ADVANCING SUSTAINABLE FOREST-BASED BIOECONOMY APPROACHES

AN EXPANDED POLICY BRIEF

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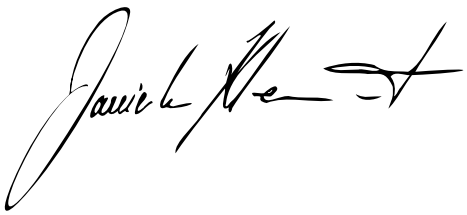
FOREWORD

In recent years, the urgency of addressing interconnected global challenges such as climate change, biodiversity loss, resource insecurity, and growing socio-economic inequalities has become increasingly evident. These pressures are further intensified by production and consumption patterns lacking efficiency, highlighting the need for transformative approaches that reconcile economic development with environmental stewardship and social wellbeing.

Forest-based bioeconomy approaches offer a powerful pathway to respond to these challenges. Sustainably managed forests can provide renewable materials, bioenergy, and ecosystem services while supporting livelihoods, strengthening rural economies, and contributing to climate change mitigation and adaptation. When grounded in principles of sustainability, equity, and resilience, forest-based bioeconomy strategies can play a central role in advancing circular economies and delivering on multiple global commitments, including the Sustainable Development Goals (SDGs), the Paris Agreement, and the Global Biodiversity Framework among others.

This Expanded Policy Brief consolidates key scientific evidence, policy insights, and practical perspectives on how sustainable forest-based bioeconomy approaches can be advanced across different contexts. It is intended as a resource for policymakers, practitioners, researchers, and stakeholders seeking to design and implement strategies that harness the full potential of forests while safeguarding their ecological integrity.

It is my sincere hope that this publication will inform dialogue, inspire action, and support those responsible for shaping policies and investments toward a more sustainable, inclusive, and resilient future.



Daniela Kleinschmit
IUFRO President

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The content of this publication draws on a comprehensive review and synthesis of current scientific literature, policy frameworks, and global assessments related to sustainable forest-based bioeconomy development. In particular, it builds upon existing international knowledge platforms and research initiatives addressing forests, sustainability transitions, circular bioeconomy pathways, and socio-ecological resilience. Additional thematic analyses were undertaken to complement these sources and ensure relevance across regional contexts.

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1. Forest forward: pathways toward a thriving forest-based bioeconomy

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1.1 Background

This Brief informs policymakers, practitioners, and stakeholders engaged in the forest sector and the broader bioeconomy transformation. It synthesizes scientific evidence and practical experience to identify actionable policy options that accelerate a sustainable, inclusive, just, and circular forest-based bioeconomy.

The brief examines the bioeconomy concept through five interlinked dimensions: policy, finance, markets, innovation, and multi-actor collaboration, and presents practical pathways that connect global frameworks with national and local implementation. Together, these dimensions form the structure of the following chapters, showing how coherent governance, investment, and innovation can jointly drive a resilient forest-based bioeconomy. The analysis covers wood products, non-wood forest products (NWFP), and forest ecosystem services (FES), taking an integration perspective within and beyond the forest sector.

1.2 Global frameworks and initiatives supporting the bioeconomy

Policy initiatives that align climate mitigation, sustainable forest management (SFM), research and development (R&D), and awareness-raising are the most effective enablers of circular forest bioeconomy transitions. Given diverse country contexts, multi-level governance (supranational, national, sub-national) platforms such as the International Bioeconomy Forum, and Global Bioeconomy Summits organised by the International Advisory Council on Global Bioeconomy (IACGB) can ensure coherence while allowing context-specific implementation.

Several global frameworks reinforce the case for a sustainable forest-based bioeconomy. The United Nations Strategic Plan for Forests 2017-2030 calls on countries to expand forests' contributions to livelihoods and markets, while the Sustainable Development Goals (SDGs) connect bioeconomy to clean energy, sustainable consumption, climate action, and green jobs. The Food and Agriculture Organization of the United Nations (FAO) Strategic Framework 2022-2031 elevates bioeconomy as a programmatic priority, supporting sustainable resource use, innovation, and rural development.

Recent political momentum has strengthened this agenda further, including the 2024 G20 Initiative on Bioeconomy with its ten voluntary High-Level Principles, the first global political commitment of its kind, which emphasises sustainability, inclusion (including Indigenous Peoples' rights and gender equality), biodiversity conservation, circularity, and science-based assessments[1]. Similarly, the United Nations Forum on Forests (UNFF) and FAO's Committee on Forestry (COFO) have urged scaling up forest-based bioeconomy approaches as part of global forest objectives.

More recently, the UNFCCC COP30 Presidency launched a wide-ranging Action Agenda that includes two major calls to action for the forest-based bioeconomy. One is the Bioeconomy Challenge, a three-year global initiative that seeks to translate the G20 Bioeconomy High-Level Principles into concrete outcomes by addressing key gaps in metrics, financing mechanisms, and market development. The other one is the Building for Forests

initiative, which aims to accelerate the decarbonization of the construction sector by promoting the use of wood from sustainable and responsible forest value chains, replacing high-emission construction materials with renewable, carbon-storing alternatives while contributing to healthy forests and sustainable, resilient housing for a rapidly urbanizing population.

1.3 Evolution of the Bioeconomy Concept

In parallel with these policy developments, the concept of "bioeconomy" has evolved over the past several decades. Early definitions were closely tied to biotechnology and the life sciences. For example, the 2009 report from the Organisation for Economic Co-operation and Development (OECD) titled *Bioeconomy to 2030* described the bioeconomy as an economic activity in which biotechnology and the use of renewable biomass play central roles, envisioning advances in genetic science leading to new products and processes. Building on this trajectory, a more recent global framing (articulated by the IACGB) emphasizes sustainable production, utilization, conservation, and regeneration of biological resources alongside innovation to enable system-wide sustainability[2].

In the 2010s, the scope broadened towards a holistic, systemic concept. The European Union (EU)'s 2018 Bioeconomy Strategy expanded the focus toward the sustainable use of biological resources across agriculture, forestry, fisheries, and industry, highlighting renewable materials and integrated circularity. Nearly 60 countries now view the bioeconomy as a key route from fossil dependence to renewable, circular production.

Bioeconomy strategies differ in emphasis: some highlight biotechnology, others biomass and biobased production, and many combine both. Recent strategies also more explicitly integrate social and environmental objectives and extend circularity beyond feedstocks to production inputs and post-consumer flows. Today, the bioeconomy is increasingly framed not only as fossil-fuel substitution, but also as a broader system transformation linking economic, ecological, and societal goals across food systems, forest-based sectors, and beyond, including cross-sectoral integration.

Box 1.1 Understanding the forest-based bioeconomy

In this Brief, a **forest-based bioeconomy** is understood as an **integrated approach that goes beyond wood products and bioenergy, encompassing the full range of forests types, their goods and services** (timber, fibre, and paper; non-wood products such as foods, resins, or medicinal plants; and ecosystem services such as carbon sequestration and storage, water regulation and purification, biodiversity, recreation, culture and identity, and protection), **as well as their integration within and beyond the forest sector**. The core principles are **sustainability, circularity, and social equity**, to ensure that forests, whether (commercially) managed or unmanaged, can contribute **to climate regulation, ecosystem health, livelihoods, and commerce**.

Operationally, the forest-based bioeconomy combines value-chain activities (from management and processing to reuse and recycling) with circular, regenerative forest stewardship within planetary boundaries. This combination is reflected in the objectives below and links industrial wood pathways with socio-biodiversity and non-wood economies.

1.4 Operationalizing the forest-based bioeconomy

To achieve an actionable, integrated forest-based bioeconomy we present the following concise set of objectives for an integrated forest-based bioeconomy:

- **Adaptive and sustainable forest management:** maintain and enhance forest health and multifunctionality.
- **Cascading use and circular efficiency:** prioritize long-lived, higher-value uses, and design for reuse and recycling.
- **Ecosystem service recognition and rewards:** value and, where appropriate, compensate provisioning, regulating, cultural, and supporting services.
- **Innovation and life-cycle accountability:** support R&D, biorefineries, and digitalization; apply life-cycle assessment (LCA) to guide decisions.
- **Knowledge integration and education:** bridge scientific, technical, and Indigenous/traditional knowledge; promote evidence-based learning.
- **Inclusive collaboration:** ensure meaningful participation and fair benefit-sharing across genders, generations, and communities, including Indigenous Peoples and marginalized groups.

This framing embraces **diversity in national pathways**, for example, socio-biodiversity models in the Amazon or advanced biorefineries in Finland, **provided that environmental limits and circular principles are met**.

This Brief consolidates **actionable options for policymakers** to scale a sustainable forest-based bioeconomy across wood, non-wood products, and ecosystem services, and across six themes: (**1) From Policy to Practice; (2) Finance; (3) From Forest to Markets; (4) Beyond Wood; (5) Building the Future (wood construction & novel biomaterials)**; and **(6) Forest-Sector Innovation**. Together, these span the policy-to-product continuum and associated trade-offs. The chapters focus on **wood products** (Chapter 3), **non-wood products** (Chapter 4), **forest ecosystem services** (Chapter 5), and an **integration perspective** (Chapter 6).

2. Global context and shared foundations of the forest-based bioeconomy

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2.1 Introduction

This chapter identifies cross-cutting features and system conditions of the forest-based bioeconomy and summarises what is known about the forest sector's current contributions and future potential within it.

The forest-based bioeconomy is in global policy arenas increasingly regarded as a pathway to reconcile economic development with environmental sustainability, even though forest functions remain under-discussed in public discourse. In the context of accelerating climate change and biodiversity loss, a forest-based bioeconomy can provide ecosystem services, energy, and renewable materials that substitute more resource-intensive products while supporting risk-aware, inclusive development.

This relevance aligns with SDG 15 and with approaches that emphasize waste reduction, circularity, and innovation. In practice, progress depends on environmental preconditions (SFM, restoration, adaptive management), economic levers (cascading use, design for recovery), and governance tools (LCA in decisions, policy coherence).

2.2 Global forest-based bioeconomy facts and figures

Forests are a cornerstone of the bioeconomy, as they supply renewable materials and energy, fix and store carbon, support biodiversity, and anchor rural livelihoods while offering lower-carbon substitutes for fossil-intensive products. Biomass currently supplies roughly a quarter of global material needs, underscoring both its role and the need to respect ecosystem boundaries as demand grows. Key facts and figures are presented in Table 2.1.

There is an uneven distribution of forest resources globally, with a handful of countries (Russia, Brazil, Canada, the United States, and China) holding over 50% of the global forest area[3], while many arid or densely populated countries have very low forest cover[4]. This concentrates much of the world's biomass supply and ecosystem-service potential in this handful of countries and determines where forest-based value chains can scale most quickly.

Additionally, deforestation and forest degradation driven mainly by agricultural expansion, infrastructure, and unsustainable harvesting continue, keeping forest resources under pressure. Despite a slowdown in the past years, net forest loss remains significant at around 10 million hectares per year in the period 2015-2020, with tropical regions being the most affected. A forest-based bioeconomy can only thrive in the long term if the resource base is maintained. Therefore, it is critical to manage forests sustainably and to conserve them where needed, preventing biodiversity loss and safeguarding regenerative capacity. Consequently, advancing a sustainable forest-based bioeconomy requires a multifaceted strategy that enhances positive contributions (e.g., jobs, income, products) while addressing negative aspects (e.g., deforestation, inequitable access).

Table 2.1 Global snapshot of the forest-based bioeconomy for 2025		
Indicator	**Global value**	**Key message**
Forest cover	32% of the world's land area (≈ 4.14 billion ha)	Forests remain a cornerstone of the planet's natural capital.
Economic contribution	≈ 1% of global GDP (USD 450-600 billion annually)	Forest-based industries represent a globally significant economic sector.
Formal employment	≈ 13 million people	Constitutes a major source of rural and industrial jobs worldwide.
Informal and subsistence employment	≈ 41 million people	Highlights the importance of informal forestry for livelihoods.
People dependent on forests	≈ 1.6 billion (≈ 25% of the global population)	Forests provide food, income, and shelter for a quarter of humanity.
Use of wood as energy source	≈ 2.4 billion people	Wood remains essential as an energy source for basic household needs, especially in developing regions.
People living in wood-based housing	≈ 1.3 billion people (18% of global population)	Wood remains a fundamental material for affordable, low-carbon housing.

Sources: FAO (2025)[5], UN (2024)[6], World Bank (2025)[7]

The following paragraphs explain why shared principles are needed to guide practice in a way that bioeconomy growth remains sustainable and inclusive, and focus on *how* the bioeconomy potential is converted into practice. First, cross-cutting *enablers* that translate principles into practice (governance and tenure; finance and markets; innovation; partnerships and inclusion; knowledge and data systems) are outlined and then, *systemic barriers* that commonly block progress are synthesised (rights and enforcement gaps; coordination and implementation gaps; finance and infrastructure constraints; R&D and skills shortfalls; social exclusion and inequitable benefits; data and valuation gaps; environmental and climate risks).

Institutional *enabling conditions*

Considering the six themes introduced at the end of Chapter 1, and reflecting on the principles of circularity, decarbonization, and resilience, several cross-cutting institutional enabling conditions can support the success of the transition to a forest-based bioeconomy (Table 2.2):

- **Coherent governance, aligned policy, and secure tenure:** predictable, cross-sector rules, implemented in practice, are essential to attract investment, particularly where bio-based solutions must compete with fossil-based alternatives that benefit from economies of scale, lower costs, stronger advocacy, and larger R&I communities. Secure tenure and use

rights for timber, non-timber products, and emerging assets (e.g., carbon) reduce risk and support long-term management. Inclusive processes that involve local communities, Indigenous Peoples, women, youth, marginalized groups, and private-sector actors strengthen legitimacy and results. Priorities include transparent, streamlined permitting; stable, proportionate regulation for bio-based products; and coordination across forestry, agriculture, energy, trade, and land-use planning to avoid policy conflicts.

- **Access to finance and markets:** without financing and functioning markets, even the best ideas struggle to take off. Public funds, private investment, blended finance, tools like green bonds and payments for ecosystem services, and climate finance can open opportunities. Just as important are reliable markets supported by good infrastructure, quality standards, and strong producer organizations. Together, these factors create the demand and incentives needed for sustainable forest management. The current barriers include regulatory and information obstacles, high investment costs for scaling of production, a lack of bankable projects, and long return on investment periods.

- **Innovation, R&D, and capacity building:** progress relies on continuous innovation across the technological, financial, institutional, social, and policy dimensions[8]. Because innovation is ecosystem-based, strong partnerships and coordinated policy "bundles" help de-risk and scale new technologies. When combined with targeted R&D and respect for traditional and Indigenous knowledge, this approach supports entrepreneurs, small and medium enterprises (SME), and large companies. Although R&D questions differ depending on geographical and political conditions, stronger global coordination can reduce duplication and unlock synergies. To materialise these benefits, the sector must overcome resource limits, risk aversion, and regulatory barriers, while using foresight and horizon scanning to build a future-oriented bioeconomy.

- **Partnerships and inclusive participation:** progress depends on coordinated action across the public, private, and community sectors. Public–private partnerships, international cooperation, and multi-stakeholder platforms are key to building value chains and sharing knowledge. Locally, inclusive engagement of communities, Indigenous Peoples, women, and youth ensures fair benefits and long-term ownership. Equity and participation are both rights-based principles and practical enablers of success. These enabling conditions complement with the principles above, providing governance and investment foundations for diverse forest-based bioeconomy pathways.

- **Knowledge integration and data systems:** robust, interoperable data enables better decisions and accountability. Open forest and land-use data, community monitoring, digital Measurement, Reporting, and Verification (MRV) tools for biomass and carbon, and value-chain traceability, including smallholders and informal actors, help align practice with policy. Cross-border data pooling and shared R&D infrastructure improve environmental protection, strengthen economic activity, and maximize returns on major investments. Investing in skills, data governance, and feedback loops turns data into adaptive management, market access, and greater credibility, trust, and social legitimacy, especially when policy trade-offs are visible.

Aside from these institutional enablers (rules, rights, regulations, finance, and capability), **environmental safeguards and adaptive management** are fundamental, spanning across practice and outcomes. Strong environmental and social safeguards (e.g., biodiversity protection, ecosystem integrity, water stewardship, climate-risk screening, "do-no-harm/ do-more-good" standards) ensure that the forest-based bioeconomy's growth is genuinely sustainable. Adaptive management then uses monitoring results to iteratively adjust policies, incentives, and on-the-ground operations, keeping pathways resilient as markets, technologies, and climate risks evolve.

Systemic barriers and common challenges

Just as there are common enablers, the forest sector faces several systemic challenges that recur across different themes of the forest-based bioeconomy. These are underlying barriers that can slow or hinder progress, regardless of context. Recognising these shared challenges is essential to inform coordinated actions by policymakers. Progress is most often slowed by governance and coordination gaps, limited finance and infrastructure (particularly for SME and smallholders), and weak innovation and data systems. Where participation and safeguards are insufficient, legitimacy and ecological resilience also erode, increasing exposure to climate and biodiversity risks.

It is recommended to follow a context-specific "spectrum of options" approach, where different countries/ regions choose different bioeconomy pathways based on geographical conditions, long standing local value chains, needs, resources, and societal priorities. Importantly, the task is to clarify conditions for transformative rather than merely transitional change.

Addressing these systemic challenges is critical for the forest-based bioeconomy to reach its potential, and recognizing a challenge is a necessary first step towards addressing it. In the chapters that follow, the forest-related fields present detailed findings and recommendations, with trade-offs noted. The commonalities outlined in this chapter provide a unifying thread, and whether formulating policy, designing financing mechanisms, or developing products, the broader context of *enabling conditions* and *systemic challenges* should remain in view. If countries and stakeholders strengthen these foundations while addressing persistent barriers, the forest-based bioeconomy can become a driver of economic opportunity, climate resilience, and ecological sustainability.

Table 2.2 Common enablers and barriers in the forest-based bioeconomy	
Common enablers	**Common barriers / challenges**
Coherent governance, aligned policy, and secure tenure	Insufficient policy enforcement, fragmented responsibilities, and unclear land/ resource rights Limited inter-sectoral and supranational coordination, inconsistent policy implementation, and regulation gaps lead to a difficult and expensive operational environment
Access to finance and markets	Financial constraints for smallholders and SME; high-risk perception; inadequate infrastructure, a limited pipeline of bankable projects; and asymmetrical access to market information
Innovation, R&D, and capacity building	Shortfalls in funding for national and international research, gaps in technical expertise; slow technology transfer (financing gaps from prototyping to scale); and a generally risk-averse innovation culture
Partnerships and inclusive participation	Lack of inclusion of specific communities (e.g., Indigenous Peoples, women, youth), and an inequitable distribution of benefits
Knowledge integration and data systems	Gaps in valuation, monitoring, and recognition of traditional knowledge; asymmetrical information flows
Environmental safeguards and adaptive management	Biodiversity loss, unsustainable extraction, and climate-related risks

Sources: FAO, 2024[8]; UNECE and FAO, 2024[9]; EIB, 2023[10]. Note: context-specific pathways remain essential for applying these insights across regions.

3

3. Wood solutions: engineered for bioeconomy

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3.1 Introduction

The threat of climate change, rising demand for bioeconomy solutions, and the mitigation potential of forests and long-lived wood products have shifted sentiment in many places from criticism of the forest sector to conditional support. The sector has long produced lumber, panels, and paper, but wood can also be converted into biochemicals and other materials that substitute many petroleum-based products, broadening pathways for a forest-based bioeconomy. This 'renaissance' is reflected in policies favouring wood in the built environment, its use for energy in some contexts, and the growing uptake of wood-based construction by innovative architects. Societal views are therefore more positive than in the past, although safeguards are needed to avoid unintended impacts from increased harvests. Materialising the potential benefits requires credible, transparent impact assessments, strong biodiversity safeguards, and robust end-of-life recovery systems.

The promise of the forest-based bioeconomy may alter societal reactions to forest management and expectations of forests' economic contributions. People's psychological connection to forests differs from that to, for example, agriculture, which is evident in contrasting perceptions of forest harvesting versus agricultural harvesting that often reflect cultural values rather than actual environmental effects. This dynamic has driven higher environmental performance requirements and intense debate on sustainable forest management, especially in forest-rich countries and regions. Outcomes range from reduced harvests to, in some cases, complete harvest bans. The bioeconomy promise also drives innovation in a sector long reliant on mature commodities, some now being phased out. However, there are early signs of large companies reducing innovation commitments, even as demand for credible 'green' products grows.

Global demand for wood continues to grow, regardless of bioeconomy developments. Overall material use has increased substantially over the past fifty years and is projected to rise by a further 60% by 2060. While material use remains dominated by non-renewables (around 75%), trends suggest that biomass use for food and fibre will increase by 50% by 2050[11]. Population growth, urbanization, and economic development, particularly in Emerging Economies, are expected to continue driving demand. Roundwood consumption has historically been estimated at roughly 50% industrial roundwood and 50% wood fuel, but recent modelling indicates that wood fuel use is about 30% higher than previous estimates[12].

Estimates for future industrial roundwood demand vary substantially. Modelling results from FAO's 2025 report *Global Forest Sector Outlook 2050* indicate that global consumption of primary processed wood products will increase by 37% by 2050. Currently, planted forests represent around 7% of global forest area, but provide about one-third of the industrial roundwood globally. Meeting the forecasted demand would require an

estimated 33 million hectares of new plantations, roughly equivalent to the current global eucalypt area, which at the current rate of gain of 1.67 million ha/year, would take about 20 years to accomplish[5]. Most likely, meeting the projected demands will require a mix of strategies combining increased area and productivity of naturally regenerated and planted forests with improved manufacturing efficiency and value addition.

3.2 From forest to market

Industrial roundwood demand is forecast to increase, although the effects of substituting forest products for non-renewables remain poorly quantified. Circularity and cascading use are important, but insufficient to meet projected growth, which may raise prices and create 'wood security' concerns, altogether implying that a sizeable bioeconomy will require additional wood supply.

Higher production must be matched with efficient use, reuse (circularity), and design-for-disassembly. Although plantations are contested in public debate, future fibre needs will likely require their expansion and intensification. Well-managed plantations can also relieve pressure on other forest types, particularly where harvesting is driven by low-value fuel use rather than higher value applications.

Productivity gains in natural forests are limited. Companies are therefore investing more in plantations, sometimes in new geographies. While plantations can contribute to fibre supply, outcomes depend on ecological and socio-economic contexts. Consumer perceptions also matter, and increasing reliance on plantations may require reframing them as managed tree farms where harvesting is expected and accepted. Agroforestry is often promoted as a middle ground, but all strategies require safeguards to ensure equity and avoid harm.

Market diffusion for new products is typically slow due to limited early supply, market inertia, or regulatory barriers, but accelerates when products offer cost or performance advantages. Rising demand for renewable products creates opportunities for both traditional wood products and new products derived from wood. This chapter addresses three primary wood-use categories: materials, chemicals, and energy, with particular focus on construction.

Materials: in the materials market, declining demand for products such as newsprint has been offset by increased demand for packaging, especially shipping boxes, etc. Efforts to reduce petroleum-based products in supply chains are driving further development of paper-based packaging.

Wood-based materials support logistics (e.g., pallets), highly specialised applications such as interior components for vehicles, and architectural components from structural elements to furniture. Expanding wood construction into regions without a strong wood building tradition may require industrialised housing models such as the Swedish model, where 45% of new homes are produced using offsite manufacturing[13]. Such approaches can also improve circularity.

Mass timber is increasingly used in commercial construction, including taller buildings, and public procurement could accelerate adoption through, for

example, infrastructure projects and social housing. Architects increasingly recognise the environmental and aesthetic benefits of wood, but **barriers to increased adoption remain**, including ***(i)*** real or perceived cost premiums, ***(ii)*** learning curves, ***(iii)*** lack of standardised carbon assessment methods ***(iv)*** limited affordable insurance, ***(v)*** limited supply paired with manufacturing facilities not being used at full capacity, and ***(vi)*** market forces such as tariffs, subsidies, or exchange rates[14].

While cross-laminated timber (CLT), with an estimated global output of 2.3 million m^3, dominates mass timber markets, a variety of other products are emerging. Production remains concentrated in Europe (80%) and North America (11%), with limited uptake in Emerging Economies[15].

Chemicals: wood-based textile fibres offer promising diversification pathways, but scaling has proven difficult. Many joint projects such as the *Woodspin JV* by Suzano and Spinnova have been slowed down or even terminated. Nevertheless, the Finnish Metsä Group showed progress in 2025, when it announced that pre-engineering for the first commercial Kuura textile fibre mill would begin, aiming to reach 100,000 tonnes of textile fibre production by 2029. Kuura is made from softwood pulp and used for both clothing and technical textiles, with a significantly lower environmental footprint than alternative fossil-based fibres.

Other chemical pathways such as tall oil, a side product in softwood chemical pulp processing used for advanced biofuels, lubricants, or rubber replacements, are mainly

Box 3.1 Mass timber: building with wood

Nanyang Technological University, Singapore (43,500 m^2)
Completed in 2023, "Gaia" is made almost entirely from mass timber and is described as Asia's largest wooden building. Elements ranging from handrails and benches to door frames and room dividers (and even an adjoining bus stop) were built using wood[16].

Peavy Forest Science Center, United States (18,400 m^2)
This building was completed in 2020 and is home to the Oregon State University College of Forestry. It is a demonstration project that includes multiple mass timber products (cross-laminated timber, glue-laminated timber, mass ply panels) as well as post-tensioned, cross-laminated timber shear walls[17].

Haut, Netherlands (14,500 m^2)
Haut is a mass timber construction completed in 2021 in Amsterdam. At 73 meters tall, it is the tallest wood residential building in the Netherlands. It has 21 floors and 50 private homes ranging from 100 to 225 square meters. It includes an energy-generating façade and the application of recyclable materials[18].

produced in Finland, the U.S., Sweden, and Canada. Wood-based bioplastics also show potential, but face commercialisation barriers. Overcoming innovation "valleys of death" (income gaps between the prototype stage and the new system becoming productive) often requires coordinated policy support, concessional finance, and offtake agreements.

Energy: wood fuel remains critical globally. Nearly 2.3 billion people, primarily in Sub-Saharan Africa and Asia, rely on fuelwood or charcoal[19], while modern bioenergy represents the largest renewable energy source, providing globally approximately 55% of the renewable energy and over 6% of the total energy supply[20]. Sustainably sourced fuelwood can support livelihoods and reduce dependence on fossil fuels, but challenges remain, including air pollution caused by inefficient combustion, which causes around 3.2 million premature deaths annually[19]. Additionally, unsustainable harvesting and inefficiently governed supply chains raise further concerns.

3.3 Financing the future

Wood-sector finance faces risks related to feedstock availability, technology adoption, and regulation. Scaling-up requires long-term, risk-tolerant capital as facilities are capital-intensive and slow to yield returns. Although forests attract long-term investors, finance must triple by 2030 to meet climate, biodiversity, and land restoration targets[21]. The challenge lies in both the volume and the design of finance needed to reduce risk and mobilise private capital.

Austria's EUR 107 million Wood Initiative, backed by the national Forest Fund (*Waldfonds*), supports timber construction, product innovation, awareness and skills training, and positioning wood as a pillar of Austria's bioeconomy and rural development. In the United States, federal programmes also support increased wood use: for example, the United States Department of Agriculture (USDA)'s Forest Service announced in July 2025 a USD 80 million budget for their Wood Innovation Grants to expand manufacturing, improve forest health, and stimulate local economies. Companies such as SmartLam North America have secured multi-million-dollar grants to expand CLT and glulam production in Montana and Alabama, illustrating how public funding can leverage private investment and strengthen regional markets. Through the use of grants and debt financing, the Australian federal government in 2024 allocated AUD 91.7 million to 31 private wood-processing companies under the "Accelerate Adoption of Wood Processing Innovation Program", and the Clean Energy Finance Corporation launched the AUD 300 million Timber Building Program in 2021 to finance mass timber construction. These examples demonstrate that blended public-private finance, grants, loans, and public programmes can stimulate supply, demand, and innovation.

In Latin America, Brazil is testing blended finance at scale. The Brazil Restoration and Bioeconomy Finance Coalition (launched at the 2024 G20 Summit) aims to mobilize USD 10 billion to conserve and restore at least 5.5 million hectares by 2030, while the government of the U.K. and the Dutch Entrepreneurial Development Bank (FMO) pledged USD 55 million to the investment bank BTG Pactual's reforestation strategy in the Cerrado,

combining restoration with sustainable plantations. The Tropical Forest Forever Facility (TFFF) is a proposed global investment fund, that aims to secure USD 125 billion to provide long-term, predictable finance rewarding tropical nations for the conservation and restoration of their forests, with payments per hectare preserved and at least 20% of funds directed to Indigenous Peoples and Local Communities (IPLC).

Across Southeast Asia, private equity is advancing the bioeconomy infrastructure. For example, the Tropical Asia Forest Fund 2 (New Forests) has raised about USD 120 million for sustainable plantation forestry and timber processing, with a first investment in Vietnam's Tavico Group[22]. In Africa, countries such as South Africa, Ethiopia, and Kenya are drafting or implementing national bioeconomy policies integrating sustainable forestry, while continental initiatives such as AFR100 aim to restore more than 100 million hectares by 2030, mainly through plantations and agroforestry, which could supply future wood markets. Infrastructure examples include the loans and grants established for Namibia's USD 152 million, 40 megawatts biomass power station at Otjikoto, and the blended corporate/ bank finance arrangement for South Africa's Ngodwana Biomass Power Station (25 megawatts) linked to a pulp and paper mill.

These cases show that effective finance also depends on enabling conditions such as clear tenure, stable regulation, secure feedstock, standardised monitoring, and supportive policy frameworks. In construction, modern building codes, procurement policies, and clearer insurance guidance can unlock demand for mass-timber.

3.4 Forest sector innovation

The FAO defines innovation across five dimensions:

- Technological - Includes new products, processes, biotechnologies (including genetic modification to increase fibre production), and digital applications (digital tools support forest management, manufacturing, and construction). Examples of recent innovative products are mass timber types, biomedical plastics, packaging and films, lignin-based adhesives, wood-based textiles, and drop-in fuels (renewable, sustainable alternatives that are chemically identical to petroleum derivates).

- Financial - Includes new approaches to mobilize flows, such as blended finance models (e.g., Brazil's Restoration & Bioeconomy Finance Coalition).

- Social - Includes new collaboration forms such as cooperatives of small-scale producers.

- Institutional - Includes new ways of organizing relationships in innovation ecosystems, such as Australia's forest-sector Research Hubs, or the EU's New European Bauhaus.

- Policy - Includes new processes and tools for policy design and implementation, including "wood first" policies in public procurement.

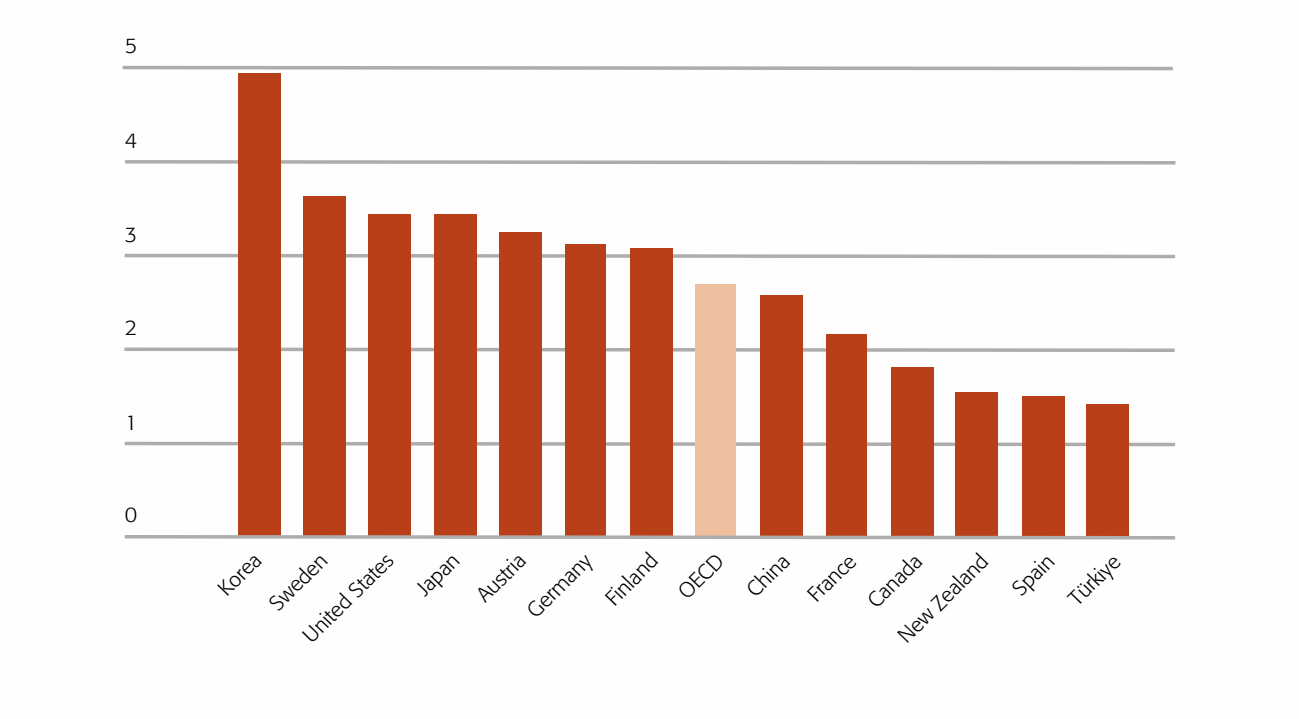
Innovation emerges from systems involving governments, businesses, non-governmental organisations (NGOs), and civil society. "Triple-helix" partnerships (industry-university-government) have

proven effective; for example, Australia's *Australia Forest and Wood Innovations* initiative follows this approach. Bioeconomy development can be accelerated through coordinated 'innovation bundles' aligning policy, finance, and technology. However, progress is often constrained by limited resources, sector culture, risk perceptions, and unsupportive policies and regulations. While sector-specific innovation statistics are limited, R&D investment differs among countries (Figure 3.1).

3.5 Multi-actor collaboration

Collaboration across the wood value chain is essential for market uptake. For example, in Scandinavia, cooperation among forest companies, packaging producers, and consumer goods firms supported the rise of fibre-based alternatives to plastics, showing how value chain integration can create viable markets. Technology transfer also depends on joint efforts, as

Figure 3.1 Gross Domestic Spending on R&D as percent of GDP[23]



illustrated by *BioFuelNet Canada* linking forestry, energy, and agriculture actors to advance lignocellulosic biofuels, and Australia's *ARC Research Hub* connecting timber producers, the construction sector, and researchers to expand engineered wood use.

Creating a level playing field can strengthen collaboration, especially in wood construction, where multiple materials are used. Performance-based standards, such as carbon-content limits per square meter, can encourage efficient hybrid designs and improve sustainability through better integration of wood, concrete, and steel.

Collaboration shapes the development of markets and consumer acceptance. Even where technologies are mature, public trust and demand determine whether new products succeed. In Japan, the Forestry and Forest Products Research Institute has worked with retailers and housing developers to promote cross-laminated timber via safety and carbon campaigns[24]. In Europe, the "4evergreen" alliance (100+ companies across forestry, packaging and food) aims to scale fibre-based packaging aligned with circular economy goals[25]. Sustainable sourcing similarly depends on multi-actor participation: certification systems (FSC, PEFC) rely on producers, NGOs and communities. Ghana's Forest Investment Program illustrates this: engaging smallholder cocoa farmers, CSOs and donors, it combined agroforestry with forest management and linked conservation outcomes with livelihood security[26].

Multi-actor processes also contribute to policy stability. An example is the *Private Forest Accord* in Oregon, U.S., where timber companies and environmental organizations co-developed rules on riparian buffers and habitat protection, showing that collaboration can deliver both safeguards and regulatory predictability. At a broader scale, the EU Bioeconomy Strategy has established multi-stakeholder platforms aligning forest policy with climate and circular economy goals.

Overall, these examples show that cooperation enables market development, technology transfer, trust, credible sourcing, and infrastructure investment. Performance-based standards, such as carbon-content limits in construction, can further encourage efficient material use. Collaboration supports integration, learning, legitimacy, and long-term progress.

3.6 From policy to practice

Key policy recommendations for developing of a wood-based bioeconomy include:

Realistic expectations: stakeholders need a clear understanding of what the bioeconomy can and cannot deliver. It must be communicated that bioeconomy development is not a panacea for de-fossilization, and that wood is not a silver bullet for societal challenges. Global limits to increasing wood-resource use must be acknowledged, and planning must be based on a realistic understanding of technical, economic, and social constraints.

Develop bioeconomy strategies: context-specific strategies are essential and should reflect the appropriate role of the forest sector within broader development pathways. While some countries and regions (e.g., Finland, Germany, Latin America) have developed bioeconomy strategies, many have not.

Strategies should reflect local conditions ranging from advanced biorefineries to improved basic processing, and should be supported by implementation policies, action plans, and concrete measures such as wood construction ratio or an obligation to ensure reusability of products.

Increase fibre supply: improving utilization, circularity, and cascading use is helpful, but a meaningful bioeconomy requires additional biological material. Well-managed plantations, complemented by fibre from other sources such as agroforestry, and governed by strict safeguards, are indispensable. Sustainable land-use planning is essential to manage trade-offs and balance food and fibre supply.

Incentivise R&D, innovation, and culture change: innovation is multi-dimensional and often implemented in reinforcing bundles. Bioeconomy development requires investment in research and innovation capacity, support for experimentation, risk-taking, cross-sector collaboration, enabling institutional environments, and cultural change.

Build capacity: the tools supporting bioeconomy transitions are evolving rapidly, making continuous skills development essential. From advanced technologies such as AI, to basic manufacturing quality control, sustained investment in people is needed.

Increase consumer knowledge: consumer understanding of forests' roles (well-being, climate, jobs, growth, biodiversity) and responsible use of renewable products is a major driver of transition. Efforts should aim to raise literacy about consumption and environmentally friendly choices.

Mobilise and structure finance: beyond increasing capital, bioeconomy finance requires an architecture that reduces risk and attracts long-term private investment. Public funds should be used strategically to leverage private finance and strengthen markets. Blended finance (grants, loans, equity, guarantees) can support restoration, innovation, and infrastructure, but enabling conditions, clear tenure, stable regulation, reliable feedstock, and standardized monitoring are also required. For example, performance-based building codes and clearer insurance guidance can accelerate mass-timber adoption.

Break down silos and create a level playing field: a sustainable built environment requires performance-based standards that encourage efficient material use, and similar approaches apply in other sectors (e.g., energy). More broadly, bioeconomy progress depends on integrated policymaking across ministries, sectors, and countries, as siloed approaches can undermine progress. Policies must therefore be coordinated and mutually reinforcing.

3.7 Key messages on wood products

KEY MESSAGES – WOOD PRODUCTS	
With scientifically robust safeguards, wood products can substitute more carbon-intensive materials, enable biochemical pathways, and support rural jobs. Demand is rising (construction, packaging, fibres), but supply limits and adoption barriers (codes, LCA consistency, insurance, skills, infrastructure) remain significant. Materialising bioeconomy benefits requires expanding sustainable supply (including well-designed plantations), accelerating circularity (cascading use, closed-loop manufacturing), and basing decisions on credible environmental performance assessments.	
From forest to markets	▪ Ensure adequate **legality, traceability, and sustainability safeguards** ▪ Invest in **processing hubs and critical infrastructure** ▪ Apply safeguards; enable the establishment of plantation forests to increase fibre supply ▪ Build consumer trust in plantations and forest management to provide raw materials and maintain carbon sequestration capacity
Financing the future	▪ Establish **blended-finance instruments** (grants, loans, guarantees, equity) with public risk-sharing to **de-risk** forestry and manufacturing investments ▪ Use **green public procurement** to increase demand for low-carbon wood construction and other renewables ▪ **Support manufacturing upgrades to low-waste, circular manufacturing** and improved quality ▪ Establish insurance mechanisms for new materials/uses such as mass timber
Forest-sector innovation	▪ Support forest sector innovation systems that embrace experimentation and accept risk taking ▪ Mitigate barriers of resource constraints, sector culture, risk, and unsupportive policies ▪ Support standardized metrics to create a level playing field for all materials ▪ Support **digital tools** in design, manufacturing, and construction to enable **circularity**
Multi-actor collaboration	▪ Remove siloed approaches at all levels to increase holistic solutions ▪ Encourage company and cross-sector collaboration to enhance innovation ▪ Support triple-helix (industry-university-gov.) and other approaches to R&D and innovation ▪ Educate consumers in order to increase environmentally friendly consumption
From policy to practice	▪ Establish wood-first procurement policies ▪ Develop context-specific forest-based bioeconomy strategies ▪ Streamline code approval processes ▪ Adopt **performance-based standards** for transparent sustainability assessments ▪ **Streamline permitting** for sustainable plantations, processing facilities, and new wood-based products ▪ Support workforce skills development

4. Non-wood forest product transition pathways to a sustainable forest-based bioeconomy

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4.1 Introduction

Forests provide more than wood, cellulose, and carbon benefits. Well-known examples include Brazil nuts, shea butter, argan oil, frankincense, ginseng, and maple syrup, although tens of thousands of plant and fungi species are used for food, medicine, energy, construction, cosmetics, decoration, spirituality, and cultural practices, supporting over 60% of people worldwide[27] in subsistence, income generation, green jobs, and major industries (e.g., health care, pharmaceuticals, cosmetics), and contributing to economies at all levels. Producer income from non-wood forest products (NWFP) is estimated at USD 88 billion per year globally, and USD 23 billion per year in Europe[28].

Forest products other than wood are described by multiple terms (non-wood, non-timber, minor, secondary, special forest products), reflecting their historical neglect. In this Brief, they are collectively termed "non-wood forest products" or NWFP, and defined as renewable environmental products, primarily forest fungi and plants, whose non-wood parts, such as roots, rhizomes, bark, leaves, fruit and others, are harvested for human use[29], including both wild and cultivated species.

Despite their widespread use and economic importance, NWFP remain peripheral to policies, forest management, poverty alleviation, food security, and development plans, and are underrepresented in bioeconomy strategies, even though their integration could benefit more people, raise the visible value of forests, strengthen biodiversity conservation incentives and reduce poverty and deforestation.

This chapter translates transition pathways into practical guidance and priority actions to support NWFP, defining pathways as coordinated sets of actions enabling a shift towards a forest-based bioeconomy illustrated with recent, replicable examples.

4.2 Transition pathways, fields of intervention, and priority actions

Three complementary pathways describe how to integrate NWFP into a sustainable forest-based bioeconomy. Progress in one while neglecting the others may not achieve sustainability, equity, and scale. Transition efforts should reflect national priorities while targeting multiple pathways.

Key barriers for integrating NWFP into the forest-based bioeconomy include poor sector definition and documentation, limited management knowledge, underdeveloped processing and quality systems, weak business models, scarce finance, and most importantly, lack of formal recognition and enabling legislation. Priority actions should address these bottlenecks. Table 4.1 summarises the three transition pathways and their different components, including priority actions, which are further described after the Table.

Table 4.1 Three NWFP transition pathways and prioritised actions across five intervention fields			
Pathway → **Intervention field ↓**	**(A) Sustainable production and sourcing**	**(B) Upgrading and industry development**	**(C) Meeting consumer demand**
From forest to markets	Forest management plans for natural populations, harvesting guidelines, inventories and monitoring (Gov/Res/Coop/ SME) | Expansion of agroforestry and forest-farming (Gov/CSO/Coop/SME) | Cultivation of priority species (Priv/Res/Gov)	Local value addition at primary stage (Coop/SME) | Infrastructure, quality labs, and food safety (Gov/ DFI) | R&D for new products (Res/ Gov/Priv) | Decrease of obstacles for businesses; remove market barriers (Gov)	Institutional procurement (school meals, hospitals) (Gov) | Local and international market development (Coop/ SME/ CSO/Gov) | Capacity-building for quality assurance (SME/ Coop/ Gov)
Innovation	R&D on germplasm and cultivation (Res/ Gov/Priv) | Extension services and technical advice for smallholders (Res/Gov/Priv) | Sustainable management and conservation practices (Gov/Res/SME/Coop) | Organisational and managerial capacities of producers (SME/Coop/CSO)	Product and process innovation (low-tech & high-tech) (Res/ Priv/Gov) | Tech transfer hubs for upscaling (Res/Priv/Gov)	Certification/branding (Priv/CSO) | Product mainstream use (Priv/ Gov) | Premium markets for sustainable products (Priv/Gov)
Finance	Global funds and working-capital facilities (DFI/Bank) | Minimum NWFP selling price schemes (Gov/Priv/Coop) | Blended mechanisms for de-risking investments (Gov/Priv/DFI)	Innovation grants (Gov/DFI) | Risk-sharing and guarantees for SME (Gov/DFI)	Blended finance for market entry (Gov/Priv/ DFI) | Re-investment of price premiums (Gov/ Priv/CSO)
Multi-actor collaboration	Engagement of value chain stakeholders (Coop/SME/CSO/Priv) | Strengthening of producer organisations (SME/Coop) | Farmer inclusiveness (Gov/Res/Coop/SME)	Industry forums (Gov/Priv/CSO/ SME/Res) | Capacity building for farmers, entrepreneurs, and SME (Gov/CSO/SME)	Codex engagement for priority products (Gov/ Res) | Science to advance innovations (Res/Gov/ Priv)
Policy to practice	Secure tenure, adequate access, and benefit sharing (Gov) | Public policies on sustainable NWFP harvesting and resource management (Gov) | NWFP in national statistics for tailoring policies (Gov)	Information access and transparency (Gov/SME/ Priv) | Policies on traditional knowledge and access (Gov) | Enabling business environment (Gov) | Establishment of R&D programmes to leverage NWFP value chains and sustainable use (Gov/Res/Priv)	National NWFP strategy (Gov) | Transparent price and performance (Gov/ Priv/SME/Coop)
__Gov__ = government; __Res__ = research; __DFI__ = development finance institution; __CSO__ = civil society organisation; __SME__ = small/ medium enterprise; __Priv__ = large-scale businesses; __Coop__ = Producer cooperative			

Transition pathways

A. Support sustainable production and sourcing of NWFP

Most NWFP are currently harvested from the wild, presenting opportunities to integrate science-based management alongside existing practices. Transitioning to sustainable management, complemented by both *in situ* and *ex situ* cultivation, is essential. Production systems range from managing natural populations to agroforestry and forest farming. NWFP cultivation that maintains canopy cover can support biodiversity and reduce deforestation. All aspects of the production system would benefit from research and development, but knowledge gaps should not delay action to advance sustainable production and sourcing.

B. Innovation for upgrading and industry development

Product, process, and functional upgrading can enhance innovation, values, and industry development, but are often overlooked. Stronger value chains depend on innovation, formalisation, quality assurance, and market linkages. Policies must anticipate trade-offs of commercialisation, including reduced availability of subsistence products, food-security risks, and gendered impacts.

C. Meeting consumer demand

Global demand for many NWFP is diversifying and growing. Consumers increasingly seek sustainable and ethical products, and emerging biobased sectors (functional foods, biopharmaceuticals) are driving innovation. This pathway incentivises high-quality production, addresses social concerns, and supports market development and expansion under sustainable conditions.

Intervention fields

From forest to markets: sustainable and efficient production systems

NWFP are often treated as open-access resources with limited science-based management and guidance. They should be integrated into multiple-use forest management objectives, supported by improved inventories and monitoring. Indigenous, local, and scientific knowledge should be combined and integrated into management plans and practices. Cultivation is often needed to reduce pressure on natural populations. *Ex situ* (on-farm, out of the forest) production systems require knowledge in cultivation, agronomy, and post-harvest practices to ensure consistent quality, while *in situ* approaches (e.g., forest farming) can support more inclusive participation because on-farm cultivation can exclude landless wild-harvesters. Adaptive management should integrate emerging evidence.

Supporting producers to improve harvesting, processing, and quality is essential. Targeted assistance can avoid residual biomass, increase circularity, and strengthen quality control needed to meet market compliance. For example, the *Wild Stewards Alliance* (Appalachian region, U.S.) works with medicinal plant harvesters to build a certified workforce supplying high-quality raw materials for premium buyers[30]. Replacing outdated processing equipment with improved technologies has improved access to higher-return markets for products such as shea butter, Brazil nuts, and bush mangoes. Infrastructure investments (storage, processing facilities, quality-control laboratories) and coordinated public-private investment in R&D are also needed. As quality and supply increase, public procurement (e.g., schools, hospitals) can strengthen markets to fulfil local needs.

Box 4.1 Baobab: from subsistence product to global markets

The baobab case illustrates how innovation, collaboration, entrepreneurship, and value-based trade can transform an informally used product into a globally traded ingredient. This transition required innovations at every stage, hygiene-focused processing, supply-chain organisation, and traceability to meet international standards. Weak innovation systems in producer countries were overcome by bottom-up collaboration led by passionate entrepreneurs and supported by development and ethical trade organisations. Through these efforts, regulatory hurdles such as the EU's Novel Food Regulation were navigated, legitimising the product and opening additional markets, which promoted the development of numerous consumer goods[31]. Marketing efforts benefited from research into baobab's nutritional profile and from targeted consumer awareness campaigns. Industry-wide collaboration continues with the formation of the *African Baobab Alliance*, striving to foster a sustainable baobab industry that benefits harvesters across Africa. Current efforts include safeguarding ethical supply chains (e.g., minimum pricing) and preventing sustainability-oriented models from being undermined by non-certified supply of unclear origin.

Innovation: increasing added value and competitiveness

Developing cultivation technologies can improve productivity and secure sustainable supply while reducing pressure on wild populations. For example, spineless *pequi* cultivars in Brazil ease consumption and industrial processing. This requires stronger innovation systems (e.g., germplasm banks, nurseries, field trials, advisory services, financing, pilots). Prioritizing key species for cultivation facilitates the creation of dedicated innovation systems, as in the case of the *macaúba* palm for oil production in Brazil. For small-scale producers, strengthening producer organisations improves supply reliability, bargaining power, and linkages to markets.

New products often face scale-up constraints, requiring joint support from governments and industry. For instance, natural fibres from date palm leaves may substitute plastics in reinforced composites for construction, automotive, and packaging, but scaling faces funding, cost-efficiency, and performance-consistency constraints.

Consumer uptake can be encouraged through competitive price and utility, and through product certification and branding schemes that guarantee attributes such as quality, origin, or safety. For example, enterprises exporting walnuts and dried fruits from Kyrgyzstan to high-value international markets such as the EU use organic certification to assure ethically motivated consumers in these markets of the sustainability of their products. To move beyond niche markets, competitiveness and scale are necessary, alongside removal of infrastructure and market barriers.

Box 4.2 Wild-simulated ginseng: industry transition through institutional and market innovation

In the Republic of Korea, wild-simulated ginseng, a high-value, healthy food product, provides forest communities with income comparable to timber production. The Korea Forest Service established a quality management system including pesticide residue testing and product certification to improve safety and authenticity[32]. Institutional support strengthened the value chain and enabled industry specialisation, including professional quality-control organisations[33]. Consequently, the wild-simulated ginseng industry illustrates how institutional investment can modernise a traditional livelihood into a bioeconomy-aligned sector.

Financing: mobilising resources for development

Access to finance is critical for NWFP producers and businesses, and development banks and global funds can support sustainable sourcing. Examples include the Tropical Forest Forever Facility (TFFF) and the Global Forest Finance Pledge (GFFP). National mechanisms such as debt-for-nature swaps, or Colombia's Sustainable Fund and biodiversity bonds can channel tailored finance. Private finance, corporate sourcing commitments, and minimum price schemes can stabilise incomes and reduce risk. For example, Brazil guarantees minimum prices to family farmers and Indigenous Communities extracting NWFP[34].

Innovation grants can support upgrading and SME development. In the Republic of Korea, special zones for wild-simulated ginseng and innovation grants support specialisation and value-chain development. Blended finance and risk-sharing approaches can support sustainable market growth, while price premiums and the commitment of global enterprises using NWFP should support stewardship and community development.

Multi-actor collaboration: leveraging intersectoral and international support

Sustainable NWFP management requires engagement among producer organisations, researchers, authorities, and certification bodies to improve traceability standards and management. Strengthened through targeted knowledge exchange and capacity building, producer organisations and cooperatives can support sustainability and equity. Partnerships can also promote inclusive cultivation and reduce elite capture.

Industry collaboration supports value addition and sector development, as demonstrated by alliances such as the *Global Shea Alliance* or the *African Baobab Alliance*, where stakeholders across the value chain work together to collaboratively tackle sector challenges. Such fora are relevant to promote industry sustainability, define and ensure quality practices and standards, or stimulate demand. Capacity building in sustainable sourcing, product development, quality control, and standards can strengthen competitiveness. Collaboration also builds consumer trust, particularly where quality standards are weak and trade is informal. Integrating NWFP into global frameworks such as the *Codex Alimentarius*

requires coordinated action by industry, research, and authorities. Strengthening global research networks can improve evidence, innovation, and policy learning.

From policy to practice: policies to advance access, adoption, and upscaling

Supportive legal frameworks and incentives are more effective than punitive approaches. Laws on biodiversity management, tenure, and harvesting should enable sustainable community use. For example, Brazil's Free Babassu Law guarantees community access to collection sites of the babassu palm kernels subject to sustainable rules (e.g., prohibition of felling, burning, and use of some pesticides). Exclusionary policies can reduce household incomes, as shown in Cambodia, where these fell by 15-19%[35].

National frameworks should integrate statutory and customary law, protect traditional knowledge, and ensure benefit-sharing with strong regional implementation capacity. Potential negative impacts of NWFP valorisation (biodiversity loss, soil erosion, reduced access) can be mitigated through policies supporting sustainable management. For example, low-impact management has increased productivity while maintaining biodiversity in açaí areas in the Brazilian Amazon, reducing risks such as increased Chagas disease associated with high-density and low-diversity açaí systems.

Monitoring production and markets remains weak. Yet, species- and product-level data are urgently needed to support transparency, planning, and investment.

Policies should promote market development and equitable benefit while recognising NWFP diversity. Policies that foster adequate access and benefit-sharing arrangements should be promulgated to avoid potential negative implications on vulnerable communities reliant on NWFP. Promoting public-private partnerships has shown positive benefits, as is the case with Brazil's collaboration with a major cosmetics company who has invested in production and distribution infrastructure as a socio-environmental compensation[36]. National strategies and bioeconomy frameworks prioritising sustainable biodiversity use (e.g., in Colombia, Brazil, Costa Rica) are needed to leverage NWFP value chains and support R&D.

Box 4.3 Açaí from the Brazilian Amazon: coexistence among different forms of production, distribution, and consumption

For over 20 years, the açaí boom has been studied, including the shift from short local supply chains to more complex agro-industrial configurations, alongside substantial income gains for harvesters. Açaí palm density increased in some areas, and, in the Amazon estuary region, biodiversity declined by 36.4% between 2001 and 2018 across 32 açaí plots[37], indicating species loss and a trend towards monoculture. To mitigate biodiversity impacts, Embrapa (Brazilian Agricultural Research Corporation) implemented minimal-impact management in native açaí groves, notably in the states of Pará and Amapá, and developed two dryland-adapted cultivars used in reforestation.

Value-chain changes have increased demand for reliable production and market information, prompting the Brazilian Institute of Geography and Statistics (IBGE) to revise its data collection methodology and expand reporting beyond previously estimated or sales-based figures. Since 2015, IBGE has also reported cultivated açaí production, which has grown rapidly. Two production-distribution models coexist: (i) a local model supplying rural families and regional urban consumers with daily fresh açaí; and (ii) an industrial model supplying processors and distributors shipping frozen products and derivatives within Brazil and internationally, each with distinct quality and efficiency requirements.

To steer the sector towards more sustainable and inclusive practices, the *Pro-Açaí Dialogues Collective*, bringing together companies, government agencies, civil society, cooperatives, universities, financial institutions, certifiers, research centres, and technical assistance developed sustainability recommendations for the value chain. While the *Codex Alimentarius* does not yet include açaí-specific standards, Brazil's long Codex engagement (since 1968) helps to support standard-setting aligned with evolving national and international markets. Although export codes already distinguish pure pulp, mixed pulp, and dehydrated/powder products, more detailed specifications are needed to reflect the expanding product range and enable further innovation around this "superfood".

4.3 Key cross-cutting messages and policy recommendations

The potential of NWFP to contribute to a sustainable forest-based bioeconomy is under-realised, but significant progress is possible with existing knowledge. Integrated implementation of the transition pathways and actions requires national institutional recognition and support for NWFP resources. Formal recognition (e.g., a national strategy or legal designation) can codify NWFP as national assets, strengthen coordination, and enable sustainable production and trade. As shown in the case examples, institutions supporting access, innovation, and sustainable provisioning (harvest guidelines, resource management, quality systems) accelerate NWFP integration into bioeconomies. Governments could identify NWFP of national importance and adopt policies that safeguard long-term availability for subsistence while enabling responsible market development.

Governance improvements should engage actors such as primary producers, SME, multinational firms, research institutions, and civil society. National efforts should ensure that trade statistics as well as forest management strategies and plans include NWFP. Improving transparency and accountability along value chains is central to equitable benefit sharing and sustainability outcomes.

Photo © Michael Kleine

KEY MESSAGES – NON-WOOD FOREST PRODUCTS	
NWFP are key resources supporting the transition to a sustainable forest-based bioeconomy. Ensuring sustainable production and sourcing, innovating for upgrading and industry development, and meeting demand for sustainable products are complementary pathways that can overcome barriers such as informality, limited recognition, weak stakeholder involvement, financing, and weak market linkages.	
From forest to markets	▪ Develop **species-specific** and **context-dependent management plans and sustainable harvesting guidelines**; strengthen monitoring systems to maintain ecological balance and prevent overexploitation. ▪ Support domestication and cultivation of **priority NWFP**; improve **post-harvest processing** and invest in infrastructure for **quality control**, testing, and certification. ▪ Promote **local and regional market** development through public-private investment while building producer capacities to meet quality standards and add value locally. ▪ **Remove barriers** to businesses and trade while ensuring sustainable management.
Innovation	▪ **Invest in R&D and innovation** for forest farming and NWFP cultivation, processing, and product development; strengthen partnerships to accelerate technology adoption across the value chain. ▪ Develop production **models that integrate conservation with sustainable management** and strengthen producer organisations to enhance marketing, value addition, and bargaining power. ▪ Develop **certification, branding, and communication strategies** that highlight the ecological and social benefits of NWFP, strengthening access to ethical and mainstream markets.
Finance	▪ **Strengthen partnerships with** development banks, global funds, and private enterprises, and promote blended financing that leverages public, private, and NGO resources. ▪ Develop **risk-sharing and finance models** linked to price stabilisation and provide innovation grants to producer organisations and SME to boost entrepreneurship and value addition. ▪ **Reinvest gains into community development** and resource management; promote fair-trade approaches that empower local producers and sustain long-term social and environmental benefits.
Multi-actor collaboration	▪ **Engage market stakeholders and create multi-actor platforms** that promote coordination, transparency, and sustainable sourcing among producers, firms, NGO, and governments. ▪ Support and build the **capacity of producer organisations, smallholders, entrepreneurs, and SME** to enhance competitiveness, market access, and organisational strength. ▪ Facilitate the **inclusion of NWFP in international standards** such as the *Codex Alimentarius*; establish global networks to foster innovation and collaboration among early-career scientists.
From policy to practice	▪ Ensure that **legislation supports sustainable production, trade, and conservation** while safeguarding traditional knowledge through fair benefit-sharing and intellectual property mechanisms. ▪ **Engage local practitioners in policymaking** to align regulations with customary practices and equitable access. ▪ Incorporate **NWFP data into national statistics** and enhance species- and product-level information on volumes and values to inform evidence-based policy making, and resource and value chain management. ▪ **Develop national strategies** that foster business growth, market development, and equitable benefits, while promoting transparency in pricing and social/environmental impacts across the value chain, and safeguarding NWFP use for subsistence and livelihood.

5. Realizing forest ecosystem services as bioeconomy assets

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5.1 Introduction

Forest Ecosystem Services (FES) are a key component of the bioeconomy, but are often less tangible than other forest products, and are frequently treated as public (non-market) rather than private (market) goods. This complicates monetisation, value-chain development, and integration into economic decision-making. Although financing mechanisms exist, their coverage remains limited. Emerging single-attribute markets (e.g., carbon, biodiversity) capture only part of the full value of ecosystem services, while beneficiary distribution remains uneven, with global beneficiaries often outweighing local ones. Stronger quantification and communication of value could improve policy and investment uptake, but major challenges persist, including pricing public goods, designing appropriate market mechanisms, and clarifying public-private roles.

Forests provide a wide range of ecosystem services that support human well-being. FES are the benefits people obtain from forests, including provisioning services (e.g., timber, fuelwood, food), regulating services (e.g., climate regulation, water purification, flood control), cultural services (e.g., recreation, spiritual values, aesthetics), and supporting services (e.g., nutrient cycling, soil formation, biodiversity habitat). Together, they underpin economic activity and environmental stability, and are increasingly recognised as part of natural capital for climate mitigation, sustainable development and social-ecological resilience. This chapter focuses primarily on regulating and cultural services, and on water as a key provisioning service.

Regulating and cultural services account for most of forests' economic value, exceeding direct market values from provisioning services by a factor of three to four[38]. *The State of the World's Forests 2022* estimated the global value of selected FES (recreation and hunting, habitat, NWFP, and water services) at USD 7.5 trillion[21]. However, many services are difficult to monetise, some (especially cultural services) are not well suited for monetary valuation, financing mechanisms remain uneven, and governance frameworks often fail to ensure equitable access and investment. Addressing these gaps is essential for reducing deforestation, strengthening climate mitigation, and creating income opportunities for local communities.

5.2 From forest to market

Successful FES value chains exist across Africa, Europe, the Americas, Asia, and Oceania, including for the following FES: watershed services (Box 5.1), biodiversity, recreation, and ecotourism (Box 5.2), hazard mitigation and carbon benefits (Box 5.3), and combined FES (Box 5.4). Common success factors include strong property rights, public financing, long-term institutional stability, credible monitoring, public-private partnerships, secure community tenure, blended finance, and clear benefit-sharing mechanisms.

Despite growing evidence, global coverage remains patchy. Valuation studies are increasing, but lack geographic representativeness and there is no

comprehensive global data collection system for FES. Existing regional frameworks such as the Montréal Process and Forest Europe's *Criteria and Indicators*, and databases such as the Ecosystem Services Valuation Database (ESVD) provide only partial coverage.

Demand pathways also remain unclear: who pays, who benefits, and why are often poorly defined. Willingness-to-pay studies dominate particularly where non-market values prevail. This uncertainty around demand and payment responsibilities constrains scaling-up.

Opportunities – Develop and diversify value chains

FES value chains remain underdeveloped despite their strong potential. New value chains must be designed locally, reflecting ecological and socio-economic contexts. Learning from existing models, creating a structured reference library for practitioners mapping value chains, connecting custodians with beneficiaries, and strengthening market intelligence can accelerate replication. Tourism operators as well as water utilities and other downstream users can co-finance FES when links between forest condition and operational benefits are clear. An example of this is Austria's long-standing Vienna watershed protection model.

5.3 Forest sector innovation: driving new markets

Carbon markets are now well established, and biodiversity credit schemes are emerging. Voluntary environmental markets show potential to incentivise services such as water regulation, soil stability, and habitat conservation. However, challenges remain, as shown by the short-term political cycles conflicting with the long-term environmental goals, or the trade-offs between timber production and biodiversity conservation. Additionally, monitoring, verification, and valuing remain complex. Some schemes require buyers to fund specific interventions such as predator control (e.g., Ekos in New Zealand) rather than generic outcomes due to uncertainty and time lags.

Opportunities – Drive innovation and market creation

Biodiversity credit instruments, supported through public-private partnerships, could align conservation incentives with global targets, creating new revenue streams. Certification schemes can also build trust and enable price premiums. Evidence from the United States suggests that landowners may substantially delay harvests when premiums reward ecosystem service outcomes. Technology (e.g., remote sensing,

Box 5.1 Watershed forests (Austria, U.S., and France)

Watershed protection value chains are flagship examples of forest ecosystem services (FES) and nature-based infrastructure. Austria's Vienna Watershed Forests, France's Vittel/Contrex aquifer protection scheme, and the U.S.'s New York City Watershed programme show how upstream forest and land-management investments can eliminate or substantially reduce the need for expensive drinking-water treatment plants. New York City's approach, investing roughly USD 200 million per year in land easements, riparian buffers, and community partnerships, helped avoid an estimated USD 6–10 billion in capital costs for filtration. France's Vittel model shows how a private company can finance aquifer protection through long-term contracts with farmers, improving water quality while sustaining a premium brand.

Vienna's drinking-water security rests on a long-standing, landscape-scale watershed protection system. The city draws spring water via the First (1873) and Second (1910) Mountain Spring Pipelines from the Rax-Schneeberg and Hochschwab catchments about 120 km away. The gravity-fed system requires minimal treatment because raw water quality remains consistently high. This outcome is enabled by municipal ownership and easements, legally designated water-protection zones, and forest management focused on soil stability and water conservation. Grazing, forestry operations, road construction and tourism are tightly regulated to limit erosion, protect recharge areas, and prevent contamination, reducing downstream treatment needs for more than a century.

Box 5.2 Ecotourism (Namibia and Peru)

Namibia and Peru illustrate FES value chains that align conservation with community livelihoods. In Namibia, communal conservancies under Community-Based Natural Resource Management (CBNRM) link wildlife and forest/grassland stewardship to local economic benefits. Rights established under the 1996 Nature Conservation Amendment Act enable communities to manage wildlife and earn tourism revenues. Conservancies set up governance structures, form joint ventures with private lodges, and share revenues through fixed fees and turnover-based payments, supporting households, jobs, social projects, and wildlife monitoring. These incentives drive active stewardship (wildlife, fire, and vegetation management). Economically, conservancies generate about USD 10-15 million annually and thousands of jobs. Ecologically, they support wildlife recovery and reduce poaching. Socially, they strengthen local institutions, increase financial independence, and reduce human-wildlife conflict.

In Peru's Tambopata region, long-term Brazil nut concessions provide secure forest tenure, while high-end ecolodges partner with concession holders through employment, training, and profit-sharing. Communities maintain forests through fire control, patrolling, and monitoring, protecting both nut yields and tourism quality. Combined income from nut sales and ecotourism supports households, regional employment, and community development; intact forests sustain biodiversity and hydrological functions and help reduce deforestation.

Both models work because they combine secure tenure, diversified revenue streams, market demand for sustainably sourced products, transparent benefit-sharing, and strong institutional support, linking stewardship directly to economic returns.

AI) can strengthen verification and reduce transaction costs, while bundled projects combining carbon, water, and biodiversity outcomes can maximise co-benefits and attract blended finance.

5.4 Financing the future

Interest in financing FES is growing, with examples such as the EU Taxonomy and New Zealand's Emissions Trading Scheme (ETS), but robust and scalable financial mechanisms remain limited. Payments for Ecosystem Services (PES) are widely discussed but unevenly implemented. Cross-country variability in legal and institutional settings constrains comparability, market development, and scalability. FES are often treated as public goods, complicating monetisation and raising equity questions. Some services, particularly cultural services, may not be appropriate for monetisation. Political resistance also arises where new mechanisms are perceived as threatening existing subsidies or production systems.

Opportunities – Mobilizing finance

Finance should be more closely linked to measurable outcomes. Verified improvements in, for example, water quality, biodiversity gains, or ecosystem condition can strengthen accountability and attract investment. Expanding carbon and biodiversity markets supported by standardised methodologies can build investor confidence and broaden participation. Blended finance approaches (using public funds to de-risk investments) offer a practical pathway. Green bonds and climate finance instruments can support restoration, conservation, and resilience, but require credible, transparent, and comparable verification frameworks to make FES investment ready.

5.5 Multi-actor collaboration

FES benefits are distributed unevenly across both local and distant populations. Local communities benefit most directly from provisioning services, while

regulating services often benefit regional, national, or global populations. Indigenous and forest-dependent communities can benefit significantly where tenure is secure, and payment mechanisms are fair.

However, awareness of FES benefits remains limited, especially among those living closest to forests. Provisioning services are better understood than regulating or cultural services, and weak communication can lead to scepticism and disengagement. In some contexts, forests are perceived as competing with food security, which can undermine support for conservation initiatives. Public attitudes often reflect practical considerations about tangible local benefits, highlighting the need for more relatable messaging.

Opportunities – Empower stakeholders and improve understanding

PES schemes should be co-designed with local communities to ensure fairness and local relevance. Communication should focus on tangible household and community benefits, using clear, relatable narratives to build trust and uptake. Capacity building is essential, and approaches such as agroforestry can demonstrate that ecosystem services and food security are complementary. Community monitoring and adaptive governance can strengthen ownership, accountability, and long-term effectiveness.

5.6 From policy to practice

FES recognition and operationalization remain inconsistent across governance levels. While local identification is often easier, measurement and valuation rarely translate into decisions. Between 1990 and 2020, fewer than 5% of valuation studies globally have informed policy or management decisions[39], although this limited translation may improve as schemes mature.

Internationally, the FES concept has gained rhetorical support but limited operational impact. Capacity-building dominates, while integration of FES valuation into decision-making is progressing at different speeds across regions. In the EU, coherence is improving since the *European Green Deal* of 2019, but a dedicated FES framework is still lacking. In China, the *Ecological Redline Policy* is one of the first national policies to utilize multiple FES, but systematic integration of FES science into policy remains limited.

Policies often prioritise easily measurable services (e.g., carbon benefits), and neglect particularly cultural and spiritual values. These remain poorly defined and weakly integrated due to methodological challenges, despite their importance for Indigenous and local communities. Many frameworks marginalise these dimensions, and political priorities often favour sectors such as health or defence over ecosystem services.

Opportunities – Strengthen policy and governance

FES must be elevated within national and international policy agendas, and aligned with climate, biodiversity, and well-being targets. Cultural and spiritual values should be explicitly recognised, especially where Indigenous stewardship is central. Governments can strengthen regulatory frameworks by adopting established classifications such as the Millennium Ecosystem Assessment[40] and the Common International Classification of Ecosystem Services (CICES[41]), broadening policy focus beyond carbon. Localised policies, tailored to ecosystems and community contexts, can improve relevance, foster community ownership, and strengthen implementation.

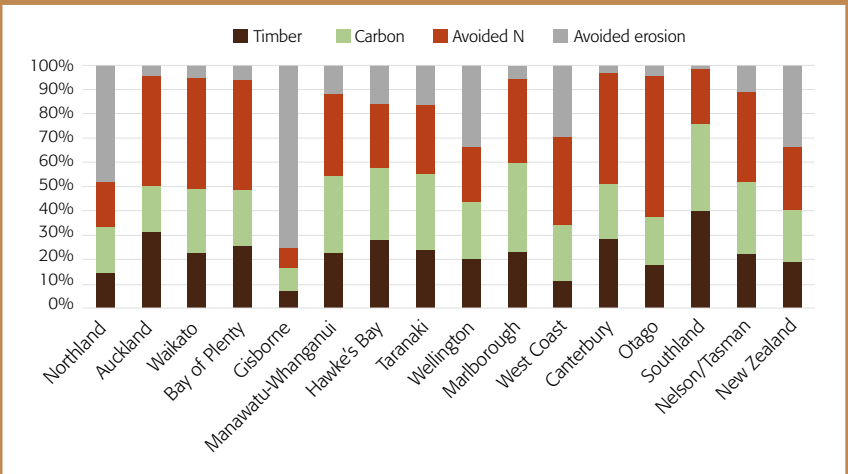
Box 5.3 Forests in New Zealand's Emissions Trading Scheme (ETS) – contributing to New Zealand's climate change mitigation efforts

New Zealand's ETS is the main policy instrument to reduce greenhouse gas emissions and support the net-zero 2050 target, with forests playing a central role. Post-1989 forests earn New Zealand Units (NZUs) for carbon stored as they grow, while harvesting and deforestation creates emissions liabilities, encouraging new planting and discouraging deforestation. Forest owners can trade NZUs, linking forestry directly to the national carbon market.

Forests in New Zealand remove roughly 20 million tonnes of CO_2 per year, offsetting about one-third of gross national emissions. Since the ETS began in 2008, it has increased investment in post-1989 plantations, especially radiata pine. Afforestation peaked in 2018-2021, when NZU prices were about NZD 60-80/tonne, driving large-scale planting for carbon income. From 2018 to 2023, around 60,000-70,000 ha of new forests were registered annually, among the highest rates since the 1990s, shifting some land from pastoral farming to forestry due to higher and more predictable revenue. Since 2023, tighter rules for permanent exotic forests have slowed down new registrations. Overall, the ETS has mobilised private capital for sequestration and supports the net-zero pathway, while balancing carbon outcomes with rural community impacts constitutes a key ongoing forest-related policy challenge.

Box 5.4 The full value of New Zealand's planted forests

New Zealand sources over 99% of its timber from planted forests, and with around NZD 6.5 billion per year, the sector is the country's fourth-largest export earner. Since 2003, multiple initiatives have developed methods to identify, quantify, and communicate forest ecosystem services (FES) for local and regional government, Māori groups, and forestry companies. This has broadened the understanding that timber is often only a small share of the total forest value. A national study[42] found that carbon benefits, erosion control, and avoided nitrate leaching can add substantial value. Other work has also valued biodiversity and recreation. Companies use these findings to evidence wider public benefits and sustainability credentials through, for example, certification. However, aside from carbon benefits, most services do not yet deliver direct revenue to forest owners due to limited financial mechanisms. New Zealand has an Emissions Trading Scheme (ETS) and is beginning to develop biodiversity credit schemes.



5.7 Key messages related to forest ecosystem services

Together, these actions provide a pathway to elevate FES from an undervalued asset to a central economic, environmental, and socio-cultural priority.

KEY MESSAGES – FOREST ECOSYSTEM SERVICES (FES)	
Forest ecosystem services (FES) can become investable bioeconomy assets, but current markets are limited; priorities include clear rules, outcome-based finance, trustworthy Monitoring, Reporting, and Verification (MRV) and data, community co-creation, and scalable value chains.	
From forest to markets	▪ **Develop and diversify value chains** for regulating and cultural services; connect custodians to buyers/beneficiaries. ▪ **Compile a reference library** of successful FES value chains and a practical "how-to" for replication. ▪ Improve **data capture and comparability**; close gaps beyond regional processes; standardize indicators.
Financing the future	▪ Link **Payments for Ecosystem Services (PES)** and emerging credits to **measurable, verified outcomes** (e.g., water quality, biodiversity). ▪ **Standardize definitions, methodologies, and verification** to build investor confidence across countries. ▪ Use **blended finance** (public risk-sharing) and **climate/green bonds** to crowd-in private capital.
Forest-sector innovation	▪ Advance **biodiversity credit systems** alongside carbon; focus on **voluntary environmental markets** with robust MRV. ▪ **Link new monitoring technologies** (remote sensing, AI) to verification schemes and open, comparable data. ▪ Support **voluntary certification** for FES-enhancing practices (e.g., tourism/recreation/forestry) to signal integrity and price premiums. ▪ Enable s**tacked/aggregated FES schemes** (e.g., carbon + water + biodiversity), where appropriate, to reflect multiple benefits. ▪ Engage **tourism, water utilities, and other downstream users** via eco-labelling, certification, and PES co-financing.
Multi-actor collaboration	▪ Focus on **raising awareness** and understanding of regulating and cultural FES, especially with rural communities. ▪ **Develop co-creation** and management approaches for PES drawing on examples/case studies of successful PES systems globally. ▪ Focus on the **integration of FES with agrifood systems** such as through agroforestry systems.
From policy to practice	▪ Elevate FES in policy by **aligning with climate, biodiversity, and well-being targets** and **localize guidance** according to geographic context. ▪ **Adopt MEA/CICES classifications** so policy covers the full suite of services (not just carbon benefits). ▪ **Recognize cultural/spiritual values** in assessments and decisions. ▪ Require **transparent "who pays / who benefits"** framing in programmes (addressing public-good characteristics). ▪ **Run integrated demonstration projects** that bundle carbon, water, and biodiversity outcomes to validate MRV and attract blended finance. ▪ **Require whole-project MRV plans** using appropriate technologies from the beginning to de-risk scaling.

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6

6. Connecting the dots: synergies within and beyond forests

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6.1 Forest-based bioeconomy integration: concept and key components

The European Forest Circular Bioeconomy Strategy initially focused on wood and non-wood forest products, but more recent frameworks have expanded this view to include circular material flows, ecosystem services, and sectors beyond forestry, such as food and health. In this broader understanding, forests are managed not only for timber, but also for a wide range of goods and services. Importantly, there is no single model of "bioeconomy"; approaches differ according to territorial characteristics, market structures, innovation capacity, governance systems, resource endowments, and socio-ecological dynamics.

This chapter focuses on an integrated forest-based bioeconomy, recognising that transformation depends on two complementary forms of integration:

- **Vertical integration** – connects raw material production to higher-value processing and markets, enabling local actors to move from supplying raw materials to producing value-added goods and services.

- **Horizontal integration** – coordinates actors operating at similar stages of the value chain and across sectors. Weak horizontal integration is often associated with uncontrolled extraction, informality, low local value retention, and limited community empowerment.

An integrated approach therefore expands the forest sector beyond wood, linking goods and services while positioning vertical and horizontal integration as levers for innovation, inclusion, and sustainable resource management. In practice, this means connecting sectors, actors, and processes that traditionally operate in silos. It enables mobilisation of wood and non-wood products alongside ecosystem services, supports circularity and inclusion, and depends on participatory arrangements among communities, enterprises, and consumers.

The forest sector can support this agenda through Sustainable Forest Management (SFM) approaches that explicitly incorporate outcomes related to food, medicine, energy, and construction. Innovation and value-chain dynamics are particularly important in natural resource-based value chains where environmental impacts and the role of public and community actors are central. Product upgrading can occur within forest-based sectors (wood products, NWFP) and across adjacent sectors (e.g., bioenergy, biochemicals, agriculture, construction, manufacturing, packaging, tourism). Process upgrading includes waste minimisation, residue valorisation, and circular economy approaches.

Territorial inclusion remains a critical condition. A bioeconomy that is not inclusive risks inefficiency, injustice, and sustainability failures. Shared governance, equitable benefit-sharing, and meaningful participation are core elements. These dynamics are illustrated through the following three examples from Brazil, Ghana, and Finland.

6.2 Brazil - Integration through restoration, concessions, and territorial innovation

In Brazil, climate commitments have not yet delivered structural change towards an integrated forest-based bioeconomy. Investment gaps persist due to uncertainty, perceived financial risk, market failures, and institutional fragmentation. A coherent bioeconomy framework is therefore needed, aligning fiscal, industrial, trade, and regulatory policies to attract mission-oriented public and private finance.

Brazil's forest agenda is gradually shifting from deforestation control towards a "standing-forest bioeconomy" through three main levers:

1. Restoration as a value chain rebuilds natural capital on degraded lands while strengthening local and Indigenous economies through fair access and benefit-sharing. It creates rural jobs across seed networks, nurseries, planting, and monitoring, and supports innovation in bio-inputs and low-carbon processing. This agenda is anchored in the National Policy for the Recovery of Native Vegetation (PROVEG) and the National Plan for Native Vegetation Recovery (PLANAVEG), covering over 12 million hectares, while the Arc of Restoration targets 6 million hectares by 2030 and 24 million by 2050. By the end of 2023, the Amazon/Climate Fund had allocated BRL 3.5 billion to prevention, monitoring, conservation, and restoration.

2. Public forest concessions convert vacant public forests, especially around 49.5 million ha of undesignated areas vulnerable to land grabbing, into lawful, long-term stewardship. Since 2008, around 1.5 million ha have been granted through 24 concessions. A recent innovation is restoration concessions linked to carbon credits revenues, with pilots launched in 2025.

3. Amazônia 4.0 applies a territorial innovation approach (*Amazon Third Way-A3W*) to upgrade bioeconomy value chains through value addition, local industrialisation, and community empowerment. While still at pilot stage, it demonstrates a potentially scalable model based on technology, design, and traceability. Complementary programmes include Bioeconomy Brazil – Sociobiodiversity[43], which strengthens biodiversity and traditional knowledge-based value chains, and the National Bio-inputs Program[44], which scales bio-based technologies for low-carbon, forest-friendly agriculture and agroforestry. Together, rather than a single programme, these initiatives form an integration package linking policy, finance, markets, innovation, participation, and safeguards.

How integration works

A policy backbone enables restoration and concessions at scale, while public and private procurement strengthens markets for seedlings, maintenance, and NTFP. Amazônia 4.0 adds standardised modular labs and traceability, allowing community enterprises to meet quality and safety requirements. Social and environmental safeguards link inclusion to performance, turning fragmented projects into a more bankable pipeline with measurable outcomes.

From policy to practice

Brazil has translated broad goals into operational instruments, including restoration targets, concession contracts with revenue-sharing, and the Arc of Restoration. The next step is to annualise delivery by

biome, standardise contracts, and publish progress to support predictable planning. While concessions have improved territorial management and reduced tenure ambiguity, delivery remains uneven across biomes. Compliance costs remain high for small processors, and tenure ambiguity persists in undesignated forests.

Opportunities

- Translate national targets into annual, biome-balanced plans (especially in the Cerrado biome), with public dashboards and standardized indicators such as hectares restored, GHG removals, local jobs).
- Organise the restoration value chain by categories (e.g., nurseries, skilled crews) and align funding calls with these categories.

Finances

Blended finance is already in use, combining public funds, PES revenues, and private capital. Restoration concessions improve bankability through MRV-linked payments, but constraints remain around working capital, guarantees, carbon price uncertainty, and climate risk. Addressing these requires institutional alignment, targeted funding for bottlenecks, and predictable revenue-sharing mechanisms. Co-financed calls for nurseries, seed networks, and community processing demonstrate how public funds can attract private effort while delivering inclusion.

Opportunities

- Strengthen the institutional framework (fiscal, industrial, trade, and regulatory alignment).
- Blend existing revenue streams to sustain long-term stewardship.
- Target new funding calls at working-capital and scaling bottlenecks (nurseries, crews, logistics, compliance).
- Use predictable revenue-sharing and MRV-linked payments to de-risk projects and attract private participation.

From forest to markets

Restoration and concessions supply timber and NWFP, while Amazônia 4.0 enables local processing with traceability and good manufacturing practices. The integration task is to secure demand, reduce compliance costs and scale standardised toolkits. Private-sector participation is central, supporting seed networks, nurseries, planting, maintenance, monitoring, and local processing. With effective safeguards and benefit-sharing, private actors become delivery partners for public policy, though challenges persist around compliance costs, fragmented logistics, risks of leakage, and short-term market commitments.

Opportunities

- Create steady demand through procurement and long-term offtake.
- Standardise Amazônia 4.0 lab kits, connect to reliable buyers, and simplify certification.
- Embed local processing and community suppliers in contracts.

Forest sector innovation

Innovation in Brazil is technological, contractual, organisational, and data driven. The programme Amazônia 4.0 equips cooperatives and Indigenous/ traditional communities with labs and equipment, demonstrating how small-scale industrialisation and traceability can retain value locally, despite constraints related to connectivity, equipment maintenance, skills, funding fragmentation, and unclear benefit-sharing.

Opportunities

- Scale prototypes tied to clear key performance indicators.
- Align innovation support within existing instruments to logistics and compliance gaps.

Community action and multi-actor collaboration

Community co-ownership is essential, requiring strong safeguards, tenure security, fair benefit-sharing, and access to markets and finance, which in this case is achieved through concessions. Restoration and concessions are increasingly co-produced with local seed networks, nurseries, and personnel. Despite the progress, constraints remain, including variable safeguards' quality, tenure insecurity, and market access.

Opportunities

- Expand community enterprises as suppliers.
- Pair concessions with participatory monitoring and tenure regularisation.
- Channel accessory charges to priority uses.
- Maintain and improve safeguards and binding benefit-sharing.

Overall, this case demonstrates that integrating restoration, concessions, and innovation can support low-carbon development and forest conservation at scale. Success depends on sustained delivery, multi-level governance, technology that complements traditional knowledge, and legal and financial certainty that makes standing forests more valuable than deforestation. In the Amazon, restoration and native regeneration take priority over classic afforestation, with agroforestry and mixed native systems preferred over monoculture plantations. Where afforestation is appropriate, it should be embedded in a landscape strategy aligned with tenure security, local processing capacity, safeguards, and value-chain development.

6.3 Ghana - Cocoa in a forest: integrating bioeconomy, livelihoods, and landscapes

Ghana is the world's second-largest cocoa producer, supplying around 20-25% of global cocoa. Yet, cocoa expansion remains a major driver of deforestation. An integrated forest-based bioeconomy reframes cocoa production from monoculture towards agroforestry, restoration, and diversified value addition, turning standing trees into economic assets. Strong institutions and centralised cocoa governance (COCOBOD) provide a foundation, but progress is constrained by tenure complexity, uneven implementation capacity, and market power imbalances.

Three levers are critical: (1) aligning policy with practice, (2) mobilising transition finance linked to outcomes, and (3) shifting markets and innovation towards agroforestry and cooperative-led upgrading. The Kuapa Kokoo Co-operative Cocoa Farmers and Marketing Union Limited (KKFU) illustrates how farmer organisations can strengthen governance, promote sustainable practices, improve credit access, and advance fair-trade upgrading.

From policy to practice

Although policies exist, farmers adopt new practices only when incentives, services, and tenure clarity align locally. Ghana is piloting landscape governance through Hotspot Intervention Areas (HIA), Voluntary Partnership Agreements under the EU's Forest Law Enforcement, Governance and Trade (VPA-FLEGT) to strengthened legality and traceability systems, but weak workplan translation, limited adaptive monitoring, tenure ambiguity, and compliance burdens persist.

Opportunities

- District agroforestry compacts bundling extension, seedling supply, and tree-registration.
- Adopt "one-form" tree tenure recognition at seedling distribution.
- Simple HIA dashboards with Key Performance Indicator set.

Finances

Financing must shift from throughput outcome-based models, supported by guarantees. Remaining constraints include limited guarantees, fragmented finance, and costly access to environmental revenues.

Opportunities

- Establish a cocoa agroforestry guarantee window (first-loss + partial credit guarantees)
- Outcome-linked loans.
- Parametric micro-insurance bundled with agroforestry packages.

From forest to markets

Markets must reward tree retention, with cooperatives playing a central role in organisation, training, and negotiation. Constraints include low agroforestry adoption, weak logistics, and limited market access for diversified products.

Opportunities

- Support farmer cooperatives.
- Secure multi-year commitments.
- Establish regional testing hubs and shared cold storage.
- Create simplified permits.

Forest-Sector Innovation

While cocoa agroforestry is a core innovation, scaling requires clearer models, interoperable data, and simplified rules. Constraints include fragmented standards and weak extension systems.

Opportunities

- National agroforestry blueprints.
- Framework contracts for services.
- Open data standards.

Community action and multi-actor collaboration

Transformation endures when communities co-own decisions. Landscape platforms and cooperatives enable this, but constraints include mistrust, gender barriers, power imbalances, and initiative overload.

Opportunities

- Formalize district landscape compacts with measurable objectives.
- Fund community monitoring.
- Establish cooperative windows in public programmes.

Ghana can move towards forest-positive, income-secure cocoa landscapes by aligning tenure, finance, and cooperative-led upgrading. While constraints remain, the foundations for an integrated bioeconomy are visible.

6.4 Finland - Äänekoski bioproduct mill: a circular, high-value forest bioeconomy in practice

Finland's Bioeconomy Strategy (2022-2035) prioritises value over volume within climate and biodiversity limits. Metsä Fibre's Äänekoski bioproduct mill exemplifies this approach as a near-zero waste biorefinery integrating pulp production with side-stream valorisation. It began operations in 2017 supported by cooperative ownership and an innovation pipeline through Metsä Spring.

From policy to practice

Äänekoski demonstrates how coordinated policy, permitting certainty, and R&D infrastructure de-risk first-of-a-kind investments. Aligned bioeconomy, forest, and climate strategies provide clarity for investment, while cooperative procurement links harvesting with regeneration and biodiversity safeguards. Raising uncertainty around carbon sink dynamics and EU rules highlights the need for stronger monitoring and adaptive SFM.

Opportunities

- Publish regional bioeconomy balance sheets and link them to project pipelines.
- Digital one-stop permitting.
- Formal adaptive SFM triggers.

Finances

Äänekoski combines equity, green finance, and EU instruments to reduce capital costs, while diversified revenues stabilise cashflows. Despite transparency being strengthened by sustainability-linked finance, constraints remain, including immature markets for novel biomaterials and high capital expenditure without guarantees.

Opportunities

- Expand sustainability-linked lending.
- Use EU guarantees to de-risk.
- Pilot contracts-for-difference (CfD).

From forest to markets

Value growth depends on high-purity fibres, advanced chemicals, bioenergy, and biocomposites, supported by traceability and standards. Äänekoski achieves near-total biomass utilisation while remaining net energy-positive. Demand for all its products exists but is constrained by immature standards and end-of-life infrastructure.

Opportunities

- Expand green public procurement.
- Fast-track standard development and testing protocols.
- Form buyer clubs for offtake contracts.

Forest sector innovation

Innovation spans technology, organisation, and social arrangements, though constraints remain around demonstration finance gaps and skills shortages.

Opportunities

- Fund open demonstration lines for lignin/hemicellulose valorisation.
- Create skills' academies for biorefinery operations.
- Develop open process/quality data schemes.

Community action and multi-actor collaboration

Social licence is maintained through cooperative governance and regional engagement. Constraints include compliance burdens and limited inclusion of youth and women.

Opportunities

- Establish territorial biodiversity contracts with performance-based bonuses.
- Set up SME compliance hubs providing shared LCA reporting and audit preparation.
- Launch targeted talent pipelines for youth and women.

Äänekoski shows how stable policy, cooperative supply, diversified finance, and open innovation can anchor regional prosperity, while tightening biodiversity and inclusion safeguards.

6.5 Summing-up: comparative synthesis and key messages

Across Brazil, Ghana, and Finland, integration in the forest-based bioeconomy follows a common logic: connecting forests, industries, communities, and markets into coherent systems that generate value and inclusion. Brazil illustrates territorial and institutional integration centred on restoration, innovation and standing forests,

enabled through multi-level governance and converting restoration goals into bankable, performance-based projects. Ghana highlights a smallholder-centred pathway in agroforestry and cooperatives, exercising inclusion and shared governance platforms. Finland demonstrates industrial integration driven by advanced technology, policy coherence, and strong institutions, where cooperative ownership and science-industry partnerships make sustainability ambitions a reality.

The core lesson is that predictable governance, clear sustainability standards, and open innovation systems enable complex industrial integration while maintaining environmental safeguards. Together, these cases show that integration is not a single model, but a continuum of context-specific pathways combining policy coherence, finance, markets, and participation to deliver sustainable forest-based bioeconomy.

Ultimately, integration means aligning value chains, finance, knowledge, and governance around shared outcomes: economic competitiveness, social inclusion, and ecological integrity. Achieving this requires **coordinated institutions, financing that rewards outcomes instead of activities, steady market demand**, and a **bioeconomy anchored in local rights and capabilities.** Integration functions both as a design principle and as a delivery strategy.

Table 6.1 Study cases summary

Criteria	Finland	Brazil	Ghana
Status/ Context	Mature and circular industrial bioeconomy; focus on maximizing value added (biorefineries).	Emerging standing forest bioeconomy; focus on restoration, concessions, and socio-biodiversity.	Smallholder-based bioeconomy; reframing cocoa into agroforestry systems.
Integration Model	Industrial symbiosis: vertical integration (high-value bioproducts) and horizontal integration (regional cluster and cooperatives).	Territorial Innovation: connection between public policies (concessions), finance (carbon credits), and local communities.	Social inclusion: integration via cooperatives and landscape platforms to align production and conservation.
Challenges/ Obstacles	Planning uncertainty (carbon sinks, biodiversity); compliance costs for SME; talent shortage.	Uneven delivery across biomes; bottlenecks in the restoration chain; bureaucracy for small processors.	Complex land/tree tenure disincentivizes planting; compliance costs; trust deficit in cooperatives.
Opportunities	Unified permitting; green public procurement; sustainability-linked loans.	Blended finance; public procurement of restoration products; organizing the seed supply chain.	Simplified recognition of tree tenure; district agroforestry compacts; financial guarantees for cooperatives.
Innovation Focus	Technological: zero-waste biorefineries and new biomaterials.	Institutional: restoration concessions and traceability.	Organizational: cooperative empowerment and landscape management.

KEY MESSAGES – INTEGRATION	
Integration aligns value chains, finance, and governance to connect silos (forests, industries, communities), transforming fragmented systems into engines of sustainable and inclusive development. It is a holistic strategy that leverages the full potential of forests to build a sustainable, inclusive, value-creating economy. It aligns innovation and value-chain upgrading with territorial (sub-national) inclusion and sustainable forest management, and relies on participatory design with communities, companies, and consumers.	
Finance	▪ Transition finance: shift from throughput financing to outcome-based payments. ▪ Risk mitigation: use blended finance to support SME and pioneer technologies. ▪ Integrated biorefineries: investment requires substantial capital and revenue from multiple sources. Combining different types of funding can reduce overall cost of capital.
From forest to markets	▪ Demand assurance: establish green public procurement and long-term offtake contracts to provide security for producers. ▪ Processing clusters: develop regional hubs with shared infrastructure (labs, logistics) to retain value locally and standardize quality. ▪ Maximising value added: support bioeconomy strategies that seek to shift from maximising volume to maximising value added within climate and biodiversity limits.
Forest-sector innovation	▪ Value-chain upgrading: agroforestry systems (AFS) and cooperative-led upgrading in global value chains. ▪ Innovation beyond technology: adopt contractual and organizational innovations. ▪ Open data and MRV: create interoperable data standards for traceability and monitoring, reducing compliance costs.
Multi-actor collaboration	▪ Territorial inclusion: strengthen landscape platforms and cooperatives for communities to co-manage decisions and benefits. ▪ Communities as suppliers: integrate local actors as formal service providers (nurseries, monitoring) in contracts. ▪ Promote farmer organisations: strengthen voice and governance of cooperatives and unions, promote sustainable practices, improve access to credit, and advance fair-trade upgrading and market access.
From policy to practice	▪ Translate targets into actionable plans: convert national strategies into bankable project pipelines with land tenure security and clear rights. ▪ Unified permitting: implement digital workflows and one-stop permitting to reduce regulatory uncertainty. ▪ Knowledge transfer: create educational programmes for the development of new skills.

7. The way forward for the forest-based bioeconomy

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7.1 Summary

Based on the evidence and case insights presented, the chapters converge on a clear message: **a well-regulated and well-financed forest-based bioeconomy can play an essential role in delivering climate and nature benefits, resilient rural livelihoods, and competitive low-carbon industries.**

Common enabling factors

The evidence identifies a set of common enabling factors for the transition to a forest-based bioeconomy:

First, progress accelerates when **policy intent is translated into delivery and implementation**. This requires coherent governance, alignment across sectors (e.g., forestry, environment, agriculture, energy, industry, trade), secure property and usage rights, and approval systems that are faster, clearer, and risk-based.

Second, **markets and finance can scale** once initiatives become investable. Successful approaches combine financeable, bankable pipelines, enabling infrastructure, and **fair market conditions** (e.g., removing fossil subsidies and pricing externalities through taxes or carbon pricing) with public risk-sharing instruments that attract private capital rather than substitute for it.

Third, **innovation delivers impact** only when it is **co-created with users, validated**, and **adopted at scale** through market uptake and sustained use in practice. This requires shared testbeds and living labs for co-development and piloting, strong standards and testing capacity, open and interoperable data systems, and innovation-to-scale support to bridge early-stage financing gaps.

Fourth, **inclusion** is not only a **rights-based obligation but also a prerequisite for effective implementation**. Meaningful participation and fair benefit sharing for IPLC, women, youth, smallholders, and SME strengthen legitimacy, reduce conflict, and improve the durability of outcomes.

Finally, **environmental and social safeguards, adaptive management, and climate-disturbance preparedness** are essential to protect biodiversity, water, and ecosystem integrity. This is particularly important under rising risks from storms, wildfires, pests, drought, and increased harvest driven by wood demand; and it is necessary to secure long-term bioeconomy benefits.

Differences: why pathways are context-specific

Forest-based products and ecosystem services differ in resource dynamics, market structures, and governance needs. Policy pathways must therefore reflect these specificities within the broader bioeconomy context.

- Wood-based pathways are typically scale- and standards-intensive. They depend on fibre supply

planning, including sustainably planted forests where appropriate, circular manufacturing and cascading use, performance-based building codes, and consistent life-cycle and whole-life carbon methods (LCA/WLC). Maintaining trust requires avoiding overstatement and ensuring that sustainability claims are evidence-based.

– Non-wood forest products (NWFP) pathways are species- and governance-specific and often highly place-based. They require formal recognition in policies and statistics, species-specific harvesting guidance, domestication or cultivation where needed, quality and testing systems, and benefit-sharing arrangements that protect traditional knowledge and subsistence uses.

– Forest ecosystem services (FES) pathways rely on credible valuation, robust Monitoring, Reporting, and Verification (MRV) tools, clearly identified buyers and beneficiaries, and long-term governance of public-good values. Scaling is improved when bundled or stacked services (e.g., carbon + water + biodiversity) are piloted with safeguards and low transaction costs.

– Integrated landscape pathways are particularly well suited to unlocking the full potential of the bioeconomy. They work best when value chains, finance, and governance are connected at landscape scale, prioritising value per unit of biomass and using mosaic supply approaches that combine sustainable forest management (SFM), restoration, agroforestry, trees outside forests, and planted forests where suitable.

Enabling conditions that must be in place

Across all pathways, success requires clear rights and predictable rules, cross-ministerial coordination, interoperable traceability and MRV systems, performance-based regulation and standards, workforce skills and extension services, and strong consumer demand supported by demand-pull tools such as public procurement and long-term offtake agreements. These measures help create a level playing field for low-carbon, circular solutions. Increased research funding further strengthens and consolidates knowledge across scales.

Risks and trade-offs to manage (and not ignore)

Key risks should not be overlooked. These include biodiversity, water, and climate negative impacts if safeguards, restoration alignment, and leakage control are poorly applied to harvesting or plantation operations; inequities in NWFP systems if formalisation displaces traditional harvesters or undermines subsistence uses; credibility and distribution risks in FES markets when MRV is weak, benefits bypass local custodians, or markets are volatile and fragmented; exclusion of SME when compliance and working-capital constraints limit participation; and disturbance and transition risks (fire, storms, pests, drought, income "valleys") that undermine bankability unless risk-transfer and transition finance instruments are embedded.

7.2 Key messages and priority actions for a forest-based bioeconomy

Forests power the bioeconomy through renewable materials, ecosystem services, and rural employment. Materialising the benefits of a forest-based bioeconomy requires **moving from principles to implementation and tailoring measures to regional** and **local realities**, as well as to **institutional and historical contexts**. There is no "one-size-fits-all" approach.

The following tables summarise **priority actions for decision-makers**, organised around six core themes acting as levers for scaling a sustainable, resilient, and inclusive forest-based bioeconomy.

KEY MESSAGES AND PRIORITY ACTIONS FOR A FOREST-BASED BIOECONOMY	
Global	
From policy to practice	▪ **Co-develop a multi-country "Forest-based Bioeconomy Implementation Guideline"** with targets, safeguards, and cross-sector coordination model. [Gov (multilateral), Res, CSO] ▪ **Promote interoperable traceability** principles for legality, origin, carbon, and ecosystem-service attributes [Gov (multilateral), Res, CSO] ▪ **Encourage performance-based regulatory models** that countries can adopt. [Gov (multilateral), Res]
Finance	▪ **Create a blended-finance fund** combining first-loss public capital with expert assessment to de-risk private investment. [DFI, Gov (multilateral)] ▪ **Harmonize climate and green taxonomies** to include restoration, circular manufacturing, and FES projects. [DFI, Gov (multilateral)] ▪ **Enable registry interoperability** and standard contracts for **PES/carbon/biodiversity credits** to scale outcome-based payments. [Gov (multilateral), Res]
From forest to markets	▪ **Advance mutual recognition of product/testing standards** and streamline **cross-border rules** on plant health, safety, and technical requirements for wood and NWFP. [Gov (multilateral), Res] ▪ **Simplify customs and phytosanitary procedures** for bio-based products. [Gov (multilateral)] ▪ **Support landscape restoration** measures that link verified producers to buyers and finance. [DFI, Gov (multilateral), CSO, Private/SME]
Forest sector innovation	▪ **Create open data and interoperability standards.** [Gov (multilateral), Res] ▪ **Establish testbeds and living labs** with open access results. [Gov (multilateral), DFI, Res] ▪ **Broker partnership agreements** (government-industry-finance-science) for innovative developments. [Gov (multilateral), DFI, Private] ▪ **Encourage joint innovation calls** across forestry, agriculture, and energy sectors. [Gov (multilateral), DFI, Private]
Beyond wood	▪ **Formalize global recognition of NWFP and biodiversity-based products** within trade and statistical systems. [Gov (multilateral), CSO, Res] ▪ **Support Codex-type standardization** for priority species and products. [Gov (multilateral), CSO, Res] ▪ **Advance stacked/aggregated FES approaches** (carbon + water + biodiversity) and common methods for valuation and verification. [Gov (multilateral), Res] ▪ **Promote Access & Benefit Sharing compliant frameworks** and credible **eco-labels.** [Gov (multilateral), CSO, Private]
Building the future	▪ **Promote global alignment of carbon-accounting methods** and **performance-based standards** to ease international adoption. [Gov (multilateral), Res] ▪ **Share open reference designs** and tested details to cut approval time. [Gov (multilateral), Res] ▪ **Support research networks on novel biomaterials** and circular design. [Gov (multilateral), Res]
*Abbreviations: **Gov** = government (incl. multilateral where stated), **DFI** = development finance institution (incl. MDB), **Res** = research/academia, **CSO** = civil society organisation, **SME** = small/medium enterprise, **Private** = Private sector beyond SME, **IPLC** = Indigenous Peoples and Local Communities*	

KEY MESSAGES AND PRIORITY ACTIONS FOR A FOREST-BASED BIOECONOMY	
National/Sub-national	
From policy to practice	▪ **Mandate inter-ministerial coordination** through unified strategies and a **one-stop permitting** portal for bioeconomy projects. [Gov] ▪ **Embed cascading use & circularity** in building codes, procurement, and waste regulations. [Gov] ▪ **Establish national traceability systems** for legality, origin, and FES. [Gov, Res, Private/SME] ▪ **Reduce regulatory uncertainty for new bio-based** products by sharing model approval pathways and risk-based permitting approaches. [Gov, Res]
Finance	▪ **Launch national blended-finance platforms** for bioeconomy projects. [Gov, DFI, Private/SME] ▪ **Scale green public procurement** with minimum low-carbon material shares. [Gov] ▪ **Phase out perverse incentives** (e.g. subsidised fossil inputs) and redirect support to **restoration and circular value chains.** [Gov]
From forest to markets	▪ **Develop regional bioeconomy hubs/clusters** with shared infrastructure. [Gov, Private/SME] ▪ **Facilitate aggregation and market access** for smallholders and SME through cooperatives and digital platforms. [Gov, Private/SME] ▪ **Condition** supply support on **legality, traceability, and safeguards**, with links to **verified restoration outcomes**. [Gov, CSO, Private/SME] ▪ **Improve market data and price transparency for wood**, NWFP and FES. [Gov, Res]
Forest sector innovation	▪ **Support national innovation funds** and **triple-helix partnerships** (industry-research-government). [Gov] ▪ **Launch innovation challenge funds** prioritising women, youth, and Indigenous enterprises. [Gov, DFI, CSO] ▪ **Support standardisation/testing capacity** to overcome adoption bottlenecks. [Gov, Res] ▪ **Deploy digital tools** to reduce costs and enable circularity. [Gov, Private/SME, Res] ▪ **Invest in skills, digital tools, and early-stage financing** for SME and start-ups. [Gov, Private/SME, Res]
Beyond wood	▪ **Include NWFP and FES value chains** in national strategies for bioeconomy and forest, and in rural development plans. [Gov] ▪ **Incentivise residue valorisation**, use **energy-from-waste only after higher-value uses**. [Gov, Private/SME] ▪ **Co-create PES schemes** with communities; run **awareness and capacity** programmes on benefits and participation. [Gov, CSO, Res]
Building the future	▪ **Update codes** to allow **mass timber**; approve **standard designs** to speed permitting. [Gov] ▪ **Run a public demonstration pipeline for wood-based construction solutions** with transparent, published performance results. [Gov] ▪ **Develop insurance and fiscal incentives** for wood-based construction of all types. [Gov, Financial institutions, Private] ▪ **Support low-carbon choices for customers and buyers.** [Gov, Financial institutions, Private] ▪ **Develop pathways for skills development** for architects, engineers, inspectors, installers, and forestry extension. [Gov, Res]
*Abbreviations: **Gov** = government (incl. multilateral where stated), **DFI** = development finance institution (incl. MDB), **Res** = research/academia, **CSO** = civil society organisation, **SME** = small/medium enterprise, **Private** = Private sector beyond SME, **IPLC** = Indigenous Peoples and Local Communities*	

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9. Glossary

Cascading use:	The efficient utilization of resources by using residues and recycled materials for material use. From a technical perspective the cascading use of wood takes place when wood is processed into a product, and this product is used at least once more either for material or energy purposes (European Commission, 2025).
Circular economy:	A system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources (Ellen MacArthur Foundation, 2025).
Forest:	Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2025).
Plantation Forest:	A planted forest that is intensively managed and meets ALL the following criteria at planting and stand maturity: one or two species, even age class, and regular spacing (FAO, 2025).
Planted Forest:	Forest predominantly composed of trees established through planting and/or deliberate seeding (FAO, 2025).
Primary Forest:	Naturally regenerating forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed (FAO, 2025).

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