawthorn (*Crataegus* spp.) and blackthorn (*Prunus spinosa*) as herbal remedies and fruit liqueurs (Kasper-Pakosz, Pietras and Łuczaj, 2016). In the Russian Federation, wild berries (bilberries, cowberries and raspberries) are made into teas that are consumed for medicinal purposes (Kolosova *et al.*, 2020).

Although the use of wild foods as medicines has diminished in Europe due to urbanization, the availability of modern medicines and the loss of traditional knowledge (Idolo, Motti and Mazzoleni, 2010; Pieroni and Quave, 2006; Quave and Saitta, 2016), the perception that they promote good health persists (Biscotti and Pieroni, 2015; Łuczaj *et al.*, 2012). In Italy, many people continue to view wild plants as healthy, although they are consumed less frequently (Biscotti and Pieroni, 2015; Hadjichambis *et al.*, 2008). Game meat is also consumed for its perceived health benefits; it is higher in protein and lower in fat and calories than most domestic meats (Strazdiņa, Jemeļjanovs and Šterna, 2013). Health-conscious consumers who also want to make ethical and environmentally friendly choices are thought to be behind a recent increase in demand for game meat (Niewiadomska *et al.*, 2020).

Recreation, spirituality and culture. Historically, foraging for berries, other plant parts and mushrooms and the hunting of game were essential food sources in Europe, particularly in rural communities and during crises, when wild foods provided a crucial food security safety net (Bakkegaard, Nielsen and Thorsen, 2017; Stryamets *et al.*, 2015). Once integral to livelihoods, forests now primarily serve recreational roles, offering cultural ecosystem services such as stress relief and a connection to nature (Stryamets *et al.*, 2015). Foraging for wild plants and mushrooms persists as a recreational activity and for the preservation of tradition. In Sweden, for example, wild-berry picking is popular as a traditional activity among older people (Stryamets, Elbakidze and Angelstam, 2012), and mushroom foraging continues in Poland as an intergenerational recreational activity, with children inheriting knowledge from older family members (Łuczaj *et al.*, 2012).

Populations of some species of wild game are increasing in many areas of Europe, leading to conflicts between humans and wildlife. Hunting is increasingly used as a means for controlling certain species (Massei *et al.*, 2015). In 2021, approximately 7 million game hunters – about 1 percent of the total population – were registered in Europe. This percentage varies across the region, with the largest number of hunters per capita in northern Europe (Finland, Norway and Sweden), southern Europe (France, Portugal and Spain), and Ireland (DJV, 2025); nevertheless, the percentages in these subregions have declined (Massei *et al.*, 2015).

Fishing in forest environments in Europe is generally for recreation; the Black Forest in Germany and the Carpathian Mountains in central and southern Europe, for example, are renowned globally for fly fishing. Surveys in northern and central Europe suggest that the motivation for angling is more often to relax, experience nature or socialize than to acquire food (Griffiths *et al.*, 2017). More than 15.7 million inland anglers were registered in Europe in 2011 (Cowx, 2015). Historically, recreational fishing has focused on wild rivers and lakes, but it has moved towards managed systems such as stocked fishing lakes (North, 2002) as these wild spaces have become more prone to pollution, habitat degradation and flow manipulation (Costa *et al.*, 2021).

Changing lifestyles in Europe have also shifted wild-forest-food consumption patterns, with younger generations increasingly lacking the time and knowledge for wild-food foraging and use (Łuczaj *et al.*, 2012; Stryamets *et al.*, 2015; Turner *et al.*, 2011b). In rural Tuscany, Italy, for example, older women once gathered weedy greens for a traditional dish, *minestrella*, as a cultural and social ritual; as more women entered formal employment, this foraging declined in favour of supermarket convenience (Pieroni and Quave, 2006).

Forest foods are particularly significant for rural and Indigenous communities, such as the Sámi and Nenet peoples, who also use wild-harvested plants and animals in crafts and construction (Evseev *et al.*, 2019; Roturier and Roué, 2009). The Sámi people of the Scandinavian and Kola peninsulas have deep knowledge of the forest, using grazing strategies to sustain semidomesticated reindeer that feed on lichens and wild mushrooms (Inga, 2009; Roturier and Roué, 2009). Wild game, fish and plants are integral to Sámi diets. For example, harvesting the inner bark of pine trees for food and crafts, once a survival necessity, remains a cultural heritage practice today (Östlund *et al.*, 2009).

The hunting of wild animals in Europe has deep cultural roots, and a range of methods is used, including firearms and traditional practices such as bow hunting, falconry and hunting with hounds (FACE, 2024). In Sweden, game hunting has shifted from necessity to recreation but remains a means for reinforcing cultural ties and connections with nature (Boman and Mattsson, 2012; Stryamets, Elbakidze and Angelstam, 2012), with game species such as moose emblematic of the country (Åkerberg, 2005).

Culinary. There is renewed interest in forest foods in Europe, reflected in restaurant dishes, new field guides, foraging workshops and the revival of traditional foods and beverages (Łuczaj *et al*., 2012; see also Box 26). The resurgence has been driven by growing interest in the health properties of wild foods and in unique gastronomic experiences (Łuczaj *et al.*, 2012). Demand is further driven by tourism, with restaurants offering wild fish, game, mushrooms and berries in traditional dishes, sourced from local collectors (Derek, 2021). Consumer preferences also stimulate the commercial production of forest foods, such as the European black truffle (*Tuber melanosporum*) and the Italian white truffle (*Tuber magnatumone*). Truffles are the basis of multimillion-euro industries in France, Italy and Spain (Reyna and Garcia-Barreda, 2014).

Wild mushrooms on sale in the central market, Slovenia

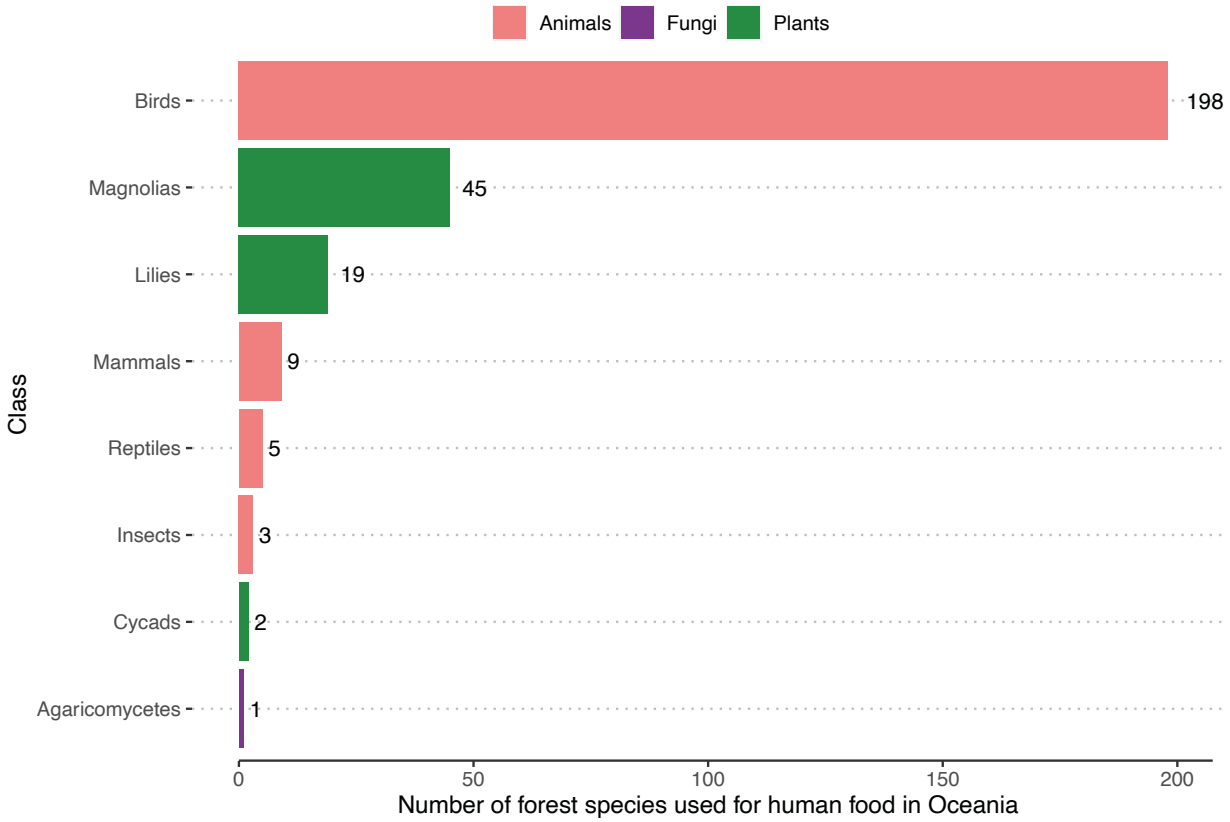
Oceania

Overview

Oceania is commonly separated into three subregions: Melanesia, Micronesia and Polynesia. Melanesia is characterized by larger, more resource-rich islands (including Australia), with diverse ecosystems that include vast forests. Polynesia encompasses smaller, more isolated islands (with the notable exception of New Zealand) and archipelagos with limited land resources but rich marine environments. Micronesia is somewhat like Polynesia but with some relatively forested larger islands. It is also useful to consider the region as forming either "high islands" with significant forest cover or "low islands" (often atolls), where land resources are very limited (e.g. coconut and some pantropical littoral vegetation) and food is mostly derived from the ocean.

Compared with the other biogeographic realms, Oceania has a relatively low diversity of forest species used for food. The IUCN Red List data show that birds are the most diverse taxonomic group (Figure 9).

Figure 9.
Number of forest species used for human food in Oceania, by taxonomic group, as listed on the IUCN Red List



Note: This figure does not include species that have not been assessed on the IUCN Red List and is therefore likely to vastly underestimate the number of forest species used for human food for some taxonomic groups.
Source: IUCN. 2024. *The IUCN Red List of Threatened Species*. Version 2024-1. https://www.iucnredlist.org.

Contribution of forest foods to food security and nutrition

Although this review found no studies in Oceania that met the inclusion criteria (requiring evidence of links between forest foods and indicators of FSN – see the appendix), other data show that forest foods play an important role in FSN in the region (Table 2).

With its larger landmasses and diverse ecosystems, Melanesia boasts a rich variety of forest foods that have been integral to the diets and cultural practices of its inhabitants for millennia. They provide dietary diversity, act as a safety net, and often contribute significantly to daily nutritional intake (Vinceti *et al*., 2013). Forest foods play an important role in some parts of Micronesia and Polynesia, but their significance for FSN is not uniform across the region. In many small, low-lying islands, their contribution is constrained by abundant marine resources and limited forest cover (Campbell, 2015; Manner, 2008).

Despite a transition towards imported and processed foods, forest (and marine) resources remain important in the three subregions for dietary diversity, complementing agricultural staples and serving as emergency food sources and safety nets during times of crop failure and disasters (Campbell, 2015; McGregor, 2009). Notwithstanding the vast area spanned by the region and its wide ethnosocioecological and cultural differences, a relatively small number of important and widespread forest plants and animals are consumed almost universally across Oceania. These include breadfruit (*Artocarpus altilis*), coconut (*Cocos nucifera*) and wild pig (*Sus scrofa*) (Box 27), which are important for FSN in all three subregions.

Melanesia, with its larger landmasses and diverse ecosystems, has a higher diversity of forest foods than Micronesia and Polynesia. This is particularly evident in the variety of fruit, nuts and animal foods (Clarke, 1971; Heim, 2014). The latter include insects, game and birds, which are less prominent in Micronesian and Polynesian forest food systems, where there is generally a greater emphasis on plant-based forest foods (Nasi, Taber and Van Vliet, 2011; Whistler, 2001).

Compared with the other two subregions, Melanesian communities tend to have a higher dependence on forest foods, especially in rural and inland areas. Many Polynesian and Micronesian communities have a more balanced reliance on forest, coastal and marine resources (Balick, 2009; Thaman, 1994). Agroforestry is practised across Oceania but is of particular importance in Micronesia, where the line between forest and agricultural resources is often blurred due to the limited land area (Raynor and Fownes, 1991). Even when consumed occasionally or in small quantities, food sourced from forests provides essential nutrients that may not be readily available from other sources, and it can play a role as a safety net in times of scarcity.

The island of New Guinea, comprising Papua New Guinea and Indonesian Papua, is home to one of the world's largest tropical rainforests, which play a crucial role in food security and meeting the dietary needs of local people. Sago, derived from the sago palm (*Metroxylon sagu*), is one of the most important plant-based forest foods in New Guinea. It is a staple food for many communities, especially in lowland areas (Ehara, Toyoda and Johnson, eds., 2018). The pith of the sago palm

is processed to extract starch, which is then used to make various foods. In Papua New Guinea's Gulf Province, sago is prepared in various ways – as a jelly, fried, and as a soup with coconut milk (Toyoda *et al*., 2005). In parts of Indonesian Papua, sago is prepared as *papeda*, a glue-like paste (Pattiselanno *et al*., 2015). Various species of wild yam (*Dioscorea* spp.), which are rich in carbohydrates and fibre, are harvested in forests across New Guinea. The purple yam (*Dioscorea alata*) is commonly foraged in forest areas in Papua New Guinea's East Sepik Province (Bourke and Harwood, eds., 2009).

Forest nuts contribute significantly to local diets by providing essential fats and proteins. Galip or ngali nuts (*Canarium indicum*, *C. decumanum*), for example, are consumed widely in Papua New Guinea, particularly in coastal and island regions (Wallace *et al*., 2022).

Wild pigs are a crucial source of protein for many forest-dwelling communities in New Guinea. In the Southern Highlands of Papua New Guinea, wild-pig hunting is a significant cultural and nutritional activity (Hide, 2003). In many parts of Indonesian Papua, wild-pig meat is a prized food source that is often shared in community feasts (Pangau-Adam, Noske and Muehlenberg, 2012). Various species of cuscus, an arboreal marsupial, are hunted for their meat across New Guinea. The spotted cuscus (*Spilocuscus maculatus*) is commonly hunted in forests in Papua New Guinea's Madang Province (Mack and West, 2005). Cassowaries are hunted for their meat and eggs in many parts of New Guinea, such as in the Crater Mountain Wildlife Management Area in Papua New Guinea, where the dwarf cassowary (*Casuarius benneti*) is an important food source and cultural symbol (Johnson, Bino and Igag, 2004). Forest rivers and streams provide various fish and other aquatic animals that contribute to local diets. The Papua black bass (*Lutjanus goldiei*) is an important food fish in Papua New Guinea's Sepik River region (Coates, 1987). Freshwater fish and other aquatic animals are important parts of the diet in the lowland forests of Indonesian Papua (Purwestri *et al.*, 2019).

Box 27
The introduction of wild pigs and deer to the islands of Oceania

Wild or feral pigs (*Sus scrofa*) were introduced in Oceania by humans in multiple waves of migration and colonization. The first introduction to Near Oceania (comprising New Guinea and Solomon Islands) occurred around 3 500 years ago during the Austronesian expansion.[i] A second wave happened from the late eighteenth century during European exploration and colonization.[ii] Wild pigs are now found in all subregions of Oceania.

Pig hunting has become an important cultural and subsistence activity in Oceania. Hunters use a mix of methods depending on local conditions and traditions, including spears, pit traps and firearms, often combined with dogs for tracking. In many Oceanic cultures, pig hunting has become integrated into traditional practices and is often associated with masculinity and prestige.[iii] Although hunting helps control wild pig populations, it has not prevented them from causing significant environmental damage.[iv]

Wild-pig meat is particularly important in rural and remote areas, where it often supplements or replaces domestic meat. One study suggests that it provides up to 50 percent of the meat consumed in rural Papua New Guinea.[v]

Deer were introduced to Oceania primarily in the nineteenth and twentieth centuries. Red deer (*Cervus elaphus*) were released in New Zealand in 1851 for sport hunting.[vi] In New Caledonia, rusa deer (*Cervus timorensis*) were introduced in 1870,[vii] and, in Fiji, white-tailed deer (*Odocoileus virginianus*) arrived on Wakaya Island in 1865.[viii] Deer are less widely distributed in Oceania than pigs and are found mostly in Fiji, New Caledonia and New Zealand.

In New Zealand, deer hunting has become an important part of rural culture and identity.[vi] In New Caledonia, deer hunting is both a subsistence activity and a popular sport.[vii] The contribution of deer meat to local diets is generally less significant than that of wild-pig meat. It can be important in certain areas but rarely exceeds 15 percent of the protein intake.

Although both wild pigs and wild deer are introduced species in Oceania, they have become important components of hunting practices and diets in many areas. Their management presents ongoing challenges in balancing cultural, nutritional and ecological considerations. There is increasing interest in sustainable hunting practices that can contribute to conservation efforts while maintaining cultural and dietary importance.[viii]

Sources: [i] Kirch, P.V. 2000. *On the road of the winds: an archaeological history of the Pacific islands before European contact*. Berkeley, USA, University of California Press; [ii] Clarke, W.C. 1971. *Place and people: An ecology of a New Guinean community*. First edition. University of California Press. https://doi.org/10.2307/jj.7968078; [iii] Sillitoe, P. 2001. Hunting for conservation in the Papua New Guinea Highlands. *Ethnos*, 66(3): 365–393. https://doi.org/10.1080/00141840120095140; [iv] Brewis, A.A. & Leach, M.A. 1983. Sex differences in the feral pig population of Auckland Island, New Zealand. *New Zealand Journal of Ecology*, 6: 131–134; [v] Hide, R. 2003. *Pig husbandry in New Guinea*. Australian Centre for International Agricultural Research. https://www.aciar.gov.au/publication/books-and-manuals/pig-husbandry-new-guinea-literature-review-and-bibliography; [vi] Nugent, G. & Fraser, K.W. 1993. Pests or valued resources? Conflicts in management of deer. *New Zealand Journal of Zoology*, 20(4): 361–366. https://doi.org/10.1080/03014223.1993.10420359; [vii] De Garine-Wichatitsky, M., Soubeyran, Y., Maillard, D. & Duncan, P. 2005. The diets of introduced rusa deer (*Cervus timorensis russa*) in a native sclerophyll forest and a native rainforest of New Caledonia. *New Zealand Journal of Zoology*, 32(2): 117–126. https://doi.org/10.1080/03014223.2005.9518403; [viii] Sherley, G. 2000. *Invasive species in the Pacific: A technical review and draft regional strategy*. Secretariat of the Pacific Regional Environment Programme (SPREP). https://library.sprep.org/content/invasive-species-pacific-technical-review-and-draft-regional-strategy-technically-edited

Table 2.
Important forest foods in Oceania

Forest food	Scientific name(s)	Usage
Bats	*Pteropus* spp.	Flying foxes are traditionally hunted and consumed in many parts of the region. They comprise 1–2 percent of protein intake in some communities
Birds	*Ducula* spp., *Casuarius* spp.	Wild pigeons (*Ducula* spp.) are widely hunted and consumed wherever they are present (e.g. in New Caledonia, Pohnpei and Samoa) Cassowaries are hunted for their meat and eggs in many parts of New Guinea
Breadfruit	*Artocarpus* spp., *Artocarpus altilis*	A major staple food, breadfruit is high in carbohydrates and fibre. The breadfruit tree is cultivated widely. Breadfruit accounts for about 10–15 percent of the traditional diets in Fiji, 20–25 percent in Pohnpei, 15–20 percent in Solomon Islands and 20–25 percent in Samoa. Now pantropical, the species originated in the Malay Archipelago, from where it spread to Oceania in prehistoric times
Coconut	*Cocos nucifera*	Found in coastal forests and plantations, coconuts provide both food and drink. The meat and water of coconuts make up 5–10 percent of many traditional diets in Oceania. It is most significant on low islands and atolls, where it constitutes the main component of the vegetation. It occurs throughout tropical Oceania on islands and in coastal areas. It occurs in wild and naturalized populations, managed smallholder groves, and commercial plantations
Coconut crab	*Birgus latro*	The large size of this crab and the quality of its meat means that it is hunted extensively and is very rare now on islands with human populations. It occurs on many tropical islands across Oceania in Micronesia, Melanesia and parts of Polynesia, but its distribution is patchy, and it is absent from many islands
Deer	*Cervus elaphus*, *C. timorensis*, *Odocoileus virginianus*	Widely hunted wherever introduced (see main text)
Freshwater animals		Forest rivers and streams on large high islands provide various fish, eels and other aquatic animals that contribute significantly to local diets
Leafy greens	*Abelmoschus manihot*, various species, *Diplazium esculentum*	Various forest leaves, such as slippery cabbage and various species of edible ferns, are commonly consumed, making up about 5–8 percent of daily vegetable intake in some communities. *Diplazium esculentum*, which occurs throughout Oceania, is considered the most important edible fern worldwide because it is rich in iron, phosphorus, potassium and proteins. Its use as a vegetable is prevalent in Asia (including the Himalayas) and Oceania
Sago	*Metroxylon sagu*	The pith of the sago palm is processed to extract starch, which is used to make various foods. It is a crucial source of carbohydrates, especially in times of food scarcity. It contributes 5–10 percent of diets in some rural areas, and more in times of food scarcity. It occurs mostly in Melanesia (and is native to Maluku and New Guinea)
Screwpine	*Pandanus* spp.	Screwpine is used widely in Oceania. The fruit of *Pandanus tectorius* and *P. julianettii* are staple foods in many Pacific Island communities. Karuka nuts from *P. julianettii* are highly valued in Papua New Guinea for their nutritional content. *Pandanus* also has medicinal applications, with leaves and roots used to treat various ailments
Wild pig	*Sus scrofa*	This introduced species now occurs throughout Oceania. It is the main game species in the region (see main text and Box 27)
Wild taro	*Colocasia* spp., *C. esculenta*	Although often cultivated, taro also grows wild in forests. It is a significant source of carbohydrates and contributes to up to 20 percent of some traditional diets. It occurs throughout Oceania
Wild yam	*Dioscorea* spp.	Various species of wild yams are harvested in forests in New Guinea. These tubers are rich in carbohydrates and provide essential nutrients, and they contribute 5–20 percent of rural diets in the region. Given their importance, they have been widely domesticated. They occur throughout Oceania

Other contributions of forest foods

Recreation, spirituality and culture. Forest foods are deeply woven into the cultural fabric of societies in Oceania. Many forest plants and animals feature prominently in traditional stories, rituals, ceremonies and gift-giving customs.

The peoples of Oceania have developed intricate relationships with their forest environments, drawing on forest resources for survival and for spiritual and social purposes. Forests have served as natural larders, providing a wide array of foods that have shaped diets, traditions and ways of life across the region.

In Australia, the concept of "bush tucker" encompasses a wide variety of native plants and animals that have sustained Aboriginal peoples for thousands of years. The knowledge of these food sources, passed down through generations, demonstrates an intimate understanding of the land and its seasonal cycles. An iconic example is the witchetty grub, which is the larva of several moth species found in the roots of certain acacia trees. Rich in protein and fat, these grubs have been a staple food source for many Aboriginal groups, particularly in arid regions. Beyond its nutritional value, the witchetty grub holds cultural significance, featuring in Dreamtime stories and traditional ceremonies (Isaacs, 1987). Another important bush food is the macadamia nut, which is native to rainforests in eastern Australia. Traditionally harvested by the Bundjalung people of northern New South Wales, macadamia nuts were a valuable food source and also played a role in trade between groups (Hardner *et al.*, 2009).

The ngali nut (*Canarium indicum*) is a significant forest food in Solomon Islands and other parts of Melanesia. These nutrient-dense nuts have been a traditional food source for thousands of years and continue to play an important role in local diets and economies. Nevenimo *et al.* (2007) found that the nuts are consumed as food and are also used in traditional medicine and as a form of currency in some areas. The harvesting and processing of ngali nuts often involve specific rituals and practices, highlighting their cultural significance beyond mere sustenance.

In New Zealand, the Māori people have a long history of forest resource use, which is reflected in the concept of *mahinga kai* – traditional food-gathering practices and places. The forest, or *ngahere*, has been a crucial source of both food and medicine for centuries. A significant forest food for the Māori is the *kererū* (New Zealand pigeon), which was hunted traditionally for its meat. The birds were prized for their rich flavour, which was influenced by their diet of native berries. Due to conservation concerns, however, hunting *kererū* is now prohibited, highlighting the evolving relationship between traditional practices and modern conservation efforts (Lyver *et al*., 2008). Another important forest food is the *mamaku* (black tree fern), whose young shoots, known as *pikopiko*, are considered a delicacy. The harvesting of *pikopiko* is governed by traditional ecological knowledge, helping ensure the sustainable use of the resource. This practice exemplifies the Māori concept of *kaitiakitanga*, or guardianship of the environment (McGowan, 2015).

In Papua New Guinea, the pandanus fruit is associated with fertility and is often used in ceremonial exchanges (Boster, 1985). An ethnographic study by Townsend (1974) described how the Heve people of the Sepik region organized sago processing camps, with families working together for several days to produce large quantities of sago. These camps serve as food production sites and as important social gatherings in which knowledge is shared and cultural practices reinforced. The pandanus tree (*Pandanus tectorius*) is an important forest resource in Micronesia. The fruit of the pandanus is rich in nutrients and has been a staple food for many Micronesian communities, particularly on atolls, where other crops are difficult to grow. In the Marshall Islands, pandanus fruit is often processed into a dried paste known as *mokwan*, which can be stored for long periods, providing a valuable food reserve in times of scarcity. The preparation of *mokwan* is labour-intensive and often involves the entire community, reinforcing social bonds and transmitting traditional knowledge (Merlin *et al.*, 1994). Beyond its use as food, various parts of the pandanus tree are used in traditional crafts, including the weaving of mats and baskets. This multifaceted use of pandanus underscores the interconnectedness of forest resources with various aspects of Micronesian life.

Breadfruit, known as *mai* in many Micronesian languages, is arguably the most culturally significant forest-sourced food in the region. Although often cultivated, breadfruit trees also grow wild in forest areas; in such areas, they are considered a crucial resource for food security. On the island of Pohnpei, for example, breadfruit plays a central role in the traditional calendar, with different varieties ripening at different times of the year. The harvesting, preparation and consumption of breadfruit are accompanied by various cultural practices and beliefs. For instance, the first breadfruit of the season is often reserved for community elders or offered in religious ceremonies (Ragone, 2011). The cultural importance of breadfruit extends beyond its use as food: in many Micronesian societies, the wood of the breadfruit tree is used for canoe building, and its bark is used to make tapa cloth. This multipurpose use of the breadfruit tree exemplifies the holistic approach to forest resources in Micronesian cultures.

In Australia, Aboriginal hunting practices are integral to cultural identity, subsistence and traditional ecological knowledge transfer (Altman and Biddle, 2014). Non-Aboriginal hunting in the country primarily serves recreational and commercial purposes. In 2019, there were an estimated 640 000 recreational hunters in Australia, who mostly hunted wild pigs, deer, rabbits, foxes and waterfowl (RMCG, 2019). Not all this hunting is in forest areas.

Challenges, opportunities and recommendations

Knowledge gaps exist on linkages between forest foods and FSN. The absence of a universally accepted classification system (see Box 2) for forest foods and other forest products hinders data collection and obfuscates comparisons between studies and regions. This, in turn, makes it difficult to aggregate data and draw meaningful conclusions about overall consumption patterns, nutrient content and sustainability. Information is lacking in various areas, including:

- the quantities of species consumed;
- the nutrient content of many (if not most) wild species;
- sustainable harvest levels for different types of forest food; and
- how different types of forest management systems affect people's access to forest foods.

Future research could address these key knowledge gaps with a view to generating information for policymakers and supporting local communities in their efforts towards conservation and the sustainable use of nutrient-rich forest foods.

Often, the identification, preparation and sustainable management of forest foods are integral aspects of traditional knowledge systems and practices and are passed down and refined over many generations (Vinceti *et al.*, 2013). Traditional knowledge linked to forest foods can be used to ensure and promote diverse, nutrient-dense diets in rural areas with limited market access to healthy food products. In many cases, however, traditional knowledge related to wild foods is vanishing due to deforestation, the loss of wild habitats, the commercialization of food systems and changes in food preferences among younger generations (Borelli *et al.*, 2020; Olesen *et al.*, 2024a; Powell *et al.*, 2015). Also, in some places, foods themselves are at risk from climate change and overharvesting. Rising sea levels, the increased frequency of extreme weather events, and changing precipitation patterns threaten both forest ecosystems and the communities that rely on them. This is particularly acute in the low-lying islands of Micronesia and Polynesia (Nurse *et al.*, 2014).

The challenges and opportunities faced by local communities in relation to the declining consumption of forest foods are highly dependent on context. Generating sound guidelines for ensuring sustainable wild harvests and avoiding the overexploitation of forest resources requires deep-rooted knowledge in the specific localities – both in terms of the carrying capacity of ecosystem services and the nutritional status of communities. It is important to provide education on and raise awareness about the importance of forest foods for FSN and to empower Indigenous Peoples and rural communities to care for and value wild foods. Strengthening traditional food systems is a crucial way to protect forests and forest foods from unsustainable harvesting and overexploitation.

4. POLICY FRAMEWORKS AND INTERNATIONAL INITIATIVES

KEY MESSAGES

- To help ensure food security and nutrition globally and maintain ecosystem services, the world's agrifood systems must be capable of sustainably producing more diverse and nutritious foods and other products without precipitating forest or biodiversity loss. This requires efficient and sustainable resource use and intensification and the integration of landscape perspectives into agriculture and forestry.
- The Committee on World Food Security produced the Policy Recommendations on Sustainable Forestry for Food Security and Nutrition in 2017 with the aim of strengthening the contributions of sustainable forest and tree management to food security and nutrition. Six of the recommendations address the integration of agricultural and forest management policies.
- The utility of the Committee on World Food Security recommendations is seen in the progress made by five countries (China, the Dominican Republic, Morocco, Türkiye and Uruguay) in managing forests to ensure their contributions to the four aspects of food security (availability, access, utilization and stability), in line with the recommendations.
- Exports from low- and middle-income economies now account for more than one-third of global agrifood trade, creating economic growth and job creation in these countries but placing natural resources at risk. Countries and companies could establish supply-chain regulations that address deforestation and forest degradation to mitigate harm and maintain the crucial connections between agriculture and forestry.
- A lack of cross-sectoral coordination between forestry and agriculture hinders land and forest management and can negatively affect food security and nutrition. Opportunities exist to boost such coordination, with the potential to benefit both agriculture and forestry and to amplify understanding of the latter's role in ensuring food security and nutrition worldwide.

Policy and legal frameworks as a catalyst for change towards food security and nutrition

Well-developed policy and legal frameworks are essential for ensuring that forests contribute effectively to FSN. They should provide guidance for the sustainable management and use of forest resources, secure the rights of forest-dependent communities and Indigenous Peoples, and enable access to forest foods, NWFPs and wood energy for cooking and water sterilization. Frameworks will be most effective when they link forestry, agriculture, nutrition, health and environmental policies to support integrated and sustainable food systems.

Key elements of an effective framework include:

- **recognition of customary and community rights** (Box 28) – formally acknowledging the tenure and sustainable-use practices of local communities and Indigenous Peoples to ensure equitable access to forest foods, medicinal plants and other resources that support nutrition and livelihoods;
- **access and benefit-sharing** – defining who can use forest resources under what conditions and understanding how benefits are distributed to strengthen local livelihoods and economic access to food;
- **procedural safeguards** – ensuring that communities can access information, participate in decision-making and resolve disputes, thus empowering them to sustainably manage forest resources and protect their food security;
- **cross-sectoral coherence** – harmonizing forestry, agriculture, land tenure, wildlife, nutrition, health and environmental policies to enable coordinated actions that enhance the stability, resilience and diversity of food systems; and
- **integration into national strategies and SDGs** – reflecting forests in national food security, nutrition and agricultural strategies, aligning with SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land) to maximize their contributions to FSN.

By combining clear policy guidance with effective legal instruments, the policy and legal framework will empower communities to sustainably manage forest resources, enhance livelihoods, improve dietary diversity and strengthen long-term food security. It will also provide a foundation for implementing international recommendations, such as the CFS's Policy Recommendations on Sustainable Forestry for FSN, made in 2017, and for participating in cross-sectoral dialogues and integrated land-use planning.

Box 28
The Sustainable Wildlife Management Programme's Legal Hub

The Sustainable Wildlife Management Programme's Legal Hub, an FAO-led initiative, is a free online platform designed to strengthen and harmonize legal and policy frameworks that support the sustainable management of natural resources and ecosystems while contributing directly to food security and nutrition. By providing open access to legal information on topics such as land tenure, ecosystem management (including forests, savannahs and wetlands), wildlife management, wood, non-wood forest products, animal production and food safety, the Legal Hub helps countries address tenure rights and promote equitable access to resources, thereby providing an essential foundation for building resilient agrifood systems.

Source: FAO, CIRAD, CIFOR-ICRAF & WCS. 2023. Legal hub. In: *SWM: Sustainable Wildlife Management Programme*. Food and Agriculture Organization of the United Nations (FAO), French Agricultural Research Centre for International Development (CIRAD), Center for International Forestry Research–World Agroforestry (CIFOR-ICRAF) and Wildlife Conservation Society (WCS). https://www.fao.org/in-action/swm-programme/legal-hub/en

Global frameworks and initiatives

Various global policies, frameworks and initiatives (Box 29) guide countries in leveraging forests and trees to support sustainable and resilient food systems, FSN and livelihoods. These instruments provide targets, guidance and platforms for action and help align forestry, agriculture and food system strategies with the 2030 Agenda for Sustainable Development. The SDGs provide a guiding framework for addressing FSN and forestry challenges.

The following three SDGs are particularly relevant:

- SDG 1 (no poverty) focuses on reducing poverty and ensuring fair access to resources, many of which are tied to forests.
- SDG 2 (zero hunger) emphasizes ending hunger, achieving food security, ending all forms of malnutrition and promoting sustainable practices in agriculture and forestry.
- SDG 15 (life on land) highlights the importance of protecting forests, conserving biodiversity and restoring ecosystems to support sustainable food systems.

Box 29
International frameworks and initiatives supporting forests for sustainable food systems

A wide range of international frameworks, agreements and initiatives are helping unlock the potential of forests and trees to support sustainable and resilient food systems, food security, nutrition and livelihoods. They include global biodiversity and climate commitments, restoration and conservation initiatives, and multisectoral programmes that integrate forests into sustainable development strategies. Key instruments include the following:

- Forest-related targets under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (ongoing since 1975; updated periodically);
- Kunming–Montreal Global Biodiversity Framework (2022);
- Paris Agreement (2015) and nationally determined contributions, including forest-related actions;
- 2030 Agenda for Sustainable Development and the Sustainable Development Goals (2015–2030);
- Bonn Challenge (2011) and other forest restoration commitments;
- Glasgow Leaders' Declaration on Forests and Land Use (2021);
- Global Forest Goals of the United Nations Strategic Plan for Forests (2017–2030);
- Land degradation neutrality targets of the United Nations Convention to Combat Desertification (2015–2030);
- One Health approach and the Quadripartite One Health Joint Plan of Action (2022–2026);
- Secretary-General's Initiative on Turning the Tide on Deforestation (2021), including the Joint Call to Action for Forests towards 2030;
- United Nations Decade on Ecosystem Restoration (2021–2030); and
- United Nations Decade on Family Farming (2019–2028).

The 2021 Glasgow Leaders' Declaration on Forests and Land Use (Government of the United Kingdom, 2021a), made at the 26th Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC), reaffirmed political commitments to halting and reversing forest loss and land degradation by 2030 while delivering sustainable development and promoting an inclusive rural transformation. The declaration promotes linkages between agriculture and forestry through recommended actions, including to implement or redesign policies and programmes to incentivize sustainable agriculture, promote food security and support the environment. Sustainable forestry underpins sustainable agriculture, which in turn is crucial for FSN. In view of their intrinsic links, policies related to forestry, agriculture and FSN should be cross-sectoral and coherent with applicable laws and regulations.

One Health is an integrated, unifying approach that recognizes the close interconnections among the health of people, animals and the shared environment, including ecosystems. By promoting collaboration across human medicine, veterinary science, environmental science and other disciplines, the approach seeks to sustainably balance and optimize health outcomes while addressing challenges such as zoonotic diseases, antimicrobial resistance and ecosystem degradation. Forest foods contribute significantly to diets and livelihoods, but their harvesting, handling and trade can create pathways for zoonotic disease if governance, food safety and ecosystem integrity are weak. Box 30 examines these dynamics from a One Health perspective; it underscores how integrated approaches across forestry, agriculture, public health and wildlife management are essential for maximizing benefits and minimizing risks.

Box 30
Forest foods, zoonotic risk and the One Health perspective

Forest foods, including wild meat and non-wood forest products, play an important role in food security, nutrition and livelihoods for many forest-dependent and forest-adjacent communities. A One Health perspective considers that these benefits are closely interconnected with human, animal and ecosystem health and that risks can emerge when the linkages are disrupted.

Wild meat provides high-quality protein and essential micronutrients, particularly in remote areas with limited access to domestic animal-source foods. Zoonotic disease risks arise along the wild-meat value chain, from hunting to butchering, transport, sale, trade and consumption. These risks tend to increase where wildlife populations are stressed by habitat loss, hunting becomes commercialized to supply urban or cross-border markets, and food safety, veterinary surveillance and public health systems are weak. Under such conditions, contact among humans, wildlife and domestic animals can facilitate the transmission of harmful pathogens.

Health risks may also arise from the misidentification of plants and fungi, microbial contamination during drying or storage, and unsafe preparation methods. Traditional ecological knowledge plays a crucial role in mitigating these risks; its erosion, combined with increased commercialization and environmental degradation, can heighten health hazards.

From a One Health perspective, forests can contribute positively to food security and nutrition only when they are healthy, wildlife populations are sustainably managed, and harvesting, handling and consumption practices are safe. Forest foods should therefore be understood as conditional safety nets, not as inherently benign or unlimited resources. It is essential to strengthen forest governance, maintain ecosystem integrity, support traditional knowledge and improve food safety and veterinary and public health systems to maximize the benefits of forest foods while minimizing risks to people, animals and ecosystems.

In Africa, FAO collaborates with the World Health Organization and the World Organisation for Animal Health to mitigate zoonotic risks and prevent outbreaks of Ebola. Efforts include training wildlife rangers and communities to identify signs of disease in animals, promoting safe handling practices for potentially infected wildlife, and strengthening laboratory capacities for rapid disease diagnosis.

Sources: FAO. 2026. One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, plants, animals and ecosystems. In: *Food and Agriculture Organization of the United Nations*. https://www.fao.org/one-health/; FAO. 2026. One Health: A healthy future for forests. In: *One Health*. https://www.fao.org/one-health/highlights/healthy-future-for-forests/

The Forest, Agriculture and Commodity Trade (FACT) dialogue (Government of the United Kingdom, 2021b) released a roadmap for action at UNFCCC COP 26 to promote the sustainable development and trade of agricultural commodities while protecting and sustainably managing forests and other ecosystems. FACT has evolved further through an action area of the Forest and Climate Leaders' Partnership, launched at UNFCCC COP 27. The first Global Stocktake of the Paris Agreement (concluded at UNFCCC COP 28 in 2023) also emphasized the importance of halting and reversing deforestation and forest degradation. Finally, the Global Forest Goals and the United Nations Strategic Plan for Forests 2017–2030 also address key elements of food security and nutrition (Box 31).

Box 31
Food security and nutrition in the Global Forest Goals of the United Nations Strategic Plan for Forests 2017–2030

A better understanding of the roles forests play in food security and sustainable agriculture at the global, regional and national levels is necessary for improving forest, agricultural and food security policies and programmes that reflect those roles.

Improved cross-sectoral policies and programmes will, in turn, contribute to achievement of the Global Forest Goals (GFGs). GFG 2 is to "enhance forest-based economic, social and environmental benefits, including by improving the livelihoods of forest-dependent people", and its five targets refer specifically to the food security of people who are dependent on forests. GFG target 2.3 is to significantly increase the contributions of forests and trees to food security, and GFG target 2.4 is to significantly increase the contributions of the forest industry and ecosystem services to development. Forests provide a source of income for an estimated 80 million people worldwide, including those in formal employment and forest owners, through employment in forest enterprises and the sale of timber, fuelwood, charcoal and non-wood forest products. Income earned from forest products helps people buy food, thus improving their food security and livelihoods.

Sources: FAO. 2022. *The State of the World's Forests 2022*. Rome, FAO. https://doi.org/10.4060/cb9360en; Lippe, R.S., Gurbuzer, Y., Carrillo, P., Schweinle, J., Katajam.ki, W., Pekkarinen, A. & Walter, S. 2026. *Updated methodology to quantify forest-sector employment: Global and regional estimates*. Rome and Geneva, FAO and ILO. https://doi.org/10.4060/cd8905en; United Nations. 2017. United Nations Forum on Forests. In: *Department of Economic and Social Affairs Forests*. [Cited 4 March 2025]. https://www.un.org/esa/forests/documents/un-strategic-plan-for-forests-2030/index.html

Together, these and other frameworks and initiatives reinforce the crucial role of forests in achieving FSN, climate resilience and sustainable development while providing platforms for cross-sectoral coordination, knowledge-sharing and policy coherence.

Plenary during the Fifty-second Session of the Committee on Food Security

CFS policy recommendations on sustainable forestry for food security and nutrition

The CFS adopted policy recommendations in 2017 on sustainable forestry for food security and nutrition (Committee on World Food Security, 2017),[15] based on a report of the High-Level Panel of Experts on Food Security and Nutrition on sustainable forestry for food security and nutrition (HLPE, 2017). The recommendations underscore the crucial role of forests in building resilient and sustainable food systems by promoting sustainable forest management, biodiversity conservation and the integration of forestry into national food security and nutrition strategies. They are aligned with the broader goals of reducing hunger, strengthening livelihoods, addressing climate challenges, emphasizing practices that enhance resilience, and ensuring the fair and equitable distribution of forest resources, with particular attention to forest-dependent communities, Indigenous Peoples, smallholders and vulnerable groups.

Case studies of five countries[16] (China, the Dominican Republic, Morocco, Türkiye and Uruguay) were prepared for the present report to examine progress against the following six of these recommendations, which are directed specifically at countries for the development, implementation and monitoring of integrated agricultural and forest management policies:

1. Promote an integrated approach, including the nexus among forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales, by reinforcing cross-sectoral coordination through a participatory and inclusive process.
2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

[15] The recommendations are available at https://www.fao.org/3/I8877EN/i8877en.pdf.

[16] The five countries reviewed in this report (China, Dominican Republic, Morocco, Türkiye and Uruguay) were selected because they met the following four criteria:
1. The country is included in the FAO State of the World's Forest 2016 report as having increased forest cover by more than 10 percent from 1990 to 2015 while also increasing food security during that timeframe (FAO, 2016b).
2. The country is making progress on achievement of SDG 1 (no poverty), listed on the Sustainable Development Report map under "SDG achieved" or "challenges remain" (Sustainable Development Solutions Network, 2024a).
3. The country is making progress on achievement of SDG 2 (zero hunger), listed on the Sustainable Development Report map under "SDG achieved" or "challenges remain" (Sustainable Development Solutions Network, 2024b).
4. The country has forest cover greater than 10 percent, according to data in the 2020 Global Forest Resources Assessment (FAO, 2020c).

3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities which negatively impact FSN.
4. Develop and promote participatory forest and trees policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.
5. Promote forest conservation, regeneration of native forests and restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.
6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

The six recommendations were used as parameters for evaluating the progress made by the five case-study countries on strengthening the role of forests and trees in sustainable food systems. The evaluation generated evidence and identified good practices that could be replicated elsewhere. It also highlighted several challenges, including cross-sectoral coordination, balancing competing interests, inclusive policymaking, institutional collaboration, the integration of forests into FSN policies, the translation of normative guidance into actionable measures, data collection and monitoring capacities, and the availability of financial resources.

The challenges and policy gaps found using these parameters were used to identify potential areas for future policy attention and targeted action. Although there was generally positive alignment between actions undertaken and the CFS recommendations, the analysis revealed areas where further efforts are needed to strengthen sustainable forest and tree management for FSN. Thus, the assessment has had the additional effect of raising awareness in the case-study countries about the recommendations, thereby generating an indirect capacity-building benefit.

This approach – using the CFS policy recommendations as a framework for monitoring national progress, identifying policy gaps and guiding the development of legislation, policies and programmes – could be extended to other countries. Support measures could include operationalizing the recommendations, integrating them into national policy frameworks, targeting activities at relevant groups and stakeholders, and fostering inclusive decision-making processes to strengthen sustainable forest and tree management for FSN.

China

China has made considerable progress in the protection, conservation and restoration of its forest resources. In 2024, it had a forest area of 247 million ha, which was 25 percent of the land area, and a forest stock volume of 20.7 billion m^3 (Ministry of Natural Resources, 2025). The area of natural forests grew by 18 million ha between 2013 and 2018 and the area of planted forests expanded by 23 million ha between 2013 to 2023; the country's planted forest area is now the world's largest (Ministry of Natural Resources, 2025). China banned all commercial logging in natural forests in 2017 and, in 2022, it designated 30.4 percent of the country's planted forests as ecological forests for protection (National Forestry and Grassland Administration, 2016, 2023). China has also strengthened its review and approval system for forest land conversion (National People's Congress, 2019).

The forest industry in China generated in excess of USD 1.35 trillion in 2023, up by more than 27 percent from 2018. The forest industry has four pillar sectors, each with an output of more than CNY 1 trillion (USD 140 billion): crop forest; wood and bamboo processing; understorey farming; and forest ecotourism (Box 32 presents definitions for some of these terms). The crop-forest and understorey-farming sectors contribute almost one-third of total forest industry outputs. About 90 million farmers – almost 18 percent of the rural population – are engaged in crop-forest cultivation and food production (National Forestry and Grassland Administration, 2025a). In 2023, the food harvested and collected from crop forests amounted to 240 million tonnes, an increase of more than 50 percent in a decade (National Forestry and Grassland Administration, 2025a). China is the top global producer of edible mushrooms, apples, pears, natural honey, walnuts, persimmons, chestnuts and tea leaves, among other forest foods. Forests are also a promising source of oil seeds: as of 2023, youcha (*Camellia oleifera*)[17] was planted on 4.86 million ha. Annual production of youcha oil was 0.8 million tonnes, comprising about 7 percent of the national yield of edible plant oils (National Forestry and Grassland Administration, 2024a).

China has enhanced its coordination of the forest, agriculture and fisheries sectors to increase food supply and achieve FSN. It has been employing the "broader food" concept since 2016 to move beyond self-sufficiency in staple crops such as rice, wheat and corn to meet the broader and evolving dietary needs of its 1.4 billion people by emphasizing variety, nutrition and sustainability (China Daily Global, 2024).

As of 2020, 129.6 million ha of natural forests (93.5 percent of the total natural forest area) was conserved under the Nature Forest Protection Programme. Some 33.9 million ha of land had been afforested and restored via the Returning Slope Farmland to Forest Programme.

[17] Youcha is a tree species native to China that produces woody oilseeds.

Box 32
Definitions related to forest foods in China

Forest

China's 2019 Forest Law includes arbour forests, bamboo forests and shrubs specified by the government. Forests are classified according to their functions as protection forests, special-purpose forests, timber forests, crop forests and energy forests.

Shrubs specified by the government include shrubs with a cover rate higher than 30 percent located in arid and semi-arid areas with less than 400 mm precipitation, above the treeline, in ecologically fragile areas in tropical and subtropical karst regions, and in dry-hot valleys, managed for the purpose of protection or economic benefit.

In the national standard, the Terminology of Forest Resources (GB/T 26423-2010), "forest" is defined as a plant community composed of trees and bamboo with a diameter greater than 2 cm and a canopy cover of more than 20 percent, or shrubs that meet the purpose of forest management, with a cover of more than 30 percent. It includes arbour forests, bamboo forests and mangroves with a canopy cover of more than 20 percent, shrubs specified by the government and the farmland forest network, and forests and trees around villages and houses and along roads and water bodies.

Crop forest

The Forest Law (2009, 2019) defines crop forests as forests managed for the production of fruit, nuts, edible oils, beverages, spices, industrial materials, medicines or other products. According to the China Forestry and Grassland Statistic Yearbook, there are eight categories of crop forest:

1. Fresh fruit – apple, pear, citrus, grape, peach, apricot, litchi, kiwi, longan, etc.
2. Nuts and dried fruit – chestnut, date, kernel-use apricot, persimmon, ginkgo, hazelnut, pine nut, pecan, etc.
3. Beverages – tea, coffee, etc.
4. Spices – Sichuan/Szechuan pepper, star anise, cinnamon, etc.
5. Forest vegetables – bamboo shoots, edible mushrooms, wild vegetables, Chinese toon, etc.
6. Forest medicines – *Eucommia ulmoides*, *Phellodendron*, *Magnolia officinalis*, wolfberry, dogwood, sea-buckthorn, *Schisandra chinensis*, etc.
7. Woody oils – youcha, walnuts, olives, *Xanthoceras sorbifolia*, peony for oil, etc.
8. Forest-based industry materials – lacquer, resin, rubber, etc.

The National Forestry and Grassland Administration collects data on crop-forest products, which are included in the China Forestry and Grassland Statistic Yearbook. The products included in crop-forest statistics varied each year between 2018 and 2023.

Understorey farming

Understorey farming is not defined in forest-related laws and planning. The China Forestry Society developed and published the Terminology of Understorey Farming in 2018, referring to understorey farming as an ecologically friendly economy based on forest, forest land and the forest eco-environment, following the principle of sustainable management and characterized by compound management. It mainly includes understorey planting, understorey animal-raising, the collection and processing of plants and meat products, and forest landscape utilization.

Forest food

There is no unified definition of forest food. According to the National Forestry and Grassland Administration, forest food has three categories:

1. Crop-forest products – the dominant sources of forest food, including woody oils, dried and fresh fruit, nuts, beverages, vegetables and spices. Most of them can be used directly as food.
2. Understorey farming products – products that are planted, raised and harvested under forests.
3. Indirect food – products that can be used as animal fodder, including mulberry trees, *Caragana korshinskii* and *Corethrodendron scoparium*.

The China Forest Ecosystem Development Promotion Association released the Specification of Forest Food Certification in 2015, defining forest food as unprocessed or processed food with animals, plants and microorganisms collected in the wild or artificially cultivated/raised in forest environments. Forest food was further defined in the Specification of Forest Food Certification Technology as edible forest products collected, cultivated or raised in line with the principle of sustainable management in well-managed forests that are raw, free from pollution, healthy and safe.

Forest contributions to food availability

At 240 million tonnes, forest food is the third-largest food source in China, behind vegetables (800 million tonnes) and grains (687 million tonnes) (National Forestry and Grassland Administration, 2025b). These foods from crop forests included 192 million tonnes of fruit (e.g. apple, pear and citrus) in 2024, 14 million tonnes of nuts and dried fruit (e.g. chestnuts and persimmons), 4 million tonnes of tea leaves, coffee beans and other materials for brewing beverages, 2 million tonnes of spices (e.g. Szechuan pepper and star anise), 13 million tonnes of vegetables (dominated by bamboo shoots and edible mushrooms), 6 million tonnes of Chinese medicines that could be used as food (e.g. wolfberry and *Hippophae rhamnoides*), and 10 million tonnes of oil seeds (dominated by walnuts and youcha) (National Forestry and Grassland Administration, 2025b).

Forests are also important sources of honey and certain fruits. Natural honey production in 2023 was 472 221 tonnes, accounting for 22 percent of the world's total (FAO, 2025h). An estimated 44 million tonnes of apples was produced in crop forests in 2023, as well as 19 million tonnes of pears, comprising 88 percent and 94 percent, respectively, of the national total, with the remainder produced on agricultural land. Forests are also a promising source of oil seeds. At the end of 2023, the youcha planting area was 4.86 million ha, and the annual production of youcha oil amounted to 800 000 tonnes, which was about 7 percent of the national yield of edible plant oils (National Forestry and Grassland Administration, 2024a; National Forestry and Grassland Administration, National Development and Reform Commission and Ministry of Finance, 2022). China is the world's largest walnut producer in terms of both planting area and yield. The walnut yield was 3.9 tonnes per ha in 2023,[18] and the total production in the shell was 1.4 million tonnes, accounting for 35 percent of global production. Walnut exports that year amounted to 152 000 tonnes in volume and USD 276 million in value (FAO, 2025h).

[18] The yield figure from FAOSTAT is calculated by dividing the total production quantity of walnut in the shell by the total harvested area of walnut.

Forest contributions to access to food

Forest industry outputs exceeded CNY 9.7 trillion (USD 1.35 trillion) in 2023, up by more than 27 percent compared with 2018 (National Forestry and Grassland Administration, 2023). Among them, crop forests and understorey farming contributed CNY 1.87 trillion (USD 260 billion) and CNY 1.16 trillion (USD 161 billion), respectively. Wood and bamboo processing and manufacturing, including primary wood/bamboo timber product processing and furniture manufacturing, had an output of CNY 2.31 trillion (USD 321 billion) and created jobs for 1.51 million people – especially in coastal economically developed provinces – and produced products for national and international markets with an export value of USD 53 billion. Forest ecotourism also created job opportunities for local people and increased their incomes, contributing an output of CNY 1.84 trillion (USD 256 billion) (National Bureau of Statistics, 2024; National Forestry and Grassland Administration, 2023, 2025b).

The reform of the collective forest-tenure system spurred development of the forest industry, especially in crop forests and understorey farming. Crop forests and understorey farming contribute at least 20 percent of household income in general – and as much as 60–80 percent in poor mountainous areas. Even when farmers decide not to engage in forest cultivation, they can improve their incomes by renting out their land or cooperating with companies that use their land as an investment asset in return for 20–30 percent of company shares.

Forest contributions to food utilization

The country's rapid economic development, large population and increasing urbanization have placed the food supply under tremendous pressure. China is dependent on food imports, especially for edible vegetable oil. The country imported 8.2 million tonnes of edible vegetable oil in the first eight months of 2021, up by 14.4 percent from the previous year, and it is estimated that imports will continue to grow through 2030 (Businesswire, 2021). Thus, China has attached great importance to crop forests to increase edible-oil security and improve the edible-oil consumption structure, including for tea oil and walnut oil.

The contributions of forest foods to energy increased from 2.3 percent in 2000 to 4.8 percent in 2022. For protein it grew from 1 percent to 2.2 percent over the same period, for fat from 2.8 percent to 6.6 percent, and for vitamin C from 12 percent to 23 percent. Forest-based Chinese medicine has also developed quickly. In Chinese culture, many Chinese medicinal foods are cooked and eaten or added to foods to enhance their nutritional value.

Forest contributions to food stability

Forests in China are significant ecological barriers against sand and wind; they help improve the environment for agriculture production and boost food security. The Three-North Shelterbelt

Programme (1978–2050)[19] has played a major role in food stability, converting sandy land to green land. To date, the programme has established 31.7 million ha of forests, increasing forest coverage in the programme area from 5.05 percent to 13.6 percent of the land area and providing forest ecosystem services valued at CNY 2.34 trillion (USD 325 billion) (Zhang, Zou and Chen, 2023). Among established forests, a protective forest network covering 1.66 million ha has been established to protect 30 million ha of farmland from damage by agents such as wind, sand, hail and frost (National Forestry and Grassland Administration, 2022). Thanks to the programme, average annual grain production has increased by 10.6 million tonnes. At the same time, forests established in the programme area contribute greatly to food stability by producing an extensive range of forest foods. Over the life of the programme, the production of fruit and nuts has increased in the programme area from less than 2 million tonnes to 48 million tonnes, accounting for 25 percent of the national total production of fruit and nuts and a total of CNY 120 billion (USD 16.7 billion) in output, helping more than 15 million people rise from poverty (National Forestry and Grassland Administration, 2022; Yang *et al.*, 2024).

Progress on recommendations

The following updates on progress in the adoption of the CFS recommendations are based primarily on opinions gathered from key stakeholders in the field in China, complemented by supporting documentation.

Recommendation 1. Promote an integrated approach, including the nexus between forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales by reinforcing cross-sectoral coordination through a participatory and inclusive process.

Forests are increasingly recognized in China as a valuable source of foods. The No. 1 Central Document for 2015 proposed that crop forest and understorey farming be developed to intensify the food supply, and the concept of "broader" (multisource) food was officially proposed in 2016, marking shifts from an emphasis on grain production and consumption to a more diverse diet and from merely having enough food to eat to having more healthy and nutritious food (Boehme, 2022; China's State Council Information Office, 2015, 2016). The No. 1 Central Document of 2021 emphasized the rural revitalization strategy, stressing the strict control of land conversion in farmland, forest and water bodies. The No. 1 Central Document of 2023 and 2024 further highlighted the concept of broader food, proposing the establishment of a multisource food-supply system by integrating grain, forest food, fodder and fishery production; requiring sectors to develop action plans; and setting up the monitoring and statistical system.

China's Food Security Assurance Law, which took effect on 1 June 2024, established the broader-food concept and created an institutional framework for the coordination and alignment of forests, agriculture, water and FSN. The law also strengthened water resource management and irrigation

[19] For more information on the Three-North Shelterbelt Programme, see https://sdgs.un.org/partnerships/three-north-shelterbelt-program

facilities to protect irrigation for food production. The 2024 Opinions on Practicing the Concept of Broader Food to Establish Multisourced Food Supply System underlined the importance of establishing a multisource food-supply system through cross-sectoral coordination.

The Outlines for National Land Planning (2016–2030) stress the building of a resource-saving and environmentally friendly society with greatly improved sustainability that encompasses all sectors. The 2021 Fourth Five-Year Period Plan for Promoting Agriculture and Rural Modernization emphasized the coordinated modernization of farming, husbandry, fisheries and crop forests, building an integrated cross-sectoral mechanism to achieve this goal.

The Integrated Ecosystem Protection and Restoration Programme aligns efforts on forest ecosystem conservation and restoration with those on environment and water protection. To further achieve alignment, the Master Plan on Major Projects for the Conservation and Restoration of National Key Ecosystems (2021–2035) highlights coherence among forests, agriculture, rivers, lakes and the marine environment to build ecological barriers against natural disasters for FSN.

Recommendation 2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

From 2017 to 2021, annual forestry financial investment consistently exceeded CNY 400 billion (approximately USD 56 billion) to support the implementation of key forestry programmes. Most of these programmes were completed in 2020/2021 after their objectives were achieved, and annual forestry investment fell to CNY 366 billion (approximately USD 51 billion) in 2022; investment in afforestation and reafforestation decreased, and more resources were directed towards enhancing forest quality.

In 2023, the central government implemented a results-based payment system for youcha and forest-sourced Chinese medicines. Local governments fund infrastructure, technology development and industry-chain growth. The Ministry of Finance and the National Forestry and Grassland Administration continue to subsidize certain youcha planting projects.

In 2017, the State Council began exploring the coordinated use of agriculture-related funds to guarantee fast-paced agriculture modernization and improved rural social welfare. Governments at different levels now pool agriculture-related funds from other sectors to provide enhanced financial support for key agriculture-related programmes and missions (China's State Council Information Office, 2017).

China has increased funding for scientific and technological research and development in forests and, since 2017, it has increased the use of advanced technologies for monitoring forest, agriculture and water resources to ensure FSN. The Heaven–Air–Ground Monitoring Network integrates remote sensing, unmanned aerial vehicles, big data, geographical information systems, laser radar and more to help monitor natural resources and warn of disasters. A terrestrial ecosystem carbon monitoring satellite was launched in 2024 to assist in forest monitoring, conservation, protection and use. Significant efforts have been made by governments at all levels to increase investment and

the use of technology in the production and processing of forest food through, for example, online training, field schools and onsite technical guidance.

China's Forest Law (2019) mandates that local governments include forest resource protection and forestry development in local economic and social development planning. In 2020, the country's Development and Reform Commission released an opinion stressing the prioritization of green development to ensure sustainable resource use.

Recommendation 3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities that negatively affect FSN.

China's Constitution, amended in 2018, states that women enjoy equal rights to men in all spheres of life. The Law on the Protection of Women's Rights and Interests was amended in 2023 to strengthen the protection of women's rights and interests by defining and promoting gender equality across various domains.

The country has enhanced the protection of women's rights and interests in land tenure and management. The No. 1 Central Document for 2019 and 2023 aimed to solve the widespread problem of rural women losing their land rights due to changes in marital status. The Law on the Protection of Women's Rights and Interests (2023) and the Rural Collective Economic Organization Law (2024) further underpinned the land-tenure rights of rural women by providing that married and divorced women retain the right to contract land for management where their original family or new family is located.

China is a large agricultural country, and women are the primary labour force in the agriculture sector, including forestry and fisheries. The number and percentage of women engaged in agriculture, forestry and fishery production are higher than those for men. In 2022, 250 million women aged 16–70 worked in agricultural production and management, exceeding 50 percent of total rural labour (Yang, 2024; Ye, 2024; Zhang and Huang, 2023). Among rural women labourers, 39.5 percent had non-agriculture jobs, an increase of 15.4 percentage points compared with 2010 (All-China Women Federation and National Bureau of Statistics, 2021).

Recommendation 4. Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.

Fifty-five ethnic minority groups inhabit Chinese territory, but these groups are not conceptualized as "Indigenous". The Constitution of China provides for the protection of the legitimate rights and interests of all ethnic groups – including political, economic, cultural and development rights – and establishes regional autonomy in ethnic regions and areas to ensure the self-governance of ethnic groups.

China has experienced rapid urbanization, with the percentage of people living in rural areas dropping from 39.8 percent in 2017 to 33.8 percent in 2023. Rural areas are populated predominantly by women, children and older men, leading to problems such as the abandonment of arable land and low agricultural productivity, threatening food security (Wang, Xu and Shen, 2023). A rural revitalization strategy was implemented in 2018 to transition from quantity to quality in

rural economic development, narrow urban–rural gaps, and modernize agriculture by promoting comprehensive and coordinated rural economic, ecological, cultural and social growth (Geng, Liu and Chen, 2023). The country's rural revitalization plans have motivated farmers to participate in forest conservation, protection, restoration and use. In 2024, the area of collective forest was 146 million ha, 37 percent higher than before the reform. In addition, the mean output of collective forests was triple that from before the reform of the collective forest-tenure system.

Under the framework for rural revitalization, ethnic minorities have more support than the Han people. Thanks to economic development, ethnic minorities in China have, to a considerable extent, reduced their dependence on forests for food, but they have increasingly relied on forests for incomes and livelihoods. Most ethnic minorities settle in mountainous areas, and crop forests provide 60–80 percent of the incomes of people in these areas, according to experts. The Returning Farmland to Forest Programme has encouraged crop-forest planting in the programme area, which mostly comprises remote, poverty-stricken areas populated by ethnic minorities.

Reform of the collective forest-tenure system has increased the scale of forest food production, and innovative carbon trading and value realization have increased the area of managed forests. Forest carbon credits, forest carbon accounts and other innovative carbon-trading mechanisms have motivated farmers to protect and sustainably manage forests, which now store 10.7 billion tonnes of carbon at an annual sequestration rate of 310 million tonnes (National Forestry and Grassland Administration, 2024c).

Income growth has led to improvements in rural diets. The annual consumption per capita of rural people increased between 2017 and 2023 by 3 percent for grains, 18 percent for edible vegetable oils, 25 percent for vegetables, 47 percent for fresh fruit and 70 percent for meat (excluding poultry and aquatic products). Annual consumption per capita by rural people in 2023 was 9.1 kg lower than the national average (60.8 kg) for fresh fruit, but it was the same or even considerably higher for edible vegetable oil, vegetables and meat (National Bureau of Statistics, 2025).

Recommendation 5. Promote forest conservation, regeneration of native forests and restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.

China's Forest Law (2019) set up a governance framework for commercial and ecological forests. Ecological forests, including protective and special-use forests, are subject to stringent protection measures, and understorey farming and forest tourism can be conducted only after a rigorous review and approval process that ensures the preservation of forest ecological functions. The Measure for Delineation of National Ecological Forests (2017) further defines the scope of national ecological forests to strengthen forest protection. Only cutting for tending is allowed in ecological forests under the Forest Law; central and provincial governments allocate funding for ecological forest establishment, tending, protection, management and compensation to non-state-owned entities that hold the use/management rights to the forest.

China has implemented six key forestry programmes since 1998 with the aim of conserving

forests, regenerating native forests and restoring degraded forests, thus increasing and improving forest resources and the ecological environment and reducing the impacts of disasters. These programmes include actions to promote the development of crop forests and understorey farming. They have been promoted and supported by policies and legislation involving land use, financing, science and technology, infrastructure and ecological environment protection. The policies and laws allow farmers to use all forest types, where appropriate, for understorey farming and to lease or transfer the rights to forest land and forests and trees thereon through tendering, auction and negotiation. Farmers have benefited from fiscal measures, taxes and financial support, such as subsidies for forest protection and establishment, low-interest loans, pledged loans, and preferential taxation for the processing of NWFPs. Farmer cooperatives are encouraged, and a model of cooperation among government, banks, enterprises, farmers and insurance agencies has been pursued as a solution to a lack of finance constraining the development of crop forests and understorey farming. China has made considerable efforts to improve infrastructure for forest products, including the sound and stable supply of water, electricity, roads and information technology facilities. Most importantly, a portfolio of policies calls on farmers to conserve and protect forest resources. When farmers allow the use of their forests by other individuals or entities, local forestry authorities are required to coordinate and avoid any loss of or damage to forest resources (key informants; National People's Congress, 2019).

Recommendation 6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

Especially since 2017, China has advocated the alignment of forest conservation and restoration, forest food production, FSN and biodiversity conservation. The National Medium- and Long-term Plan for Natural Forest Protection and Restoration (2025) underscores the significance of natural forest protection and restoration. According to the plan, all ecological forests – some of which are not natural forests – are included in the natural forest management system.

An incentive for providing forest ecosystem services while protecting FSN is the concept of "ecological product value realization" (EPVR) (Huang, Yao and Wang, 2022). To ensure the permanence of forest resources, it is crucial to transform ecological assets into monetary values to motivate farmers to protect and restore forests. The EPVR framework comprises a science-based accounting system, a compensation system and a performance evaluation system. A robust EPVR mechanism is to be established by 2035 to support the green economy and promote sustainable living.

The Regulation on Payment to Ecological Protection (2024) provides three potential compensation methods: (1) fiscal transfer compensation to entities and individuals who protect key ecological function areas, fragile ecological areas and protected natural areas; (2) payments from local governments benefiting from ecological protection and restoration to other local governments taking action to protect and restore ecosystems; and (3) market-based compensation for ecological products and services.

All sectors, and governments at all levels, are encouraged to explore specific actions to motivate

the realization of ecological product values. Forests have economic, social and environmental attributes that make them ideal sources of ecological products. The "ecological products of forests" (EPF) concept refers to products from forest ecosystems with specific economic, social and environmental value (Wang, Xu and Shen, 2023). The Action Plan for Deepening Collective Forest Tenure System Reform (2023) identifies ways to establish the EPF value realization mechanism, with a focus on forest carbon-sink accounting, monitoring and trading, and compensation for forest ecological services.

Challenges

Cross-sectoral coordination is less effective at the community level. Although China promotes a comprehensive approach to food systems, implementing policies effectively at the local level is challenging. Different departments administer forestry, agriculture, water and nutrition and tend to focus on their own responsibilities. Crop forests and understorey farming are governed by the forest and agriculture sectors, although the two sectors have somewhat different policies. For example, some understorey farming subsidies differ, depending on whether they are on forest land or agricultural land, making it difficult to coordinate the sectors.

Large disparities exist in regional capacities to develop the forest food industry. Crop forests and understorey farming have faced challenges related to value addition and market competition. The more developed provinces have made significant investments to promote industrialized, large-scale, science-based and high-value-addition development of crop forests and understorey farming, but developing provinces are reliant primarily on funds from the central government and have fewer resources to support farmers involved in the production of value-added food products. Farmers in these provinces still engage in the small-scale and traditional production of forest foods, resulting in less-competitive production that is more vulnerable to challenges such as long distances to markets, low quality and low yields.

Conflicts exist between forest ecosystem protection and forest food production. China is experiencing uneven development, with eastern coastal provinces richer but less forested than those in the north and west. To protect forest resources, some areas have been classified as ecological forests under strict protection; most such areas are poor, however, and the ecological protection compensation paid by central and provincial governments is relatively low. Falling market prices for timber make forest management less profitable and attractive. This motivates farmers to convert forests with higher ecosystem functions to pure crop forests, which have stronger economic returns. Intensive understorey farming is believed to maintain forest permanence and create higher incomes; without a balanced management plan, however, it has been found to have negative impacts on forests.

Technology, talent and financial support for understorey farming are insufficient. Most

understorey farming is in remote mountain areas and, in many regions, middle-aged women and older men with less education constitute the primary groups involved. Large-scale, intensive understorey farming has been slow to develop. The resultant lack of technological research and development does little to attract young technicians. Given that understorey farming has emerged relatively recently, support for its development is inefficient. No specific funds exist for understorey farming; financial support has been packaged into other programmes, such as the Three-North Shelterbelt Programme and actions to eradicate poverty. Understorey farming remains small in scale, and forest-food production has been hindered by unstable production and quality, high costs and low input–output ratios.

Opportunities

Enhance cross-sectoral cooperation and integration at the community level

- Ensure the success of community organizations in China because they are crucial for implementing and aligning FSN policies, while addressing the need for cross-sectoral approaches to the governance of forestry, agriculture and water.
- Strengthen local linkage mechanisms to ensure that forest policies are fully recognized in the agriculture, water and FSN sectors.
- Initiate coordinated actions to promote communication and collaboration on forest policies.
- If conditions are favourable, merge forestry, agriculture and water into a single bureau, or establish a specific integrated service centre in the agriculture bureau.
- Increase subsidies for sustainable farming and sustainable forest-food production to provide cohesive support across sectors.

Enhance support for the development of the forest industry in underdeveloped areas

- Enhance the payments transferred from the central government specifically for developing and disadvantaged provinces and explore the transfer of payments for ecological protection from eastern provinces to western provinces. These actions would help address disparities in regional capacity in the forest-food industry.
- Create special funds to support the implementation of the policy of "one type of forest food in one city" to facilitate financing for understorey farming. Ensure that these funds focus on infrastructure development in forest areas to ensure adequate access to water supply, transportation, information technology and technical training for large-scale forest industry growth, including forest-food production.
- Foster stronger partnerships between developed and underdeveloped provinces to help create market demand, improve capacity building and enhance information technology for monitoring forest resources and production.

Enhance the balance between forest conservation and the utilization of forest resources

- Enhance forest classification management to address the conflicts between forest resource protection and restoration and the use of forests for timber as well as for food and other NWFPs.
- Use natural forests more sustainably and non-natural ecological forests for food production at an appropriate intensity, with the precondition that understorey farming should not change the attributes and nature of land or damage forests and trees.
- Include understorey farming in the plan for forestland protection and utilization.
- Before large-scale understorey farming is carried out, conduct the necessary environmental and biodiversity impact evaluations.
- Organize capacity-building activities for forest authorities at various levels in developing provinces to help them better understand the relationship between forest conservation and forest use.
- Encourage and subsidize farmers to adopt green production using organic fertilizers and lower quantities of pesticides.

Enhance technological, financial and skilled-personnel support for forest-food competitiveness

- Boost research on applied technologies, including genotype, genome and gene sequencing for the breeding and propagation of excellent varieties of forest crops (Box 32).
- Encourage understorey-farming and crop-forest operators to partner with research organizations and universities.
- Promote joint science and technology breakthrough projects with specific funds for the forest-food industry, focusing on the breeding of excellent varieties, water saving and soil retention, pollution-free disease and pest control, value-added processing, and the fresh preservation of forest-food products.
- Support local forest technology stations with more funds to host technical training, field farmer schools, online discussions and technology-needs investigation.
- Increase the capacity of local communities in areas such as crop-forest management, forest-food marketing, and the application of technology.
- Foster expertise in these fields and thus contribute to the practical advancement of crop forests and understorey farming, ultimately leading to a more robust and sustainable forest industry.

Dominican Republic

According to the 2021 national forest inventory, the Dominican Republic has 1.81 million ha of forest (Ministry of Environment, 2021), dominated by humid broadleaf forests (39.8 percent of the total forest area), dry forests (22.6 percent) and semi-humid broadleaf forests (15.2 percent) (Ministry of Environment, 2021).[20]

Although forests play a crucial role in ecosystem services, dependence on NWFPs for food security is minimal, due partly to the absence of Indigenous Peoples who traditionally relied on forests for their livelihoods. Agroforestry approaches that combine forest management with high-value crops such as coffee and cocoa show potential for supporting food security and strengthening rural economies, although adoption is limited (Inter-American Development Bank, 2019; UNDP, 2024).

Forest contributions to food availability

Forests in the Dominican Republic produce products from which thousands of families obtain benefits that complement other economic livelihoods. One of these is natural honey: the country had 2 334 apiaries and 1 734 beekeepers in 2021 (Polanco, 2022), producing 1 235 tonnes of honey (Alvarado, 2024).

Forest contributions to access to food

In addition to coffee and cocoa, NWFPs such as palms, resins, medicinal plants and oils provide rural groups with supplementary incomes. Wood production creates jobs and economic opportunities for families involved in production chains, facilitating their access to food. The wood sector grew by 13.9 percent per year in the decade to 2022, with the value of production estimated at USD 747 million in that year. The industry consists of 400 businesses providing about 7 000 jobs (Ministerio de Industria, Comercio y Mipymes, 2023). The incomes generated help families purchase food, which is particularly important in communities with limited economic alternatives.

Forest contributions to food utilization

Woodfuel produced in forests in the Dominican Republic is an important energy source. About 25 percent of total energy consumption in urban households is from fuelwood and charcoal, primarily for cooking and heating water. The percentage is significantly higher in rural areas, with 60.5 percent of total energy derived from fuelwood and charcoal (Ministerio de Energía y Minas, 2020). According to the National Statistics Office, the percentage of households using non-clean

[20] According to data compiled for the 2025 Global Forest Resources Assessment, forest area in the Dominican Republic is 2.16 million ha (FAO, 2025i). The area of planted forests grew from 166 100 ha in 2017 to 205 950 ha in 2022, an increase of 24 percent.

fuels (fuelwood, charcoal and agricultural residues) for cooking decreased from 5 percent to 2 percent between 2016 and 2022, although the percentage was up to 19 times higher in rural areas, highlighting the importance of forests for these lower-income populations (Oficina Nacional de Estadística, República Dominicana, 2024).

Forest contributions to stability

Forests in the Dominican Republic are vital for the stability of the water supply and the protection of watersheds, especially in a climate-vulnerable context. Forests regulate water flow and act as natural barriers against floods and landslides, which is crucial for agriculture and therefore food security in rural areas. Forests help mitigate the impacts of droughts and other extreme climatic events on agricultural production, thereby strengthening the stability of food systems (World Bank, 2022). Initiatives are being developed to promote adaptation and resilience in six priority sectors – (1) food security and water security; (2) health; (3) resilient cities; (4) coastal and marine resources; (5) tourism; and (6) ecosystems, biodiversity and forests. These policies consider the country's insular nature and its high exposure to climate change and disasters (Ministerio de Agricultura de la República Dominicana, 2021).

Progress

The following updates on progress in the adoption of the CFS recommendations are based primarily on opinions gathered from key stakeholders in the field in the Dominican Republic, complemented by supporting documentation.

Recommendation 1. Promote an integrated approach, including the nexus among forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales by reinforcing cross-sectoral coordination through a participatory and inclusive process.

The Dominican Republic has made substantial progress in aligning policies related to forestry, agriculture, water and FSN. Through initiatives such as the National Climate Change Programme and the National Plan for Food Sovereignty and Security 2023–2026, the country promotes a multisectoral approach that emphasizes natural resource preservation, watershed conservation and sustainable agricultural practices. Legislative progress is also reflected in Law 589-16, which establishes cross-sectoral coordination through the National Council for Food Sovereignty and Nutrition Security to integrate FSN with environmental management.

Agroforestry systems that integrate forest management with high-value crops such as coffee and cocoa are emerging as sustainable strategies for FSN in the Dominican Republic.

Recommendation 2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

Forest management is under the responsibility of the Ministry of Environment and Natural Resources, and the Ministry of Agriculture oversees key aspects of food security. Both ministries have specialized departments for forest conservation, reforestation, biodiversity and agricultural and livestock production. Interministerial coordination is facilitated through mechanisms such as the AFOLU (agriculture, forestry and other land uses) 2040 Initiative, which promotes sustainable land-use practices throughout Central America, integrating forest conservation and food security.

The National Plan for Food Sovereignty and Nutrition Security 2023–2026, led by the National Council for Food Sovereignty and Nutrition Security, articulates the relationship between forests and food security through a participatory process that emphasizes the role of forest conservation in building climate-change resilience in the food system. The budgets allocated to the Ministry of Agriculture and the Ministry of Environment are relatively low, however, with a significant proportion of the national budget spent on public-debt servicing, education, health and other sectors.

Recommendation 3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities that negatively affect FSN.

The Dominican Republic has made progress in integrating gender perspectives into forest, agricultural and water policies, highlighting the roles played by women in family farming, resource management and climate resilience. Despite these advances, however, significant gender disparities persist, particularly in access to finance, land tenure and formal recognition within these sectors.

The National Plan for Food Sovereignty and Security (2023–2026), the Gender and Climate Change Action Plan and the National Gender Equality Policy in the Agricultural Sector aim to reduce these gaps, with support from organizations such as FAO and the United Nations Development Programme (FAO, 2024a; Ministry of Economy, Planning and Development, 2018; Ministry of Environment and Natural Resources, 2019a). Challenges such as limited resource allocation and structural barriers hinder full implementation, however, especially in rural and family farming contexts. For example, women earn 18 percent less than men for the same work, and the gap is double for working women in a state of poverty (UNDP, 2022). To overcome such challenges, international organizations emphasize the importance of increasing investments and coordinated support for inclusive gender policies to strengthen food security and sustainable development (Ministry of Environment and Natural Resources, 2019b; UNDP, FAO and La Red Latinoamericana y del Caribe de Mujeres Rurales, 2023).

Recommendation 4. Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.

Local communities and small-scale farmers in the Dominican Republic depend on forest products such as woodfuel and mangoes for subsistence and commercial activities. Forest legislation, although recent and designed to incorporate social and environmental elements, is oriented towards industrial exploitation, thus limiting community participation in policymaking.

Agroforestry is a productive system that integrates trees, livestock and crops in a single unit, providing both economic and nutritional benefits. The Ministry of Planning manages regional councils that incorporate local voices in municipal and provincial planning, although the quality of participatory documentation varies. At the national level, the Public Participation Law and the General Environmental Law (64-00) require government projects to undergo consultations and environmental assessments, but community participation in these evaluations needs to be strengthened.

Recommendation 5. Promote forest conservation, the regeneration of native forests and the restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.

The Dominican Republic has implemented agroforestry policies and programmes that aim to balance agricultural production with forest conservation, using systems such as live fences, shade-grown crops, fruit-tree plantations and contour farming; these practices are emphasized in the 2023 National Reforestation and Ecosystem Restoration Plan. Initial efforts have been concentrated in urban areas, with ecologically critical regions such as watersheds receiving less attention.

The country has adopted key programmes such as the Resilient and Low-Carbon Development Strategy and the National Reforestation and Ecosystem Restoration Plan to promote forest conservation, native forest regeneration and the restoration of degraded areas (Ministry of Environment and Natural Resources, 2023). Among other aims, these initiatives work to protect watersheds to ensure access to water. A major challenge is to transform international agreements and resources into concrete actions that directly benefit local communities.

Although participation has increased, territorial implementation could be improved, as could the capacity of universities to generate applied technical knowledge (Ministry of Environment and Natural Resources, 2022).

Recommendation 6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

Incentives for forest ecosystem services have increased, including those boosted by international process such as REDD+ and its results-based payment mechanism for countries. The aim of Law No. 44-18 on Payments for Environmental Services is to protect and sustainably manage ecosystems by providing a legal framework for compensating those who safeguard ecosystem services related to water, carbon and biodiversity (República Dominicana, 2018). The law is implemented through a general regulation stipulating that economic beneficiaries of ecosystem services must pay fees calculated according to resource usage (i.e. volume and type of activity). Beneficiaries include landowners and usufructuaries generating ecosystem services, particularly in priority areas, as well as local communities receiving compensation in the form of direct payments, infrastructure development and strengthened property rights.

Payments are managed by the Ministry of Environment through the MARENA Fund via contracts that establish conservation commitments and are monitored periodically to ensure compliance.

Available resources are used to finance reforestation and restoration programmes, but payments to landowners and usufructuaries have been limited or not yet executed.

Incentives are essential for sustainable agriculture. By encouraging forest conservation, they help maintain ecosystem functions such as water regulation, soil stabilization and biodiversity conservation that sustain agricultural productivity. Stable access to water and fertile soils ensures a consistent local food supply, benefiting rural communities and reducing food insecurity (Ministry of Environment and Natural Resources, 2020).

REDD+ and agroforestry initiatives led by organizations such as Sur Futuro also play a significant role in improving food security by building resilience into rural agricultural systems. Such programmes integrate forestry and agriculture to diversify food sources, reduce dependence on monocultures, and enhance income stability. National reforestation plans complement these efforts by restoring degraded land and protecting watersheds that provide irrigation, which is particularly important in drought-prone areas. Collectively, these programmes strengthen agricultural resilience and contribute to the consistent availability of nutritious food in vulnerable communities.

Regulations in sectors such as mining require the restoration of degraded areas according to environmental standards. The state also intervenes in forest areas affected by fire and pests, working with international organizations such as FAO to implement post-fire recovery strategies. These initiatives reflect a trend towards the integration of economic incentives and restoration policies, thereby reinforcing a sustainable development model that supports agricultural sustainability and food security (Ministry of Environment and Natural Resources, 2022).

Challenges

It is difficult to translate frameworks into effective action. The Dominican Republic has made significant progress in enacting regulations and creating public policies and multisectoral frameworks that integrate forestry, agriculture, water and FSN. Translating these frameworks into more operational and effective actions, and implementing monitoring and evaluation systems, are challenging, however, due to institutional barriers, limited funding, and the need for stronger cross-sectoral coordination, especially at the local level, where policy integration is essential. Given the existing institutional structure, the National Food Sovereignty and Security Council and the AFOLU 2040 Initiative are considered the most suitable entities for improving operational actions and the measurement of results.

Import dependence is too high. The limited cultural awareness of the use of forest products for food in the Dominican Republic adds complexity to the promotion of agroforestry systems and diversified production models that could support FSN. The country meets 84 percent of its food needs through domestic production, but its dependence on the import of wheat, corn and other staple products exposes the country to food sovereignty risks, particularly in the face of climate-related vulnerabilities (National System for Food and Nutritional Sovereignty and Security, 2023).

Monitoring capacity and community participation are insufficient. Regulatory advances, including the Environmental Services Law (Law 44-18) and the AFOLU 2040 Initiative, are positive steps forward, but limited monitoring capacity and the need for more community participation hamper the full potential of policies designed to support forest conservation and FSN. To date, payments for ecosystem services have not been made to landowners and usufructuaries. Progress has been made in fundraising and resource management, which are administered by a fund designed to finance reforestation activities.

Ministries do not adequately coordinate with each other. The ministries of environment and agriculture play complementary roles in managing natural resources and FSN. Resilience-focused policies are somewhat constrained by a lack of interministerial coordination, however.

Budgets are insufficient. The AFOLU 2040 Initiative and similar mechanisms would benefit greatly from a stronger financial foundation to fully achieve their objectives. Additionally, the relatively modest budgets allocated to both ministries, and the significant proportion of national resources directed towards priority areas such as debt service and healthcare, limit the implementation of resilience strategies that could enhance food security through improved forest conservation.

Gender gaps persist. Efforts to integrate gender considerations into agricultural and forest policies have shown substantial progress, but disparities persist in areas such as access to finance, land ownership and formal recognition in these sectors. Initiatives such as the National Plan for Food Sovereignty and Security and the Gender and Climate Change Action Plan represent valuable progress, but structural and resource limitations hinder their implementation, particularly in rural areas. Strengthening financial support and training for women in rural communities is crucial for further enhancing their contributions to FSN.

Opportunities

Strengthen interministerial coordination and financial support

- Strengthen multisectoral platforms by creating a robust financial framework to ensure that resilience-focused and sustainable land-use policies are fully operational. Clearly define roles for ministries and interdisciplinary technical teams to ensure coordinated planning and execution.
- Increase budget allocations to the ministries of environment and agriculture to reduce financial gaps in linking forest conservation and food security and to ensure that the objectives of the National Plan for Food Sovereignty and Nutrition Security and the National Climate Change Policy are met. Integrate gender considerations in line with the Gender and Climate Change Action Plan to strengthen the regulatory and institutional framework to enhance operational actions and the monitoring and evaluation frameworks.
- Supplement state resources with international cooperation and public–private partnerships to support comprehensive national implementation.

Expand community participation and local capacity

- Actively involve local communities in forest and agricultural planning, particularly in ecologically sensitive areas such as watersheds. Programmes should integrate community feedback and local knowledge to ensure that forest conservation and restoration policies align with specific community needs. Strengthening participatory policies will increase local ownership and boost the effectiveness of conservation measures, and targeted training programmes will enhance community capacity to implement and sustain these initiatives.

Strengthen gender inclusion in resource management

- Address gender disparities in forest and agricultural policies by providing targeted financial support, land-access initiatives and training programmes for women, particularly in rural areas. Building on the Gender and Climate Change Action Plan, creating specialized financing channels and technical support programmes for female farmers and forest stewards will enhance their contributions to sustainable resource management and FSN and foster more inclusive growth.

Improve incentive mechanisms for ecosystem services

- Refine and operationalize financial incentive mechanisms to ensure direct compensation for rural communities and landowners engaged in conservation, enhancing the effectiveness of Law No. 44-18.
- Simplify distribution channels and implement transparent and locally accessible payment processes. Expanding awareness campaigns about these incentives and providing guidance on sustainable land management practices will increase long-term participation in forest conservation.

Promote data collection and monitoring

- Invest in comprehensive data collection and real-time monitoring tools to assess ecosystem services, including water regulation, carbon sequestration and biodiversity conservation.
- Establish partnerships with research institutions and non-governmental organizations to enhance monitoring capabilities, and use digital tools and remote-sensing technologies to improve policy impact assessments.

Increase resilience through agroforestry and diversification

- Promote agroforestry systems that integrate high-value crops with sustainable forestry practices, particularly in vulnerable rural areas.
- Establish targeted subsidies and training programmes for cocoa, coffee and other high-value crops to diversify income sources, reduce dependence on monocultures and improve food resilience. Focus agroforestry expansion policies on ecologically sensitive areas, and provide technical assistance and financial support for long-term sustainable adoption.

Strengthen the sectoral integration of ecosystem services

- Encourage the integration of ecosystem services into national development plans and align policies across agriculture, environment, tourism and finance.
- Establish clear coordination mechanisms to ensure that ecosystem services are incorporated consistently into territorial planning. Prioritize sustainable land use over short-term economic expansion in agriculture and tourism, balancing conservation efforts with economic growth. Reinforce the importance of ecosystem services for long-term resilience.

Morocco

Forests in Morocco cover about 9 million ha, which is 12 percent of the national territory. This natural wealth plays a fundamental role in conserving biodiversity, regulating hydrological cycles, combating erosion and desertification, and sequestering carbon. It is also a vital resource for millions of rural people through the harvesting of timber, cork and aromatic and medicinal plants, as well as pastoral activities. Moroccan forests are a popular destination for ecotourism, which provides local communities with additional economic opportunities.

The country's multifunctional forests underpin the rural economy of users and neighbouring populations and perform a wide range of functions, including protection (e.g. soil conservation), regulation (e.g. surface water flows), production (e.g. wood, fodder, fruit, acorns, cork, and aromatic and medicinal plants), and carbon sequestration. The economic, social and environmental roles of forest ecosystems are valued at about MAD 17 billion per year (CESE, 2023).

The forest sector is a key component of the economy, contributing about 2 percent to national GDP (FAO, 2025j) and playing a major role in job creation by providing 8 million–10 million workdays per year, which is equivalent to about 50 000 permanent jobs. The forest sector also contributes to the country's energy and food security and covers about 17 percent of national livestock needs. Forests supply about 30 percent of the national demand for construction and industrial timber and 4 percent of the global cork supply (CESE, 2023).

Argan forests offer significant economic opportunities. The sale of argan oil involves more than 3 million people (1.6 million in rural areas [High Commission for Planning, 2025]), many of whom are women (Degen, 2023; Gebrai *et al.*, 2025). More than 850 women's cooperatives and 500 private companies are involved in the processing and marketing of argan products (Faouzi, 2024).

The country's forest ecosystem services are essential for agriculture, particularly watershed protection and water resource regulation. In 2023, the agriculture sector – comprising agriculture, fisheries and forestry – contributed an estimated 11.1 percent of national GDP and employed 30 percent of the active population (World Bank, 2025).

The aim of the Forests of Morocco 2020–2030 Strategy, launched by His Majesty King Mohammed VI in February 2020, is to make the forest sector more competitive and modern. It sets out a new vision for the development of forest areas through the adoption of an inclusive, sustainable and wealth-creating management model that places forest users at the heart of forest management.

The objectives set for 2030 include the restoration of degraded forests, the expansion of forest cover by 133 000 ha, the creation of 27 500 additional direct jobs per year, and the improvement of incomes from production chains and ecotourism to reach an annual market value of MAD 5 billion.

The strategy is structured around four pillars:

1. the creation of a new model based on a participatory approach involving communities in forest management;
2. the development of forest areas according to their specific resources;
3. the promotion and modernization of forestry professions through the establishment of modern forest nurseries and the introduction of digital tools in forest-sector management; and
4. institutional reform through the qualification of human resources, the establishment of a training and research hub, and the creation of the National Agency for Water and Forests (ANEF).

The strategy involves the development and enhancement of ten national parks to promote ecotourism and ensure economic and social development while fully respecting natural, cultural and territorial heritage.

Forest contributions to food availability

Rural communities in Morocco consume various natural foods, including fruit, nuts, wild mushrooms and, in certain regions, small game. Wild plants such as mallow (*Rumex* spp.), watercress (*Nasturtium* spp.), jujube, carob and arbutus are important dietary components. Many are collected in forests, and others come from riverbeds, agroforestry systems and non-agricultural lands.

Forests provide grazing areas for livestock, thus supporting the production of meat, milk and wool and reducing dependence on purchased animal feed. Forests support beekeeping and produce high-quality honey, including thyme honey and cedar honey.

Moroccan forests supply a wide range of edible plants and nuts, such as acorns, berries and roots. The nuts produced by the endemic argan tree are processed into oil for cooking and food.

Forest contributions to food access

NWFPs, particularly aromatic and medicinal plants, are widely sold on the national market for traditional medicines and processed into essential oils and dietary supplements. Small-game hunting and inland fishing constitute complementary food sources. Many families derive income from forest-based activities (e.g. the production of argan oil and the sale of medicinal plants), which adds to their capacity to purchase foods.

Forest contributions to food utilization

Forest and agroforestry systems in Morocco are essential for the dietary diversity of many people. Nearly all plants consumed in Morocco originate from natural species that thrive in agroforestry systems or in forests and non-agricultural areas.

Forests also produce woodfuel. Despite the gradual transition to gas as an energy source, wood remains important in rural and mountainous areas. Many households still use fuelwood and charcoal to cook certain dishes and bake traditional bread in wood-fired ovens. Annual woodfuel consumption is estimated at 11.3 million tonnes, of which 89 percent is consumed in rural areas and 11 percent in urban areas (Atouk, 2013; CDER, 2008; La Vie éco, 2012). About 6.3 million tonnes (53 percent) comes from forests, but sustainable production capacity is estimated at 3.25 million tonnes.

Forest contributions to food stability

Forest ecosystems support biodiversity, which is essential for pollination, biological pest control and other services that enhance agricultural production. They also help maintain soil fertility, reduce erosion and ameliorate the impacts of drought and floods by regulating the water cycle. Forests play a key role in mitigating climate change and help ensure more stable agricultural conditions. They also serve as habitats for pollinators and natural predators of pests.

Progress

The following updates are based mainly on feedback collected from key stakeholders in the Moroccan forest sector, complemented by available documentation.

Recommendation 1. Promote an integrated approach, including the nexus between forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales by reinforcing cross-sectoral coordination through a participatory and inclusive process.

Morocco promotes a cross-sectoral integration approach and policy alignment that enables coordination among all institutions with mandates related to food security (i.e. agriculture, forestry, water, health and nutrition). The Ministry of Health and Social Protection leads several initiatives on nutrition aligned with national objectives, particularly the SDGs. Joint implementation of the National Multisectoral Nutrition Strategy 2024–2030 – developed with the involvement of all relevant sectors, including agriculture – illustrates this commitment.

Soil erosion affects a significant proportion of land in Morocco, potentially compromising downstream dam storage capacity. To address this, ANEF has implemented a large-scale watershed management programme in coordination with key sectors (agriculture and water). Forests play a central role in watershed protection, and Moroccan policy promotes integrated water resource management to address the impacts of climate change and encourage water conservation practices. Other protection efforts include terracing on steep slopes, conservation agriculture, grazing management, and community engagement in sustainable land management, supported by local and international institutions.

The country's climate policy is designed as a dynamic and inclusive tool to build a resilient, low-carbon future. The National Climate Plan 2020–2030, launched in 2019, is structured around five pillars, including climate resilience and the transition to a low-carbon economy. Building on the momentum of UNFCCC COP 22, the plan defines the country's climate-change mitigation and adaptation road map through to 2030 (Government of Morocco, 2024). Morocco aims to reduce its emissions by 45.5 percent by 2030 and by 77 percent by 2050, notably by strengthening reforestation and integrating climate considerations into all sectoral policies (UNEP, 2025).

Recommendation 2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

The Forests of Morocco 2020–2030 Strategy serves as a fundamental lever for climate-change mitigation and adaptation while also contributing to the achievement of numerous SDGs – particularly those related to poverty reduction, the restoration of terrestrial and aquatic ecosystems, and the promotion of access to sustainable energy.

In addition to national financing efforts, this strategy – recognized as a nature-based solution – benefits from the support of technical and financial partners, including the European Union, the French Development Agency, the World Bank, the European Investment Bank, the African Development Bank, the German Agency for International Cooperation, the German Development Bank, the French Global Environment Facility, Global Affairs Canada, and FAO.

Recommendation 3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities that negatively affect FSN.

Through the participatory approach of the Forests of Morocco 2020–2030 Strategy, ANEF is fully committed to integrating gender considerations in the forest sector. It conducted a gender diagnostic of the country's forest sector to identify key gender issues and modalities for integrating gender into public policies, thereby improving the incorporation of gender equality into the agency's budget programming. The study yielded three major interrelated outcomes:

1. a sectoral gender diagnostic using a participatory, multilevel, multistakeholder approach;
2. recommendations for identifying gender-equality objectives and indicators in programmes to better target public action and address the specific and differentiated needs of communities, particularly those in vulnerable situations; and
3. a roadmap for gender mainstreaming by ANEF in budget programming based on the diagnostic results. By way of illustration, the roles of women in producing argan products are protected by Moroccan legislation; for example, the Interprofessional Argan Federation requires a minimum of 50 percent women among its members, primarily from small-scale operations.

Recommendation 4. Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.

Most Moroccan forests are in mountainous areas. Rights and tenure related to forest lands and resources are controlled largely by ANEF, which strictly regulates use. Management is considered by many to be essential for successful reforestation and the reduction of deforestation and thereby for ensuring the provision of crucial ecosystem services, particularly water for agriculture.

The Forests of Morocco 2020–2030 Strategy provides appropriate responses for conserving and restoring forest ecosystems, enhancing forestry and ecotourism value chains, and improving the quality of life of rural populations by placing user communities at the heart of forest management. To this end, ANEF is deploying significant efforts to:

- establish a network of field facilitators responsible for federating and mobilizing forest users around coordinated intervention programmes;
- promote the emergence of local forest organizations serving as platforms for potential local partners; and
- strengthen participatory local and territorial forest planning through the development of local forest development plans.

Recommendation 5. Promote forest conservation, the regeneration of native forests and the restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.

The forest sector plays a crucial role in combating desertification and conserving the environment in Morocco. Under the Forests of Morocco 2020–2030 Strategy, the aim is to restore forest ecosystems, combined with sustainable and innovative forest management. It targets the reforestation of 600 000 ha using native species and increasing the annual reforestation rate to 100 000 ha by 2030 with a success rate exceeding 80 percent.

Another key pillar is biodiversity conservation through the development of national parks and nature reserves. Major wildlife conservation projects are being implemented to protect and restore threatened species. Among these, Ifrane National Park stands out as a biodiversity jewel. Species reintroduction programmes have been carried out there, and a buffer zone is being developed for ecotourism, with outdoor and sports activities aimed at making the park a renowned ecotourism destination.

Integrated watershed management programmes have enabled extensive anti-erosion treatments. Efforts are underway to combat sand encroachment using appropriate mechanical and biological solutions, including specific plant species.

Morocco has one of the lowest rates of forest fire in the Mediterranean Basin. This reflects the effectiveness of its integrated forest fire management system, which focuses on prevention, awareness-raising, infrastructure development, surveillance, risk prediction, technological innovation and rapid response using efficient ground and aerial resources.

Recommendation 6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

Morocco has launched extensive reforestation programmes to combat desertification and restore degraded ecosystems under the Forests of Morocco 2020–2030 Strategy, which aims to intensify efforts to restore and expand forest areas. ANEF has established an incentive compensation mechanism for grazing exclusion, aimed at involving users of silvopastoral areas targeted for reforestation or regeneration. This mechanism consists of temporarily purchasing grazing rights to protect livestock, new plantations and regenerating areas. It also involves organizing concerned populations into associations or silvopastoral groups and providing them with annual financial compensation. The mechanism improves both forest conditions and the living conditions of local communities, for example by enabling them to purchase livestock feed and by improving water points.

The Forests of Morocco 2020–2030 Strategy recommends increasing compensation from MAD 250 per ha per year to MAD 1 000 per ha per year for forest species and from MAD 350 per ha per year to MAD 1 100 per ha per year for argan trees.

Challenges

Community participation and resource-sharing mechanisms have proved effective and could be further strengthened, particularly to enhance the benefits derived from forest ecosystems. The dynamic is one of continuous improvement, supported by the gradual strengthening of institutional capacities, the adjustment of regulatory frameworks, and the optimization of the design and coordination of incentive mechanisms in favour of local stakeholders.

Soil erosion and issues related to water rights are receiving sustained attention because of their potential and real impacts on agricultural productivity and ecosystem functioning. Policy orientations on integrated water-rights management are progressively and steadily being implemented through an approach adapted to local realities, with notable progress observed across contexts.

The dynamics of collaboration among stakeholders are part of continuously evolving processes that may differ depending on institutional and territorial contexts. The CFS recommendations are progressively being adopted through their gradual integration into policies and programmes. Interministerial and intersectoral coordination mechanisms are being put in place with a view to strengthening the coherence of actions and better leveraging existing complementarities.

Gender-related issues are receiving increased attention. In particular, the forest sector now has a gender action plan aimed at integrating gender dimensions into all forestry projects. This is part of a continuous improvement process that is progressively mobilizing technical capacities, methodological frameworks and institutional practices.

The interactions among different uses of natural resources and conservation priorities are core, with the adoption of adapted approaches aimed at reconciling development and sustainable valorization.

This dynamic is also part of a continuous improvement process, based on a permanent adaptation logic reflecting the diversity of contexts and needs. The need to maintain ecosystem services is integrated into broader action frameworks, with implementation modalities varying depending on the situation. Finally, awareness-raising and support initiatives related to the valorization of NWFPs and sustainable management practices are part of the sustained effort.

Opportunities

Strengthen policy coherence through cross-sectoral coordination

- Improve data collection and promote evidence-based cross-sectoral policy processes in support of NWFPs and agroforestry products.
- Establish monitoring and evaluation systems for multisectoral FSN strategies.
- Strengthen land-use laws to combat desertification and promote sustainable land management.

Integrate forest-related resilience dimensions into agricultural and FSN policies

- Diversify funding sources towards the private sector, public–private partnerships and participatory financing.
- Fund awareness-raising campaigns and training programmes.
- Mobilize international climate finance (e.g. the Green Climate Fund and the Adaptation Fund).
- Establish monitoring and evaluation frameworks to assess financing effectiveness.

Strengthen women's rights and reduce gender disparities

- Expand and strengthen support for women's cooperatives.
- Implement targeted training for women.
- Systematically integrate gender assessments into forestry and agricultural projects.

Provide incentives for forest ecosystem services.

- Ensure the measurement and valuation of forest ecosystem services.

Türkiye

Forests occupy 23.4 million ha in Türkiye, which is about 30 percent of the total land area (FAO, 2025i). The country has faced significant deforestation challenges in the last two decades, losing an estimated 371 000 ha of forest (roughly 1.5 percent of the forest area) between 2001 and 2021 due to agricultural expansion, urban infrastructure development and reservoir construction (Global Forest Watch, 2022). Wildfires are also an issue, burning 140 000 ha in 2021 (San-Miguel-Ayanz *et al.*, 2022). On the other hand, Türkiye is making a huge effort to restore degraded forest land, including by planting multipurpose trees and other plants. Consequently, the country is ranked fourth among all countries globally for its average annual net forest area gain, according to Turkish President Recep Tayyip Erdogan (TRT World, 2025).

Forests play a vital role in supporting FSN in Türkiye, particularly for rural communities living in or near forested areas. They provide a variety of NWFPs that contribute to local diets and nutrition. They also support livestock grazing, especially in regions where agricultural land is limited, helping to maintain meat and dairy production, which are important for family diets and incomes. Around 7.5 million people in Türkiye depend on forests for their livelihoods, with many using them to supplement their food sources and incomes (Yıldırım and Erol, 2024). In times of agricultural downturns, forests act as safety nets, particularly in rural and forest-adjacent communities, by offering alternative food sources and raw materials that can be traded or sold.

Agriculture and forestry are pivotal in the economy, particularly in rural areas. In 2020, the agriculture, forestry and aquaculture sectors collectively reported net sales of TRY 72.4 billion (USD 2.51 billion), supporting 16 500 workplaces across the country (Ministry of Agriculture and Forestry, 2021a). The forest sector employed 95 600 paid workers, with an average monthly income of TRY 3 150 (USD 89.1). Türkiye is the world's top producer of hazelnut, an NWFP. In 2021, hazelnut exports brought in around USD 1.7 billion (total production and trade, including both public and private supply chains) (FAO, 2021a).

The total value of marketed NWFPs in Türkiye in 2019 (public sector only) was about USD 880 million (Ministry of Agriculture and Forestry, 2024). These products are sourced predominantly from state-owned forests, with residents of forest areas and nearby villages the main collectors. According to Article 170 of the Turkish Constitution and other related legislation, "forest villagers" are given priority in collecting, processing and selling NWFPs. In 2019, a comprehensive inventory documented 250 NWFP species on 1.7 million ha, leading to the development of 1 953 NWFP utilization plans for sustainable use and management (General Directorate of Forestry, 2024). The General Directorate of Forestry recorded significant advances in NWFP production and ecotourism between 2019 and 2023, including the completion of 24 ecotourism management plans, a production target of 1.2 million tonnes of NWFPs, and revenue generation amounting to TRY 37 000 000 (about USD 1 million) (Ministry of Agriculture and Forestry, 2024).

Forest contributions to food availability

Forests in Türkiye offer a diverse array of NWFPs – such as nuts, fruit, mushrooms and honey – that contribute to local diets and livelihoods. Seventy-six edible wild plants[21] belonging to 34 families are consumed widely as food in Türkiye (Akbulut, 2022). Türkiye is a leading global producer of nuts, many of which are harvested in forested regions. Türkiye is a global leader in pine honey production, with over 90 percent of the world's supply sourced from Turkish pine forests. This honey provides significant income to local communities, contributing more than USD 30 million to the economy in 2021 (Ministry of Agriculture and Forestry, 2021b). According to the General Directorate of Forestry of Türkiye, which has prioritized the production of organic bee products, 880 honey forests have been established on 101 000 ha of forested land, promoting sustainable apiculture (General Directorate of Forestry Department of Ecosystem Services, undated). The country's forests are also rich sources of mushrooms, particularly in the Black Sea region, where local communities – especially women and children – gather mushrooms such as *Russula delica*, with potential to earn USD 600 annually (up to 10 kg can be collected per person per day, in peak periods). Common morel (*Morchella esculenta*) is a high-value mushroom found in cedar and red pine forests, especially after forest fires.[22] Fresh morels sell for USD 35 per kg, and dried morels can fetch up to USD 700 per kg (FAO, 2020c). Forests also support livestock grazing in areas where agricultural land is limited, supplying essential food resources and acting as a buffer against shortfalls in agricultural production.

Forest contributions to access to food

Mushrooms, honey, medicinal plants and other NWFPs are crucial for generating income and enhancing dietary diversity among forest-dependent communities. According to TURKSTAT data, Türkiye exported about 1 080 tonnes of pine nuts in the first 11 months of 2024, generating an inflow of USD 32.3 million for the national economy (Turkish Statistical Institute, 2024). NWFPs such as wild fruit, nuts, mushrooms and medicinal plants offer alternative food and income sources, particularly in times of hardship (FAO, 2021b).

Forest contributions to food utilization

Edible forest products such as mushrooms, wild berries, nuts and medicinal plants provide essential nutrients, including vitamins and antioxidants, that diversify diets and address nutritional deficiencies in forest-dependent populations (Gee and Borelli, 2022). Medicinal plants collected in forests further contribute to community health by supporting traditional remedies and reducing

21 All these plants can be considered NWFPs.

22 Morel mushrooms (*Morchella* spp.) thrive in post-fire forest environments. Masaphy and Zabari (2013) examined the development of black morel mushrooms in an Israeli forest after a fire in 2006. They found that morels thrived in areas where the burnt forest underwent specific post-fire management activities: clearing away burnt tree stumps, compacting the soil with heavy machinery, and covering the soil with woodchips created ideal microsites for morel growth. According to the authors, these observations highlighted the ecological factors influencing morel distribution and abundance, which is crucial for conservation and management efforts (Masaphy and Zabari, 2013).

reliance on external healthcare resources (OECD, 2019). Access to woodfuel further strengthens food use by providing energy for cooking and preserving food in rural areas.

Forest contributions to stability

Forests help regulate the climate, moderate extreme weather and ensure steady water availability for irrigation, all of which contribute to consistent crop yields. Forests also prevent soil erosion, enhance soil fertility and host pollinators essential for many crops, supporting agricultural resilience and diverse food supplies (Ministry of Agriculture and Forestry, 2024). Forest lands in Türkiye, 99.9 percent of which are owned by the state and protected against privatization, are managed for sustainable use, and the country incentivizes private afforestation and sustainable forest management through grants, low-interest loans and technical assistance. National strategies emphasize agroforestry and sustainable land management practices with the aim of boosting agricultural productivity, promoting environmental health and strengthening rural livelihoods. The country's National Forestry Programme (2004–2023) emphasizes the sustainable management of forest resources to maintain food stability and bolster rural and agricultural resilience in the face of environmental challenges (General Directorate of Forestry, 2023).

Progress

Recommendation 1. Promote an integrated approach, including the nexus among forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales by reinforcing cross-sectoral coordination through a participatory and inclusive process.

Türkiye has focused since 2018 on policy restructuring to enhance sectoral integration, including via the merger of the Ministry of Agriculture, Food and Livestock with the Ministry of Forestry and Water Affairs to create the Ministry of Agriculture and Forestry. Within this ministry, the General Directorate of Forestry is the key agency responsible for implementing forestry policies in Türkiye.

The Eleventh Development Plan (2019–2023) emphasized agriculture and forestry as strategic sectors for sustainable growth and food security, with objectives to expand irrigated land and improve water-use efficiency to counter rising water stress. The Twelfth Development Plan (2024–2028) continues this trajectory by merging agriculture and food security into a unified objective, aiming for an agriculture sector that balances economic, social and environmental priorities. It also highlights the need for unified objectives in agriculture, forestry and water management, prioritizing the efficient use of resources through enhanced technologies tailored for local conditions.

The country's Climate Change Mitigation Strategy and Action Plan (2024–2030) addresses climate-related challenges through collaboration across the forest and agriculture sectors, promoting resilience against desertification, erosion and water scarcity, and prioritizing efforts to manage forest and agricultural lands. The National Watershed Management Strategy (2014–2023) focuses on rehabilitating forested watersheds through integrated management approaches, and the

National Regional Development Strategy (2014–2023) also emphasizes sustainable resource management in rural areas, aiming to create green development programmes for forest-adjacent villages and improve the livelihoods of local people. The Ministry of Agriculture and Forestry's Strategic Plan (2024–2028) highlights sustainable practices, food safety and biodiversity conservation through cross-sectoral policy integration.

Recommendation 2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

Even though policies recognize the vital contributions of forests to FSN, it has been difficult to translate them into practice because the professionals involved continue to work in sectoral and departmental silos. Capacity-building programmes should focus on the roles of trees and forests in soil health, water conservation and climate resilience, with modules tailored to all stakeholders (Selek and Selek, 2020). The country needs robust research on the environmental and economic contributions of forests to agriculture. Collaboration with universities, research institutions and international organizations might be necessary to generate reliable data on the benefits of agroforestry systems to inform evidence-based policymaking and improve resilience assessments (OECD, 2019).

There is no readily available assessment of the funds required to translate policies into practice, enhance institutional collaboration, increase efforts for research and data generation, or organize capacity building. A full assessment of budget requirements is needed to realize the full contributions of forests to FSN in Türkiye. Funding sources should be explored, including the national treasury and international development funding.

The alignment and integration of national development policies into forestry and agricultural policies is a crucial step. There is no ready-to-go analysis or documentation, however, on how relevant policies are aligned or on the proactive measures that could be taken to formulate and amend future policies. Resilience-building practices involving forests and trees should be integrated into the country's National Agricultural Strategy and rural development policies; this could involve revising agricultural policies to promote mixed-cropping systems, sustainable land management and tree cover on farmlands.

The Government of Türkiye has recently developed NWFP guidelines. It could also develop agroforestry guidelines, tailored to the country's varied climate and ecosystems, to inform farmers, extension workers and local authorities on best practices for resilience-enhancing agroforestry and encourage standardized practices for maximum impact. The country's climate action plans and nationally determined contributions under the Paris Agreement could play an important role by highlighting the contributions of forests and trees in agricultural landscapes.

Recommendation 3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities that negatively impact FSN.

The Twelfth Development Plan (spanning 2024–2028) includes policy provisions to encourage women's active participation in economic, social and cultural life and in decision-making

processes, strengthening equal opportunities for men and women. Policy measures to support women span a range of actions, from providing training and subsidizing girls' education to guiding female entrepreneurs, encouraging women's economic participation, and ensuring equal pay for equal work.

The country has a strong overall Human Development Index ranking of 45 (out of 193 countries), but its gender-adjusted ranking is 63, indicating that men enjoy greater development than do women (World Economic Forum, 2024). Türkiye ranks 127 out of 146 countries in the 2024 World Economic Forum Global Gender Gap Index, with a score below the global average. Despite incremental progress in recent decades, women remain underrepresented in politics and various spheres of decision-making. Unpaid care and domestic work pose structural constraints to women's labour market participation, employment and career advancement.

Türkiye has launched capacity-building programmes focused on gender-responsive development, prioritizing support for women-led cooperatives and other rural women's organizations that help rural women access markets, earn incomes and gain skills for economic independence. The country has also introduced nature-based solutions in agriculture, agroforestry and land restoration that include significant female participation. Approximately 38 percent of participants in FAO Farmer Field Schools are women, and vocational training programmes have prioritized female involvement, with women participating at greater rates than men.

Recommendation 4. Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.

Forest management in Türkiye is usually grouped into three main functions: economic, ecological and sociocultural. According to a national study by Eraslan (1982), forest functions include product production, nature protection, erosion prevention, climate protection, hydrological health, community health, aesthetics, ecotourism and recreation, including national defence and scientific functions. Functional planning also includes informing stakeholders and consulting them before implementation. This multifunctional and participatory approach provides a practical way to integrate FSN into forest management by linking forest ecosystem services and NWFP value chains with agriculture, water management and rural livelihoods.

The Government of Türkiye has formulated several policy documents to strengthen participatory forest and tree management, particularly related to NWFPs that can enhance nutrition and livelihoods for local communities, forest villagers and smallholders. The Twelfth Development Plan builds on existing policies to enhance participatory forest management and expand forest-based products and services within a sustainable framework, with a focus on increasing the economic contribution of the forest sector. It outlines several measures to support diversification and sectoral growth and supports private-sector industrial afforestation, emphasizing the use of genetically improved, fast-growing species to provide local employment and help curb migration by increasing opportunities for forest villagers.

Türkiye has institutionalized the monitoring and reporting of sustainable forest management through the national Sustainable Forest Management Criteria and Indicators, coordinated by the General Directorate of Forestry. The aim of the Sustainable Forest Management Criteria and Indicators framework is to support cross-sectoral dialogue and transparency by enabling the tracking, assessment and reporting of forest trends and performance.

The General Directorate of Forestry has been pivotal in advancing individual and cooperative initiatives to strengthen economic and social resilience in forest-dependent communities. Individual beneficiaries received substantial financial support in 2023, including socially qualified support of TRY 105 million (USD 3.0 million) and economically qualified support totalling TRY 1.07 billion (USD 30.5 million). This support reflects the dedication of the General Directorate of Forestry to improving forest community welfare and sustainability.

Under the General Directorate of Forestry, the Afyonkarahisar Medicinal and Aromatic Plant Centre operates to strengthen research, sustainable management and value chains related to forest-based foods and associated products and to increase the knowledge and livelihoods of local women and villagers. The centre is playing a pivotal role in supporting innovation and technology in forest-based foods and associated products.

Recommendation 5. Promote forest conservation, regeneration of native forests and restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.

The country's forest conservation policies are strongly influenced by international commitments, including the SDGs, the Global Forest Goals, and the three Rio Conventions. The Twelfth Development Plan explicitly integrates the Sustainable Forest Management Criteria and Indicators to guide efforts to expand the forest area. The plan reflects the country's commitment to enhancing the contributions of forests to sectors such as health, food, tourism and energy by combating disasters, improving ecosystem services and addressing land degradation.

Forest-sector policies, guidelines and strategies in Türkiye have traditionally been shaped by the country's constitutional guarantee that 99.9 percent of forest land is owned by the state, ensuring that forests are safeguarded from privatization and unsustainable exploitation. Certain permits allow the limited use of forest resources, provided that ownership remains with the state. Policy and legal frameworks support the protection and sustainable use of degraded forests.

The National Forestry Programme (2004–2023) set the strategic direction for forest management. Türkiye ranked sixth among all countries globally for its average annual net forest area gain between 2010 and 2020 (FAO, 2020). The programme also outlined measures to mitigate the impacts of climate change on forest ecosystems, underscoring the importance of resilience and sustainability in forestry practices. Additionally, the programme seeks to combat desertification and erosion and ensure the multidimensional benefits of forests through sustainable management. By integrating trees into agricultural landscapes, agroforestry enhances biodiversity, improves soil quality, and provides economic opportunities for local communities. The programme's emphasis on "sharing and benefiting the community" with forest resources strengthens the role of agroforestry in supporting both conservation and livelihoods.

The National Forestry Strategy (2014–2023) sought to increase forest cover and enhance forest resilience to climate change. It prioritized afforestation and reforestation projects, particularly in degraded areas, and promoted the use of native species for ecosystem restoration. The strategy also encouraged the participation of local communities in forest management, recognizing that sustainable forest management can only be achieved with the active involvement of those who depend on forest resources for their livelihoods.

In its strategic plan for 2019–2023, the General Directorate of Forestry outlined several measures that contribute directly to the conservation, regeneration and restoration of forests. The plan also emphasized the importance of the national forest inventory for providing accurate data on forest resources and guiding conservation efforts.

According to the General Directorate of Forestry (2024), Türkiye established a total of 129 000 ha of new forest areas between 2019 and 2023, including 78 700 ha dedicated to industrial purposes. Private afforestation efforts targeting 25 000 ha received TRY 155 million (USD 4 440 000) in grants, demonstrating the government's commitment to supporting private afforestation initiatives. Significant progress was made in sapling production, with 133 million saplings produced in 2023, alongside the care of 128 million saplings and the collection of 118 tonnes of seeds from various tree species. Rehabilitation efforts were also prominent, with work carried out on a total of 321 000 ha between 2019 and 2023. These efforts are important for ensuring the sustainability of afforestation programmes and the regeneration of native forests.

Performance indicators published in General Directorate of Forestry (2024) for the period 2019–2023 included the following:

- The area of productive forest land expanded from 13.1 million ha to 13.7 million ha, and the volume of wood per ha increased from 73.8 m^3 to 75.9 m^3.
- The area of certified forest grew from 2.4 million ha to 8.3 million ha, indicating the nation's strong commitment to sustainable forestry practices.
- Fire management saw improvement as well, with the area affected decreasing from 2.6 ha to 2.2 ha per fire.
- The income cost recovery of forestry operations improved from 57 percent to 62 percent, reflecting increased financial returns from sustainable forest management practices.[23]

The National Biological Diversity Strategy and Action Plan, published in 2018, recognizes forests as crucial habitats for the country's biodiversity. It calls for the protection and restoration of forest ecosystems to conserve biodiversity and ecosystem services. It also highlights the importance of NWFPs and the need for sustainable harvesting practices to prevent overexploitation. Türkiye has actively integrated forest conservation, the regeneration of native forests and the restoration of degraded forests into climate-change-related policies and strategies.

The National Combating Desertification Strategy and Action Plan (2015–2023) addresses land degradation and promotes the restoration of degraded forests. It emphasizes the rehabilitation of

[23] Nevertheless, forestry in Türkiye is guided largely by social and environmental objectives rather than profit maximization, with significant expenditures on aspects such as ecosystem protection and support for forest-dependent communities, irrespective of direct revenue generation, meaning that financial returns do not fully capture the sector's value.

degraded forest areas, especially arid forests, and calls for breeding plans for in-forest pastures to support the regeneration of forest ecosystems by enhancing their biodiversity and ecosystem services. The plan promotes integrated watershed rehabilitation and management as a key approach to restoring forest landscapes and preventing further degradation.

Recommendation 6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

The Ministry of Agriculture and Forestry's 2017 Forestry Policy Paper emphasized the need for sustainable environmental services from forests, including initiatives to plant drought-resistant tree species and research the ecosystem-level impacts of forestry practices (World Bank, 2017). Further studies could help explain more fully the impacts at an ecosystem level so that mitigating measures can be developed and put in place, helping ensure the ongoing provision of the complete range of ecosystem services from forests.

The Twelfth Development Plan prioritizes sustainable ecotourism expansion and enhanced public access to forest ecosystem services with the aim of strengthening the role of forests in supporting FSN and sustainable agricultural systems. The plan encourages eco-friendly tourism and broadens understanding of forests as multifunctional landscapes that support rural development, biodiversity and sustainable food systems (Ministry of Agriculture and Forestry, 2024).

The National Strategy and Action Plan to Combat Desertification underscores the importance of integrating biodiversity and ecosystem services into forest management practices and monitoring them. The 2018 Energy Productivity Strategy advocates the creation of management systems that deliver comprehensive data on the scope and value of ecosystem services, enabling informed land management decisions by documenting these benefits effectively and making them accessible to stakeholders.

The General Directorate of Forestry has advanced conservation and sustainable management projects that contribute to the delivery of ecosystem services.

Challenges

There is limited cross-sectoral integration and policy coherence. The Twelfth Development Plan takes a more integrated approach by putting agriculture, forestry and irrigation within the "Agriculture and Food" priority area, but forest-sector policies still lack explicit objectives for FSN and do not explicitly mention forestry's role in FSN.

Data gaps on forest contributions to food security are prevalent. The country is actively involved in NWFP management, and the General Directorate of Forestry gathers data on the production of more than 40 NWFPs. Nevertheless, data limitations hinder a clear understanding of the contributions of forests to FSN. A 2020 FAO assessment of NWFPs in Türkiye (FAO, 2020d) provided data on product quantities, prices and economic contributions, but it lacked information on the specific contributions of natural forests to food production. With conventional agriculture taking precedence, the potential of forests to support FSN through NWFPs and other ecosystem services is inadequately acknowledged.

Institutional collaboration is weak. There is insufficient collaboration among the institutions responsible for forestry, agriculture, water and food security, limiting the integration of forests into FSN policies. No formal platform or mechanism exists to facilitate consistent dialogue and collaboration among sectors. The weak interaction between the General Directorate of Forestry and directorates related to agriculture in the Ministry of Agriculture and Forestry exemplifies this issue and illustrates the challenge of implementing integrated solutions for food security that leverage both forestry and agriculture.

Resource assessments have been inadequate for integrating forests into FSN policies. Without a comprehensive assessment of financial and institutional needs, policy support is inadequate to enhance the resilience of FSN frameworks through forests and trees. This leaves the integration of forest-related dimensions into FSN policies and programmes underfunded and low in priority, hindering efforts to create a resilient and sustainable food system.

Local communities and the private sector have had limited participation in afforestation. Despite incentives aimed at encouraging community and private-sector participation in afforestation and agroforestry programmes, engagement remains low. Among the challenges are frequent policy changes (stemming primarily from shifts in regulations governing land use, afforestation incentives and the role of local communities and private actors in forestry activities (Caliskan, Birben and Ozden, 2025; Gençay, Birben and Durkaya, 2018)), restricted afforestation permits,[24] and insufficient loan coverage for land preparation, planting, maintenance and other essential activities. The migration of rural people to urban areas has reduced rural engagement and weakened efforts to involve communities in forestry programmes that could contribute to FSN. The formal establishment of a voluntary carbon marketing system in the country may increase the engagement of the private sector in afforestation activities.

Forest policies and cultural perceptions have a wood-centric focus. Forest practices in Türkiye have traditionally centred on wood production, leading to a limited focus on NWFPs and other forest ecosystem services that could support FSN. This focus is reinforced by cultural perceptions in forestry institutions that limit appreciation of the broader role of forests in food security. The wood-centric approach is rooted in longstanding institutional priorities and cultural perceptions that emphasize timber production. Nevertheless, an opportunity has emerged in a gradual shift – albeit small in scale – over the past two decades towards the increased recognition of NWFPs and ecosystem services in national forestry policies. Significantly, the National Forestry Programme (2004–2023) acknowledged the importance of diversifying forest-based outputs beyond timber, and the Strategic Plan of the General Directorate of Forestry (2017–2021) and subsequent plans have emphasized sustainable forest management, including the promotion of NWFPs such as medicinal plants, resins and beekeeping.

[24] Restrictions on afforestation permits arise mainly from land classification rules, bureaucratic hurdles and environmental concerns. Key issues include:
- **Land-use designations.** Certain lands, particularly pasturelands and protected forest areas, have strict legal restrictions on afforestation to prevent land-use conflicts.
- **Bureaucratic approval processes.** Private-sector actors and community groups often face long approval times and complex administrative procedures to obtain afforestation permits.
- **Balancing conservation and development.** Some restrictions stem from efforts to prevent inappropriate afforestation that could affect biodiversity, water resources and existing ecosystems.
- **Conflicting sectoral policies.** Regulations on agriculture, urban development and forestry sometimes overlap, leading to inconsistencies in afforestation permits.

Opportunities

Better integrate forests, agriculture, water and food security

- Align policies related to forests, agriculture, water and food through participatory and inclusive processes.
- Update sectoral strategies, as highlighted in the Twelfth Development Plan, which advocates an integrated approach and provides opportunities to expand expertise on the role of forests in FSN. Strengthening policy coherence among these sectors will create synergies that increase the role of forests in achieving national FSN objectives.

Strengthen policy, institutional and financial support

- Create a formal meeting on a regular basis among the forestry, agriculture, water and food security departments and ministries to develop and implement integrated solutions.
- Create a coordinating body or interministerial taskforce to bridge gaps between departments, promoting dialogue and joint action on resilience and FSN.
- Tailor training and capacity building to the needs of professionals working at different levels across the various disciplines.
- Undertake a comprehensive assessment of the financial requirements of each of these efforts.

Respect, protect and fulfil women's rights in forestry and agriculture and tackle gender disparities

- Continue addressing gender disparities in forestry and agriculture by strengthening targeted policies and programmes that empower women and enhance their participation in economic activities.
- Focus efforts on expanding women's access to resources, training and leadership opportunities while addressing structural barriers such as unpaid care work and limited land ownership.
- Scale up programmes such as the FAO–Türkiye Partnership Programmes across forestry, agriculture, food and livestock, with particular emphasis on supporting women's engagement in NWFP value chains to boost their economic independence.
- Integrate gender-responsive approaches into all forestry and agricultural policies to advance women's contributions to food security, climate resilience and sustainable development.

Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders

- Enhance participatory forest and tree policies to improve access to nutritionally important forest products for local communities, forest villagers and smallholders.
- Expand legal frameworks to secure forest user rights, increase investment in NWFP value chains and improve market access.

- Establish targeted training and financial incentives to support sustainable practices and professionalization among forest villagers.
- Increase efforts to mitigate rural-to-urban migration by fostering income diversity and creating localized employment opportunities to sustain rural livelihoods.

Promote forest conservation and the regeneration of native forests and the restoration of degraded forests

- Strengthen efforts to conserve forests, regenerate native species and restore degraded lands by enhancing financial support and policies that align with sustainable forest management and international commitments.
- Expand agroforestry systems to enhance biodiversity, improve soil quality and boost rural livelihoods, making them an essential component of the strategy.
- Invest in private afforestation, supported by improved incentives and funding, to complement state-led initiatives and address gaps in land restoration.
- Integrate advanced monitoring systems and community-based approaches into conservation efforts to help ensure the effective protection of forests while addressing land degradation and increasing resilience to climate change.

Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN

- Strengthen incentives for forest-based ecosystem services to enhance sustainable agriculture and FSN.
- Integrate forest services such as water regulation, soil stabilization and pollination into agricultural systems.
- Expand the Forest Ecosystems Monitoring Programme and local community projects with targeted incentives to strengthen forest–agriculture linkages, improve rural livelihoods and enhance FSN.

Enhance monitoring and evaluation for policy and project effectiveness

- Establish a robust system for monitoring and evaluating the impacts of forestry projects, policies and practices to ensure their effectiveness and alignment with stated objectives.
- Establish long-term policy instruments based on reliable data and projections.
- Enhance the operationalization of development and action plans and other national policy instruments to achieve intended outcomes.
- Root policies in reliable projections and data, with clear prioritization and financial feasibility analyses.

Uruguay

Deforestation in Uruguay is close to zero, due largely to policies on sustainable forest management and forest conservation. The country continues to focus on conservation and the expansion of planted forests, minimizing forest-cover loss. The area of planted forest grew by more than 127 000 ha from 2018 to 2024, and native forest cover increased by more than 11 800 ha between 2016 and 2021.

No people in Uruguay depend on forests as a primary food source, and the extraction of NWFPs is limited. About 95 percent of forested areas are owned privately, with varying property sizes.

Forest plantations are integrated into value chains related to pulpwood and solid-wood production. Non-coniferous wood extraction averaged 13.8 million m^3 per year in 2017–2022, and coniferous wood extraction increased from 2.26 million m^3 to 3.14 million m^3 over the same period, an annual growth rate of 6.7 percent (Instituto Nacional de Estadísticas, 2024). Pulp exports were valued at USD 2.54 billion in 2024, up by 34 percent compared with 2023; wood and wood product exports were valued at USD 434 million in 2024, down by 4.6 percent compared with the previous year (Uruguay XXI, 2024a). Pulp exports are expected to surpass beef exports, highlighting the forest sector's growing importance in Uruguay's export structure, driven by the operations of major industrial plants such as Montes del Plata and UPM (Uruguay XXI, 2024b).

Agriculture represented 6–7 percent of the country's GDP in 2019–2022 (Uruguay XXI, 2024c). The agroindustrial sector, including the agriculture subsectors and associated industries, contributed 14–16 percent of GDP in those years (Uruguay XXI, 2024c). Forest production includes the value of timber extraction and related services (Ministry of Livestock, Agriculture and Fisheries, 2023a). Agricultural production amounted to USD 4.47 billion in 2021, and forestry production was USD 958 million, down slightly compared with previous years.

Forest contributions to food availability

Neither native nor planted forests constitute direct sources of food. Although some NWFPs are produced, including honey, mushrooms and fruit (FAO, 2020d), they are not well quantified. The FAOSTAT database shows that natural honey production increased from 8 200 tonnes in 2010 to a peak of 13 800 tonnes in 2020 before declining to 10 500 tonnes in 2023 (FAO, 2025h). Most of the honey (more than 70 percent in most years, and sometimes as much as 90 percent) produced in Uruguay is exported (Ministry of Livestock, Agriculture and Fisheries, 2023b).

Forest contributions to access to food

Forest plantations help create jobs and economic incomes, benefiting thousands of families who, among other uses, allocate these resources to food acquisition. Data published by the Society of

Forest Producers (2026) indicate that the forest sector contributed 5.8 percent to national GDP in 2024 and generated 2.7 percent of total national employment, which translates into 23 200–46 000 direct and indirect jobs.

Forest contributions to food utilization

Woodfuel is one of the main energy sources used for cooking and heating in Uruguay, alongside electricity and liquefied petroleum gas (LPG) (Ministry of Industry, Energy and Mining, 2021). Uruguay has an advanced energy infrastructure, ensuring that nearly 100 percent of the population has access to electricity and liquefied petroleum gas networks. The energy transition has been strongly supported by government initiatives aimed at reducing dependence on woodfuel and improving air quality (ECLAC, 2022). Nevertheless, woodfuel consumption in Uruguay remains high. An estimated 56 percent of households have at least one wood-burning appliance that they use 3–4 times per month in summer (mostly barbecues). Additionally, 54 percent of households use wood stoves or boilers during winter. In 2019, residential woodfuel consumption amounted to approximately 1 million tonnes, with eucalypt the most sold variety. Woodfuel from native forests is consumed on a smaller scale, with its harvesting, transport and commercialization regulated by Forestry Law No. 15.939 (Ministry of Industry, Energy and Mining, 2021).

Forest contributions to food stability

Riparian forests act as natural barriers, protecting agricultural soils from water and wind erosion and thereby preserving soil fertility. A recent evaluation by the National Institute of Agricultural Research found a direct correlation between the presence of riparian forests and increased agricultural yields (Instituto Nacional de Investigación Agropecuaria, 2022). The Ministry of Livestock, Agriculture and Fisheries reported that these forests had significantly reduced soil loss in agricultural areas, regulated water flow, and mitigated the impacts of floods and droughts, thereby ensuring water availability for irrigation (Ministry of Livestock, Agriculture and Fisheries, 2023c). The biodiversity of Uruguayan forests is another crucial factor for food security because it includes a wide variety of pollinators, such as bees and butterflies, that are essential for the production of many crops. A study found that agricultural lands adjacent to forested areas had higher pollination rates, leading to higher fruit and seed production (University of the Republic, 2021). Forests also host numerous natural predators of agricultural pests, reducing the need for synthetic pesticides and contributing to safer and healthier food production.

Progress

Recommendation 1. Promote an integrated approach, including the nexus among forestry, agriculture, water and FSN, to strengthen policy coherence across sectors and at different scales by reinforcing cross-sectoral coordination through a participatory and inclusive process.

Uruguay has made significant progress in implementing regulations and policies to ensure forest protection, increase the area of forest plantations, create consultative bodies for water protection, and issue strategies and regulations that acknowledge the importance of the ecosystem services provided by native forests. The General Forestry Directorate, which is responsible for forestry supervision, management and conservation in Uruguay, operates under the Ministry of Livestock, Agriculture and Fisheries. Although there is no formal interinstitutional coordination mechanism between forestry and FSN, different functions related to this issue are distributed among various government agencies.

Uruguay has begun implementing silvopastoral systems and other mixed forest-use practices in forest plantations and rural areas, combining livestock and forestry activities. These systems and practices cover limited areas but have the potential for expansion. They integrate food production (through livestock farming) with forested areas and represent an approach that could be strengthened to indirectly support FSN. It is estimated that, in 2020, the area under this system covered 6 390 ha nationwide, distributed across 39 identified farms (Sancho, Arocena and Ordeig, 2020).

The National Strategy for Agricultural Development (Ministry of Livestock, Agriculture and Fisheries, 2024a) notes the importance of sustainability in agricultural production systems and promotes practices that integrate production with natural resource conservation, including forests. It emphasizes the need to implement policies that ensure the quality of ecosystems on which production depends (e.g. water resources, soils and biodiversity) and calls for reviewing and adapting environmental regulations to harmonize production with environmental conservation, including through proper forest resource management.

Recommendation 2. Provide the institutional and financial requirements and policy support to integrate resilience-enhancing dimensions of forests and trees into agricultural and food security and nutrition policies and programmes.

Uruguay has an advanced institutional framework, with various bodies involved in implementing policies and programmes related to FSN and forest management. Although no formal interinstitutional coordination mechanism has been identified, significant advances in collaboration have been made through the National Sustainable Bioeconomy Strategy and the platforms proposed by the REDD+ Strategy.

A review of the budget allocations of various public agencies shows that resources assigned to the Ministry of Livestock, Agriculture and Fisheries are relatively low. According to National Budget Law 19.924 (2020–2024), the annual budget for the ministry represented 0.6 percent of the total budget

for current expenditure and investments in 2024. According to interviewees, budget constraints limit the ability of the Ministry of Livestock, Agriculture and Fisheries, the General Forestry Directorate and the National Institute of Agricultural Research to address challenges.

Institutional platforms and mechanisms facilitate dialogue and collaboration among sectors, representing significant progress in coordination and institutional strengthening. For example, a key discussion platform fostering coordinated institutional work is the National Sustainable Bioeconomy Strategy, led by the Ministry of Livestock, Agriculture and Fisheries. The institutional framework established by this strategy could serve as a model for the desired cross-sectoral coordination space because it seeks to diversify the country's production matrix by promoting an economic model based on the sustainable, efficient and innovative use of biological and natural resources.

Recommendation 3. Respect, protect and fulfil the rights of women in the forest and agriculture sectors and tackle gender disparities that negatively impact FSN.

Uruguay has made notable improvements in gender inclusion and women's participation in the agriculture sector, particularly through the National Gender Plan in Agricultural Policies, which has increased women's involvement across value chains, including in the forest sector. The country has a national policy, integrated across multiple sectors, to close the gender gap. The Gender Equality Strategy 2030, for example, which is aligned with the SDGs, acknowledges structural barriers to women's access to resources such as financing, employment and training. The strategy has a defined institutional framework, led by the National Gender Council, the National Institute for Women, and gender offices in each state entity.

Although significant efforts have been made to reduce the gender gap, it is commonly held that inequalities persist in various dimensions, including access to land, employment, equal representation in decision-making positions in both the public and private sectors, and access to financial resources. Uruguay's progress towards SDG 5 on gender equality shows that, although there have been advances, several challenges remain (Sustainable Development Solutions Network, 2025).

According to the country's October 2024 Gender Plan Progress Report, 80 percent of the goals have been achieved (Ministry of Livestock, Agriculture and Fisheries, 2024b). However, interviewees stated that gender biases persist, with lower representation of women in leadership positions, challenges in land ownership, and employment inequalities.

According to gender statistics published by the Ministry of Social Development, men are overrepresented in certain economic sectors, particularly agriculture (79.9 percent men) and transport and storage (82.3 percent men). On average, women in the agriculture sector earn 76 percent of what men earn (Ministry of Social Development, 2021).

Recommendation 4. Develop and promote participatory forest and tree policies and management planning and measures that enhance access to nutritionally important forest food products for Indigenous Peoples and local communities and smallholders.

The implementation of forest policy by the Ministry of Livestock, Agriculture and Fisheries and its Forestry Directorate involves multiple consultative and interinstitutional coordination processes.

Specifically, within the framework of policy implementation and management, the Ministry of Livestock, Agriculture and Fisheries reports on the existence of inclusive rural development programmes, institutional articulation with state entities and the private sector, strengthened programmes for rural women, and programmes for family farming. Although these focus primarily on agriculture, they are also relevant to the forest sector.

The National Sustainable Bioeconomy Strategy, which relates to forest sustainability, was drafted through consultative processes with multiple stakeholders and includes a broad institutional framework.

Recommendation 5. Promote forest conservation, regeneration of native forests and restoration of degraded forests, where appropriate, as well as the development of agroforestry systems.

Uruguay has made strong progress in the protection and conservation of its native forests, but there remains a need to strengthen forest regeneration and restoration efforts and to continue expanding agroforestry systems.

Forestry policy has been effective in maintaining and even slightly increasing the area of native forests. This is supported by the Forestry Law and its regulations, which, among other measures, prohibit logging without express authorization and provide incentives through tax exemptions. In recent years, the Ministry of Livestock, Agriculture and Fisheries introduced the Agro-export Product Certification Project, which proposes a public certification system for production chains in relation to native forest conservation and a platform that facilitates certification, ensuring that agro-export products originate from deforestation-free lands. This initiative is a response to the European Union Regulation on Deforestation-Free Products, which was due to prohibit the import of beef, soy and timber, among other commodities, from deforested lands from the end of 2025.

Recommendation 6. Provide incentives for the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN.

Uruguay has advanced in its REDD+ process and has implemented a conservation policy for protected areas that acknowledges the full value of biological resources and promotes ecological management. In 2022, Uruguay issued its first Climate Change-Linked Sovereign Bond, an initiative that ties the cost of sovereign debt to the achievement of two environmental objectives: reducing the intensity of greenhouse-gas emissions, and conserving native forests, with a commitment to maintaining and increasing the area of native forests compared with the 2012 baseline (Ministry of Livestock, Agriculture and Fisheries, 2023c). All these conservation initiatives strengthen the provision of ecosystem services. Key stakeholders have discussed the role of planted forests in carbon-dioxide absorption, which contributes to achieving a carbon-neutral footprint for the country, particularly given the predominance of livestock activities.

The National System of Protected Areas in Uruguay safeguards ecologically significant regions covering 383 550 ha, representing 1.2 percent of the national territory and including extensive riparian forests. This protected-area network conserves biodiversity and helps ensure the integrity of forest ecosystems, indirectly contributing to FSN by regulating water cycles and protecting soils, which are essential for sustainable agricultural production (Ministry of Environment, 2023).

Challenges

Gender inequalities remain. Although Uruguay has made significant efforts to reduce the gender gap, a common view is that inequalities persist in various dimensions, including access to land, employment, equal representation in decision-making positions (in both the public and private sectors) and access to financial resources. The country's progress measurement for SDG 5 on gender equality indicates that, although advances have been made, several challenges remain (Sustainable Development Solutions Network, 2025).

Many private forests are unregistered. Despite the existence of tax incentives, not all private landowners – particularly those with smaller landholdings – register their forests. This is primarily because registration is costly because it requires hiring professionals to assist in developing a management plan.

Research is insufficient on the impacts of plantations on native forests. Research is needed on the effects of forest plantations on native forests. Some documents highlight possible impacts on grassland ecosystems, particularly medium-sized mammal species (Cravino and Brazeiro, 2021), as well as changes in organic matter, soil acidification, clay composition and nutrient dynamics (Ministry of Environment, 2019). Sufficient resources are needed to enable the study of these impacts and their amelioration.

Native forests are being degraded. A significant proportion of native forests exhibit degradation and change due to factors such as livestock presence, proximity to urban centres, and human activities. It is estimated that just 40 percent of forests have not undergone extensive logging. Human interventions have altered forest density, species composition and genetic diversity, facilitating the invasion of exotic species – ten of which are classified as aggressive woody species. Land-use change, illegal logging and modifications to hydrological regimes have also had significant impacts on biodiversity, particularly in coastal and riparian forests. Insect and fungal infestations exacerbate degradation (Ministry of Livestock, Agriculture and Fisheries, 2018).

Information is lacking on NWFP value, including nutritional benefits. There is a need to improve understanding of species with the potential for medicinal, ornamental or essential-oil use and to deepen knowledge on agroforestry and silvopastoral systems as a balance between forests and livestock production (which remain underdeveloped). Also needed are a legal framework and a methodology for payments for ecosystem services based on forest type and watershed protection (Ministry of Livestock, Agriculture and Fisheries, 2018).

Forest degradation needs better monitoring and research. There is a need to strengthen monitoring and research systems related to forest degradation, a problem highlighted in the National Native Forest Strategy. Current monitoring efforts are focused on watersheds, indicating the need for a more integrated valuation of ecosystem services to ensure budget allocations that reflect the full contributions of forests to national and local sustainability goals.

Opportunities

Promote an integrated approach that links the forest, agriculture and water sectors and FSN and strengthens policy coherence by enhancing cross-sectoral coordination

- Define the institutional architecture for policy coordination to improve the links between forest management and FSN.
- Establish actions for the valorization and promotion of NWFPs and their benefits within a comprehensive framework for forest use and management.
- Update policies to harmonize agricultural production with environmental conservation, including the appropriate management of forest resources.

Meet institutional and financial requirements and provide policy support to integrate forest and tree dimensions into policies and programmes related to FSN

- Review budget programming to ensure sufficient resources for implementing policies related to forest management and their impacts on FSN. This includes monitoring the status and health of forests, researching conservation measures for ecosystem services, restoring degraded forests to promote landscape integration (reducing fragmentation), and promoting silviculture.

Respect, protect and guarantee the rights of women working in the forest and agriculture sectors and address gender inequalities that negatively affect FSN

- Continue implementing the Gender Equality Strategy 2030 and the National Gender Plan in Agricultural Policies, ensuring their specific impacts on the forest sector.
- Continue reducing identified gender gaps, aiming for equal rights and opportunities in terms of access to land resources, employment, income and decision-making positions.

Formulate and promote policies and participatory planning systems for forest and tree management and establish measures that improve access to important forest food products for nutrition, particularly for Indigenous Peoples, local communities and small-scale producers

- Improve incentives to increase the percentage of forest owners with registration and management plans.

Promote forest conservation, the regeneration of natural forests, the restoration of degraded forests and the development of agroforestry systems

- Allocate sufficient resources for conducting scientific studies on the possible impacts of forest plantations on native forest biodiversity, soil degradation and watercourses. Based on this, establish appropriate mitigation measures.

- Define incentives for native forest owners to receive compensation for providing ecosystem services, generating genuine interest in conservation and restoration.

Encourage the provision of forest-based ecosystem services that benefit sustainable agriculture and FSN

- Improve research on native forest ecosystem services.

Cross-sectoral policies and programmes

To help ensure that FSN and meet food and nutrition needs while maintaining ecosystem services, the world's agrifood systems must be capable of sustainably producing more diverse and nutritious foods and other products without precipitating forest or biodiversity loss. Doing this will require efficient and sustainable resource use and intensification alongside the integration of landscape perspectives into agriculture and forestry. The landscape approach seeks to balance agricultural productivity, livelihoods and land uses, including critical forests and wetlands.

Integrating forestry, agriculture and food security and nutrition

As integral components of agricultural landscape systems, forests contribute directly to sustainable agricultural production through a broad range of ecosystem services, including water regulation, soil conservation, carbon sequestration and habitat protection. Much of the world's accessible freshwater, including the water needed for agricultural production, originates in forested watersheds and wetlands.

Rising global agrifood trade has increased stress on the world's forests and other natural resources. International food trade quadrupled between 1995 and 2021, from just under USD 400 billion to nearly USD 1.7 trillion (Lipp, Fattori and Avesani, 2023). Exports from low- and middle-income economies now account for more than one-third of global agrifood trade; although this can boost economic growth and job creation in these countries, it brings with it great risks for natural resources. Supply-chain regulations can help address deforestation and forest degradation while maintaining the essential interconnections between agriculture and forestry.

Challenges and opportunities

Existing forest policies tend to focus on economic efficiency but fail to consider the contributions of forests to FSN. Typically, for example, the conversion of forests to other land uses is justified for economic reasons, with insufficient attention on the long-term environmental and livelihood impacts of this on people (primarily forest communities but also national and global populations).

The lack of cross-sectoral coordination between forestry and agriculture can hinder land and forest management and thus negatively affect FSN. Agriculture is the single largest driver of deforestation, but the conversion of forests to agricultural uses is a land-use decision typically tasked to the agriculture ministry rather than forestry (FAO and European Union, 2017). When ministries of

agriculture preside over food security policies, decisions tend to encourage agricultural expansion into forest lands without taking into account the role played by forests in supporting agriculture and providing food security.

As noted by the Committee on Agriculture at its 29th session in 2024 (FAO, 2024b), opportunities exist to boost coordination and benefit both agriculture and forestry, amplifying the latter's role in helping ensure FSN. These include the following:

- Sectoral policies, programmes and legal frameworks – including those on agriculture, livestock, forests, conservation and environment, land use, water, rural development and FSN – can be aligned and harmonized.
- Improvements can be made in data collection, analysis, monitoring and reporting on land use, land-use change, ecosystem services, sustainable production and other aspects related to the forest–agriculture nexus, as well as on good practices, including agroforestry and agroecology, and accelerating modelling and data analysis.
- Agricultural production can be optimized to reduce pressure on forests in such a way that it can grow alongside the expansion of forest resources (FAO, ed., 2016b), with a net benefit for food security.
- Degraded agroecosystems and forest ecosystems can be restored and the management of planted forests improved; both are essential for reducing pressure on crucial natural biomes and lessening the need to expand the agricultural frontier.
- Research and development can be supported to catalyse innovations and novel strategies, including by incentivizing innovation in farmer-centred management and financing models.
- Land-use governance and planning can be strengthened and improved, including by mainstreaming integrated landscape management approaches and ensuring secure land tenure and other aspects of an enabling environment that benefit Indigenous Peoples, local communities, women and marginalized people.
- Rural community-based institutions can be strengthened to improve access to knowledge, finance, markets and technologies and enhance the entrepreneurial, planning and marketing skills of small-scale producers and producer organizations. The private sector can be engaged in agrifood systems transformation, with a focus on the sustainable management, conservation and restoration of forests.

Recommendations for improving coordination

National economic, social and environmental policies must recognize the importance of sustainable agriculture, food security and sustainable forest management, including their contributions to achievement of the SDGs and the Paris Agreement on climate change. Although conflicts and trade-offs exist, opportunities for synergies and win–win situations are prevalent. For example, concerns about the impacts of population growth on agriculture, food and forests could be alleviated by an analysis of the extent to which food security needs can be met by agricultural intensification

and improved agroforestry; this analysis could then form a basis for the development of land-use conversion targets.

FAO and the European Union (2017) made several recommendations for improving coordination, as listed below. Adopting and implementing these recommendations will require ongoing political will and the close coordination of policies on, for example, forests, agriculture, food, land use, rural development, water and climate change.

- Recognize and strengthen the rights of Indigenous People and other local communities to sustainably use and manage forests and trees outside forests.
- Promote community-based forest management practices with the potential to meet the FSN needs of local people.
- Promote agroforestry and other integrated forest management practices.
- Support smallholders and communities in increasing their incomes from forest and tree products and ecosystem services by enhancing their access to credit, technology, extension services, insurance and markets.
- Develop and strengthen mechanisms for the timely collection and dissemination of data on the contributions of forests to FSN.
- Support research to identify best practices to enhance the contributions of sustainable forest management to FSN.
- Develop forest management guidelines for meeting FSN objectives.
- Adapt forestry curricula to include FSN subjects.
- Provide on-the-job training to forestry staff on the role of forests for FSN.

To maintain momentum for implementing such policy recommendations (once adopted), the following additional steps should be taken (FAO, 2010):

- ensure that institutions and their frameworks are aligned with the recommendations;
- align forest-related legislation and other regulatory provisions;
- develop and adjust action plans, as needed, including for communicating and building capacities; and
- establish financial arrangements and budgets.

5. CONCLUSIONS AND RECOMMENDATIONS

KEY MESSAGES

Twelve recommendations are made, in four areas – policy, management, information and governance.

Policy

1. **Adopt context-specific and integrated policies** that address the primary drivers of deforestation and promote sustainable land-use planning, with inclusive stakeholder collaboration for better food security and nutrition outcomes.
2. **Strengthen and harmonize policy and legal frameworks** to secure land tenure, ensure equitable access to resources and maintain coherence across land, environment, wildlife and forest policy and legal frameworks.
3. **Avoid forest conversion** that undermines biodiversity, food security, nutrition and long-term sustainability.

Management

4. **Promote the sustainable management and use of forest foods** and diversify production systems – including agroforestry, agroecology and climate-smart agriculture – to enhance diets, livelihoods and ecosystem health.
5. **Promote participatory and inclusive approaches** that mainstream gender equality and youth engagement in decision-making processes.
6. **Increase public investment and mobilize diverse funding sources** for sustainable agriculture and forest management initiatives.
7. **Apply robust social and environmental safeguards** to protect communities and ecosystems from adverse impacts that could worsen food insecurity.

Information

8. **Strengthen forest food data systems** by establishing consistent and agreed methodologies that are globally representative, investing in primary data collection, harmonizing datasets on forest foods and building national capacities to better inform policies.
9. **Strengthen investment in research and technology** to improve understanding of the biological and ecological processes that determine forest food availability, address constraints to their sustainable harvesting and enhance processing methods, thereby maximizing their contributions to diversified and nutritious diets.

Governance

10. **Build institutional and human capacity** through education, training and interdisciplinary research to support sustainable forest and food system governance.
11. **Foster multisectoral partnerships** among governments, civil society and the private sector to advance sustainable land management and FSN goals.
12. **Ensure coordinated and cross-sectoral action** at all levels to sustain the vital contributions of forests to FSN.

Forests cover 4.14 billion ha, or 32 percent of the global land area, equivalent to 0.5 ha per person (FAO, 2025a); half these forests are in the tropics. Globally, some 50 000 wild species are used for food, energy, medicine and materials – including around 7 500 wild fish, 31 100 plants, and various fungi, invertebrates and animals – and at least 10 000 wild species are used as food (IPBES, 2022a). Forests provide diverse foods such as fruit, nuts, leaves, wild meat, mushrooms, tubers and insects that enrich diets, supply crucial nutrients and enhance food security and livelihoods worldwide.

The role of forests in FSN is especially pronounced in low- and some middle-income countries. Approximately 3.5 billion rural people – nearly half the global population – depend to some extent on wild species for their livelihoods. For Indigenous Peoples and local communities, forests also serve as vital spaces for spiritual, cultural and communal life.

The importance of forest foods is growing. The global population is projected to rise by nearly 1 billion people in the next 25 years, and agricultural production may need to increase by about 60 percent by 2050 relative to levels in 2005–2007, driven by population growth, rising incomes, and dietary changes (FAO, 2012). Yet just 15 crops account for 90 percent of humanity's energy intake, with rice, maize and wheat making up two-thirds. This dependence on a few calorie-rich but nutrient-poor staples underscores the urgent need for more diverse and nutritious food systems.

The First International Conference on Forests for Food Security and Nutrition, held in Rome in 2013, was a turning point in recognizing the value of forests for FSN. Since then, efforts have expanded to build capacity among countries and stakeholders to manage forests in ways that support the SDGs, particularly SDG 1 (no poverty), SDG 2 (zero hunger) and SDG 15 (life on land). The CFS endorsed a set of voluntary policy recommendations on sustainable forestry and FSN at its 44th session in 2017, another important global step towards aligning forestry, agriculture and nutrition goals.

Momentum can be maintained through research, innovation and better data; Table 3 presents a set of recommendations and action points arising from the present report. Ensuring the long-term viability of forests requires stronger understanding of their value for FSN, underpinned by improved data collection, analysis and accessibility. Evidence-based policymaking depends on data that reflect the contributions of forests to FSN and their other economic, social and environmental roles, as well as on evaluations of how land-use governance and enforcement affect forest-to-agriculture conversion.

For example, addressing persistent data and methodological challenges requires agreed-on approaches and globally consistent classifications for forest-related data – particularly for forest foods. This should be supported by greater investment in primary data collection, improved data harmonization and strengthened capacity in developing countries. Integrating ecosystem services into economic analyses will also help reflect the contributions of forests to FSN and sustainable forest management.

Meeting future food needs demands sustainable land management, improved productivity and the protection of natural ecosystems such as forests. Countries will need tailored policy instruments informed by context-specific drivers of forest use. At present, more than half the forests worldwide (2.13 billion ha, or 55 percent of total area) are under management plans, up by 365 million ha

since 1990 (FAO, 2025a). For the best outcomes for FSN, these plans should make explicit the links between forests and FSN. Where deforestation stems from large-scale agriculture, policies may be needed to regulate land conversion and safeguard tenure; it might also be necessary to revise policies that prioritize short-term economic gains over the long-term sustainability of forests, including the conservation of biodiversity, which underpins ecosystem functions and the ecosystem services that contribute to food security and nutrition**.** Where small-scale subsistence farming drives forest loss, the focus should be on improving practices, promoting agroforestry, and supporting broader strategies for rural development and poverty reduction.

An estimated 1.20 billion ha (29 percent of forests) are managed primarily for production, and 616 million ha are managed for multiple use (FAO, 2025a). Additional areas are designated for biodiversity conservation (482 million ha), soil and water protection (386 million ha) and social services (221 million ha) (FAO, 2025a), all of which support sustainable food and agriculture production.

The sustainable management of forest foods involves practices such as promoting biodiversity-friendly harvesting, supporting Indigenous knowledge systems, and integrating forest foods into national nutrition strategies. Sustainable forest-food systems diversify diets, provide nutrient-rich foods, strengthen rural livelihoods and improve resilience in the face of climatic and economic shocks.

Effective national legislation is essential. Securing forest and land tenure will be key to ensure equitable access as part of promoting sustainable forest management. Cross-sectoral coherence among agriculture, food, environment and forestry policies can enhance decision-making and better address challenges such as population growth and competing land uses. Land-use analyses, for example, can help determine how agricultural intensification and agroforestry might support FSN goals and guide land conversion decisions.

Forest policies often emphasize economic returns while overlooking the contributions of forests to FSN. Forest conversion, although perhaps providing short-term economic gains, risks long-term social and environmental costs – including the loss of nutrient-rich foods, declines in biodiversity, and growth in unsustainable agricultural practices. Degraded ecosystems reduce productivity, constrain water supplies and limit access to woodfuel – all of which should be accounted for in national policy frameworks.

Legal frameworks governing land-use change must be consistent and aligned with broader goals. This is difficult where legal frameworks addressing land rights, conservation and forestry are fragmented. Legal clarity on land tenure and resource rights is essential for effective forest governance.

Integrated land-use planning – at the national, subnational and landscape levels – should include climate-change adaptation measures that enhance ecosystem resilience. These efforts should be informed by technical data and developed through coordination among public agencies and stakeholders. Sustainable management approaches such as agroforestry, agroecology, climate-smart agriculture and adaptive grazing should be promoted through collaborative research and extension systems involving both agricultural and forest actors.

Building institutional capacity is essential for integrating FSN goals into forest governance. Education and training systems play a key role. Universities worldwide should expand forestry programmes and adopt more interdisciplinary, systems-based curricula that reflect challenges such as climate change, conflict, population growth and economic transition. Forest-related research should explore innovative uses of forest foods to improve nutrition and address hidden hunger, including mapping the health benefits of such foods and their dietary potential.

Strong institutions and inclusive governance frameworks are foundational. These should involve local communities, civil society, the private sector and government agencies. Many public institutions, particularly those supporting Indigenous Peoples, smallholders and local communities, require capacity support. Participatory approaches should be promoted to ensure that all stakeholders, especially marginalized groups, play meaningful roles in shaping and implementing land-use policies and programmes. Gender-responsive policies should guarantee access to land and resources and promote women's participation in decision-making and leadership. Youth engagement is equally important and should be supported through training, employment and entrepreneurship opportunities in sustainable forest-based sectors.

Public–private partnerships and civil-society engagement can encourage sustainable land and forest management through certification schemes, corporate social responsibility initiatives and voluntary sustainability standards. Where appropriate, governments should consider transferring forest management rights to communities and smallholders to improve outcomes and strengthen benefit-sharing.

Public investment is essential, especially to catalyse private finance, improve infrastructure for processing and distribution, promote innovation and best practices, and build the capacities of producer and community organizations. Targeted investment in afforestation and reforestation, for example, including assisted natural regeneration, can deliver wider social and environmental benefits such as climate-change mitigation, land restoration, biodiversity conservation, agricultural resilience, access to nutrient-rich forest foods, and improved rural livelihoods.

Diverse sources of funding exist, with potential for further mobilization, including national budgets, forest revenues, payments for ecosystem services, private investment, and development assistance. Safeguards must accompany all investments to avoid unintended social or environmental harm.

The role of forests in nourishing people – especially forest-dwelling and forest-adjacent communities – and sustaining ecosystems calls for coordinated and integrated action. Aligning food, forest, climate and social policies, anchored in secure tenure and inclusive governance, offers a realistic pathway forward. With clear political commitment, forests can be a cornerstone of resilient, inclusive and sustainable food systems for the benefit of all people and future generations.

Table 3.
Recommendations and proposed action points

	Key recommendation	Proposed action points
Policy	Adopt context-specific and integrated policies addressing the drivers of deforestation	Develop national land-use plans integrating forests, agriculture and food security and nutrition by leveraging existing tools and processes (e.g. the FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security and national action programmes under the United Nations Convention to Combat Desertification). Conduct multistakeholder consultations to align local and national priorities, including nutrition objectives, dietary guidelines, strategies for strengthening forest-food value chains, local processing initiatives, forest-based tourism for income generation, and the integration, preservation and strengthening of Indigenous and traditional knowledge for sustainable food use. Prepare regional cross-sectoral policy briefs and roadmaps for forestry, agriculture and food security and nutrition, in collaboration with regional organizations
	Strengthen and harmonize legal and policy frameworks	Review land tenure and forest laws using international legal guidance and ensure that policies support equitable access to forest foods, nutrition-sensitive objectives, and linkages to regional and national forest-food markets. Establish interministerial taskforces for coordination across forestry, agriculture, environment and health/nutrition ministries
	Avoid forest conversion that undermines biodiversity, food security and nutrition	Strive to halt the clearing of primary forests, in alignment with guidance from the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. Incentivize the restoration of degraded lands with payments for ecosystem services and nature-based solutions, prioritizing the production of nutrient-rich forest foods, sustainable wood-energy sources for cooking, and forest-based tourism to support local livelihoods while enhancing ecosystem services that support agricultural productivity
Management	Promote the sustainable management of forest foods and diverse production systems	Promote the sustainable use of nutrient-rich forest foods, especially targeted at younger generations. Support agroforestry and climate-smart agriculture initiatives, prioritizing trees and crops rich in vitamins and minerals. Develop community-based sustainable harvesting programmes for non-wood forest products and nutrition-sensitive forest foods, with training on storage, processing, value addition along forest-food supply chains, the integration of traditional knowledge, and forest-based tourism opportunities. Promote sustainable wood-energy systems for cooking (e.g. improved cookstoves, clean fuel options) to reduce pressure on forests while improving household nutrition and health
	Promote participatory and inclusive approaches	Establish community forest committees with youth and women, including representatives from the nutrition and health sectors and local value-chain, tourism and Indigenous knowledge initiatives. Use digital participatory platforms, such as mobile apps and text messaging, to gather community-level nutrition, forest food, value-chain and traditional knowledge data
	Increase public investment and mobilize diverse funding sources	Allocate government budgets for forest food security initiatives, prioritizing nutrient-rich foods while also supporting income generation, sustainable livelihoods, value-chain development and cultural/traditional food systems. Leverage private and donor funding through partnerships, international development funds and blended finance (e.g. public–private partnerships, the Global Environment Facility and the Green Climate Fund), including nutrition-oriented forest food programmes and sustainable wood-energy solutions. Explore innovative financing such as green bonds for sustainable forest-food landscapes, value chains and tourism development projects
	Apply social and environmental safeguards	Conduct social and environmental impact assessments for all forest-related projects, including the evaluation of food security and nutrition outcomes for local communities. Implement grievance and consent mechanisms to ensure that community rights and access to forest foods, local markets, value chains, traditional foods and sustainable energy sources are protected, for example through REDD+ and national forest programmes

	Key recommendation	Proposed action points
Information	Strengthen forest-food data systems	Enhance national capacities to collect comprehensive data on forest foods, including their nutritional composition, from formal and informal sources, to meet national and international reporting needs and obligations. Develop open-access databases and dashboards showing the availability, consumption, nutrient content and market potential of forest foods for policymakers, researchers and communities
	Strengthen investment in research and technology	Fund research on the sustainable harvesting, processing, storage and nutritional quality of forest foods through national research institutions, universities and research centres. Pilot innovative technologies such as mobile forest-food mapping apps, artificial intelligence for predicting yields and nutrient content, improved post-harvest storage and nutrient-preserving processing methods, and sustainable wood-energy solutions
Governance	Build institutional and human capacity	Develop capacity among government staff, local leaders and community organizations on sustainable forest management for improved food security outcomes, including nutrition-sensitive practices, traditional knowledge integration and value-chain development. Promote interdisciplinary research linking forestry, nutrition, agriculture and climate science through national and regional research networks
	Foster multisectoral partnerships	Establish multistakeholder platforms that include the forestry, agriculture, health/nutrition, energy and tourism sectors to coordinate strategies and programmes that leverage national food security platforms and United Nations country teams. Develop public–private partnerships to promote sustainable, nutrient-rich forest products, value-added processing, forest-based tourism and sustainable wood-energy solutions in local and regional markets. Facilitate regional dialogues on forestry, agriculture, nutrition, energy and tourism policies, including knowledge-sharing workshops on forest foods, value chains, and improved wood-energy systems via regional institutions
	Ensure coordinated and cross-sectoral action	Integrate forest-food strategies into national nutrition, agriculture, climate, energy and tourism plans, aligned with international food systems guidance and the Sustainable Development Goals. Monitor and evaluate programmes that link forest management, dietary diversity, micronutrient outcomes, local livelihoods, value chains, traditional food systems and sustainable wood energy use with reporting to national multisectoral platforms. Pilot "forest-food observatories" to provide real-time insights on forests, biodiversity, food security and nutrition outcomes, including traditional knowledge

Appendix. Methodologies, detailed results, data gaps and limitations

A. General methodologies

Various methodologies were used to gather data and synthesize the contributions of forests to FSN in chapters 2, 3 and 4, as described below. The methodology used to determine reliance on woodfuel for household energy needs is also given.

Chapter 2

To assess the contributions of forests to FSN, this report used a methodology based on literature reviews and the synthesis of existing data. For each of the realms of food security (availability, access, utilization and stability), the specific methodologies used are as follows (see Appendix Table 1 for additional details):

- **Availability (forest foods, including some NWFPs).** A systematic literature review of papers on forest foods was conducted for the period 1993 to 2024 to examine their diversity, consumption patterns and other relevant aspects. Data limitations, particularly regarding non-commercial NWFPs, are acknowledged.
- **Access (forest income).** For informal income from wood products and NWFPs, the analysis used data and methodology from *The State of the World's Forests 2014* (FAO, 2014) and its literature review of more than 90 studies. Income estimates were derived from formal-sector data where informal data were lacking. For formal forest-sector income, data from FAO Forestry Working Paper 33 (Li *et al.*, 2022) were used, incorporating indirect and induced economic effects using an input–output model.
- **Access (forest ownership).** Global forest ownership was assessed by refining the methodology used in *The State of the World's Forests 2014* (FAO, 2014), incorporating data from pan-European datasets and agricultural census information from 2016 to 2024 as proxies. The methodology also included a literature review of private forest ownership in Canada, Colombia and the United States of America and on the roles of individuals granted use rights in China, India and the Philippines. Additionally, the report examined the importance of customary rights in the Pacific nations of Cook Islands, Fiji, Kiribati, Marshall Islands,

Micronesia (Federated States of), Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tuvalu and Vanuatu, providing a comprehensive perspective on forest management. Although the research had certain limitations and did not encompass all countries in the Pacific region, the total for forest ownership identified was considerably higher than that given in FAO (2014). This highlights the evolving understanding of forest ownership and customary rights, which were not fully considered previously (see Box 3 on the definition of forest ownership as it applies in certain countries).

- **Utilization (woodfuel used for cooking and boiling water).** New data on woodfuel (fuelwood plus charcoal) usage is presented in the report through the World Health Organization (WHO)'s Household Energy Database and FAO's extension to the Global Household Energy Model, which analysed more than 1 600 surveys from 171 countries (1960–2022). The WHO's Global Household Energy Model provides estimates for the global use of six cooking fuels, including biomass and charcoal, and the FAO extension offers more specific insights into fuelwood consumption. The analysis incorporates multivariate methods that consider gross domestic product per capita, regional dynamics and temporal trends, enhancing understanding of woodfuel utilization.
- **Stability (water supply).** A systematic literature review assessed the role of forested watersheds and wetlands in maintaining reliable water resources, focusing on studies that examined hydrological processes and the impacts of deforestation and forest regeneration.
- **Stability (carbon sequestration).** This section synthesized findings from FAO (2014), FAO (2024c), Tubiello *et al.* (2021), the Intergovernmental Panel on Climate Change (IPCC)'s Climate Change 2022 Mitigation Report (Nabuurs *et al.*, 2022), the 2024 Global Carbon Budget (Friedlingstein *et al*., 2024), and FAO (2025e) to compare data and methodologies on terrestrial carbon sinks and their fluctuations. The report acknowledges the inherent complexities and uncertainties in measuring carbon sequestration.

Appendix Table 1.
Data sources for research on the four dimensions of food security

Dimension	Indicator	Data sources	Methodology
Availability	Forest foods, including edible non-wood forest products: production	Systematic literature review of published scientific literature on forest foods for the period 1993 to 2024	Systematic literature review, with case studies
Access	Forestry employment	Information and data reported in FAO (2022) and FAO (2025a)	Used data and findings from Lippe *et al.* (2022), which addressed data consistency challenges using microdata from the International Labour Organization (ILO), supplemented by data from the Global Forest Resources Assessment and INDSTAT, and used a new wave-based method to fill the gaps caused by missing data points Used data and findings from FAO (2025a). A forest employment model was constructed using regression and in accordance with the ILO's methodology for modelled estimates
	Forest-sector income (informal)	FAO (2014) (literature review of 90-plus studies; no new calculations, no new data), formal sector data where informal data were lacking	Used existing data and methodology from FAO (2014), supplementing informal data with formal sector data Fuelwood and charcoal: literature review (90-plus sources), labour productivity, urban/rural data, gender analysis. Used formal sector data where needed (74 studies, 33 countries) Housing: housing material data, consumption calculation (area/person, forest product use, etc.). Compared with FAOSTAT and used formal data when needed
	Forest-sector income (formal)	Li *et al*. (2022) (no new calculations, no new data)	Incorporated indirect and induced economic effects using an input–output model
	Forest ownership*	Data and information on forest owners reported in different sources, including articles; the World Bank (2017); the World Economic Forum (2024); the website of Canadian Forest Owners (forestowners.ca); and FAO (2025a)	A literature review focused on forest owners. Information and data on forest ownership and user rights was available for some countries, revealing the diversity of ownership types, tenure and institutional arrangements

Dimension	Indicator	Data sources	Methodology
Utilization	People using woodfuel as their main energy source for cooking	World Health Organization (WHO) Household Energy Database of nationally representative household surveys (more than 1 600 surveys in 171 countries, 1960–2022) FAO extension to the WHO Global Household Energy Model Surveys conducted in a small number of countries annually by national statistical organizations, averaging about 20 countries per year (2020 to 2022)	WHO's Global Household Energy Model estimates the worldwide use of six types of fuel used for cooking (biomass, charcoal, coal, electricity, kerosene and gaseous fuels) FAO extended this model for specific estimates of fuelwood and total woodfuel The model uses multivariate probability distributions and fits relationships with gross domestic product per capita, regional structures and time effects
Stability	Forested watershed water supply	Published scientific literature focusing on the hydrological cycle, evapotranspiration, water flow patterns, and the impact of land-cover change (deforestation, wetland degradation) on water availability. Specific studies mentioned were by Douville *et al.* (2021), van der Ent *et al.* (2010), Del Petrillo *et al.* (2024), Ogden *et al.* (2013), Hassler *et al.* (2011), Litt *et al.* (2020), and FAO (2025b)	Systematic literature review focusing on studies examining the role of forested watersheds and wetlands in maintaining reliable water resources
	Carbon sequestration	Systematic literature review: Tubiello *et al.* (2021), IPCC (2024), (FAO, 2025a), *Forest emissions and removals* (FAO, 2025b)	Synthesized findings from various reports and studies, comparing data and methodologies on terrestrial carbon sinks and their fluctuations. Acknowledged complexities and uncertainties in measuring carbon sequestration

Note: * This information is presented in Box 2.

Sources: De Petrillo, E., Fahrländer, S., Tuninetti, M., Seaby Andersen, L., Monaco, L., Ridolfi, L. & Laio, F. 2024. Reconciling tracked atmospheric water flows to close the global freshwater cycle. Preprint.; Douville, H., Raghavan, K., Renwick, J., Allan, R.P., Arias, P.A., Barlow, M., Cerezo-Mota, R. *et al.* 2021. *Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. First edition. Cambridge University Press. https://doi.org/10.1017/9781009157896; FAO. 2014. The State of the World's Forests: *Enhancing the socioeconomic benefits from forests*. Rome, FAO; FAO. 2022. *The State of the World's Forests 2022*. Rome, FAO. https://doi.org/10.4060/cb9360en; FAO. 2025a. *Global Forest Resources Assessment 2025*. Rome, FAO. https://doi.org/10.4060/cd6709en; FAO. 2025b. Food Balances (2010-). In: *FAOSTAT*. [Cited 20 November 2025], https://www.fao.org/faostat/en/#data/FBS; AO. 2025e. *Forest emissions and removals*. FAOSTAT Analytical Briefs 114. FAO. https://doi.org/10.4060/cd7163en; Hassler, S.K., Zimmermann, B., van Breugel, M., Hall, J.S. & Elsenbeer, H. 2011. Recovery of saturated hydraulic conductivity under secondary succession on former pasture in the humid tropics. *Forest Ecology and Management*, 261(10): 1634–1642. https://doi.org/10.1016/j.foreco.2010.06.031; Li, Y., Mei, B., Linhares-Juvenal, T., Formenton Cardoso, N. & Tshering, C. 2022. *Forest sector contribution to national economies 2015: The direct, indirect and induced effects on value added, employment and labour income*. Forestry Working Paper No. 33. Rome, FAO. https://doi.org/10.4060/cc2387en; Lippe, R.S., Schweinle, J., Cui, S., Gurbuzer, Y., Katajamäki, W., Villarreal-Fuentes, M. & Walter, S. 2022. *Contribution of the forest sector to total employment in national economies*. Rome and Geneva, FAO, International Labour Organization. https://doi.org/10.4060/cc2438en; Litt, G.F., Ogden, F.L., Mojica, A., Hendrickx, J.M.H., Kempema, E.W., Gardner, C.B., Bretfeld, M. *et al.* 2020. Land cover effects on soil infiltration capacity measured using plot scale rainfall simulation in steep tropical lowlands of Central Panama. *Hydrological Processes*, 34(4): 878–897. https://doi.org/10.1002/hyp.13605; Ogden, F.L., Crouch, T.D., Stallard, R.F. & Hall, J.S. 2013. Effect of land cover and use on dry season river runoff, runoff efficiency, and peak storm runoff in the seasonal tropics of Central Panama. *Water Resources Research*, 49(12): 8443–8462. https://doi.org/10.1002/2013WR013956; Tubiello, F.N., Conchedda, G., Wanner, N., Federici, S., Rossi, S. & Grassi, G. 2021. Carbon emissions and removals from forests: new estimates, 1990–2020. *Earth System Science Data*, 13(4): 1681–1691. https://doi.org/10.5194/essd-13-1681-2021; Friedlingstein, P., O›Sullivan, M., Jones, M. W., Andrew, R. M., Hauck, J., Landschützer, P. *et al*. 2024. Global carbon budget 2024. *Earth Syst. Sci. Data Discuss* [preprint]. Available https://doi.org/10.5194/essd-2024-519; Van der Ent, R.J., Savenije, H.H.G., Schaefli, B. & Steele-Dunne, S.C. 2010. Origin and fate of atmospheric moisture over continents. *Water Resources Research*, 46(9). https://doi.org/10.1029/2010WR009127; World Bank. 2017. *Forestry Policy Note*. Ministry of Agriculture and Forestry, Republic of Türkiye. https://documents1.worldbank.org/curated/en/694751507885204989/pdf/12-10-2017-13-48-33-TurkeyForestPolicyNoteweb.pdf; World Economic Forum. 2024. *Global Gender Gap 2024: Insight report*. https://www3.weforum.org/docs/WEF_GGGR_2024.pdf.

Chapter 3

Overview of forest foods

To estimate the number of species of forest food consumed in the various regions, data were extracted from the International Union for Conservation of Nature (IUCN) Red List[25] for species that:

- have been assessed on the IUCN Red List (i.e. that have a profile);
- were stated to occur in forests (subset by the "habitat" category); and
- were listed as consumed for human food (subset by the "use" category).

For each biogeographic realm, the number of species is presented by class that meet the three inclusion criteria. Although the counts of consumed forest species in various regions on the IUCN Red List may be accurate for well-assessed taxonomic groups such as mammals and birds, they are underestimates for groups that are not as well assessed, such as fungi, plants and insects. For example, just 0.4 percent of described fungi worldwide – about 600 species (see Antonelli *et al.*, 2023) – have had their global conservation status assessed for the IUCN Red List (Dahlberg and Mueller, 2011; Mueller *et al.*, 2022; Mueller, Dahlberg and Krikorev, 2014), and it is known that more than 1 000 species of fungi are eaten globally (Boa, 2004). More than 73 500 plant species have been assessed for the Red List, representing about 17 percent of the world's known plants (IUCN, 2025). The World Checklist of Useful Plant Species categorizes 7 039 species as "human food" (Gori *et al.*, 2022).

Forest foods and food security and nutrition

A structured global literature scoping review was conducted to summarize the literature on the contributions of wild forest foods to FSN in the various regions, combining terms related to forest foods and FSN to create the search strings shown in Appendix Table 2. The search string applied the Boolean operator "AND" to capture articles that assessed both "forest foods" and "food security and nutrition". Because forests can be referred to in various ways, such as with the terms "tree cover" and "deforestation", the wildcard function was used to increase coverage. For example, the term "*forest*" covers words and phrases such as "deforestation", "afforestation", "forest cover", "humid forests" and "dry forests". A similar strategy was used for the variables related to diet and nutrition. The "OR" operator was used to ensure that the search string captured as many papers as possible. The searches took place in August and September 2024 using the search engines Web of Science, Scopus and CAB.

Appendix Table 2.
How terms related to forest foods and food security and nutrition were combined to create the search string

Forest foods	**forest* OR *wood* OR *jungle* OR "wildlife consumption" OR "bushmeat" OR "wild meat" OR "wildmeat" OR "wild food*" OR "wild fruit*" OR "wild vegetable*" OR "bush" OR "mangrove*"*
	AND
Food security and nutrition	"food security" OR "food insecurity" OR "food consumption" OR "diet* intake" OR "nutrition* transition" OR "nutrition* security" OR "malnutrition" OR "diet* quality" OR "diet* diversity" OR "food dependence" OR "human* health" OR "child* health" OR "child* diet*" OR "human* diet*" OR "human* nutrition*" OR "child* nutrition*" OR "welfare*" OR "livelihood*"

[25] The IUCN Red List is accessible at https://www.iucnredlist.org.

First, a search string was run on titles, keywords and abstracts. This produced 26 860 hits from the three databases, which was reduced by applying the search string to titles only. Thus, the results should be seen as representative of the literature rather than exhaustive. By limiting the search to titles only, the authors obtained a pool of 927 publications. After six non-English-language publications were removed, a pool of 921 papers remained. A two-phase screening process was then conducted based on the following two inclusion criteria, in which publications should:

- **Examine linkages between consumption of forest foods and food security and/or nutrition.** Because the main interest was evidence on links between forest foods and FSN globally, rather than descriptions of forest food use, the review was restricted to publications that applied measures of FSN.
- **Be based on a scientific case study including primary or secondary data.** Only original scientific studies that used primary or secondary data were included; excluded, therefore, were policy reports and reviews, which summarize findings from the literature and may have resulted in double counting of the scientific evidence.

In the first phase of the screening process, the two inclusion criteria outlined above were applied to the abstracts, reducing the number of publications from 927 to 122. In the second phase, the criteria were applied to the full articles, reducing the number of papers to 61 for the final review. The screening process did not include assessments of the quality of the studies or of the robustness of results.

The publications included in the final pool had a skewed geographical representation, with most studies from Africa and some from Asia and the Americas. No studies from Europe or Oceania were found. This does not necessarily mean that forest foods are irrelevant for FSN in these regions but rather that scientific interest is distributed unevenly. It is also possible that there are more studies in languages other than English in the underrepresented regions.

Methods for "other contributions of forest foods"

In many high-income countries, wild foods do not play an important role in FSN for the general population, although they may still be significant in the diets of some groups – particularly Indigenous Peoples. For other groups, wild foods are still often valued and consumed. In some countries with long traditions of wild-food collection, people continue to collect wild foods as a way of connecting to their culture and traditions. In other countries, hunting and harvesting wild foods are recreational activities. And, in some places, people simply enjoy the taste and experience of eating wild foods. In many low- and middle-income countries, too, wild foods play cultural, recreational and culinary roles beyond their food security and nutritional values.

It was not possible to systematically collect information on these myriad contributions for all countries. Instead, expert elicitation was used, and literature reviews were conducted, for each global region, using the following search terms:

- forest AND wild AND (food OR meat) AND (consumption) AND "Country/Region X".

Papers were selected from the review to provide illustrative examples for each political region, as defined by the United Nations.

Chapter 4

Country case studies were developed via interviews with key stakeholders, who were identified in collaboration with national governments and FAO Country Offices. Each interview was conducted based on a list of guiding questions relevant to six CFS recommendations made in 2017[26] aimed at strengthening the contributions of sustainable forest and tree management to FSN and contributing to the realization of the right to adequate food for all (Committee on World Food Security, 2017). The CFS recommendations were elaborated based on the findings of the High-Level Panel of Experts on Food Security and Nutrition report, *Sustainable Forestry for Food Security and Nutrition* (HLPE, 2017).

In addition to stakeholder interviews, country case studies used reviews of literature recommended by stakeholders and others involved in the process.

The five case-study countries (China, the Dominican Republic, Morocco, Türkiye and Uruguay) were selected because they met all of the following four criteria:

1. The country is included in FAO, ed. (2016b) as having increased forest cover by more than 10 percent between 1990 and 2015 while also increasing food security in the same timeframe.
2. The country is making progress on achievement of SDG 1 (no poverty), based on its listing on the Sustainable Development Report map[27] under "SDG achieved" or "Challenges remain" (Sustainable Development Solutions Network, 2024a).
3. The country is making progress on achievement of SDG 2 (zero hunger), based on its listing on the Sustainable Development Report map[28] under "SDG achieved" or "Challenges remain" (Sustainable Development Solutions Network, 2024b).
4. The country has a forest cover greater than 10 percent, according to data from FAO (2020c).

B. Data gaps, challenges and recommendations

Significant data gaps and methodological challenges were encountered during this report's assessment of the contribution of forests to FSN. As one of the 21 Global Core Set of Forest-related Indicators (GCS) that aim to simplify and harmonize concepts and terminology, GCS 14 was developed to improve data on FSN, specifically in terms of the contributions of forests to FSN (FAO and CPF, 2022).

FSN is inherently a multidimensional construct, making it impossible to identify a single metric that comprehensively captures its complexity. Although the adoption of the subindicator approach helps address this challenge and highlights the crucial role of forests in supporting global food security and nutrition, difficulties in collecting accurate and comparable cross-country data continue to obscure their important contributions to global FSN.

[26] These policy recommendations are available at https://www.fao.org/3/I8877EN/i8877en.pdf.
[27] The map is available at https://dashboards.sdgindex.org/map/goals/SDG1.
[28] The map is available at https://dashboards.sdgindex.org/map/goals/SDG2.

Data gaps

- **Non-wood forest products.** National statistics often focus on marketed production, neglecting self-consumption and informal trade (Sorrenti, 2017) and thus substantially underestimating the contributions of NWFPs to FSN. The diversity of NWFPs complicates data collection and analysis and hinders comparisons among regions and countries (FAO and CPF, 2022), as does the absence of a universally accepted definition and classification system that distinguishes between wild and farmed products (Sorrenti, 2017) (see Box 2). Moreover, data on the nutritional composition of NWFPs are incomplete and inconsistent across studies, hindering the accurate assessment of their dietary contributions.
- **Forest employment.** Accurate data on forest employment (both formal and informal) are scarce, especially in developing countries. Given that the informal sector is often underrepresented in national statistics, assessments of the total number of people dependent on forest-related income and their contributions to FSN tends to be underestimated. Inconsistent reporting of part-time employment as full-time equivalents further hampers accurate data assessment.
- **Formal forest-based income.** The IMPLAN data and software used for the study have certain limitations. The models rest on a set of assumptions, some of which may be unrealistic. Because informal economic activities are often not captured in national statistics, the study focused on formal forestry activities. Additionally, the ecosystem service subsector was excluded from the study because separate statistics for forest-based ecosystem services are often unavailable. Therefore, the results could underestimate the economic contribution of the global forest sector, including a substantial extent in countries where such activities represent a significant share of the forest sector (Li *et al.*, 2022).
- **Informal forest-based income.** Income derived from informal forest activities (charcoal production, fuelwood collection, NWFP harvesting, etc.) is often excluded from national accounts due to methodological challenges in data collection (FAO and CPF, 2022). The lack of reliable data on informal income streams results in significant underestimates of the overall contribution of forests to household livelihoods and FSN.
- **Forest harvesting.** In some countries, harvesting forest foods in public or state-owned forests is illegal or restricted, leading individuals to underreport such activities. This is particularly true for hunting, which is frequently criminalized or ambiguously regulated, pushing it into informal or illicit channels and limiting data unavailability.
- **Forest ownership.** Determining forest ownership is difficult due to the diversity of tenure systems and legal frameworks. Data on forest ownership are often incomplete, especially for informal and customary systems, obscuring the relationships between ownership and FSN. This lack of consistent and accurate data limits assessment of the management and sustainability of forest resources.
- **Forested watersheds and wetlands.** Significant methodological challenges make it difficult to quantify the role played by forested watersheds and wetlands in ensuring water security.

Although models estimate the overall contribution of land evaporation to precipitation, for example, isolating the specific roles of these ecosystems requires detailed and localized data that are often unavailable. Wetlands support agriculture and livelihoods and thus play a crucial role in global food security, but agricultural systems can negatively affect wetlands through habitat destruction, pollution and the overuse of water (FAO, 2025k).

Methodological challenges

- **Data harmonization.** The lack of globally representative methodologies for data collection and classification across countries and studies makes data comparison and synthesis difficult, potentially leading to biased global assessments. The absence of a globally agreed list of NWFPs hampers comparable worldwide assessments of their importance for FSN.
- **Incorporating informal activities.** Methodologies for capturing informal income streams from forest-related activities are often inadequate and may not capture the full extent of their contributions to FSN.
- **Measuring ecosystem services.** It can be difficult to assess the contributions of forests to ecosystem services such as water regulation, climate regulation and biodiversity conservation. Many of these services are difficult to quantify and monetize, making integration into economic analyses complex.

Recommendations for addressing these issues

The following recommendations are proposed to address the challenges described above:

- **Develop consistent and globally representative data collection methodologies.** Establish universally agreed standards for estimating, collecting, classifying and reporting forest-related data, including forest foods and their contribution to diets. Ensure that indicators of food security, diet and nutrition are valid and comparable across countries.
- **Invest in primary data collection.** Increase investment in primary data collection, particularly for NWFPs, informal forest-based incomes, and forest foods. This should include conducting targeted surveys and leveraging advanced data collection techniques and technological solutions.
- **Improve data harmonization.** Create robust systems for harmonizing and comparing data from various sources and methodologies to enable meaningful cross-country and temporal comparisons. Collaborate with national statistical offices, trade associations and international agencies to integrate forest-food data with existing surveys on food security, diet, and nutrition.
- **Enhance capacity building.** Support capacity building for data collection and analysis in developing countries to ensure the consistent availability of reliable data. Facilitate knowledge exchange between FAO and the end users of statistics and emphasize the integration of forest foods into food consumption and nutrition studies.

- **Develop comprehensive classifications.** Create and implement globally consistent definitions and classifications of NWFPs.[29]
- **Integrate ecosystem services into economic analyses.** Develop methodologies for accurately valuing ecosystem services and incorporating them in assessments of the economic contributions of forests, including their role in food security and nutrition.
- **Link food security, diet and nutrition data.** Encourage national statistical offices to include forest foods in surveys that capture food consumption, diet and nutrition to better understand how forests contribute to dietary patterns and nutrition outcomes.

Addressing these data gaps and methodological challenges is crucial for improving understanding of how forests contribute to FSN and for codesigning effective policies for sustainable forest management.

C. Reliance on woodfuel for household energy needs

Methodology: data sources

The main source of information on woodfuel use for cooking used in the report was the WHO's Household Energy Database (WHO, 2025) of nationally representative household surveys. This database, which was accessed in February 2024, contains more than 1 600 surveys conducted in 171 countries between 1960 and 2022 (IEA *et al.*, 2024).

Information on the number of people treating/sterilizing water by boiling was obtained mainly from Demographic and Health Surveys and Multiple Indicator Cluster Surveys, the former for 46 countries and the latter for 65 countries. The earliest of these surveys was conducted in 2006 and the latest was in 2023, and more than half were conducted between 2018 and 2023. These data were supplemented by a national survey of rural areas in China carried out in 2017 (Zhu *et al.*, 2023).

Total population estimates were taken from United Nations World Population Prospects 2024 (United Nations, 2025a), and estimates of the urban/rural split were taken from United Nations World Urbanization Prospects 2018 (United Nations, 2025b). Regional and global estimates were made using the United Nations Statistics Division Standard Country or Area Codes for Statistical Use (M49) (United Nations, 2025c). Estimates and forecasts of national economic indicators were obtained from the April 2024 World Economic Outlook (International Monetary Fund, 2024).

Methodology: analysis framework – woodfuel use for cooking

Household surveys provide direct insights into how individuals and families meet their energy needs. Because they include a limited number of people, however, they do not necessarily adequately represent entire countries. Moreover, surveys are carried out in relatively few countries each year

[29] For a discussion of NWFP analysis in the framework of international classification systems, see Sorrenti (2017).

(e.g. an average of about 20 countries per year in 2020–2022). Statistical models can help fill the gaps and reduce the impact of sampling differences.

The WHO's Global Household Energy Model (GHEM) provides worldwide estimates of the percentage of people primarily using six fuel types for cooking – biomass, charcoal, coal, electricity, kerosene and gaseous fuels (Stoner *et al.*, 2020, 2021). GHEM assumes that household survey data on the percentage mainly using each fuel come from a multivariate probability distribution for percentages summing to 100 percent. The model fits relationships with gross domestic product per capita, hierarchical regional structures, and smooth time effects to explain changes in fuel use over time and differences between countries. An extended version of this model was used to provide estimates of fuelwood, charcoal and total woodfuel (fuelwood plus charcoal) consumption for cooking.

Applying the WHO's standard filtering criteria for these surveys (Stoner *et al.*, 2021), 1 408 surveys covering 161 WHO Member States were available for modelling. The modelled woodfuel estimates cover 194 WHO member states and three associate members. Regional and global estimates were calculated as population-weighted aggregation for 197 countries and territories. Because the analysis methodology is adapted from the WHO Global Household Energy Model, it is only possible to provide estimates for WHO Member States and associate members.

Wherever possible, 95 percent uncertainty intervals are given alongside point estimates in parentheses. For example, "23 percent (20–27)" means that 23 percent is the "best" estimate and, given uncertainties, we should consider that reasonable estimates include the range from 20 percent to 27 percent.

Methodology: analysis framework – woodfuel use for water boiling

Unlike in the case of household cooking, fuel use for water boiling is not monitored regularly at the international level. A simple aggregation was carried out combining survey data on the percentage of people treating water by boiling and the modelled estimates of the percentage of people mainly using woodfuel for cooking.

For low- and middle-income countries (The World Bank, 2025b), where survey data on water boiling were lacking, the mean percentage for other countries in the same M49 subregion was assumed. For each country, a "low" estimate of the percentage mainly using woodfuel for cooking was computed by multiplying the survey or imputed percentage of households boiling water with the modelled estimate of the percentage mainly using woodfuel for cooking in 2022; a "high" estimate was computed by taking the lower value of these two percentages. The final values used for the analysis were the mid-points of the "low" and "high" estimates. As the only exception, the 2017 national survey of rural areas in China reported the percentage using woodfuel for boiling (Zhu *et al.*, 2023), and this was multiplied by the percentage of people living in rural areas in China in 2022 (United Nations, 2025b) for direct use in the analysis. It was possible to estimate the percentage (and number) of people mainly using woodfuel to boil water for 137 countries and territories, of which 110 had survey data on the percentage of people boiling water and 27 used subregional means.

Comparison with previous methodology

For woodfuel use for cooking, *The State of the World's Forests 2014* (FAO, 2014) presented estimates for 2011 based on one household survey per country, the majority of which were carried out in 2005–2011. The percentage of people mainly using woodfuel reported by surveys carried out before 2011 was then multiplied by changes in per-capita woodfuel consumption between 2011 and the survey year. The new methodology pools information from all suitable survey data for each country, accounting for fuel use and quantifying changes over time without relying on estimates of woodfuel consumption per capita.

The previous 2011 estimates were compared to 2011 estimates generated using the new methodology. On average, estimates for total woodfuel use differed between the two methods by 7 percentage points (mean absolute error) in countries where the previous estimates were based on original source data, and 14 percentage points in countries with no source data and where the previous estimates were imputed.

The two methods yielded near identical results at the global level and were very close for Africa, the Americas, Asia and Europe. The new method yielded a substantially higher estimate of fuelwood use for Oceania, driven by a higher estimate for one country, Papua New Guinea, which represented about 80 percent of the estimated population in 2011 mainly using fuelwood for cooking in Oceania.

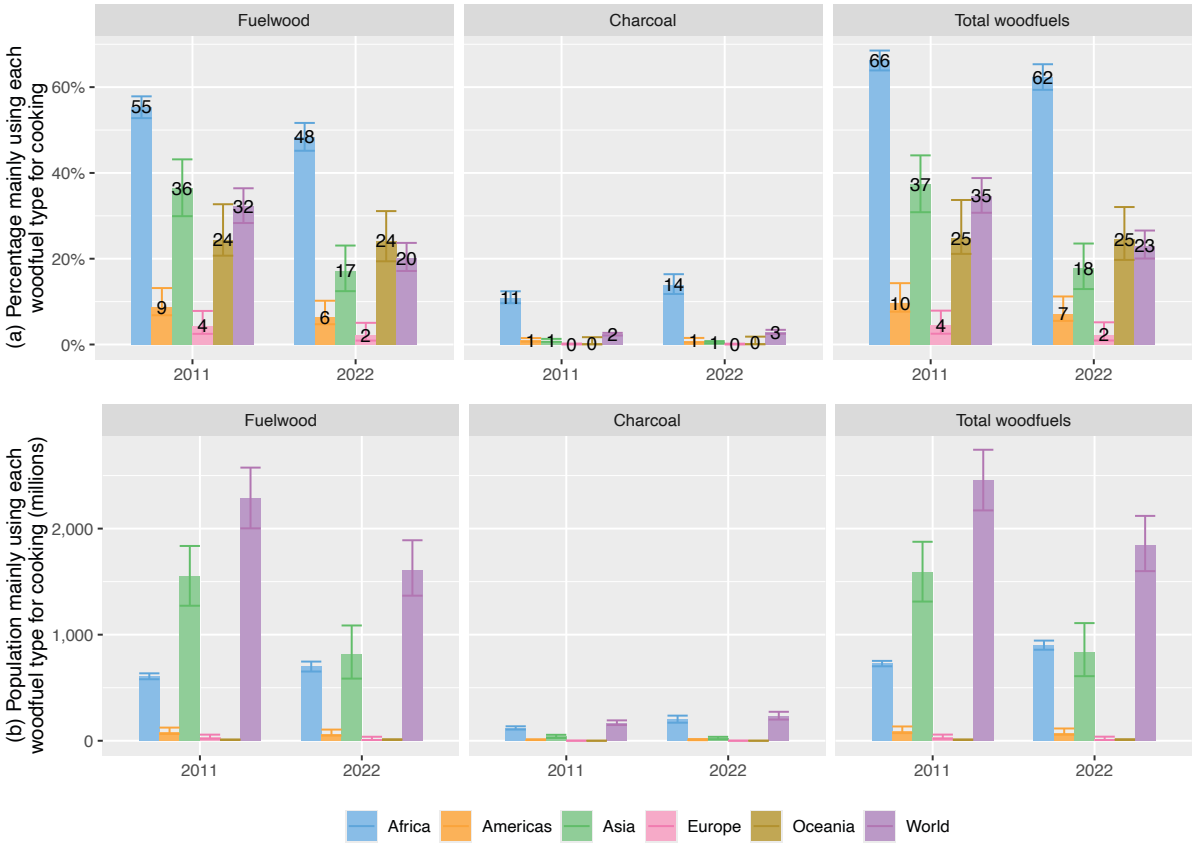
Methodology limitations

Estimates of woodfuel use for cooking capture only the main fuel used by households for cooking; many households around the world use multiple fuels and technologies. The number of people relying on woodfuel as their main fuel for cooking is an underestimate of the total number relying on woodfuel. Surveys, including World Bank Multi-Tier Tracking Surveys, have started to explicitly capture all fuels used by households. The number of such surveys is too small, however, to produce reliable estimates covering most of the global population. These measures do not capture use of woodfuel for heating. In many countries with cool or temperate climates, woodfuel plays a key role as the main energy source for household heating.

Reliance on woodfuel for household energy

In 2022, 23 percent (20–27) of the world's population (Appendix Figure 1), an estimated 1.8 billion (1.6–2.1) people, relied on woodfuel as the main energy source for cooking. This is a clear decrease since 2011, when 35 percent (31–39) of the world's population – 2.5 billion (2.2 billion–2.7 billion) people – relied mainly on woodfuel. Of the 1.8 billion people relying mainly on woodfuel, 1.4 billion (1. billion–1.5 billion) resided in rural areas and 0.4 billion (0.4 billion–0.5 billion) resided in urban areas. Most of the decrease in the number of people mainly relying on woodfuel between 2011 and 2022 was in rural areas (about 620 million people).

Appendix Figure 1.
Percentage (a) and number (b) of people using mainly woodfuel for cooking in 2011 and 2022, by region, with 95 percent uncertainty intervals



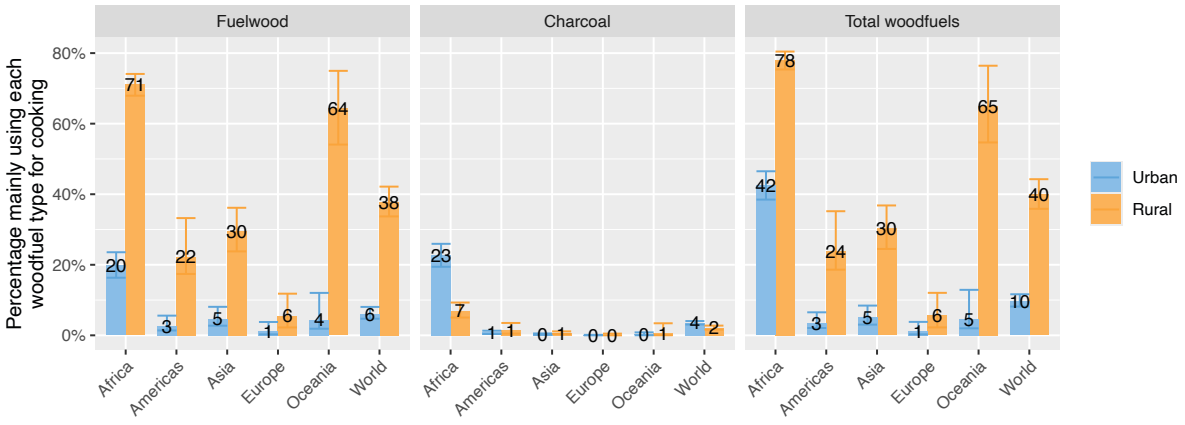
Note: Based on N=197 countries and territories.

Broadly, and proportional to economic growth, the percentage of the population relying mainly on woodfuel for cooking declined between 2011 and 2022 as people became more able to afford or otherwise access alternative household energy services.

Urban–rural divide in the use of woodfuel for cooking

Globally, reliance on woodfuel as the main fuel for cooking in 2022 was much higher in rural areas, at 40 percent (36–44) of people, than in urban areas, at 10 percent (8–12) (Appendix Figure 2). The vast majority of rural households in Africa (78 percent (75–80)) and Oceania (65 percent (55–76)) used mainly woodfuel. The use of woodfuel for cooking in rural areas was also substantial in Asia, at 30 percent (24–37), and the Americas, at 24 percent (19–35). The percentage of urban dwellers using mainly woodfuel was 5 percent or lower in all regions except Africa, where it was 42 percent (38–47).

Appendix Figure 2.
Share of the population mainly using woodfuel for cooking in urban and rural areas, by region, 2022



Note: Based on N=197 countries and territories.

Regional trends in woodfuel for cooking

Africa

Sixty-two percent (59–65) of people in Africa mainly used woodfuel in 2022, down from 66 percent (64–69) in 2011. Despite the decrease in percentage, the total number of people mainly relying on woodfuel increased from 730 million (700 million–750 million) in 2011 to 900 million (860 million–940 million) in 2022, due to population growth.

Americas

Woodfuel was still the main cooking fuel for 70 million people (60 million–120 million) (7 percent [6–11] of the total regional population) in the Americas in 2022. This was a decrease compared with 2011, when 90 million (70 million–130 million) people (10 percent (8–14)) relied mainly on woodfuel for cooking.

Asia

Eighteen percent (13–24) of people in Asia mainly used woodfuel for cooking in 2022, for a total of 840 million (610 million–1 110 million) people. Both the percentage and number of people were down by about half compared with 2011, when it was 37 percent (31–44) and 1.6 billion (1.3 billion–1.9 billion) people.

Europe

Woodfuel was used as the main cooking fuel by 2 percent (1–5) of Europe's population in 2022, for a total of 17 million (7 million–39 million) people, mainly in eastern and southeastern European countries. Both the percentage and number of people were down by about half from 2011, when 4 percent (3–8) – 33 million people (19 million–58 million) – mainly relied on woodfuel.

Oceania

Twenty-five percent (20–32) of Oceania's population relied mainly on woodfuel for cooking in 2022, which was 11 million (9 million–14 million) people, most of whom were in Papua New Guinea. The percentage was also 25 percent (21–34) in 2011, and the total number of people was 9 million (8 million–12 million).

Shifts in reliance on woodfuel for cooking and water boiling

Woodfuel for cooking

The largest decreases in the number of people mainly using woodfuel for cooking between 2011 and 2022 were in China and India, both at about 300 million people. The next largest decreases were estimated to be in Indonesia, Viet Nam and Myanmar (in descending order). The number of people cooking mainly with woodfuel increased in many sub-Saharan African countries over the period as their populations grew.

Charcoal cooking

Three (2.5–3.4) percent of the world's population, or 230 million (200 million–270 million) people, relied mainly on charcoal for cooking in 2022, considerably higher than in 2011, when the total was 170 million (150 million–190 million) people. The vast majority of households relying on charcoal were in African countries (Appendix Figure 1), where 14 percent (12–16) of people mainly used charcoal. An estimated 23 percent (19–26) of people living in urban areas in Africa used charcoal as the main cooking fuel and 20 percent (16–24) used fuelwood (Appendix Figure 2).

Household water treatment by boiling

About 410 million people worldwide mainly used woodfuel to treat/sterilize water by boiling in 2022. Of the total population treating water by boiling in Africa in 2022, 89 percent were estimated to have used mainly woodfuel to do so – a higher percentage than in Oceania (71 percent), the Americas (25 percent), and Asia (24 percent). In Europe, about 60 million people were estimated to treat water by boiling in 2022, but only 2 million people were estimated to have used mainly woodfuel to do so.

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