Forest Bioeconomy, Climate Change and Managing the Change

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Chapter 1
Forest Bioeconomy, Climate Change and Managing the Change

Lauri Hetemäki and Jyrki Kangas

Abstract In order to realise Agenda 2030, or the United Nations' Sustainable Development Goals, and the Paris Climate Agreement, the business-as-usual model—the policies, production and consumption habits we have been following thus far—will not work. Instead, it is necessary to change the existing economic model and how we advance societal well-being. Here, we argue that a forest-based bioeconomy will be a necessary, albeit insufficient, part of this transformation. The European forest-based sector has significant potential to help in mitigating climate change. However, there is no single way to do this. The means to accomplish this are diverse, and these measures also need to be tailored to regional settings. Moreover, the climate mitigation measures should be advanced in synergy with the other societal goals, such as economic and social sustainability. Climate mitigation in the forest- based sector requires a holistic perspective.

Keywords Circular bioeconomy · Transformation · Forests · Climate change mitigation · Synergies · Trade-offs

1.1 Introduction

The world states agreed, in 2015, on Agenda 2030, or the United Nations' (UN) Sustainable Development Goals (SDGs), and the Paris Climate Agreement. It is widely agreed that the business-as-usual model—the policies, production and

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consumption habits we have been following thus far—will not help us to reach these goals. These agreements and goals can therefore be interpreted as providing a mandate to change the existing economic model–how we advance societal well-being. In this book, *we argue that a forest-based bioeconomy is a necessary part of this transformation*.

There are many definitions of the bioeconomy, as well as usage of similar terms, such as *biobased economy* and *green economy* (D'Amato et al. 2017). In practice, the bioeconomy has turned out to be a changing concept and adjustable for various purposes. One useful definition is from the Global Bioeconomy Summit (GBS) 2015: "*bioeconomy as the knowledge-based production and utilization of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors*". The bioeconomy therefore encompasses the traditional bioeconomy sectors, such as forestry, paper and wood products, as well as emerging new industries, such as textiles, chemicals, new packaging and building products, biopharma, and also the services related to those products (research and development, education, sales, marketing, extension, consulting, corporate governance, etc.), and forest services (recreation, hunting, tourism, carbon storage, biodiversity, etc.).

Hetemäki et al. (2017) extended this definition to a *circular bioeconomy*, also linking it to the *natural-capital* concept. A circular bioeconomy builds on the mutual efforts of the circular economy and bioeconomy concepts, which in many ways are interlinked. The European Environment Agency (EEA) has indicated that implementing the concepts of a bioeconomy and circular economy together as a systemic joint approach would improve resource efficiency and help reduce environmental pressures (EEA 2018). We further suggest that these two concepts, which are often considered separately, could create marked synergies when applied as a hybrid approach, making simultaneous use of both, as is the concept of the circular bioeconomy.

In this book, we understand bioeconomics along similar lines to the GBS (2015), and the extension of this introduced by Hetemäki et al. (2017). We particularly emphasise three key aspects of bioeconomics:

- the transformational role of the bioeconomy in helping to mitigate climate change, and to replace fossil-based products (e.g. oil-based plastics and textiles), non-renewable materials (e.g. steel, concrete) and non- sustainable biological products (e.g. cotton in certain regions);
- the enhancement of the *natural-capital* approach to the economy, involving better integration of the value of natural resources and life-sustaining regulatory systems (e.g. biodiversity, freshwater supplies, flood control) with economic development, as suggested by Helm (2015) and in the action plan of Palahí et al. (2020); and
- the improvement of the quality of economic growth, making it sustainable and operating in synergy with SDGs rather than trade-offs.

The first aspect is generally already well understood in bioeconomic strategies, the latter less so. The long-term sustainable production of natural capital relies on the key role of forests as the most important land-based biological infrastructure on the

European continent (see Chap. 1, Box 1.1). Forests provide the largest supply of renewable biological resources not competing with food production (unlike biomass from agricultural land). Moreover, combining digital technology with biology can offer increasing opportunities for the bioeconomy in the future.

Although the concepts used in the chapter title—*bioeconomy* and *climate change*—have attendant ambiguities, and there is a scientific discourse concerning what they actually mean (e.g. Hulme 2009; Kleinschmit et al. 2017), these terms are not discussed here. Rather, given the above definition of the bioeconomy, we examine its substance in the context of the forest-based sector, examining how it can be implemented, what the outlook is, and its relationship with climate change. In turn, we perceive climate change as global warming and its effects. We also follow the understanding of the Intergovernmental Panel on Climate Change (IPCC), which has posited a human influence on climate that has been the dominant cause of the observed warming since the mid-twentieth century.

Moreover, this book highlights the forests of the European Union, although many of the issues and implications discussed could probably be generalised to other regions. Yet, when discussing climate change and forests, it is important to acknowledge some key distinctions between world regions. For example, there are major differences between tropical forests (45% of the world total in 2020), boreal forests (27%), temperate forests (16%) and subtropical forests (11%) (Food and Agriculture Organization [FAO] 2020), and between the institutional settings in which these forests are located. For example, in Europe, the forests are mainly boreal and temperate, whereas in South America, they are tropical. Moreover, in terms of the environmental opportunities and challenges that climate change is promoting, and the institutional contexts of the continents, contrasting measures may need to be prioritised more in South America than in Europe. The crudest and simplest way to illustrate this point is to look at the forest statistics from the last three decades (see Table 1.1).

Table 1.1 Different trends in forest development in Europe and South America, 1990–2020

Variable (unit)	1990	2000	2010	2020
European forests 1990–2020 *(50 countries and territories)*				
Forest area (million ha)	994	1002	1014	1017
Forest area (% of land area)	44.9%	45.3%	45.8%	46.0%
Growing stock (billion m^3)	104	108	113	116
Carbon stock in biomass (Gt)	45	48	51	55
Total carbon stock (Gt)	159	162	168	172
South American forests 1990–2020 *(14 countries and territories)*				
Forest area (million ha)	974	923	870	844
Forest area (% of land area)	55.8%	52.8%	49.8%	48.3%
Growing stock (billion m^3)	207	199	191	187
Carbon stock in biomass (Gt)	106	102	98	96
Total carbon stock (Gt)	162	155	148	145

Data Source: FAO (2020)

In terms of forest area (ha), Europe and South America were almost of equal size in 1990 – Europe's forest area was only 2% larger. From 1990 to 2020, the European forest area grew by 2.3% and the carbon stock in the forest biomass by 18% (Table 1.1). However, exactly the opposite trend took place in South America, where the forest area and carbon stock have declined by 13.3% and 3.3%, respectively (Table 1.1).[1] Thus, today, the European forest area is one-fifth bigger than that of South America. One clear implication from these statistics is that South America should focus on reversing its deforestation trend in order to better contribute to climate-change mitigation (among other things), whereas in Europe, the priority might not be so much the forest area, but rather other mitigation measures, which this book will discuss in more detail.

When discussing forests and climate change, sometimes the media, and even some scientists, seem to forget these differences in opportunities and challenges that distinct forests and continents are facing deforestation or declining carbon stock may not to be the priority issue in European boreal and temperate forests. Moreover, forests and climate change together present complex issues, and there appears to be no silver bullet that would work in all circumstances and regions, even within Europe (Hulme 2009; Nabuurs et al. 2017; Nikolakis and Innes 2020).

The diversity, complexity and feedback effects among the different channels through which forest-based-sector mitigation can be increased have not always been well understood in the discussion. Rather the media reporting, and occasionally the scientists' messages to policy-makers, have tended to narrow and simplify the topic in a way that misses the holistic picture (Hetemäki 2019; Chapters 8 and 9). For example, the links between climate mitigation and adaptation, the role of forest disturbances, the socioeconomic context (techno-system) in which we are operating, the importance of considering both the short- and long-term impacts, and the need to consider climate mitigation simultaneously with the other grand challenges of humanity. The different roles of forests in climate mitigation are summarised in Table 1.2, which gives a simplified taxonomy that lists some of the most important features between the forest-based sector and climate mitigation.

In Table 1.2, any one of the channels through which the forest-based sector can impact climate mitigation points to a specific action to maximise the mitigation potential under that specific option. Thus, if for example, one was only concerned about maximising the sequestration of carbon in forests and soils, it would make sense to conserve forests, allowing no commercial harvests, at least in the short term (i.e. the coming decades). On the other hand, if the substitution impact was being emphasised, the remedy would be to increase wood production. Furthermore, if the vulnerability of forests to disturbances and damage is also considered, the complete conservation of forests and refraining from harvesting would not be recommended, especially in the long term, as forest ageing increases the probability of both abiotic damage and a number of biotic injuries to trees (see Chap. 3).

[1] In Africa, forest area (ha) has declined from 1990 to 2002 by 14.3%, whilst in North and Central America and Oceania, it has stayed basically the same, and in Asia, it has grown by 6.5% (FAO 2020).

Table 1.2 Forest-based-sector climate-mitigation impacts and actions to strengthen these

Mitigation channel	Possible actions to increase mitigation by 2050 *(action could be modified if the target was long term, e.g. beyond 2050)*
Forest biophysical impacts	
Forest carbon sequestration in trees and soils *(forest sink)*	Stopping deforestation, increasing afforestation and forest conservation. Turning global forest loss to forest gain, and reforestation always after final felling. Increasing tree growth, and reduce harvests.
Forest albedo	Changing coniferous forests to broadleaves or mixed forests
Forest aerosols	Afforestation and conserving forests
Forest disturbances	Adapting forests to changing climate and increasing resilience (e.g. changing tree species and provinces). Decreasing disturbance risks via forest management measures (e.g. increasing mixed forests and decreasing monocultures)
Substitution and storage impacts	
Substituting forest biomass for fossil raw materials, energy and products	Forest management and wood production for forest- based products. Policies to enhance demand for forest- based products, such as wood construction
Storing carbon in forest products	Forest management and wood production for forest- based products
Emissions from forest products value-chain	
Production and logistics	Reducing and eliminating the use of fossil fuels in transport, heating and electricity generation in forest-based industries
Socioeconomic and political impacts*(feedback impacts)*	
Synergies or trade-offs between the mitigation channel and other societal objectives *(e.g. leakage impacts, political support for mitigation measures, biodiversity impacts, income and employment impacts)*	Seek to maximise synergies and minimise trade-offs between mitigation measures and other societal goals
Combination of several different channels	No single policy/action can enhance all the different mitigation channels > need a mixture of different policy and management actions

Clearly, if all the different channels and socioeconomic and political responses are considered simultaneously and holistically, the action may be different than for any single option alone. The planning of mitigation actions is even more complicated by the fact that, depending on the time span of the policy target, different actions may be favoured. That is, if the target is short term (up to 2050) or long term (beyond 2050), the actions required might be somewhat different. Indeed, the occasionally different messages received from scientists on the most appropriate measures to mitigate climate change via forests may reflect them focusing on different time spans. Moreover, one can come to well-founded but different conclusions, depending on whether an analysis is based on looking at only one (or some) of the many possible mitigation channels, or if it is based on a holistic approach, seeking to synthesise the different impact channels and feedback loops. In this book, we follow the IPCC (2019) understanding, where the forest-based sector can contribute to climate mitigation by enhancing forest carbon stocks and sinks, storing carbon in harvested wood products, and substituting for emissions-intensive materials and fossil energy.

In general, this book is based on an approach that stresses the importance of taking a *holistic approach* to assessing how to best utilise forests to mitigate climate change. The *Climate Smart Forestry* (CSF) approach has been introduced as a means of integrating the holistic approach to increase climate mitigation via forests and the forest sector (Nabuurs et al. 2015, 2017; Kauppi et al. 2018; Yousefpour et al. 2018). It is based on acknowledging the diversity and complexity of the issue, as outlined in Table 1.2. The CSF approach seeks to connect forests to bioeconomics, link mitigation and adaption measures, enhance the resilience of forest resources and ecosystem services, while at the same time, seek to meet the other societal challenges (employment, income, biodiversity, etc.). CSF has been introduced in the European context (*see references cited above*), but the approach is of global relevance. CSF builds on the concepts of sustainable forest management, with a strong focus on climate and ecosystem services. It builds on three mutually reinforcing components:

- increasing carbon storage in forests in conjunction with other ecosystem services;
- enhancing health and resilience through adaptive forest management; and
- using wood resources sustainably to substitute for non-renewable, carbon-intensive materials.

CSF aims to incorporate a mix of these measures by developing spatially diverse forest management strategies that acknowledge all carbon pools simultaneously to provide longer-term and greater mitigation benefits, while supporting other ecosystem services. Such strategies should combine measures to maintain or increase carbon stocks in forest ecosystems and wood products, and maximise substitution benefits, while taking regional conditions into account.

1.2 What Are the Future Challenges and Opportunities?

The fact that humanity and forests are not facing only one challenge at a time, but several simultaneous environmental, societal and economic problems, points to there being no simple answers. Just think, for example, about the need to increase climate mitigation efforts, biodiversity, and employment and income opportunities for the growing population and middle class. Moreover, depending on the country or region and its particular circumstances, the needs may have a somewhat different emphasis, and the opportunities to fulfil these may also be different. Therefore, it would be unrealistic to assume that there can be a simple answer to all the needs and local opportunities. This situation is also reflected in the CSF approach, which should be tailored to local conditions (Nabuurs et al. 2017). The optimal measures taken under the CSF approach in forests and the forest- based sector can vary even among different parts of a country. This book seeks to clarify the different options under CSF, and why some measures might be preferred to others, depending on the regional specificities (Chap. 10).

It is also evident that there can be synergies and trade-offs between the many ecosystem services forest generate, or between the environmental, economic and social objectives that society demands from forests. We argue that the objective of bioeconomy strategies and policies should be to maximise the potential synergies and minimise the trade-offs between the bioeconomy, biodiversity and climate mitigation. Hetemäki et al. (2017) illustrated the role of synergies and trade-offs (see Fig. 1.1; see also Biber et al. 2020; Krumm et al. 2020).

In economic terms, the green curves show a forest bioeconomic *production-possibility frontier*, when there is a trade-off between the outputs that forests can provide. The frontier describes all output combinations when outputs are produced efficiently. It is, of course, possible that society is operating inefficiently and would be located below the production possibility frontier.

The vertical axis in Fig. 1.1. describes non-product forest services (biodiversity, carbon sink, water quality, recreation, tourism, etc.), whilst the horizontal axis represents forest products (pulp, sawnwood, bioenergy, etc.). The Fig. 1.1 illustrates a bioeconomy that can use forest resources to produce both material forest products and non- product services at the same time, and can choose between alternative combinations of each production type. The green curves—the so-called

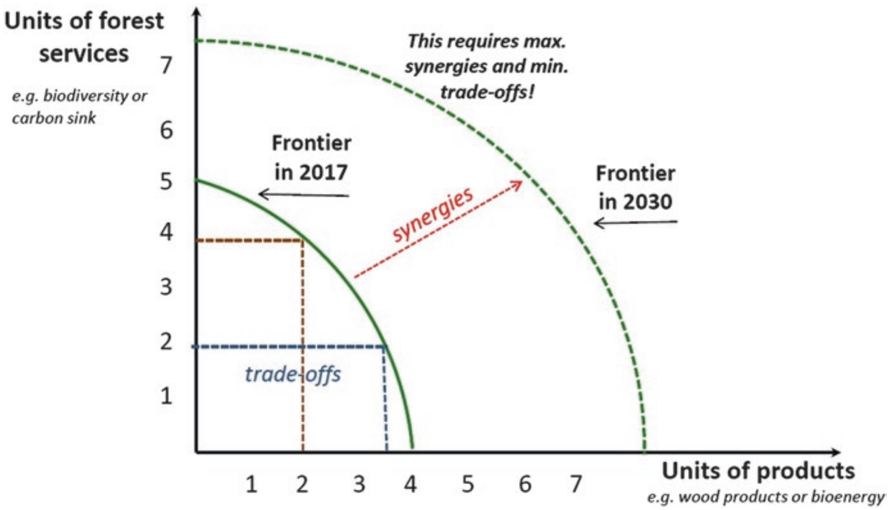

Fig. 1.1 Illustration of a forest-based, bioeconomic production-possibility frontier, with trade-offs and synergies between forest products and non-product forest services

production-possibility frontiers—indicate the maximal combination of outputs (e.g. biodiversity and pulp) for a given amount of inputs (forest, capital, labour). The location of the frontier is determined by technological constraints and resource availability. By picking any point on the green line, the respective amounts of forest products and non-product services can be read from the axes.

As Fig. 1.1 suggests, the more intensively forests are used for forest products, the less societies can produce services such as biodiversity, and vice versa. The challenge for society is to find a sustainable combination of both. The role of synergies is important, because they can move the frontier outwards, and in this way alleviate the trade-offs. In Fig. 1.1, the frontier may move outwards in two ways—either via more from more, or more from less. In both cases, more forest products and non-product services are produced. This results in more sustainable forestry, irrespective of whether the society values more forest products or non-product forest services, *ceteris paribus*. The outward movement of the frontier is, in principle, possible via three pathways:

- technological change (innovation) and learning-by-doing (e.g. better management experience);
- increased resource efficiency with given production inputs (e.g. more forest growth, capital and/or labour productivity); and
- a combination of these two.

Evidence seems to support that outward movement of the frontier is possible. For example, Bieber et al.'s (2020) European case studies indicated a considerable range of forest management options that would not automatically cause trade-offs between wood production, biodiversity and carbon sequestration, also showing options for building synergies between these. However, the new production-possibility frontier would usually not be possible in the short term, especially with forest management taking time to implement and produce changes. However, in the longer term, when technology and innovations are introduced, or higher productivity, movement is possible. Innovations and technological progress (including better institutions and management) are key to producing more from existing resources.

Figure 1.1 illustrates that the bioeconomy can be advanced in different ways, and therefore *it would be optimal to provide policy incentives that help to minimise the trade-offs and maximise the synergies between different components of the bioeconomy*. By increasing the profitability of forest management, and possibly forest areas, a well-promoted bioeconomy could enhance the possibilities of taking care of biodiversity. But the opposite is important as well. Successful adaptation to climate change and extreme weather conditions (increasing forest fires, storms, pests and other hazards) is imperative to provide a basis for the bioeconomy.

So, a key question for bioeconomics is, how can the synergies be made stronger and trade-offs reduced using policies and different measures in forests and the forest sector? In this book, we examine this question, seeking to provide some general answers. We also show that this may mean different actions in disparate regions and under contrasting circumstances.

Finally, the above approach also requires the need to abolish the conventional and still-dominant thinking in which the economy (e.g. wood production) and the environment (e.g. biodiversity) are seen as necessarily and fundamentally opposed to each other. Certainly, there are plenty of cases in the past in which this has been true, as it can be in the future. However, it would be much more fruitful to start to find ways to embrace the synergies than could exist between the economy and the environment. In this book, we argue that the circular bioeconomy, and more specifically CSF, can be an approach for enhancing these synergies and minimising trade-offs in the forest- based sector.

1.3 Outline of the Book

To the best of our knowledge, this is the first comprehensive book to examine the forest bioeconomy and its connection to climate mitigation and adaptation in the EU forests and forest-based sector. It also describes how the CSF approach is a useful tool for combining bioeconomics and climate mitigation. The CSF approach is illustrated using countries that differ in terms of their forest sectors as case studies. The focus is on the EU context, but the principles of the approach may be tailored to other regions.

The analysis in the book is based significantly on the results of an interdisciplinary research consortium project funded by the Strategic Research Council of the Academy of Finland, *Sustainable, climate-neutral and resource- efficient forest-based bioeconomy* (FORBIO) that was carried out in 2015–2021. Needless to say, not all the wisdom on the topic presented in this book lies in the findings of one research project. To try and address this shortcoming, the analyses in the book also refer to the international scientific literature and syntheses of this, such as the IPCC assessment reports. Authors outside the FORBIO project have also contributed to the analyses.

In terms of forest and climate mitigation analysis and discussion, this book endeavours to show the complexity and diversity of the ways in which that can take place, linking these to other demands placed on forests by society. It describes the individual mitigation channels in detail in the different chapters. However, in those chapters discussing the implications of policy and forest management measures, the perspective is typically holistic. That is, for policy and forest management measures, it is necessary to consider the implications of all the individual mitigation channels at the same time, and find an optimal balance between these actions, which individually may even point to opposing measures. In summary, all the different mitigation channels shown in Table 1.2 and the societal context should be kept in mind.

Box 1.1 Forest Bioeconomy in the EU

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The EU's updated Bioeconomy Strategy promotes bioeconomy as a means of tackling global challenges, such as climate change, ecosystem degradation and the unsustainable consumption of natural resources, while simultaneously supporting the modernisation of European industries and strengthening Europe's competitiveness in global markets (European Commission [EC] 2018). The objectives of the updated Bioeconomy Strategy (ensuring wood security, managing natural resources sustainably, reducing dependency on non-renewable resources, mitigating and adapting to climate change, strengthening European competitiveness and creating jobs) are the same as in the original Bioeconomy Strategy of 2012. However, in the updated strategy, the concepts of sustainability and circularity are emphasised as being at the core of the bioeconomy, and are integral prerequisites for the acceptability and future success of the bioeconomy. In fact, while recognising the need for recycling and waste streams as an alternative source of biomass, the original Bioeconomy Strategy did not address circularity or circular economy explicitly (EC 2012).

Despite the emphasis on the ecological dimension of sustainability, the updated Bioeconomy Strategy identifies competitiveness and job creation, representing economic sustainability, as key drivers of bioeconomy. By 2030, the strategy envisages the creation of one million new jobs in bio-based industries (EC 2018). These jobs would emerge in rural and coastal areas especially.

The Joint Research Centre (JRC) publishes bioeconomy statistics for the whole EU and its individual member states. These statistics are based on the data collected in the European Statistical System (ESS). The ESS employs the NACE Rev. 2 classification in its collection of data on economic activity from different fields of the economy. The development of the NACE classification began in the 1970s, and this division of the economy into different industries and sectors is well established, reflecting the traditional way of classifying a multitude of economic activities for the needs of sectoral policymaking. However, the bioeconomy crosses the boundaries of traditional sectors, and the statistics based on the standard classification are inadequate to provide a comprehensive picture of the scale and trends of the bioeconomy. Thus, in the JRC's bioeconomy statistics, some of the NACE Rev. 2 sectors, such as agriculture, fisheries, food, forestry, wood products, and pulp and paper production, are included entirely in the bioeconomy, while only the bio-based share of other sectors, such as the chemical, biotechnological and energy industries, is included (for more details, see Ronzon et al. 2017).

(continued)

Box 1.1 (continued)

According to the JRC's statistics, the bioeconomy created €614 billion value added and employed 17.5 million people in the EU27 in 2017 (JRC DataM 2021). The bioeconomy's contribution to the gross domestic product (GDP) was, on average, 4.7% across all the EU27 member states, but the variation between the member states was substantial (Fig. Box 1.1). In Lithuania, the contribution of the bioeconomy to the national GDP was the highest, at 8.1%, whereas in Luxemburg, it was the lowest at 0.8%. Even greater variation between the member states can be detected in the bioeconomy's contribution to employment. On average, the number of employees in the bioeconomy was 8.9% of the total number of employees across all sectors in the EU27, while the share was the highest, at 27.8%, in Romania, and the lowest, at 3.5%, in Luxemburg. Geographically, the bioeconomy's role in the national economies tends to be higher than average in the Eastern

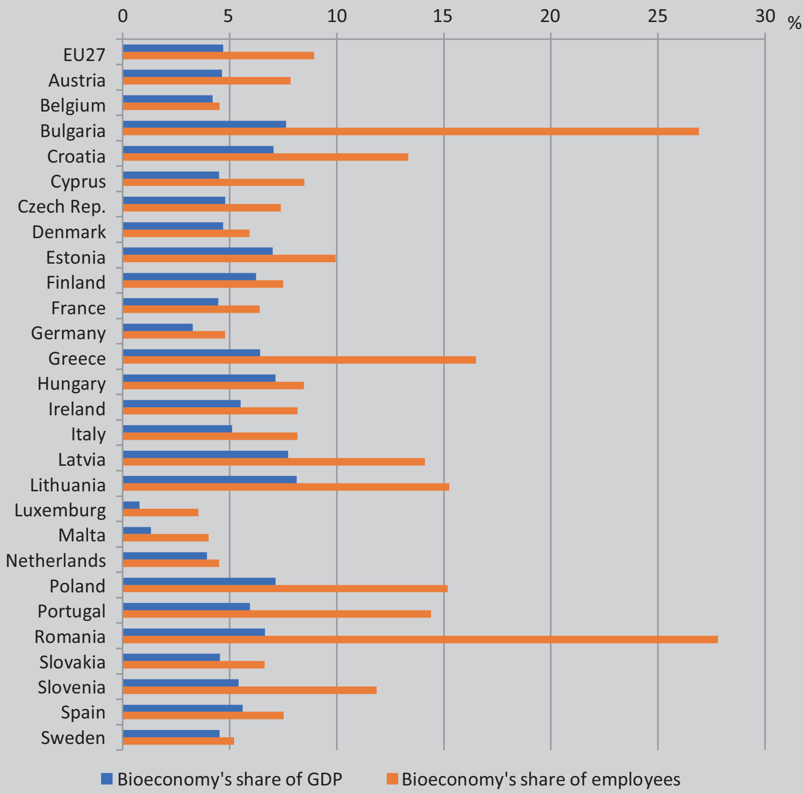

Fig. Box 1.1 The bioeconomy's share of GDP and number of employees in the EU27 in 2017. (Sources: JRC DataM 2021 and Eurostat 2021)

(continued)

Box 1.1 (continued)

European countries, where the agricultural sector is large compared to other sectors, especially in terms of people employed.

By sub-sector, the EU's bioeconomy is dominated by agriculture and the food industry. Agriculture accounted for 53% of employment and 31% of value added in the EU27 bioeconomy in 2017, while the corresponding figures for the food industry and the production of beverages and tobacco were 25 and 35% (Fig. Box 1.2). At the same time, the forest bioeconomy, including forestry, wood products, furniture, and the pulp and paper industries, generated 19% of the total value added and employed 2.5 million people – that is, 14% of the total number of employees in the EU27 bioeconomy. The importance of the forest bioeconomy varies greatly between the member states. In Austria, Finland, Sweden, Estonia, Latvia, Slovakia and Slovenia, the role of the forest bioeconomy is especially pronounced, generating more than 30% value added in the national bioeconomy (Fig. Box 1.3).

In the EU Bioeconomy Strategy, the potential of the forest bioeconomy is recognised as a source of raw materials that could replace fossil materials in the construction, packaging, furniture, textile and chemical industries. Emphasis is also placed on new business models based on the ecosystem services provided by forests, such as carbon storage and sequestration, water regulation and business opportunities in nature tourism. However, the possibility of increasing harvesting volumes, even without exceeding the annual increment, is treated with caution, since trade-offs between the use of woody biomass and other ecosystem services are considered significant and have to be analysed carefully.

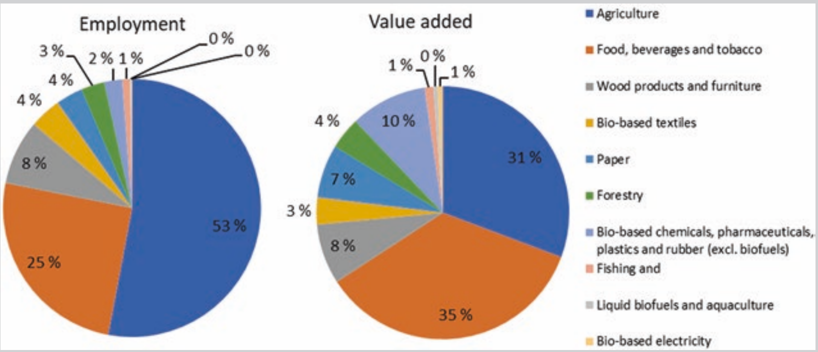

Fig. Box 1.2 Shares of employment and value added by sub-sector in the EU27 bioeconomy in 2017. (Source: JRC DataM 2021)

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Box 1.1 (continued)

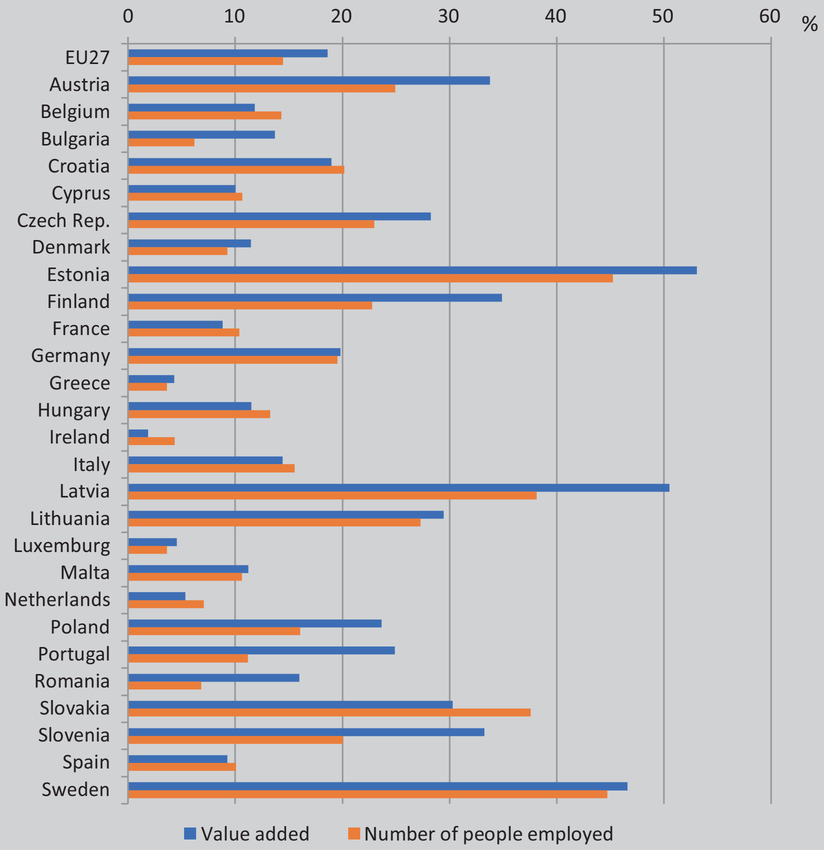

Fig. Box 1.3 The forest bioeconomy share of value added and employment in the EU27 in 2017. The forest bioeconomy covers forestry, the manufacture of wood products and wooden furniture, and of pulp and paper. (Source: JRC DataM 2021)

The definition of bioeconomy and its boundaries in relation to traditional industries and classification framework are not unambiguous, and the JRC's database is only one source of bioeconomy statistics. For example, Natural Resources Institute Finland (Luke) has recently started publishing Finnish bioeconomy statistics, according to which the share of value added created by bioeconomy was 12.2% of the Finnish GDP in 2017, a figure almost twice as high as the estimate provided by JRC (Fig. 1.1). The discrepancy between Luke's and JRC's figures is solely due to the differences in the industries and the proportions of industries included in the bioeconomy. Kuosmanen et al. (2020) studied the relevant industries to be included in the bioeconomy at EU level and proposed a method of determining the size of bioeconomy which combines both the input- and output-based approaches in contrast to the

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Box 1.1 (continued)

purely output-based approach employed by the JRC and Luke. The analysis emphasized the importance of bio-based services, i.e. tertiary sector, such as construction sector, restaurants, and transportation of bio-based goods. According to Kuosmanen et al. (2020), the value added of bioeconomy in the EU28 was EUR 1,460.6 billion or 11% of the GDP in 2015. Robert et al. (2020) studied wood-based bioeconomy in the EU28, and the results stressed the importance of secondary processing, such as wood-based construction,

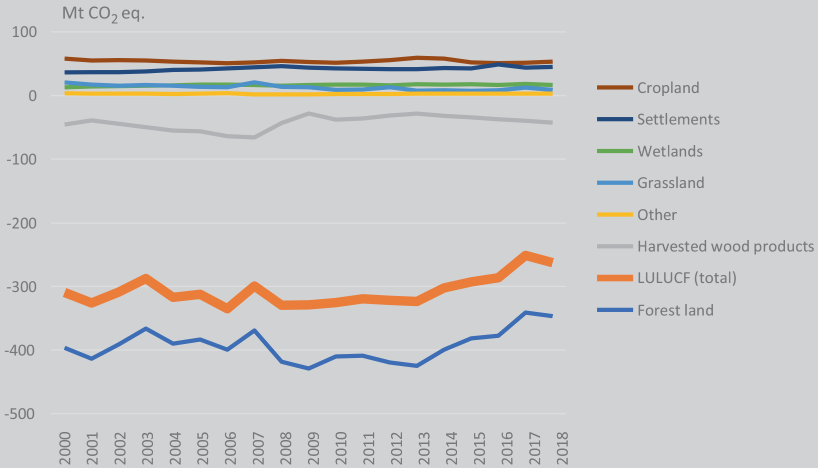

Fig. Box 1.4 GHG net emissions (+) and removals (−) from the LULUCF sector and its sub-sectors in the EU27 in 2000–2018. The 'Other' category includes the following sectors: other land; other land use; land-use change; forestry; and indirect N_20 emissions from managed soils. (Source: EEA 2021)

Fig. Box 1.5 Production volumes (overbark) of industrial roundwood and wood fuel in the EU27 in 2000–2019. Underbark figures were converted to overbark using the coefficient 1/0.88 (FAO, International Tropical Timber Organization [ITTO] and UN 2020). (Source: FAO 2021)

(continued)

Box 1.1 (continued)

printing, and wood-based energy production, in the creation of jobs, and the total number of people employed in the wood-based bioeconomy was 4.5 million in 2018. Obviously, there is a need for developing the statistics to provide the decision makers with comprehensive and consistent data on the scope and trends of bioeconomy.

The role of forests in combating climate change has been recognised relatively recently. Forest land and harvested wood products (HWPs) form the most important sink for greenhouse gases (GHGs) in the EU27. In 2018, the GHG net removal from forest land and the HWP sectors was −389 million tonnes of CO_2 equivalent, which corresponded to roughly 10% of the net emissions from all the sectors, excluding the land use, land use change and forestry (LULUCF) sector. The role of forests in achieving the goals of the Paris Agreement is also recognised in the LULUCF regulation ([EU] 2018/841), which aims to maintain and strengthen the forest sinks in the long term in order to reach the goal of balancing GHG emissions and removals in the second half of this century.

Until the financial crisis of 2007–2008, the GHG net removal (i.e. the carbon sink) of forest land fluctuated yearly in the EU27, but overall, the level of the forest sink was quite stable. After a temporary strengthening, the forest sink started to decline after 2013, however (Fig. Box 1.4). This decline is attributable to the age structure of the European forests, with the forests ageing and harvesting volumes increasing. The total volume of roundwood removals have been growing relatively steadily since 2009, while simultaneously, the share of wood fuel from total removals has increased slightly (Fig. Box 1.5). From the early 2000s up to the financial crisis, the share of wood fuel was one fifth of the total removal, whereas in the 2010s, the share was roughly a quarter. The increased production of wood fuel, as well as other short-lived wood-based products, such as pulp for paper and paperboard, is reflected in the GHG sink of HWPs that has not increased in parallel with the total roundwood removal volumes. In fact, the manufacture of long-lived wood products (i.e. sawnwood and panels) has only recently reached the pre-2009 level.

In forest-rich countries where the forest bioeconomy has more than a marginal role in the national economy, such as in Finland and Sweden, the national bioeconomy and forest strategies are aimed at increasing the use of woody biomass to reach the maximum sustainable volumes, alongside the nature conservation and biodiversity targets of the forests. At the European level, where the forest bioeconomy plays a minor role compared to agriculture and food manufacturing, the aims of the forest-rich countries are perhaps not fully understood. However, the recent forest damage due to storms and bark-beetle outbreaks in Central Europe, as well as the forest fires in the Mediterranean countries, Australia, Russia, California and Canada, have increased the general level of knowledge and understanding of the positive effects of active, sustainable forest management combined with a competitive, vibrant wood-processing industry in the context of climate change mitigation and adaptation.

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