Forest bio-based economy in Europe

S. Mubareka, R. Jonsson, F. Rinaldi, J. Azevedo, D. de Rigo, R. Sikkema

A bio-based economy may be defined as one using "... production paradigms that rely on biological processes and, as with natural ecosystems, use natural inputs, expend minimum amounts of energy and do not produce waste as all materials discarded by one process are inputs for another process and are reused in the ecosystem."[1].

The transition towards a more sustainable primary production and resource efficiency will certainly benefit the environment but also induce a number of significant economic benefits, such as stimulating the economy through encouraging innovation and building new and competitive industries through the emergence of new sectors such as biomaterials and green chemistry.

The bioeconomy in Europe already exists, and has been estimated at 2.4 billion Euro for 2012, employing more than 22 million people[2]. The Commission's bioeconomy strategy and action plan aims at further shifting the European economy towards a greater and more sustainable use of renewable resources; however the transition towards a true bioeconomy relies on a series of breakthroughs in technology and cost effectiveness, as well as the pure availability of biomass[2].

Pine logs, Cannock Chase, UK.
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Forests and Europe's economy

The forest-based sector plays an important role within the European Union (EU) in terms of value added, trade balance, and job creation. The forest industry includes products such as buildings (see box on "Wood in modern urban construction"), books, magazines and newsprint, furniture, food (see box on "The importance of non-wood forest products in Europe"), textiles, packages, energy (see box on "Forest-based energy") and bio-based products (see box on "Forest resources in bio-based products"). The values of sales for these products total to more than 200 billion Euro[3].

Overall, 58 % of harvested EU wood biomass is processed by EU forest-based industries, which represents approximately 7 % of EU manufacturing GDP and nearly 3.5 million jobs. The remaining 42 % is exploited for energy and accounts for about 5 % of the total energy consumption in EU[4].

As an example, some 101 million m^3 of sawnwood were produced in the EU-28 in 2013, close to two thirds of which came from the five largest producing EU Member States; namely Germany (21.3 %), Sweden (16.2 %, 2012 data), Finland (10.1 %), Austria (8.8 %) and France (8.0 %)[5].

The volume of roundwood produced is strongly linked to the value added to the raw material (see Figure 3).

The important role of forests in reaching the EU's Renewable Energy Directive targets, which include the production of energy from renewable sources in the EU, has raised questions about the sustainability of mobilising biomass for these purposes and the forest economy-environment-energy nexus.

Box 1: Wood in modern urban construction

Many countries across Europe, encouraged by EU policies, have set targets to reduce carbon dioxide emissions and are adopting legislative methods to ensure that buildings and materials satisfy the requirements implicit in individual country targets. In many cases this has led to an increased use, or at least consideration, of wood as an alternative to conventional construction materials such as steel and concrete[6].

Until the late 1980s, wood-framed buildings with more than two storeys were prohibited by building regulations in most European countries, due to the negative perceptions arising from historic city fires. However, national building regulations are being revised towards functional criteria as opposed to prescriptive criteria, driven by the Construction Products Directive adopted in the EU in 1988. Thus, a larger number of storeys with a wooden frame is being allowed throughout Europe[7].

As a result of the adoption of functional building regulations and technological development, the share of wood-frame in multistorey construction is on the rise, particularly so in the Nordic countries, the UK, Ireland and the Alpine region of Europe[7]. In Sweden wood-frame multistorey construction (WMC) already has a market share of around 10%[6], and also in Finland WMC is approaching a ten per cent market share[7].

In the UK, the market share of wood-frame in residential construction increased from 8 % in 1998 to 25 % in 2008, but there are as yet no data on the WMC segment specifically. However, residential WMC has made a breakthrough in the UK as a result of environmental policies, the rising interest towards WMC among the developers, and the lightness of wood making it possible to utilise building sites that could not sustain corresponding buildings made of concrete. Also in Ireland, the building practice has been changing from on-site construction to wood-frame off-site construction. However, while the overall market share of wood-frame in all construction increased from 1 % in 1990 to 30 % in 2007, the market share in the WMC segment is still rather small. In Austria, wood-frame is common in the single-family housing sector, with a 40 % market share, yet the regulations and attitudes towards wood use vary from one province to another, and on average the market share of WMC has remained low. Likewise, in Germany and Italy, there are regional differences in the attitudes towards WMC. In Southern Germany, the use of wood for construction has been increasing in the 2000s, and it has been suggested that the market share of WMC could increase from 2 % to 10 % towards 2030[7].

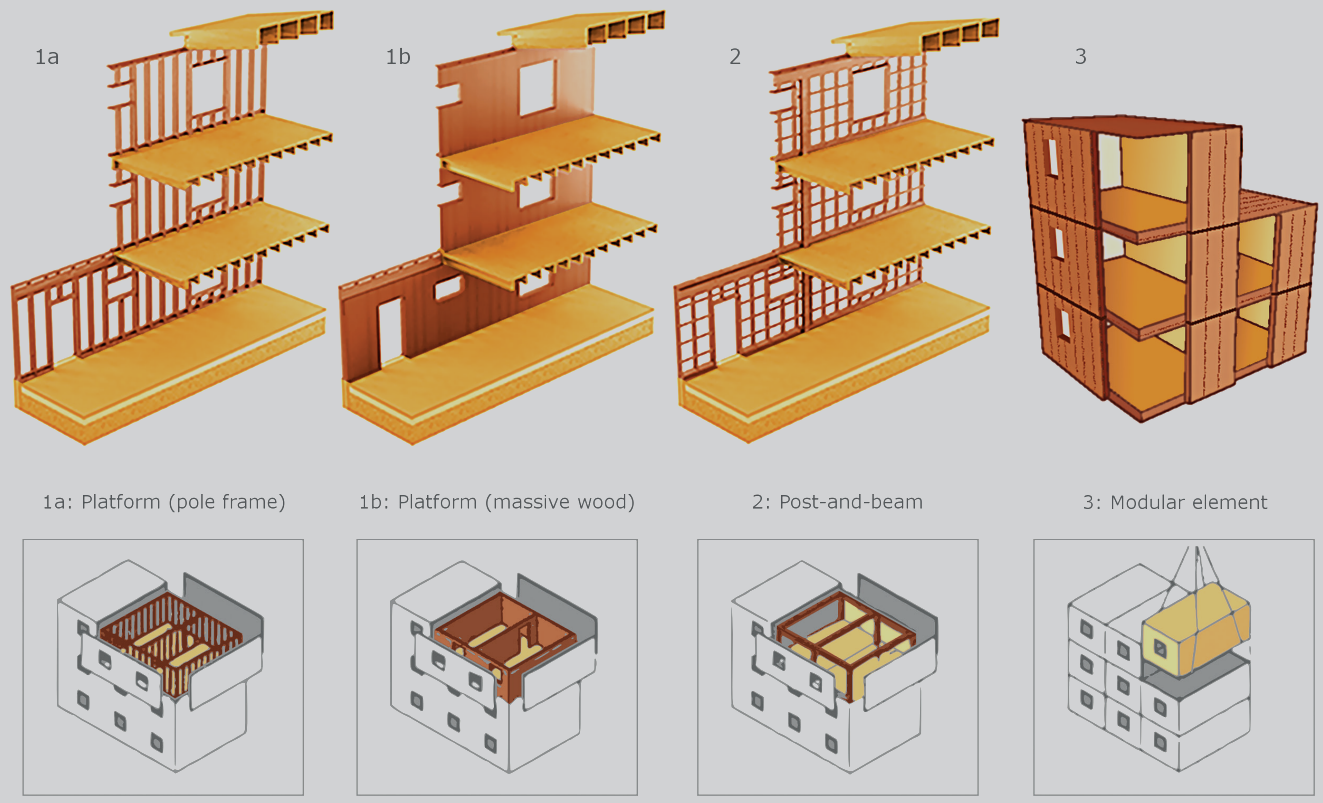

Fig. 1: Three different wood-frame multi-storey construction (WMC) techniques and corresponding key wood elements[7]. 1: Platforms may be based on pole frame structures (1a) or on panel elements (1b). 2: In the post-and-beam technique, massive supporting columns are exploited. 3: Modular elements are instead directly manufactured at the factory, including several final elements such as doors and windows, electricity appliances, or heating. Different WMC techniques imply different industrial workflows. WMC diffusion is dependent on regulatory framework and industry structure[7]. Modified from Hurmekoski, et al.[7]
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Timber Bridge Construction in Arbon, Bodensee in Steinach, Canton of St. Gallen, Switzerland.
(Copyright Norlando Pobre, www.flickr.com: CC-BY)

Traditional timber frame building in the Burgenstraße (Castle Road), southern Germany.
(Copyright Thomas Quine, CC-BY, https://archive.is/sdVn7)

Box 2: The importance of non-wood forest products in Europe

Forests systems are responsible for a diversity of very valuable ecosystem services throughout Europe. Among these, Non-Wood Forest Products (NWFPs) such as mushrooms, chestnuts, cork, pine nuts, honey truffles and berries are among the most important from economic and social points of view. The FAO has classified NWFPs into two broad categories: animal and plant products.

In several European countries, the Nordic common rights (right of public access to the wilderness, or freedom to roam) grant access for picking non-wood forest products such as berries.
Top: Blueberry picking.
(Copyright Ragnar Jonsson, CC-BY)
Bottom: Understorey of *Vaccinium myrtillus* in a coniferous forest.
(Copyright Yuri Timofeyev, CC-BY, https://archive.is/D6fqw)

In northern Europe, the Nordic common rights allow access for picking berries, mushrooms and other non-wood forest products (NWFP), even from private forests. This free access, facilitated by a dense network of forest roads, makes berry and mushroom picking an essential part of the way of life in rural areas of the Nordic countries. Opportunities in the sale and processing of NWFPs to provide additional income vary widely between products, regions and seasons. Earlier interventions to promote NWFP utilisation have included training in identification, picking, processing and marketing of natural products. As an example, in Finland 55 000 commercial mushroom pickers have been trained since the early 1970s. Sales tax and income tax exemptions on selling berries and mushrooms picked by an individual continue to be key incentives for commercial picking. About one-third of berries and some one tenth of mushrooms picked in the Nordic countries enter the market. In recent years, berries sales have decreased as a result of urbanisation and aging of the rural population, as well as low berry prices. As a result, commercial berry picking has, during the past decade, relied largely on migrant pickers, including workers from neighbouring countries and from as far as SE Asia[11].

In the Mediterranean region, non-wood forest products such as mushrooms, cork, pine nuts, chestnuts, resin, honey and truffles are of extreme importance to the economy. Despite this, there is a general lack of regulation of the cultivation of these non-forest wood products[12].

For example, in the Northeast of Portugal, mushrooms have traditionally been picked for self-consumption. This region is one of the few in the country where there is a strong local knowledge concerning wild (and even cultivated) mushrooms. Thanks to this strong tradition and a rich stock of mushrooms, commercial picking has become a very important economic activity in the region since the 1980s. This activity has provided significant income for families and individuals on an annual basis. At the same time, the first studies on mushrooms in the region were conducted with the purpose of assessing diversity, productivity and the economic potential of mushrooms as a forest resource[13, 14]. This activity is still mainly undertaken by locals, usually self-employed or retired elderly woman, individually or in groups of two, and within the limits of the village where they reside or the neighbouring village[15]. Almost all the mushrooms picked locally have international markets as final destination including Spain, France, Germany, and Italy. Although no official statistics are available for the production and trade in the region, mushrooms are estimated to contribute 5 to 10 million Euro to the local economy every year. Population in cities have recently developed an interest in wild mushrooms which has led to the organisation of courses, workshops and other training initiatives by forest, agriculture and environment associations. Formal education in mushrooms has been offered in the Polytechnic Institute of Bragança since 1991[16].

Chestnuts are a very important non-wood forest product of forests in Mediterranean countries. The high market price of chestnuts and the low level of inputs required in the chestnut systems have led to the recent expansion of chestnut agro-forestry systems in some Mediterranean regions. This process is favoured by the movement of people from the countryside to cities in the region and abroad and by the abandonment of traditional agriculture systems. Chestnut diseases such as "ink disease" and "chestnut blight" and the newly arrived "chestnut gall wasp" (*Dryocosmus kuriphilus*) are serious threats to this product. Localised research (for example[17]) and forest extension promoted by forest associations has, however, contributed to minimise the effects of these agents.

In 1993-2013, the European average production of chestnuts has been 130 000 tonnes per year, i.e. more than 10% of the global production[18].
Top: Chestnut bur.
(Copyright William Warby, CC-BY, https://archive.is/0qaSn)
Bottom: Chestnuts.
(Copyright Maja Dumat, CC-BY, https://archive.is/05xeX)

Variety of mushrooms found in the forests of Priekuļi, Latvia.
(Copyright Inga Vitola, CC-BY, https://archive.is/5L6W2)

Raspberries.
(Copyright Maja Dumat, CC-BY, https://archive.is/wqkTZ)

Truffle hunter with his dog, Tuscany, Italy. Italian white truffles are highly sought after and have high value.
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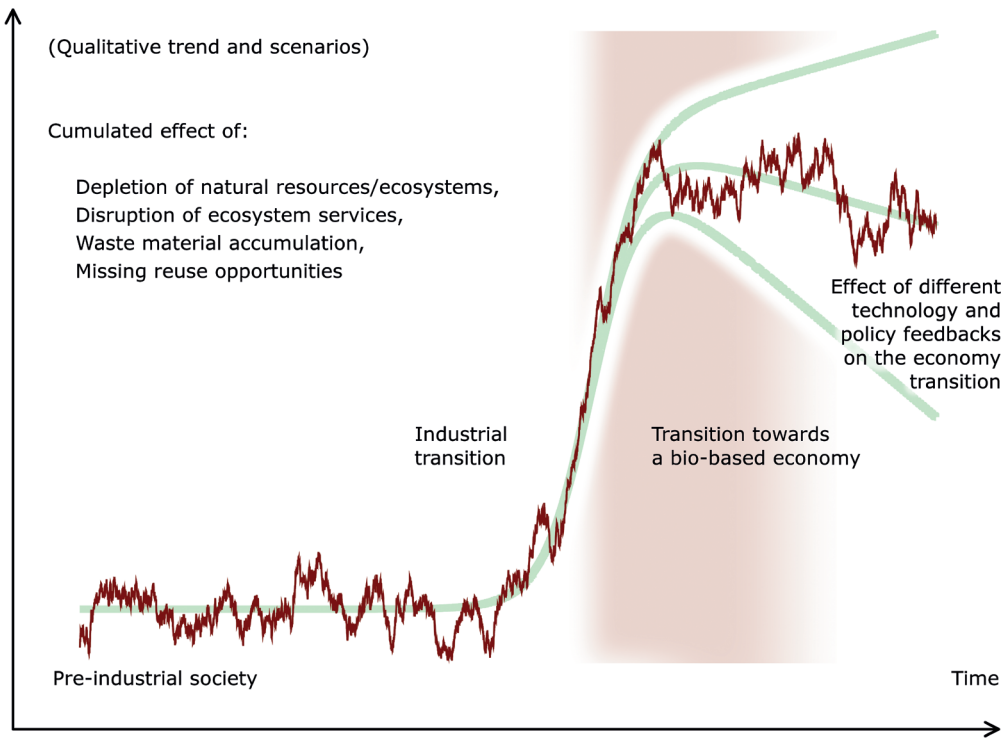
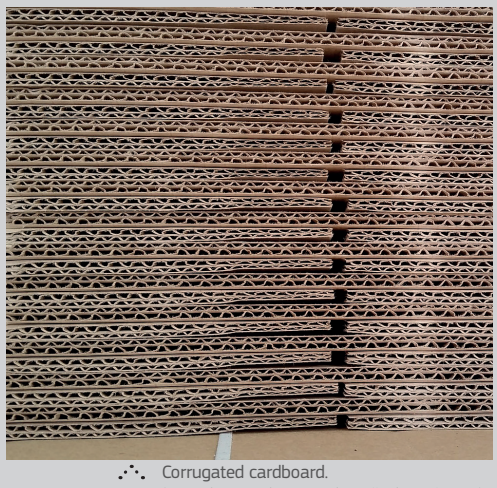


Fig. 2: Qualitative evolution from the pre-industrial society to two subsequent transitions. First, the transition to the industrial society and economy. Then, toward a bio-based economy. The short-term patterns of the actual evolution may be complex since they are subject to several sources of local fluctuations. The qualitative future trend will also depend on the cumulative feedback effect due to different potential technology and policy scenarios.
(Author: Daniele de Rigo)

Box 3: Pulp and Paper Industry

The pulp & paper industry is an important industry within the forest-based bioeconomy of Europe. Using some 150 million cubic meters of wood per annum, this industry provides 1.5 million jobs in the value chain, adding 15 billion euros to the Gross Domestic Product of the European Union. The industry is going through structural changes. Thus, while the consumption trend for graphic paper is a decreasing one, consumption of paper for sanitary and packaging purposes is rising. Recycling plays an important role within this industry. Indeed, paper is the most recycled product in Europe, with a recycling rate that increased from 40% in 1991 to 72% by 2014. Recovered paper make up 54% of the raw material used in the paper industry[34].



Corrugated cardboard.
(Copyright jaymethunt, CC0, https://archive.is/cG356)

Waste paper for recycling.
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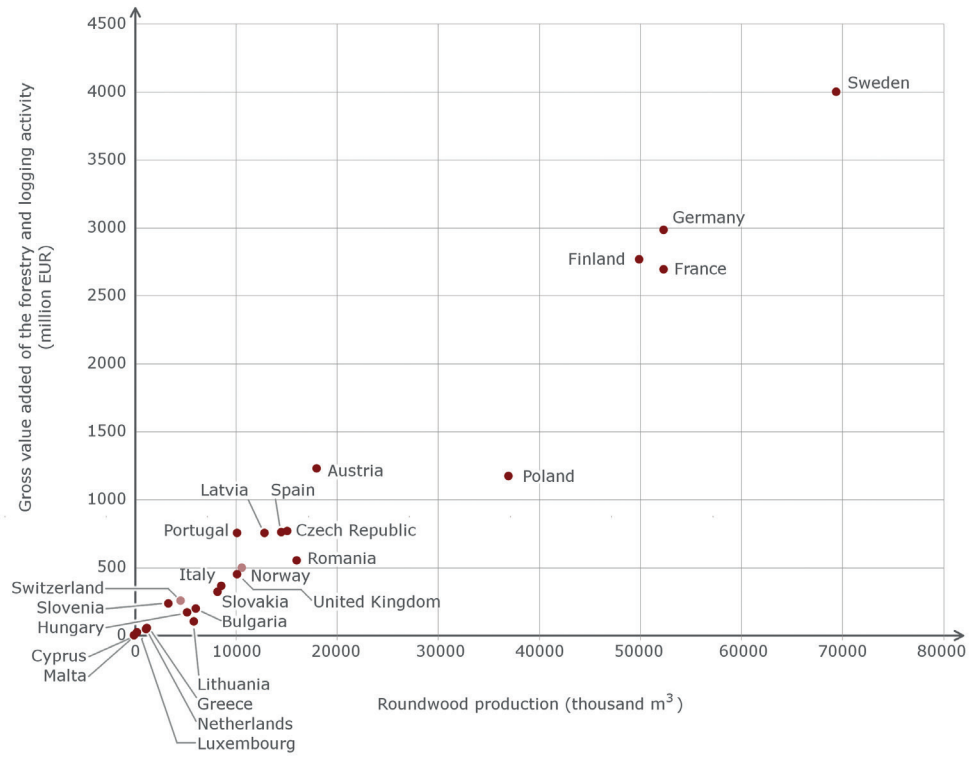

Fig. 3: Roundwood production in 2012 and gross value added of forestry and logging. For Italy, Lithuania and the Netherlands, the available data refer to 2006. For Spain, data refer to 2007. For Hungary and Malta, data refer to 2009. For Greece, Latvia and Luxembourg, data refer to 2011. France, Portugal and Norway data are provisional.
(Source: Eurostat[5])

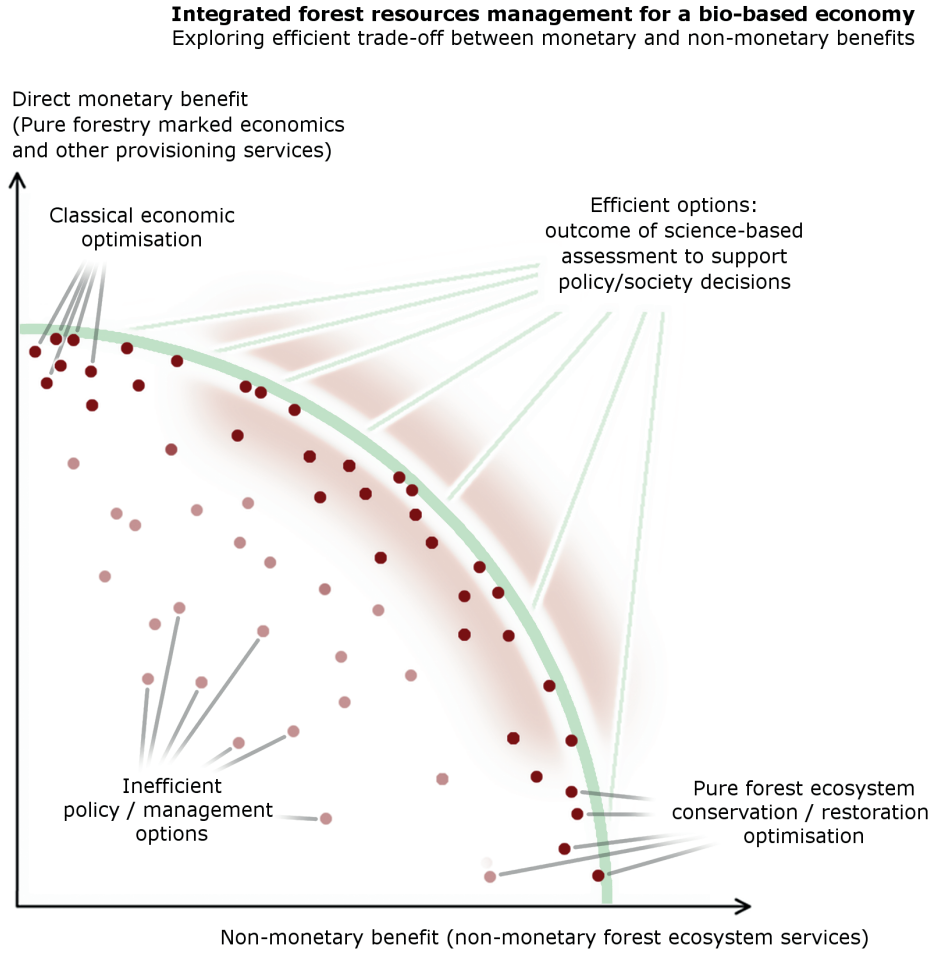

Fig. 4: Integrated forest resources management within the context of a bio-based economy. Qualitative trade-off between monetary and non-monetary benefits. The trade-off emerges considering different optimisation frameworks. Two extreme frameworks optimise policy / management options towards classic economic optimum (forestry marked economics and other provisioning services of forest resources) or instead towards pure forest ecosystem conservation / restoration (maximising non-monetary forest ecosystem services). Intermediate efficient options to support policy and society decisions may emerge with a multi-criteria framework for integrated forest resources modelling and management.
(Author: Daniele de Rigo)

Box 4: Forest-based energy

Forest-based woody biomass is currently the most important source of renewable energy in the European Union (EU), accounting for around half of the total renewable energy consumption. The targets for renewable energy have resulted in a surge in the use of wood pellets within the EU. The EU-28 is the largest global producer of wood pellets, its output reaching an estimated 13.2 million tonnes in 2013; production in the EU-28 rose by 97.6% overall between 2009 and 2013. The EU-28 is a net importer of wood pellets: the level of imports from non-EU Member States rose to 6.4 million tonnes by 2013, which was an overall increase of a staggering 267.6% compared with 2009[19]. In countries such as Germany, Austria and Italy, wood pellets are exclusively used in heat production for the residential sector while the industrial use for power generation prevails in the United Kingdom, the Netherlands and Belgium. In Sweden and Denmark, both sectors are well established[20]. According to the National Renewable Energy Action Plans, biomass used for heating, cooling and electricity would supply about two-fifths of the 20% renewable energy target for 2020. If achieved, the amount of wood used for energy purposes in the EU would be equivalent to today's total wood harvest[4].

Left: Forest-based production of wood pellets. (Copyright Richard Sikkema, CC-BY).

Right: wood pellets, detail. (Copyright Andrew_Writer, CC-BY, https://archive.is/cv7JF)

Relationship between bioeconomy and non-monetary aspects of forest ecosystem services

Aside from the monetary value associated with forest resources considering the wide variety of industry products, energy and bio-based assets, forests provide important non-monetary services to the economy and society (see previous chapter).

As discussed, a forest bio-based economy already considers some crucial aspects linked to sustainability and to minimising energy consumption and waste material production; e.g. emphasising the role of chaining processes so that materials discarded by one process become inputs for another process, or so that they can be reused in the ecosystem. In a wider perspective on the overall role of forest resources, the monetary benefits associated with the bioeconomy may be considered together along with the ecosystem services which forests can provide to the society. There is a partial overlap between these two concepts, highlighted by the clear monetary value of some ecosystem services (e.g. recreational activities and the tourism industry/sector). However, a significant part of forest ecosystem services provides a non-monetary benefit which requires a sometimes quite challenging[21] multi-criteria economic framework to be properly assessed[22-24]. A few examples of this last category are summarised below.

One of the major sources of damage to soil resources in Europe, unfortunately leading to surprisingly high direct and indirect costs, is due to soil erosion by rainfall and runoff and its monetary and non-monetary impacts[25, 26]. Landslides are also associated with considerable costs[27, 28] and the impact of both erosion and slope instability hazards may occur together with even greater effects[29]. The multiple layers of vegetation in a typical forest (canopy, sub-canopy or midstorey, shrub of understorey and ground-layers) make a significant contribution to reducing the potential erosion caused by rainfall[30, 31]. Forest soil and topsoil are also able to reduce the surface runoff mitigating the risk of both erosion and slope instability[32].

Moreover, the soil layers of forests have a high filtering capacity regarding most of the chemical components of pollutants[32]. In Europe, 65% of public water supplies come from groundwater. Part of the remaining water supplies relies on rivers, lakes, water dams and reservoirs, whose water quality critically depends on land use within the catchments[33]. Several of the main European cities either obtain a significant proportion of their drinking water from protected forest areas, or explicitly manage forests for watershed protection[33]. Furthermore, many European forest authorities explicitly mention watershed functions within their plans[33].

These few examples among many underline the tight relationship between environmental economics and conservation/restoration efforts focusing on key functional aspects of healthy forest ecosystems. Depending on the society and policy needs, these efforts may require an integrated perspective focusing on both monetary and non-monetary aspects. Research innovation on both forest bioeconomy and ecosystem services may thus contribute to integrated modelling and management of forest resources, providing a science-based support to critical policy and society decisions.

Box 5: Forest resources in bio-based products

Products are considered "bio-based" if they are either wholly or partially composed of materials of biological origins. Bio-based materials should be able to replace fossil fuels on a large scale for chemicals and materials applications. Methods such as fermentation and biological catalysts replace traditional chemical approaches, thus increasing efficiency in processing products and ultimately resulting in reduced resource-use and toxic waste production. A shift towards bio-based products can lower our dependence on fossil fuels. According to the European Commission, bio-based products and biofuels represent approximately EUR 57 billion in annual revenue and involve 300 000 jobs.

Large quantities of different types of base or platform chemicals can be isolated or produced from wood, pulping liquors and different types of forest residues in bio-refineries[8]. Forest products can be used in biopolymers; as phenol substitutes through liquefaction or pyrolysis of forest biomass[9]; as injection moulding for musical instruments; for cups, plates and utensils by mixing natural fibres and plastics; in food, drink and cosmetic industries (tree sap). Slowly, anaerobic digestion-based biorefineries may replace our main source of energy and materials: petroleum. This depends on the efficient conversion of feedstocks, often low-value, into high-value biofuels and bio-based products. These range from municipal and industrial organic wastes, to agricultural and forest residues, and energy crops[10].

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Timber stack, Barrow Haven, United Kindgom. (Copyright David Wright, CC-BY, https://archive.is/Mqv4W)

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