

16 The keys to unlocking the bioeconomy with non-timber forest products

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Towards a better understanding of the forest-based bioeconomy

The term bioeconomy is not new, although it has become more prevalent in recent years. As Wang et al (Ch 4) point out, “bio-economics” was first used in the early 20th century to describe fisheries. In the 1970s, Georgescu-Roegen developed a theoretical foundation of bioeconomics emphasising the need for degrowth for the survival of the human species (Gowdy and Mesner, 1998). More recently, Bugge et al (2016) and Vivien et al (2019) grouped the concepts and discussions into three streams: the first around a biosphere-based economy, the second around biotechnology, and the third around a biomass-based economy. And most recently, Piplani and Smith-Hall (2021) further developed the bioeconomy paradigm identifying five approaches to a forest-based bioeconomy. The cases examined within this book further expand the knowledge of NTFPs relative to a bioeconomy.

When it comes to defining the bioeconomy, the above wider approaches and the specific examples presented herewith contain the same message: *we need to move beyond thinking of the bioeconomy as a tool primarily to reduce the use of petrochemicals by increasing reliance on sustainably sourced natural resources to mitigate climate change impacts*. Attention is needed on poverty reduction through enhancing local economies by, for example, pursuing added value and cascading use of forest resources while addressing biodiversity conservation concerns through explicit attention to sustainability and recognising the ecological boundaries of economic activities. The chapters demonstrate the substantial contributions of non-timber forest products to the forestry sector, with such contributions usually underreported and invisible. Recognising these contributions constitutes opportunities to rethink and reposition the global and national forest sectors. Forests and non-timber forest products contribute to local and national incomes, food security, nutrition, health, and energy. This support to current consumption, safety nets and gap filling, and moving out of poverty (Vedeld et al, 2007) needs recognition and integration into bioeconomy thinking and interventions. A forest-based bioeconomy with NTFPs fully integrated allows for repositioning of the forest sector in relation to changing societal concerns and

priorities, contributing not only to climate change mitigation and adaptation but also to poverty eradication and biodiversity conservation.

Evidence of this repositioning is negligible, although the chapters demonstrate that movement is occurring. The growing interest in the bioeconomy (Fig. 1.1) and an increasing number of bioeconomic country-level strategies – about 60 countries were pursuing bioeconomy-related policies in 2020 (IACGB, 2020) – indicate a shift. In almost all countries, forests and trees are treated as tools in a biotechnological oriented bioeconomy “toolbox”. Rarely, as documented in the chapters, are non-timber forest products included in this toolbox. An exception is found in Argentina (Ch 12), where there have been explicit multi-sectoral concerted efforts over years to integrate non-timber forest products into the bioeconomy and using this initiative to realise broader benefits, such as in education and conservation. There is substantial scope to learn from these country and subnational level efforts to stimulate transition in other places. The scope for using non-timber products in a forest-based bioeconomy for the non-economic benefits of rural development, local communities, and indigenous people is noted in several chapters, particularly in China (Ch 4) and the Guiana Shield countries (Ch 6).

The emphasis in the literature on the provision of biomass to substitute fossil fuels and conversion into new wood-based products to replace energy-intensive materials may reflect the limited geographical (north- and western EU) and thematic (biotechnological) priorities of existing strategies. Refocusing and using the bioeconomy to address poverty reduction and biodiversity conservation issues will require changes in national priorities and mobilising and engaging a wider research community. As reflected throughout this book, current thinking about the bioeconomy is new to most people and institutions working in the forest sector or on forest-related issues. The point of departure was non-timber forest products and the forests whence they originate, and not the bioeconomy. This signals opportunities to build greater awareness of the forest-based bioeconomy among professionals, researchers, and their institutions. Expanding the terms and concepts related to a forest-based bioeconomy and providing more accessible and transparent examples of the approaches would help operationalise a forest-based bioeconomy with non-timber forest products. As most people interested in and working with a forest-based bioeconomy come from the forest sector in a broad sense (as also demonstrated by the list of authors in this book), the onus of realising opportunities presented by the increased interest in the bioeconomy rests with this group. Ultimately, the forest sector that embraces a bioeconomy is much broader than current thinking.

A forest-based bioeconomy involves biodiversity conservation, biomass production, scientific and technological capacity development, and public and private collaboration in promoting innovation. It also represents a way to reconsider links within the forestry and other sectors and to promote value addition of products within these sectors. Forests as production systems need to be viewed more holistically, such that food and medicine

become unambiguous objectives of management. Including diverse and often disparate stakeholders in developing knowledge and technologies, with supportive institutions and favourable frameworks, are part of the pathways to facilitate such rethinking.

A forest-based bioeconomy thus arguably constitutes a ‘new vision of life’, enabling economies to move away from fossil fuels and embrace sustainable production of natural resources through the comprehensive engagement of stakeholders at all levels of the production network. The chapters exemplify this. In Brazil (Ch 5), policies related to the bioeconomy are gaining importance, strengthening technology and innovation at all levels. Indeed, the Brazilian approach recognises the limited effectiveness of environmental policies implemented since the early 2000s and now encourages dialogue with civil society and the scientific community. Since the beginning of the 21st century, Canada (Ch 3), likewise, has made substantial progress toward a bio-based economy, especially recognising indigenous stakeholders. Inclusivity is revealed as an essential factor for developing sustainable transition pathways.

In terms of worldviews, the presented cases emphasise the relationships between nature, the economy, and the roles of research and technology. In most countries examined, a forest-based bioeconomy needs to incorporate conserving ecosystems into economic development to a higher degree than at present. This implies a more prominent role of sustainable resource management than found in a biotechnological approach to a forest-based bioeconomy (Piplani and Smith-Hall, 2021). The case of açai is emblematic of a forest food ripe for the bioeconomy, or as phrased by the authors, a “socio-bioeconomy” (Ch 6). Baobab, used traditionally for food, has had a tremendous investment in research and technology, such that today baobab is an ingredient in more than 180 products worldwide (Ch 10). New technologies converge with traditional productive sectors, implying opportunities to transit from the contemporary market-based economy to a progressive, sustainable bioeconomy. Even if biotechnology need not play a substantial role in a forest-based bioeconomy, biotechnology opportunities should be pursued when relevant. For instance, in the wild-simulated ginseng example (Ch 9), biotechnology provides tools for adapting and modifying biological organisms, products, processes and systems, leading to higher value-added products.

Despite the challenges and shortcomings, the combined chapters point to a pragmatic and optimistic point of departure: *knowledge can be developed and applied to solve problems that may impede shifting to an economic model that embraces these under-recognised products for the betterment of all humans*. Non-timber forest products have a substantial role in contributing to the transition to a forest-based bioeconomy. Forests and humankind have been closely connected since time immemorial (Williams, 2003), a relationship that can evolve as the emphasis moves from economic utilitarianism to sustainable management in a bioeconomy. This includes the Global South, where a

forest-based bioeconomy can continue to contribute to the remarkable transformation of the past three decades with rising incomes, better education, health, and governance (Radelet, 2015).

Towards a better understanding of non-timber products in the forest-based bioeconomy

While there is some variation in what the authors present as non-timber forest products, the lack of a uniform definition is not detrimental: in each case, the products are well-defined (making the product focus clear in each chapter). The chapters support a general pattern, increasingly documented over the last three decades, of non-timber forest products as important to economies and ecologies around the world (e.g. Shackleton et al, 2011; Hickey et al, 2016; Meinhold et al, 2022). These products contribute directly and indirectly to people's livelihood and national economies through the consumption of more than 40,000 species (Diazgranados et al, 2020) harvested by billions of people (Shackleton and Vos, 2022). Wild harvesting of NTFPs is often linked directly to rural lifestyles and traditions (Chs 3 and 4), with limited use of technology and scope for development, e.g. to increase secondary processing as in the case of commercial medicinal plants in Nepal (Ch 11). The countries showcased in the book are home to large portions of the planet's biodiversity, with documented deep historical economic and cultural connections to NTFPs (Chs 4–7). Across the examples, there is a pattern of intensified production and marketing efforts such that subsistence or low-value NTFPs have expanded from having marginal economic importance in local markets to being integrated into national and global production networks.

NTFPs invigorate local economies, are important sources of subsistence for rural people, and are under-utilised natural resources with a wide range of uses. A general perception is that the NTFP-based industry has grown into a significant sector, often contributing much to the forest-based economies. Overall, their level of contributions to a bioeconomy is unrecognised due partly to a lack of monitoring and reporting of the data needed for reliable and regular assessments. In some cases, the contributions may be comparable to or even exceed timber (Ch 2). One of the greatest challenges with integrating NTFPs into bioeconomies is the lack of data to facilitate such movement. Across the spectrum of NTFPs, data are needed on collection levels with transparent traceability schemes that include inventory and monitoring. Such data include product-specific sustainable harvest levels. Creating higher value-addition through longer value chains and scaling up production depends on the availability of yield and market data for all relevant actors, especially the primary producers. Moving along a sustainable transition pathway to a bioeconomy necessitates research to determine and validate market and economic dynamics.

Many of the cases exemplify the continued economic and cultural invisibility of non-timber forest products at subnational, national, and global

levels. The reasons remain the same: *the multitude of products and uses, the trade in informal markets, and the lack of NTFP registration in standardised reporting systems in the forest sector.* In most cases, NTFPs remain un(der) reported and in the dark, even if they are national priority products (such as commercial medicinal plants in Nepal, Ch 11) or of substantial economic importance (Chs 2 and 8). Thus, NTFPs are still principally perceived as an extensive group of niche products with slight potential for added value and scalability, with a wide range of small economic and cultural contributions to forestry, tourism, and rural development, disregarded by inter-sectoral policy and governance frameworks (Ch 2). This neglect hinders their integration into bioeconomic thinking, making it harder to realise transitions, even as changes in consumer demand and behaviour are driving up prices and interest in sustainably sourced products.

The findings below are organised around the three themes presented in Chapter 1. The first examines the current bioeconomy-NTFP linkages and projected progression, including assessments of bioeconomy resources and strategies. The second theme delves into bioeconomic transition pathways, providing examples of how to move towards the forest-based bioeconomy. The third theme investigates tools and technologies to help transitioning.

Theme 1 – Where are we? Important emerging factors to integrate NTFPs into the bioeconomy

Nations seeking to integrate NTFPs into the bioeconomy must recognise the tremendous range of products and related markets that are made more complex with cultural and other intangible values, as well as the challenges in reporting for valuation. The populations of primary producers are marginalised in society yet are essential to a sustainable bioeconomy. Drivers of transition to a bioeconomy include increased demand from distant urban markets, with consumers concerned about social justice and sustainable product sourcing. Recognising these drivers, national leadership with related development of knowledge is essential to much of the global rethinking of forest-based bioeconomies.

Leadership investing in knowledge development

Leadership is essential to facilitate change, e.g. as Radelet (2015) identified in explaining why some countries move faster out of poverty than others. The bioeconomy transition started to take off with leadership from within Europe resulting in significant development of knowledge about products, markets, governance of access and harvest, and the need for technology development. For instance, recent scholarship documented that more than a quarter of the European population forage NTFPs for direct and indirect consumption (Ch 2). Recognising that most species are wild-harvested or stewarded using local knowledge, with little or no science-based understanding, EU countries have

invested in developing tools for NTFP yield and inventory assessments. At the national level, some European countries are leading efforts to require forest management to include NTFPs. Similar situations are found in other regions, such as China (Ch 4) where knowledge about mushroom harvesting and associated value chains leads to product market development.

Leadership in the transition to an NTFP-based bioeconomy is expanding. Indeed, Latin American countries are actively transitioning to a bioeconomy, recognising the significant contributions of NTFPs, with wide stakeholder involvement. The example of the Argentina bioeconomy initiative (Ch 12), which started by identifying key actors and building bridges between sometimes disparate groups, typifies progressive actions to stimulate bioeconomy transitions. Recently established inter-ministerial programs and the Forest Bioeconomy Working Group facilitate participation in national and regional bioeconomy transition efforts. Leadership like this creates environments conducive to public investment and may also increase impacts at subnational levels.

Drivers of transition

Fundamental changes in demand and supply are driving the bioeconomy transition. As illustrated in Europe (Ch 2), the drivers of change manifest two contrasting pathways: a supply-side trend toward the cultivation of the most profitable NTFPs, and a demand-side trend of consumers asking for more 'natural' socially and environmentally acceptable products. All evidence indicates sizeable and growing demand for many commercial NTFPs, yet by all contentions, the reported volumes and values are lower than actual trade levels, reflecting a lack of investments in accurate reporting. It is also noteworthy that final consumers in far-off international urban markets may influence local resource management patterns, e.g. through demand for new highly nutritious products that are sustainably sourced (Ch 6). Market demand for many of the products examined, including açai, baobab, pine nuts, and mushrooms, has expanded from restricted local consumption to top tier global markets. To meet this demand requires consistent, high-quality products that can be assured through branding, labelling, or certification, and infrastructure development such as e-commerce (Ch 4). A growing demographic also is demanding better benefit-sharing with local primary producers, many of which are indigenous communities. Value chains must develop to ensure that the primary producers can access markets and generate more income. These changes in demand have associated supply issues, especially the sustainable sourcing of products traded in informal markets.

There is growing recognition of the contributions of NTFPs in supplying the needs of billions of people around the world. Most products are harvested from natural populations managed by local knowledge. Some species (e.g., sugar maple in Canada, Ch 3) are recognised as important to national economies and have science-based knowledge to support management. Yet,

data for growth and yield estimates to support sustainable production are lacking for most species. A supply-side pathway focused on the cultivation and domestication of profitable NTFPs is recognised as much needed for a bioeconomic transition (Chs 3, 9, 10, 11, 14). Integrated forest production systems, from natural stands to agroforestry and monoculture plantations, that provide sustainably sourced products are also part of the supply side ‘toolbox’ (Ch 13).

Understanding, embracing and including these drivers will contribute to a forest-based bioeconomy that includes non-timber forest products. Such a shift is reflective of changing societal values to align more with concepts of sustainability.

Informal markets and marginal populations

Commercial collection of NTFPs has increased rapidly worldwide over the past decades. Much of the increase in harvesting has occurred in indigenous communities in response to market opportunities with rising affluence in the urban middle-class – today, most people live in middle-income countries (Rosling, 2018). This shift from subsistence consumption to commercial production has significant implications for bioeconomy transitions. In general, most producers are on the fringes of society and function through informal markets. The Guiana Shield and global markets for açai exemplify this (Ch 6), as does the case of mushrooms in China (Ch 4). The three countries of the Guiana Shield are a global source of the flavourful fruit of the palm, while indigenous mushroom harvesters in China are serving urban markets in Japan. Around the world, indigenous peoples and local communities, typically the primary producers, have gained much visibility, especially through their crucial roles in providing raw materials. Nevertheless, this socially marginalised demographic’s contributions to the bioeconomy are not well documented. Statistics on production, marketing, and consumption used to monitor and value informal markets are unreliable, a noticeable problem for many of the transitional products investigated in this book.

NTFPs have great cultural and social significance across communities. Equitable emphasis of these less intrinsic values is necessary for successful transition pathways. Strengthening social capital and promoting social organisation as part of the product marketing process may positively impact the transition to a bioeconomy, as better organised communities find more marketing opportunities (Ch 5). Across the examples, building social structures that consider and respect cultural and social values emerges as key to driving transition strategies.

Local and indigenous knowledge can play pivotal roles in developing commercial management strategies that assist local livelihood transitions. As presented, indigenous harvesters in parts of China understand the symbiotic relationship between mushrooms and trees, and many communities have

developed management regulations and protocols (Ch 4). Integration of this knowledge with modern science into hybrid knowledge systems can make management more responsive to local needs and more accepted by local harvesters. Indigenous knowledge may have a crucial role in promoting bioeconomy transition, and when integrated with science-based knowledge, forest production systems may be more productive and sustainable.

Resource, product, and market diversity

The extent and diversity of a country's forest resources provide priorities for transition. Brazil, with the second-largest forest area in the world, and perhaps the most diverse, has products that have contributed to regional and national economies for generations (Ch 5). The Brazilian case provides context to the diversity of products; indeed, most are forest foods that contribute to household and local economies, yet some are also part of the national economy. Production of some species, such as rubber, has transitioned from wild-harvested to cultivation, in the country of origin and elsewhere, relieving pressures from natural populations in the country of origin and indicating the potential for a sustainable bioeconomy. The cultivation potential is also recognised for Mediterranean pines in Chile (Ch 14).

The range of products and related markets (domestic, regional, and global) amplify bioeconomic possibilities and the challenges. Challenges are intensified when cultural and other intangibles are considered, yet these are essential factors in NTFP-based bioeconomies. For many non-timber forest product markets, informality, with associated lack of reporting, makes valuation challenging. As is evident in most cases presented, their full contributions simply are not available, as the Canada (Ch 3) analysis emphasises. Most authors concur that comprehensive assessments and valuations would be challenging as the high number of products span many sectors. Yet, this may present opportunities to expand the forest products sector and the value of forests. With some products, such as high valued commodities that draw the attention of national statistical reporting institutions, accurate estimates are possible because production and trade are monitored. However, the volumes and values remain elusive for most NTFPs in the informal economy. Even though significant investment has been made to quantify the NTFP sector, data are incomplete, collected using different methods, and scattered across non-comparable classifications.

Theme 2 – Moving on! Examples of transition pathways

Understanding the status of efforts to transition is important, as is determining transition pathways. Science-based assessments of product potential are necessary, as are support frameworks for transitioning. Further, there are many lessons from countries' experiences from which to learn of the potentials and pitfalls of transitioning.

The multiplicity of (uncharted) pathways

There is no standard transition pathway. The concept of a forest-based bioeconomy with non-timber forest products is so new that a multiplicity of pathways is evolving, with many likely to still being uncharted. At least 60 countries are actively pursuing the development of bioeconomy strategies and thus plotting pathways that may include NTFPs. A growing body of knowledge on transitioning can support analytical frameworks (Ch 11) that will help to clarify transition pathways. As evident in the analyses presented, transition pathways may be characterised by cost, rate of change, centrality to system, complementarity of pathways, and durability of the change. Constructive frameworks can support transition pathways from status quo to a forest-based bioeconomy, as well as from one type (e.g., biotechnological) to another (e.g. bioresource). Developing and implementing a transition framework may require modifications of current thinking and may result in even more transition approaches as the concept of a forest-based bioeconomy with NTFPs matures.

There are significant challenges with transition pathways. The predominance of wild-harvested production and the lack of standardised production techniques can lead to high variability of product characteristics and the associated stress on natural resources. Limited cultivation and commercialisation, as illustrated with baobab (Ch 10), impact most other product examples. The limited power of local entrepreneurs to invest in risky ventures and access markets will impede transition efforts. Diverse and dissimilar NTFP value chains need to be better linked to capitalise on economies of scale and aggregate waste streams and create more efficient value webs. Research and technology development, such as life cycle analysis and green process engineering, can make production compatible with bioeconomy principles.

Transition pathways are made difficult by the lack of official trade statistics that underestimate NTFP volumes and values. As the analysis of NTFPs in Mexico reveals (Ch 7), data are limited to the most prominent commodities of commercial importance. This constraint is evident throughout the examples presented in the chapters. The number of plant taxa included in national reporting is generally restricted to a few large-volume products representing a few ecosystems. Meaningful estimates of more products from expanded taxa would provide knowledge to define transition pathways better. Initiatives to develop an NTFP-based bioeconomy would benefit from more differentiation of the great variety of products and their origins within countries.

Learning from identified transition pathways

The examples presented in this book demonstrate that transition pathways require resources, investments, and political commitment. Many see the

development of opportunities for local producers and entrepreneurs through innovative bio-based products as critical pathways to a bioeconomy, which requires investments in product development, value chains, and commitments from the public sector. As the case with baobab in Malawi (Ch 10) contends, increasing demand for traditional forest foods among ‘new’ consumers and developing possibilities for novel raw materials is important to support transition. However, realising this potential is reliant on the development of infrastructure. As evident in the Argentina case (Ch 12), a transition is also enabled by strong high-level political commitment. National efforts may benefit from active and organised stakeholder dialogue that agrees on what is needed.

Many transition pathways may be evolving and remain uncharted, yet clarity is provided by multi-levelled structured analysis that leads to the development of frameworks to smooth paths forward (Ch10). These can be enhanced through structured, phased approaches, as discussed for ginseng in South Korea (Ch 9). Stable production of quality products is contended as a primary phase of a transition pathway. Cultivation, and more broadly sustainable production that reduces pressures on natural populations, is critical for transitioning to a bioeconomy with NTFPs (Chs 9–11). As seen in the case of Latin America, establishing a regional collaborative forum is a recommended element of such frameworks. Developing domestic processing and improvement to value chains that extend to international and global markets are part of phased transitional pathways that may be appropriate for lower-income countries’ bioeconomy strategies, such as Nepal and other countries examined. Across the examples presented, “decentralised resource management” and local stakeholders’ inclusivity in management decisions are central to transition.

Theme 3 – Tools and technologies to support transitions

Technology development and improved tools are fundamental to the forest-based bioeconomy. Managing the non-timber resources to sustainably source products is vital to a successful transition. Transitioning may require multiple foci and stages. Basic and advanced forestry technologies and tools, such as species selection to improve production or geographic information systems (GIS) for better inventory and monitoring, can enhance transition.

Sustainable forest management with NTFPs integrated

Well established forest management practices and knowledge are part of the ‘toolbox’ for moving toward a forest-based bioeconomy with NTFPs. Sustainably managed forest resources providing a gambit of diverse products is a basic tool for transitioning to a bioeconomy. Transitioning to sustainable forest management for co-production of timber and non-timber forest products may require new ways to consider silvicultural prescription, although

well-established practices can be adapted to broader objectives (Sheppard et al, 2020). Consideration of compatibilities and trade-offs between forest management goals and objectives is imperative (Ch 13). Traditional forestry practices can impact NTFP occurrences, survival, and abundance. They can change the ecological dynamics of forest stands, which may positively impact species that benefit from canopy gaps or negatively impact those that prefer less solar radiation. Hence, appropriate forest management strategies and actions to support and account for NTFP contributions are essential. Innovative silvicultural prescriptions that mix species with multiple objectives reflecting the natural systems are needed. Silvicultural strategies and treatments modelled on the ecologies of non-timber and timber species, with inclusive governance mechanisms that consider socio-economic and legislative actions, are also elemental tools for transition pathways.

Technology use and development

Long-established forestry technologies can support transitions, including alternative production systems, such as agroforestry, and the use of basic interventions, such as species selection. Many NTFP bearing tree species have been planted for production for generations, and forest management technologies for sustainable sourcing of products, such as fruit and sap, are well developed. Forest production systems that use technologies rare in conventional forest management, such as grafting, ectomycorrhizal inoculation for mushroom production, and planting rootstock of understory species, may be warranted. Knowledge-based sustainable production of exotic tree species that produce non-timber products with positive economic returns, such as stone pine in Chile (Ch 14), is a tool for transition efforts. The flexibility of species in different environments and ecological requirements makes some NTFP bearing trees, such as stone pine, capable of withstanding climate change challenges. Forest production systems that integrate the spectrum from plantations to agroforestry and natural stands are also tools for sustainable sourcing to address food security and risk issues and generate incomes.

Much of the potential value addition demands a reliable and secure supply of raw materials, requiring regular monitoring and assessments, which is problematic for most NTFPs. Modern approaches, such as citizen scientists and GIS, are powerful technological tools, effective in inventory and product assessments, as the case of berries in Finland showed (Ch 15).

Research and technology development is needed to address production, profitability, acceptance, environmental, social and economic challenges, value chain structure and functioning, and inclusive institutional frameworks. Developing agronomic and forestry technologies to improve the production, management and conservation of at-risk species would advance a bioeconomy transition. The lack of sophisticated production systems illustrates the need to invest in research that leads to technologies that expand their (NTFP) potential.

Advanced biotechnologies and bio-based products as primary pathways to the bioeconomy may also be relevant to NTFPs. Biotechnology research and development for novel, high-quality products could stimulate market expansion and diversification that encompass new and under-recognised sectors as part of a forest-based bioeconomy, as seen in the case of forest-grown ginseng in South Korea (Ch 9). Research to document products' quality, safety, and sustainable sourcing is essential to many industry segments, e.g. cosmetics and pharmaceuticals.

Structured and deliberate approaches

Identified transition pathways provide general lessons for innovating and integrating NTFPs with the forest-based bioeconomy. A systematic and thoughtful phased approach that includes diverse stakeholders is promising. The case of wild-simulated ginseng production in Korea highlighted transition in three phases focused on modifying production systems with institutional support for developing advanced cultivation and reproduction, improving value chain and export conditions, and innovation through the development of novel bioproducts, such as maximising chemical constituents in medicinal plants and creating functional food products (Ch 9). The latter phase may expand the forest sector by linking to other 'non-traditional' industries. Development of strategies that operationalise activities across institutions, value chains, governance approaches, and research and technology development is key.

Diversification, specialisation, and/or innovation of 'traditional' product markets for the benefit of local producers and value chain enhancement is another promising approach (Ch 10). This includes improvements from cultivation to processing and distribution, as well as related technological developments (Ch 11). Transparent and inclusive governance, communication among all stakeholders, and public/private cooperation are also needed.

All of this requires innovative interventions that scale up, out, and deep (Ch 10). Scaling up requires creating institutions and policies for effective and efficient production and quality control. Scaling out entails building capacity and creating incentives to improve production and quality of life. Scaling deep focuses on transforming values and cultural practices to reflect changes in society. All these contribute to sustainable pathways to bioeconomies with non-timber forest products.

Directions for future research

The examples and findings in this book contribute to a more solid foundation for a forest-based bioeconomy, focusing on the overlooked contribution of non-timber forest products in facilitating the transitions. Many issues stand out as important for future research. First, efforts should be intensified to support research into peoples' daily uses and reliance on forest products.

There is substantial low-technology forest use with the potential to contribute to a forest-based bioeconomy; everyday undramatic events of importance to peoples' livelihoods and the future of forests. This may appear less attractive than investing in mainstream research, such as the effect of climate change on forest use, but this is essential to identify transition pathways to a sustainable forest-based bioeconomy. Expanding the empirical basis for understanding the many and diverse contributions of non-timber products is needed – what works and why? Second, research and assessment are required to synthesise our understanding of transition pathways – what characterises successful pathways, and how can these be supported? Can transition pathways be refined and aggregated to identify general pathways to a forest-based bioeconomy? Such understanding of transition pathways would benefit from more analyses using theoretical lenses from other fields of study, making more structured use of existing theories. Lastly, work should be done to understand and position the development and transition to a forest-based economy in relation to emerging trends and funding opportunities such as the Glasgow Leaders' Declaration on Forests and Land Use and the Global Forest Finance Pledge.

Conclusions

This book sheds new light on the NTFP Paradox: *the evidence illustrates the tremendous contributions of non-timber forest products to household and national economies, yet also finds that these products remain underestimated in official statistics, exempt from consideration in official policies and interventions, and not perceived as part of a bioeconomy.* The focus of bioeconomy transition strategies has been on biotechnology development to improve the use of forest products, particularly timber and allied wood products, to reduce dependence on fossil fuels and mitigate the impacts of changing climate. No doubt, this focus is critical and reflects national and global priorities, but it disregards the thousands of other forest products that billions of people consume directly and indirectly for food security, nutrition, income, and cultural purposes. These products represent new possibilities for transitioning to a forest-based bioeconomy. Unlocking the bioeconomy for non-timber forest products requires their integration into national bioeconomy strategies. Certainly, there may be a reluctance to include NTFPs, but the cases presented demonstrate that leadership and knowledge development can move the pendulum. Evidence presented in the chapters may help stimulate nations to take more action.

The road to a forest-based bioeconomy with NTFPs has been murky and uncharted. The analyses presented provide elements of pathways for a clearer course of action for NTFP-integrated bioeconomies. The road starts with actions to include the primary producers, who harvest directly from forests that are not formally managed for the products. Sustainable sourcing of NTFPs to conserve biodiversity while supplying quality novel bio-based

products to growing global markets are elements of pathways. In many cases, primary producers are indigenous communities on the margins of society that function primarily through informal value chains. Actions to improve benefit-sharing along the value chains are part of this less travelled road. Ultimately, technology development, such as producing wild-simulated ginseng with consistent and high-potent medicinal constituents, will have a role in a transition road. Even for place-product combinations that are not central to bioeconomic transitions, such as the occasional collection of berries for own-consumption by well-off households in Western Europe, the existence of such behaviour may be indicative of support for a transition to a forest-based bioeconomy for other products and places. As of yet, there is no standard transition pathway to a forest-based bioeconomy with non-timber products. A differentiated approach considering location-specific contextual factors, such as the types of resources and their economic importance, is required.

Key messages for unlocking the bioeconomy with non-timber forest products

- The in-depth examination of NTFPs relative to the concept of a forest-based bioeconomy deepens the understanding of the productive connections between ecology, markets, and institutional arrangements critical for the bioeconomy paradigm.
- People around the world consume non-timber forest products directly and indirectly for food, nutrition, income, and other purposes. This everyday use of forests constitutes a solid bioeconomic foundation and requires more attention and recognition.
- NTFPs contribute much to local and national economies, although estimates are unreliable and undoubtedly too low because much of the NTFP trade is through informal markets.
- Simple and cheap improved data recording and reporting are needed to provide accurate valuation estimates and make the products and values visible.
- Transitioning to a forest-based bioeconomy with non-timber forest products is taking place around the world. This book provides specific examples of possible pathways. There is no common bioeconomic experience but a multiplicity of them.
- Transitioning to a forest-based bioeconomy that embraces NTFPs is an opportunity to rethink, redefine, and expand the forest sector, making it relevant to the challenges of the 21st century.

References

- Bugge, M.M., Hansen, T. and Klitkou, A. (2016) What is the bioeconomy? A review of the literature. *Sustainability* 8: 691.

- Diazgranados, M., Allkin, B., Black, N., Cámara-Leret, R., Canteiro, C., Carretero, J., Eastwood, R., Hargreaves, S., Hudson, A., Milliken, W., Nesbitt, M., Ondo, I., Patmore, K., Pironon, S., Turner, R. and Ulian, S. (2020) *World checklist of useful plant species*. Kew: Royal Botanical Garden.
- Gowdy, J. and Mesner, S. (1998) The evolution of Georgescu-Roegen's bioeconomics. *Review of Social Economy* 56 (2): 136–156.
- Hickey, G.M., Pouliot, M., Smith-Hall, C., Wunder, S. and Nielsen, M.R. (2016) Quantifying the economic contribution of wild food harvests to rural livelihoods: a global-comparative analysis. *Food Policy* 62: 122–132.
- IACGB. (2020) *Global Bioeconomy Policy Report (IV): a decade of bioeconomy policy development around the world*. Berlin: International Advisory Council on Global Bioeconomy.
- Meinhold, K., Dumenu, W.K. and Darr, D. (2022) Connecting rural non-timber forest product collectors to global markets: the case of baobab (*Adansonia digitata* L.). *Forest Policy and Economics* 134: 102628.
- Piplani, M. and Smith-Hall, C. (2021) Towards a global framework for analysing the forest-based bioeconomy. *Forests* 12: 1673.
- Radelet, S. (2015) *The great surge: the ascent of the developing world*. New York: Simon & Schuster.
- Rosling, H. (2018) *Factfulness*. London: Sceptre.
- Shackleton, S., Shackleton, C. and Shanley, P. (Eds.) (2011) *Non-timber forest products in the global context*. Heidelberg: Springer.
- Shackleton, C.M. and Vos, A. de (2022) How many people globally actually use non-timber forest products? *Forest Policy and Economics* 135: 102659.
- Sheppard, J.P., Chamberlain, J., Agúndez, D., Bhattacharya, P., Chirwa, P.W., Gontcharov, A., Sagona, W.C.J., Shen, H.L., Tadesse, W. and Mutke, S. (2020) Sustainable forest management beyond the timber-oriented status quo: transitioning to co-production of timber and non-wood forest products – a global perspective. *Current Forestry Reports* 6: 26–40.
- Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E. and Berg, G.K. (2007) Forest environmental incomes and the rural poor. *Forest Policy and Economics* 9 (7): 869–879.
- Vivien, F.-D., Nieddu, M., Befort, N., Debref, R. and Giampietro, M. (2019) The hijacking of the bioeconomy. *Ecological Economics* 159: 189–197.
- Williams, M. (2003) *Deforesting the Earth – from prehistory to global crisis*. London: The University of Chicago Press.