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BIOMASS SUPPLY AND USES IN THE EU

Summary for policymakers

2023

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Contents

Abstract

The European Union (EU) uses biomass to meet its needs for food and feed, energy, and materials. The demand and supply of biomass have environmental, social, and economic impacts. Understanding biomass supply, demand, costs, and their associated impacts is particularly important for relevant EU policy areas, to facilitate solid and evidence-based policymaking.

This summary report aims to provide an overview of biomass production, supply, uses and flows for the EU-27, covering primary production systems and waste. We find that although we are improving our reuse of biomass, we are also producing and consuming more overall, putting pressure on ecosystems. We caution that efficiency should not be a goal in itself as it often results in an overal increase in consumption, which cannot be afforded in the case of biomass. We report the gaps in knowledge and data in each of the chapters, and conclude the report with an overview of where the data generated through this effort can be downloaded.

As the European Commission's (EC) in-house science service, the role of the European Commission's Joint Research Centre (JRC) is to provide EU policies with independent, evidence-based, scientific and technical support throughout the whole policy cycle, thereby contributing to coherent policies.

Foreword

Director Alessandra Zampieri
Directorate for Sustainable Resources,
Joint Research Centre

As we strive to find solutions to increasingly pressing and alarming direct and indirect impacts of the climate and biodiversity crises, we find great consensus for the bioeconomy. Over the past decade, the European Commission has adopted a number of initiatives that set goals aimed at decoupling economic growth from resource use. The European Green Deal accelerated the protection of biodiversity (Biodiversity Strategy), the mitigation of climate change (Stepping up Europe's 2030 climate ambition), a more sustainable food system (Farm to Fork Strategy) and, in general, the increasing sustainability of the economy and circular use of resources. In all these initiatives, biomass is a key resource.

We turn to biomass, and therefore the bioeconomy, as a means to transform our societies and economies so that we can live in harmony with the planet and achieve a sustainable balance in the socio-ecological system. This means relying on biomass that is sustainably sourced and transformed. The bioeconomy offers an opportunity to realign the economy with the biosphere, stimulating us to seek innovative alternatives to non-renewable sources, while also – and principally – inviting us to consume less.

As scientists at the Joint Research Centre (JRC), our role is to provide a high standard of scientific and technical support to

EU policy by delivering evidence and by curating knowledge in a holistic way, such as required by the topic of the bioeconomy. The JRC provides the European Commission services, on a long-term basis, with data, models and analyses of EU and global biomass potential, supply, demand and related sustainability. This task requires integration across sectors and policies, and calls for state-of-the-art biomass-related data, knowledge and modelling tools.

This issue in the series of reports prepared under the JRC Biomass mandate, highlights our increasing dependency on biomass for material and energy over the past decade. Although we are getting better at recovering our bio-waste for material and energy, we still require an increasing amount of biomass from primary production systems. The report points out the potential to re-engineer biomass for high-value-added products, and examines the full life cycle of a representative basket of bio-based products in terms of their environmental impacts. It also highlights that, although we are doing better at replenishing our seas, they are still not fully healthy. The forest biomass embodied in our traded commodities is considerable, and our consumption of natural resources needs to be curbed.

Biomass is a sine qua non for a Green Transition. Biomass produced from ecosystems is being re-engineered while new uses for biomass are being invented to offset emissions. However, ecosystems are under great pressure. We expect forests, the seas, and freshwater and agro-ecological systems not only to generate goods, but also to mitigate climate change and maintain biodiversity at the same time.

Our economies and societies depend on a healthy planet. Therefore, we should stop asking "How much biomass is available for human use?", but rather ask ourselves "How can we live in harmony with our planet to foster a lasting equilibrium between humans and the natural world?

Acknowledgements

The JRC would like to acknowledge the support of the technical experts of the Interservice Group on Biomass Supply and Demand in the European Commission, chaired by the Directorate General for Research & Innovation, whose comments were essential during the execution of the work. We would also like to thank Sing Sing Ngai, Translator – Terminologist in the Directorate General for translation for her translation of data from China on macroalgae, and the European National Forest Inventory Network for their collaboration in efforts to harmonise forest parameters, as well as Udo Mantau for his continued support in the effort to harmonise statistics on woody biomass, allowing for a hamonised overview of woody biomass flows and the wood resource balance.

Executive summary

The European Union (EU) uses biomass to meet its needs for food and feed, energy, and materials. The demand and supply of biomass, our technological innovation and push for resource efficiency, have economic, environmental, and social impacts. Understanding biomass supply, demand, costs, and their associated impacts is particularly important for relevant EU policy areas, to facilitate solid and evidence-based policy-making.

In this report, we describe the biomass sources and uses for the agricultural, forestry, algae, and fisheries and aquaculture sectors with the latest available data both in comparative terms (using the same units), as well as with deep dives into the sectors themselves, highlighting the most salient issues in the respective sectors. We also examine the contribution of food, wood and other biowaste to the biomass supply. Each of these sectors are assessed by experts whose methods and models differ from one another. The basis upon which the approaches are selected by the experts will vary for any number of reasons, and each approach has its limitations and caveats.

A description of the trends in biomass supply and uses of these sectors indicates the direction in which the EU-27 is heading. Much of the data in this and previous reports are reported in the EU Bioeconomy Monitoring System[i] or elsewhere in the Knowledge Centre for Bioeconomy (KCB)[ii]. This ensures a curated and long-lasting legacy of the JRC Biomass Mandate. The data is also reported in the relevant portals and reports to the topics treated here. They are summarised in Chapter 12 of this report.

Several specific topics were selected for in-depth studies for this Summary for Policy Makers. These include a specific study on the prices of timber; a detailed analysis of the algae sector; a special look at trade of bio-commodities; and industrial uses of biomass.

Policy context

Biomass is very much centre stage in the European Green Deal. Forests, the seas, freshwater and agricultural systems, are expected to simultaneously mitigate climate change, house biodiversity and generate goods. As a result, the biomass produced from these sources is being re-engineered, and new uses for biomass are being invented to offset emissions. Meanwhile, the societal challenges we are all facing are being addressed at a global level and the EU's pledges to international commitments are resulting in a series of overarching EU-level strategies. These are engaging commitments towards the Sustainable Development Goals and more specifically, to mitigate climate change, enhance ecosystems and conserve and enhance biodiversity, as well as promote justice, equality, and competitiveness. Geopolitical events are, in turn, also impacting the EU and forcing us to re-think how our resources are managed, as well as the EU's food and energy sovereignty.

Main findings

The total sources of biomass, which includes domestic production and net imports, in the EU-27 amounts to approximately 1 billion tonnes of dry matter (tdm), whereas the uses amount to 1.2 billion tdm. The additional biomass in uses with respect to sources, which is domestic production plus net-imports, is due to the recovery of waste from industry and households.

The trend in biomass supply is increasing from both primary domestic production and secondary sources.

Roughly, 924 Mtdm of biomass is produced from the agricultural sector. Of this amount, a little over half is economic

(i) https://knowledge4policy.ec.europa.eu/visualisation/eu-bioeconomy-monitoring-system-dashboards_en

(ii) https://knowledge4policy.ec.europa.eu/bioeconomy_en

production, amounting to roughly 500 million tonnes dry matter (Mtdm) in a year produced in the EU for food purposes (including inputs). Of this, approximately 96 Mtdm is plant-based food while the remaining 393 Mtdm is for animal feed and bedding.

While half of the EU Biomass sources are from the agricultural sector, roughly 27 % are from forestry. Based on the specific assessment carried out by JRC within the present study, we estimate a total above ground living biomass stock of 18.4 billion tonnes of dry matter. While 89 % of forest area is available for wood supply, this corresponds to 92 % of the biomass stock that is available for wood supply in the EU-27. On the uses side, the total amount of woody biomass used for material and energy in the EU-27 was 932 Mm3 (in 2017) with a rough share of 45 % for energy and 55 % for materials.

The supply of fish from aquaculture reached 1.1 million tonnes wet weight (tww), while wild catch is at a level of 3.9 million tww. Spain, France, Greece, and Italy represent 66 % in weight and 61 % in value of the total EU aquaculture production in 2020, according to FAO data. There has been a reduction in the EU seafood supply and economic performance from marine fishing since 2016-17. This reduction in the supply is largely driven by the efforts to reduce overexploitation and external factors that have undermined the performance of the EU fishing fleet, such as Brexit, the impact of the COVID-19 pandemic and more recently, high fuel prices.

Seaweed is an increasingly important source of biomass, with its direct and indirect climate change mitigation potential. According to 2022 FAO data, the EU produced 81,911 tww (7 % of the global production) in wild stock and 207.3 tww from aquaculture (0.0006 % of global) in 2020. In 2020 EU-27 Member States imported 146.6 thousand tww of seaweed products from outside of the EU (measured in net product weight) and exported a total of 62.8 thousand tww to outside the EU.

Waste is also an important source of biomass in the EU. Biowaste from agriculture, industry and households amounted roughly to 147 Mtdm in 2018. Of this, 90.4 % was recovered. When using more detailed data, using a mass-balance approach for food, the food waste generated in 2019 is computed at 84.7 Mtdm alone, and the wood waste, when computed with more detailed data, is computed at 137.5 Mtdm (in 2017).

The trend in biomass supply is increasing from both primary domestic production and secondary sources.

The content of this Summary for Policymakers was taken from the main report.

Mubareka, S., Migliavacca, M. and Sanchez Lopez, J. editor(s) of

Biomass production, supply, uses and flows in the European Union

Avitabile, V., Baldoni, E., Baruth, B., Bausano, G., Boysen-Urban, K., Camia, A., Cazzaniga, N., Ceccherini, G., De Laurentiis, V., Doerner, H., Giuntoli, J., Gras, M., Guillen Garcia, J., Gurria, P., Hassegawa, M., Jasinevičius, G., Jonsson, R., Konrad, C., Kupschus, S., La Notte, A., M`barek, R., Mannini, A., Migliavacca, M., Mubareka, S., Patani, S., Patinha Caldeira, C., Pilli, R., Rebours, C., Ronchetti, G., Ronzon, T., Rougieux, P., Sala, S., Sanchez Lopez, J., Sanye Mengual, E., Sinkko, T., Sturm, V., Van Leeuwen, M., Vasilakopoulos, P., Verkerk, PJ., Virtanen, J., Winker, H. and Zulian, G., EUR 31566 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-68-04915-0 (online), doi:10.2760/811744 (online), JRC132358.

1 Introduction

Biomass is very much centre stage in the European Green Deal (EEA, 2023). Forests, the seas, freshwater and agricultural systems, are expected to simultaneously mitigate climate change, accommodate biodiversity and generate goods. As a result, the biomass produced from these sources is being re-engineered, and new uses for biomass are being invented to offset emissions. Meanwhile, the societal challenges we are all facing are being addressed at a global level and the EU's pledges to international commitments are resulting in a series of overarching EU-level strategies. These are engaging commitments towards the Sustainable Development Goals and more specifically, to mitigate climate change, enhance ecosystems and conserve and enhance biodiversity, as well as promote justice, equality, and competitiveness. Geopolitical events are, in turn, also impacting the EU and forcing us to re-think how our resources are managed, as well as the EU's food and energy sovereignty.

The powerhouse systems that we rely on to bring us through a green transition to a new way of living with lower impact are the terrestrial, marine and freshwater systems. Our own waste streams also provide an increasingly important source of biomass, alleviating direct impacts on primary production systems, yet re-engineering waste is also not without costs.

Basic data and information about them and the services they provide – which includes, but is not exclusively, biomass provision – are a fundamental piece of policymaking. Monitoring is essential to identify areas in need of policy intervention as well as to assess the coherence and the impacts of existing legislation. The Joint Research Centre Biomass Mandate is an important source of data for the EU Bioeconomy Monitoring System[1] for the biomass-related indicators, which are provided by the collective efforts related to this Mandate. A description of the trends in biomass supply and uses of these sectors indicates the direction in which the EU-27 is heading.

In this summary and in the main report accompanying the summary[2], we describe the biomass sources and uses for the agricultural, forestry, algae, and fisheries and aquaculture sectors with the latest available data, both in comparative terms (using the same units), as well as with deep dives into the sectors themselves, highlighting the most salient issues in the respective sectors. We also examine the contribution of food, wood and other biowaste to the biomass supply. Each of these sectors is assessed by experts whose methods and models differ from one another. Readers are invited to consult this main document for more details on the methodologies, the limitations and uncertainties associated with the data presented here, as well as additional data, results and interpretations of results.

This summary presents some selected facts, figures and findings of the JRC Biomass Mandate (see ***Box 1***) 2023 report ***Biomass production, supply, uses and flows in the European Union***. Different scientific units of the JRC have assessed biomass supply, production, flows, and uses of biomass through the relevant sectoral lenses and for this reason, the data and knowledge are published in numerous shapes and forms. In this summary we aim to highlight some main findings of the 2023 report, as well as direct the readers to the relevant JRC data and knowledge resources.

(1) https://knowledge4policy.ec.europa.eu/visualisation/eu-bioeconomy-monitoring-system-dashboards_en

(2) https://publications.jrc.ec.europa.eu/repository/handle/JRC132358

Box 1. The JRC Biomass Mandate.

We need good, overarching, coherent and visionary governance to ensure that ecosystems are not overexploited, while biomass is acknowledged to be a valuable resource in the bioeconomy. Recognising the need for a balanced, wide-ranging and scientifically robust approach to assess the status and trends of biomass sources and uses, the European Commission has committed to a long-term mandate to provide data, models and analyses on the supply and demand of EU and global biomass, as well as its environmental, social and economic sustainability.

2 European biomass supply and uses

The total supply of biomass, which includes domestic production and net imports, in the EU-27 amounts to approximately 1 billion tonnes of dry matter and the uses amount to 1.2 billion tdm. The additional biomass in uses with respect to production plus imports is due to the recovery of waste from industry and households.

There is an overall trend for increase in biomass supply from all sources: domestic production, net imports, and re-use. This increase is from both primary domestic production and secondary sources (***Figure 1***). The trend in biomass use in the EU-27 is also increasing, most significantly for bioenergy, followed by material uses, while food uses for biomass remain largely constant (***Figure 2***).

These data are presented here in harmonised units of tonnes of dry matter. In the following sections, we present a deep dive into the sectors producing biomass. These are presented in native units and are therefore not necessarily comparable, but by avoiding conversions, the figures remain close to their original measure.

Figure 1.
Trends in biomass sources in the EU-27 (2009-2017) in millions of tonnes of dry matter (Mtdm).
(source: JRC, 2023)

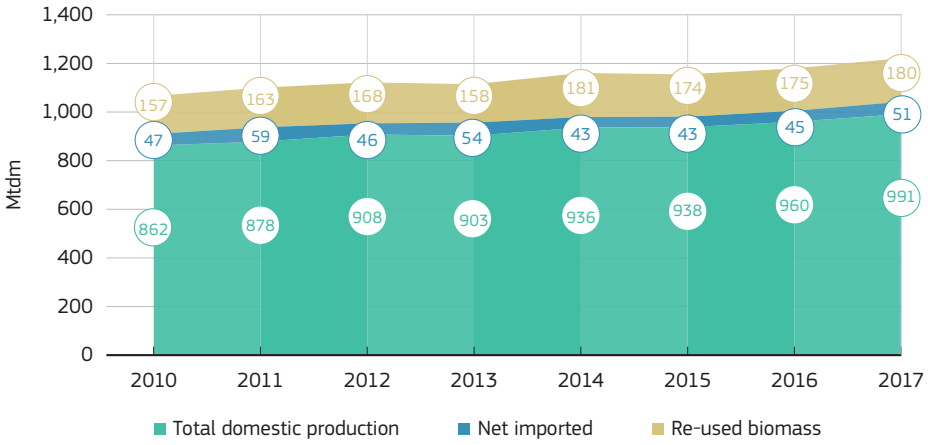
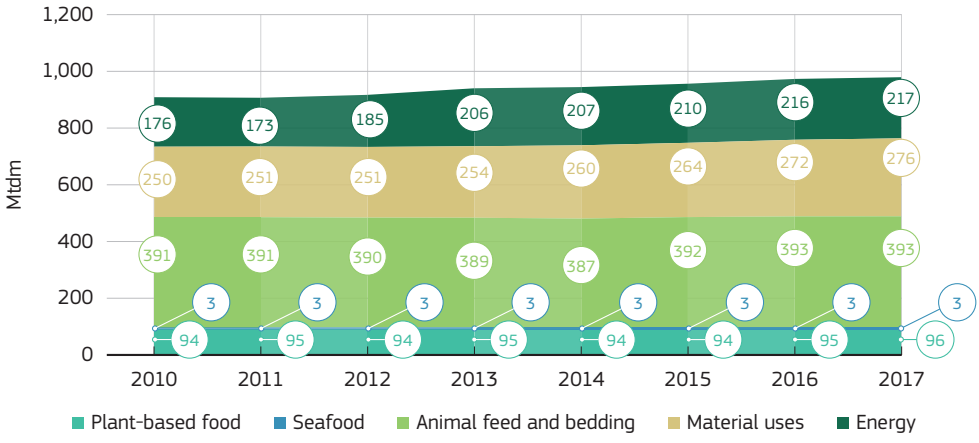


Figure 2.
Trends in biomass uses in the EU-27 (2009-2017) in millions of tonnes of dry matter (Mtdm).
(source: JRC, 2023)

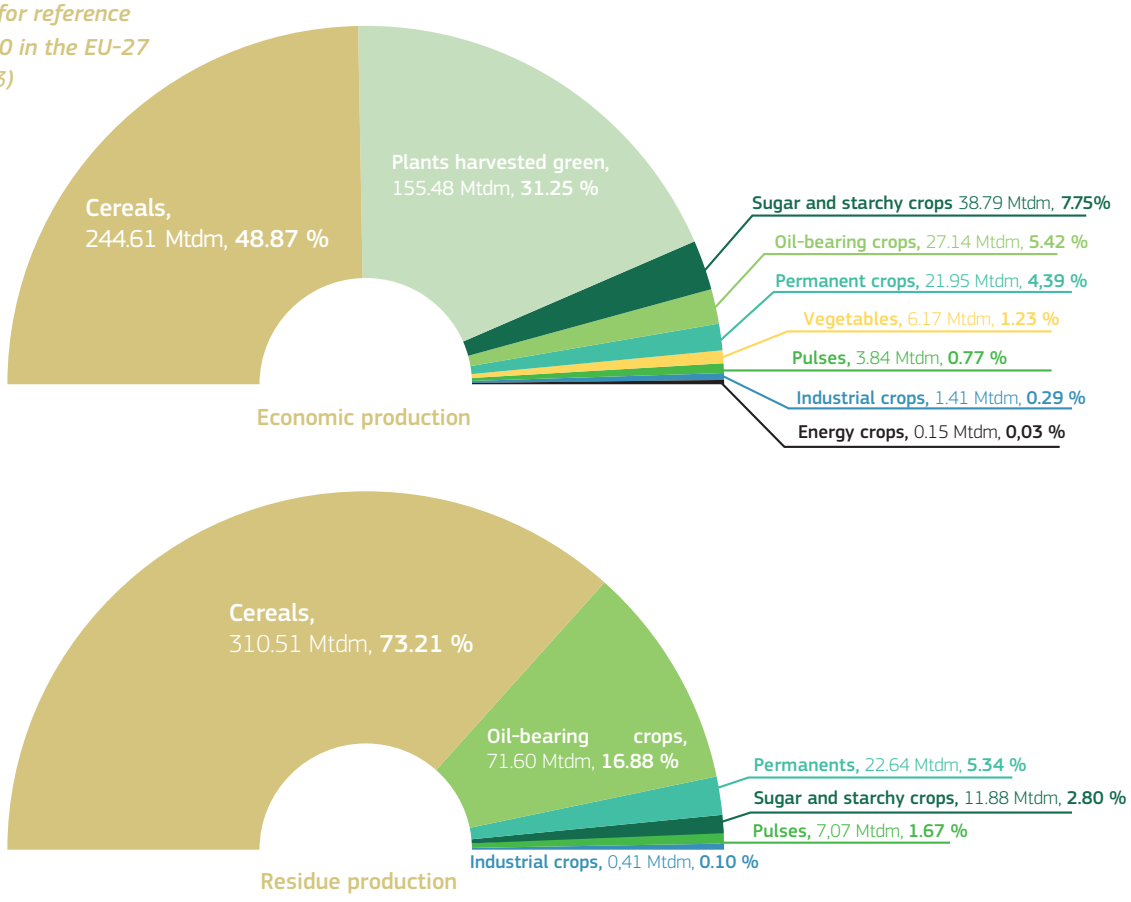


3 Agricultural biomass production, sources, and uses

The total annual agricultural biomass production in the European Union for the reference period 2016 – 2020 is estimated at 924 million tonnes dry matter (Mtdm) per year. Up to 54 % of the biomass produced is economic production while the remaining 46 % is residues. Agricultural biomass includes the major crops cultivated in Europe, grouped in nine main categories: cereals, sugar crops, oilseeds, plants harvested green, permanent crops, vegetables, pulses, industrial crops and energy crops. Cereals (245 Mtdm/y) and plants harvested green (156 Mtdm/y) dominate the economic production, jointly accounting for about 80 % of total biomass production. The residue production comes predominantly from cereals (73 %) and to a lesser extent from oilseeds (17 %). Regarding crops: wheat and maize are the major contributors to agricultural biomass and for both crops, the biomass from residues exceeds the economic component (***Figure 3***).

About 70 % of both the economic production (358 Mtdm/y) and their residues (295 Mtdm/y) originates in six Member States, namely France, Germany, Italy, Poland, Romania, and Spain. The availability of agricultural biomass in the European Union in the next years will be highly influenced by the impacts of climate change on agriculture.

Figure 3.
Annual average of economic and residue production from agriculture for reference period 2016-2020 in the EU-27 (source: JRC, 2023)



3.1 Agricultural biomass supply

Biomass supply from agriculture is estimated at approximately 740 Mtdm when considering that not all residues are collected and that some agricultural biomass is imported. Roughly 70 % of this biomass is sourced from domestic (EU-27) crop production (516 Mtdm) and the harvested crop residues provide an additional 93 Mtdm of biomass. 95 Mtdm are directly grazed by animals in pastures and meadows ***(Table 1)***.

Table 1.
Biomass supply from agriculture (2017, Mtdm).
(source: JRC, 2023)

agriculture crops	516.40
agriculture residues	92.56
grazed biomass	95.25
imported	34.99
Virgin sources (total)	**739.20**

3.2 Agricultural biomass uses

Plant-based food amounts to 96 Mtdm of the agricultural-based biomass in the EU-27, while animal feed and bedding amounts to 393 Mtdm. Of the harvested residues, an estimated 33 % (31 Mtdm) are used for feed. The remaining two thirds are either used for other purposes (biomaterials or energy), lost, or discarded. An additional 95 Mtdm of biomass are grazed (**Table 2**).

Table 2.
Biomass uses from agriculture (2017, Mtdm).
(source: JRC, 2023)

material	1.11
energy	12.44
animal feed and bedding	393.01
plant-based food	95.68
exported plant products	0.00
exported animal-based food and live animals	23.20
Uses (total)	**525.45**

Detailed biomass flows from agriculture are available here:
https://knowledge4policy.ec.europa.eu/visualisation/biomass-flows_en

4 Macroalgae biomass production, sources, and uses

Algae play an important role in marine ecosystems, contributing to global primary production and supporting complex food webs in coastal zones. Algae resources have been explored for centuries by coastal communities as a source of fertilizers, cattle feed, and human food. Algae biomass is a valuable resource in the European bio-based economy, currently used by the food and chemical industry. Over the last decade, the demand for algae biomass in Europe has increased as a result of growing interest in the development of innovative algae biomass-based applications (feed and food supplements, nutraceuticals, pharmaceuticals, third-generation biofuel, bioremediation and other materials).

Global macroalgae biomass production has increased exponentially in the last decades as a result of market demands. Globally, production is mainly based on aquaculture, while in Europe, harvesting from wild stocks still supplies most of the macroalgae biomass. The European aquaculture sector is currently seen as a means to meet the increase in the market demand for high quality sustainably produced algae biomass.

Table 3.
Summary of production of macroalgae biomass from wild stock harvesting and aquaculture in the EU-27, other European countries and the rest of the world for 2020 and 2016-2020 average. (Source: FAO, 2023)

	Wild stock		Aquaculture		Comments	
	2020	2015-2020 average	2020	2015-2020 average		
EU-27	**81.911 tww** (7.1 % of global)	**76.515 tww** (7.1 % of global)	**207.3 tww** (0.0006 % of global)	**224.8 tww** (0.0007 % of global)		
Other European countries [3]	**168.535 tww** (14.5 % of global)	**182.859 tww** (16.9 % of global)	**441.0 tww** (0.001 % of global)	**240.1 tww** (0.0007 % of global)	Laminaria hyperborea is the most harvested species in Europe with 149.853 tonnes wet weight	Seaweed cultivation is a nascent sector in Europe and has been focused mostly on the kelp species: *Saccharina latissima and Alaria esculenta*
Rest of the world	**910.371 tww** (78.4 % of global)	**823.332 tww** (76.0 % of global)	**35.01 Mtww** (99.9 % of global)	**33.4 Mtww** (99.9 % of global)	The top 5 countries harvesting seaweed from their wild stocks are Chile, China, Norway, Indonesia, and Japan (78 % of the world's seaweed wild harvest)	The top 5 countries producing farmed seaweed in 2020 are China, Indonesia, Republic of Korea, Philippines, Democratic People's Republic of Korea, and Japan (98 % of world's farmed seaweed)

(3) The EU-27 comprises the EU Member States as in 2020 (i.e. AT, BE. BG, HR, CY, CZ, DK, EE, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, PL, PT, RO, SK, SI, ES, and SE) while other European countries refers to Faroe Islands (FO), Iceland (IS), Norway (NO), and the United Kingdom (UK).

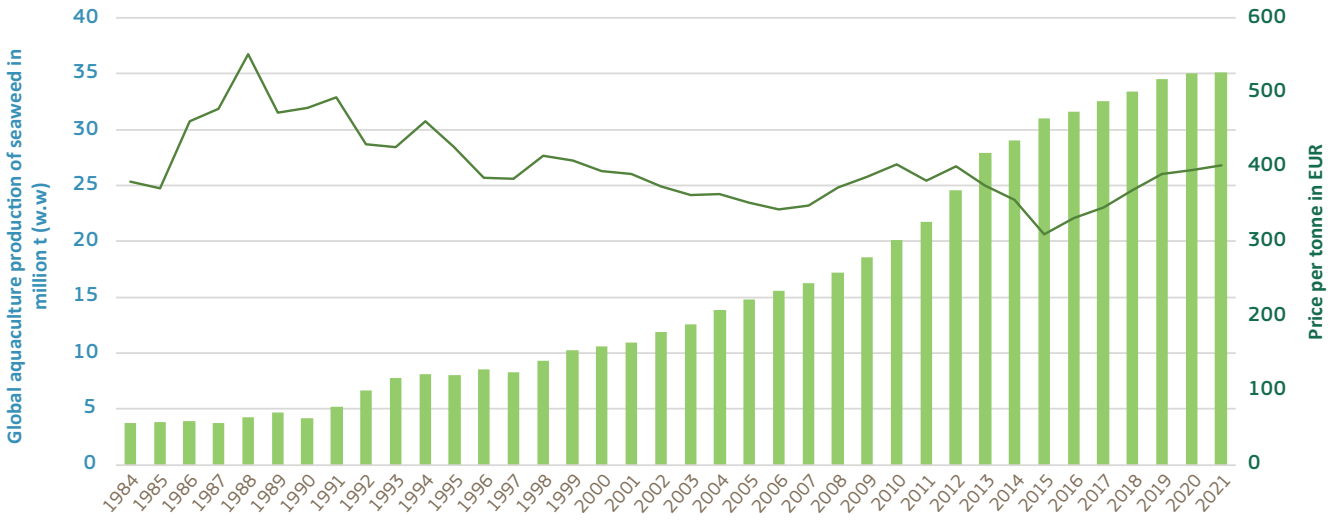
4.1 Macroalgae biomass supply

The production of macroalgae in the EU-27 is placed within the European and Global contexts in Table 3, both from harvesting of wild stocks and aquaculture production.

Wild harvested seaweed is dominated by Chile and China at global level and by Norway at European level, but most seaweed worldwide is produced through aquaculture. Aquaculture of seaweed started over a century ago and developed to an industrial scale since the 1950´s in Asia. Production worldwide was reported to reach 35 Mtww for a value of EUR 13.9 M in 2020. The main countries producing farmed seaweed in 2020 were China, Indonesia, Republic of Korea, Philippines, Democratic People's Republic of Korea, and Japan. These countries account for almost 98 % of the world's production. Worldwide, the average price for farmed seaweed has not changed since the 1950´s and fluctuates around 399 EUR per tonne (Figure 4). However, there is a high variability in prices between the producer's country and the species sold.

According to data from the Food and Agriculture Organization of the United Nations (FAO, 2022), in 2020 the EU-27 Member States imported in total 146.6 thousand tww of seaweed products (measured in net product weight) and exported a total of 62.8 thousand tww. The Member State that recorded the largest traded seaweed products was Ireland, with 64.8 thousand tww imported and 57.2 thousand tww exported outside the EU, followed by France (62.3 thousand tonnes of net product weight Imported from outside the EU, and 2.0 thousand tonnes exported outside the EU).

Figure 4.
Global aquaculture production of seaweed in million tonnes wet weight and price per tonne in EUR.
(Source: JRC own elaboration based on FAO[4] 2022 data)



(4) FAO. Fishery and Aquaculture Statistics. Global Fish Processed Products Production 1976-2020 (FishstatJ). In: FAO Fisheries and Aquaculture Division [online]. Rome. 2022. www.fao.org/fishery/en/statistics/software/fishstatj/en.

4.2 Macroalgae biomass uses

Regarding seaweed uses, data on the quantity of macroalgae biomass dedicated to different bio-based uses could not be derived in this study due to the poor availability of information (see ***Box 2***). The best available data have been collected by Vázquez Calderón and Sánchez López (2022), who report on the number of enterprises dedicating the biomass produced to broad groups of uses. According to that study, the food and feed sectors, including human food, food supplements, nutraceuticals and animal feed, are the main markets for macroalgae biomass (up to 60 % of the enterprises identified in Europe). Other minor uses are cosmetics (18 % of the enterprises), and fertilisers and bio-stimulants (11 %).

At the European level, macroalgae production methods include harvesting from wild stocks and cultivation in land-based systems or at-sea facilities. For Europe to find its place in the global seaweed market, there are still many knowledge gaps regarding the algae sector, mainly related to biology, technology, as well as understanding and access to the market. Management guidelines are needed to ensure the sustainable exploitation of algae resources considering climatic and anthropogenic pressures on the marine environment and the ecological and economic viability of the biomass production sector. Sustainable algae biomass production and use can be developed as an application of EU environmental and maritime policies related to the Bioeconomy, Blue Growth and Circular Economy.

Box 2. Data issues in the macroalgae sector.

The low quality and availability of data about production volumes, product flows, and uses prevent an overarching approach to assess the potential use and value of this biomass source in the bio-based European economy. The improvement of the quality and quantity of the available information is critical to support policymaking and the development of the macroalgae sector in Europe.

5 Fisheries and aquaculture biomass production, sources, and uses

After a radical reform in 2002, the EU Common Fisheries Policy (CFP) became one of the European Union's tools for the sustainable management of fisheries and aquaculture. Currently, its main objective is to ensure the long-term sustainability of the activities of the fisheries and aquaculture sectors activities in the long-term, by reducing their impact on marine ecosystems and living aquatic resources. Aquaculture has the potential to become a major sustainable food system, in especially low environmental impact aquaculture (i.e., micro- and macro-algae, and non-fed species, such as filter feeders like molluscs, organic aquaculture and integrated multi-trophic aquaculture).

5.1 Fisheries & aquaculture biomass supply

The wild catch production is estimated at 3.9 million tonnes wet weight (Mtww) for 2020. There has been a reduction in EU seafood production from marine fishing since 2016. This reduction in the supply is largely driven by efforts to reduce overexploitation (see Box 3) and external factors that have undermined the performance of the EU fishing fleet, such as Brexit, the impact of the COVID-19 pandemic and more recently, high fuel prices.

According to FAO data, EU-27 aquaculture production in 2020 reached 1.1 million tonnes, worth EUR 3.7 billion. Spain, France, Greece, and Italy represent almost two-thirds in weight and value of total EU aquaculture production (***Table 4***).

Table 4.
Summary of production levels of wildstock and aquaculture fisheries in the EU-27 for 2020. *(Source: FAO, 2022)*

	Wild catch	Aquaculture
EU-27	3.9 million tonnes of seafood (including fish)	1.1 million tonnes

Detailed biomass flows from fisheries and aquaculture are available here: https://knowledge-4policy.ec.europa.eu/visualisation/biomass-flows_en

Box 3. Pressures from fisheries.

The indicators for fishing pressure are computed for stocks in the selected seas. The pressure on the Mediterranean & Black Seas remained at a high level during the period 2003-2019. While there appears to be a slight downward trend in the median value for the ratio of current Fishing mortality (F) over the reference Fishing mortality (FMSY) F/FMSY since 2013, it remains close to twice FMSY, which is not in line with the objective of the Common Fisheries Policy. The latest results indicate a reduction in the overall exploitation rate and an increase in biomass of stocks in the NE Atlantic, even if some stocks remain overfished and/or outside safe biological limits. The situation with regard to stocks in the Mediterranean and Black Seas remains challenging, with annual fishing mortality estimates around twice that of the reference fishing mortality FMSY.

The main species produced in weight are: mussels (without distinguishing between sea mussels, blue mussels, and Mediterranean mussels) accounting for 37 % of the total production, followed by rainbow trout (17 % of the total production), seabream (9 %), oysters (8 %), seabass (7 %), and carp (7 %). Marine fish represent 21 % of the weight and 40 % of the value of EU aquaculture production. The main species produced in value terms are rainbow trout (17 % of the total value), seabream (13 %), seabass (13 %), oysters (11 %), tuna (10 %), mussels (10 % considering the three species reported), carp (5 %), and clams (4 %).

The EU is the world's largest importer of seafood – it is around 30 % self-sufficient in meeting a growing demand for seafood products from its own waters. In other words, EU citizens consumed more than three times as much as they produced. EU citizens on average consume around 24 kg of seafood and spend around EUR 100 on seafood per year and the fishieries and aquaculture sectors are very important to the EU-27 (see ***Box 4***).

Box 4. Fisheries and aquaculture sectors.

Direct employment generated by the sector amounted to 124 636 fishers, corresponding to 82 272 full-time equivalents (FTEs), and there are considerable differences in wages between EU Member States.

The EU fishing fleet consumed 1.9 billion litres of fuel, spent 5.3 million days at sea in 2020, producing 3.9 million tonnes of seafood (including fish) landings with a value of EUR 5.8 billion. The amount of Gross Value Added (GVA) and gross profit (all excluding subsidies) generated by the EU fishing fleet in 2020 was €3.3 billion and €1.16 billion, respectively. GVA as a proportion of revenue was estimated at 55 %, higher in 2020 than in 2019 and gross profit margin at 19.7 %, similar to that obtained in 2019. After accounting for capital costs, 7 % of the revenue generated by the fleet was retained as net profit, again a drop from that obtained in 2019

The EU aquaculture sector generated about €1.7 billion in GVA, and earnings before interest and taxes (EBIT) of €666 million in 2018, which are also expected to be slightly reduced in recent years (STECF, 2021).

According to the 2021 Economic Report of the EU Aquaculture Sector (STECF, 2021), there are about 15 000 aquaculture enterprises in the EU-27. More than 80 % of these enterprises are micro-enterprises, employing fewer than 10 employees. The sector employed about 69 000 employees (39 000 FTE) in 2018 but this number may have decreased in recent years due to the Covid-19 pandemic.

In 2019, the EU fish processing sector was made up of about 3 200 firms and employed about 111 000 people to produce a turnover of €28.5 billion and a GVA of €4.2 billion.

6 Forest biomass production, sources, and uses

Forests are becoming increasingly relevant for several forest-related policies in the EU under the Green Deal, such as the Bioeconomy Strategy and The New European Bauhaus, the Forest Strategy, the Biodiversity Strategy, the Renewable Energy Directive, the Land Use Land-Use Change and Forestry (LULUCF) Regulation, the Nature Restoration Law, the Regulation on deforestation-free products and the Carbon removal certification regulation proposal.

6.1 Forest biomass supply

The estimated total above-ground living biomass stock of the EU forests for the year 2020 is equal to 18.4 billion tonnes of dry matter (tdm), corresponding to an average biomass density of 117 tdm per hectare (tdm/ha)[5]. The countries with the largest biomass stock are mostly located in Central Europe (Germany, France and Poland) and in the Fennos-candia region (Sweden, Finland). The EU Forest biomass is almost equally distributed between broadleaves (50 %) and conifers (49 %), and is mostly produced by two conifer species, *Picea* sp. (22 %) and *Pinus sylvestris* (20 %), followed by the broadleaves *Fagus sylvatica* (11 %), *Quercus robur* (8 %), *Betula* sp. (6 %) and *Quercus cerris* (4 %) (***Table 5***).

Table 5. Forest area, biomass stock and biomass density in EU-27 for the year 2020 according to our harmonised reference dataset. The EU regions are defined according to the State of Europe's Forests (SoEF) 2020 report and include the corresponding EU countries. (tdm, tonnes of dry biomass) *(Source: JRC, 2023)*

EU regions	Forest area	Biomass stock	Biomass density
	(1000 ha)	(Mill. tdm)	(tdm/ha)
North	58 301	4 740	81.3
Central-West	33 516	5 687	169.7
Central-East	23 350	4 357	186.6
South-West	30 850	2 352	76.2
South-East	11 115	1 262	113.5
EU-27	157 133	18 398	117.1

The data presented in this section are the result of a harmonisation effort in collaboration with the European National Forest Inventory Network (ENFIN). As a consequence of this harmonisation effort, these data diverge from other public data sources. Details on how these numbers were derived are in the main report. The harmonised forest biomass database for EU-27 and related maps contained in this chapter are available at https://data.jrc.ec.europa.eu/collection/fise **(data and meta-data) and** http://jeodpp.jrc.ec.europa.eu/ftp/jrc-open-data/FOREST/BIOMASS/SUSBIOM/LATEST/ **(maps)**

Most of the forest area not available for wood supply was limited by economic restrictions linked to low profitability, while most of the biomass not available was due to environmental restrictions, such as protected areas with high-biomass forests: 89 % of the forest area and 92 % of the biomass stock of EU-27 is available for wood supply.

The JRC supported dedicated efforts of EU National Forest Inventory (NFI) institutions to make a harmonised assessment of the main restrictions to wood availability and to quantify the forest area and biomass stock not available for wood supply, as well as to achieve more harmonised forest increment statistics.

EU forests in 2015 produced a Net Annual Increment (NAI) of 770 million m^3, or 85 % of the gross increment. The highest average NAI in Europe, at roughly > 8 $m^3\ ha^{-1}\ yr^{-1}$, is in Central Europe, while the Scandinavian and Mediterranean countries presented the lowest rates: < 4 $m^3\ ha^{-1}\ yr^{-1}$. The recent stabilisation of the NAI and the expected reduction within the coming decades is probably due to the ageing of the European forests. According to JRC modelling results, the average age of the even-aged forest stands increased from 58 to 64 years from 2000 to 2020, and most of this increase is due to the ageing of the broadleaf stands.

(5) The total forest area is derived from the harmonisation of the NFI data directly provided from 21 Member States (see Avitabile et al., 2020).

The trend of the felling rate, that is the ratio between the total fellings and NAI, determines the evolution of the forest biomass stock. The felling rate for the EU-27 slowly decreased from 82 % to 78 % of the NAI between 2000 and 2015, but it is estimated to grow and reach the 88 % of the NAI in 2020.

The salvage loggings following the disturbances might be partly responsible for the increased harvesting rates observed in the EU over recent years. Salvage loggings increased by 138 % during the period 2014-2018 in 17 countries, The overall fellings rate at EU level has been increasing over the last decade but is still below the current NAI. However, the increasing impact of natural disturbances and the recent increase of the harvest demand may further reduce the marginal share of increment available for wood supply.

6.2 Forest biomass uses

Reported woody biomass sources and uses should be balanced. However, for all the years analysed (2009 to 2017), the total amount of woody biomass used in manufacturing of wood-based products and for producing heating and power (H&P) exceeds the total amount of reported sources (***Table 6***). This gap amounted to close to 104 Mm^3 for the EU-27 overall in 2017, with large differences among Member States (***Table 6***).

The total use of woody biomass (primary wood, secondary wood, unreported and net-traded) for material and energy in the EU-27 was 932 Mm^3 in 2017. The total woody biomass used for energy was 424 Mm^3 (45 %) and woody biomass used for material was 508 Mm^3 (55 %) in 2017. Domestic removals are the largest source of woody biomass in the EU-27. The sawmill industry is the largest industrial user of woody biomass and the main producer of secondary wood fibres. About half of the available industrial by-products are produced by the sawmill industry, namely high-quality secondary wood that could be used by wood-based panel and wood pulp industries. The wood pulp industry is the second largest industrial user of primary and industrial by-products. Black liquor is a result of wood pulp manufacture and is primarily used for producing energy, often within the same pulp mill. The wood-based panel industry is the third largest industrial user of woody biomass. This industry uses primary wood, industrial by-products, and a small amount of post-consumer wood. The wood-based panel industry produces only small amounts of industrial by-products. Roughly 40 % of the paper and paperboard industry is made up of recycled pulp.

Detailed biomass flows from forestry are available here: https://knowledge4policy.ec.europa.eu/visualisation/interactive-sankey-diagrams-woody-biomass-flows-eu-member-states_en

Table 6.
Summary of wood resource balances 2009-2017.
(Source: JRC 2022)

	Sources			Uses		Balance
Mm^3SWE	Primary	Secondary	Post-consumer wood	Material	Energy	(Uses - Sources)
2009	464	148	29	378	324	61
2010	524	165	31	408	357	45
2011	522	162	32	412	349	45
2012	520	170	34	407	373	56
2013	530	169	36	412	399	76
2014	533	171	35	419	397	77
2015	544	170	35	425	409	85
2016	551	176	37	440	421	97
2017	551	181	38	451	424	104

7 Organic waste recovery

Waste biomass[6] has a significant role in the transition to a circular economy and contributes to the sustainable use of natural resources. The biowaste (industrial + household) generated in the EU-27 in 2018 amounted to 147 Mtdm. The biowaste (industrial + household) recovered (recycled or used for energy recovery) in the EU-27 in 2018 totalled 133 Mtdm.

The annual biowaste (industrial + household) not recovered in the EU-27 in 2018 was 14 Mtdm, indicating a possible margin for improvement. This biomass waste, which was incinerated or landfilled, demonstrates potential for improvements towards a circular economy.

Data on waste generation are collected from EU Member States in a framework set up by the Waste Statistics Regulation and published by Eurostat. Although these data include a mix of organic and inorganic waste generated from various economic activities (including households), the JRC has developed a model to distinguish the biodegradable component in the different waste categories.

The European Commission has identified reducing food waste as one of the priority areas of its Circular Economy Action Plan and Farm to Fork Strategy, both important components of the European Green Deal. In the Farm to Fork strategy, the EC commits to halving per-capita food waste at retail and consumer levels by 2030 (in line with Sustainable Development Goal Target 12.3) and foresees the definition of a baseline and binding targets to reduce food waste across the EU. To this end EU Member States are obliged to measure and report the amount of food waste generated at all stages of the food supply chain. The first year for which Member States reported food waste data was 2022, referring to the year 2020[7]. Food waste reduction strategies focused on food waste prevention and valuation, which are key to the achievement of a circular economy.

The JRC has developed a model to estimate yearly food waste generation in EU Member States. Using this model it estimated that EU Food waste in 2018 amounted to 84 Mtdm, representing roughly 13 % of the food produced in the EU and along the whole supply chain.

Consumption is the stage of the food supply chain with the highest share of food waste, ranging between 56 % and 80 % in EU countries. When looking at food waste generation at consumption level, perishable food groups such as fruit, vegetables and dairy tend to be the largest contributors, although there are significant variations across Member States. More than half of the food waste generated is disposed of via landfill, sewage or incineration. Composting and anaerobic digestion are the other two main destinations for food waste (19 % and 18 % respectively). Finally, 8 % of the waste is used in other ways, such as home composting or food for pets.

(6) The Waste Framework Directive (WFD) defines bio-waste as biodegradable garden and park waste; food and kitchen waste from households, restaurants, caterers and retail premises; and comparable waste from food-processing plants (European Parliament and of the Council, 2018).

(7) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Food_waste_and_food_waste_prevention_-_estimates&stable=0&redirect=no#Methodology.

8 Wood trade and wood price volatility

Price movement is an indicator of changing market conditions, or expectations of such change, on the demand side, supply side, or both. For example, during a construction and home renovation boom, more consumers accept to pay more for construction materials. On the supply side of the market, a storm or a very harsh winter would lead suppliers to require higher prices to cover increased logistic costs. Some price changes are temporary – they return to the original level after the situation has gone back to normal – while other price changes, reflecting structural market changes, are likely to be permanent. The JRC has examined the drivers of price volatility in the forest sector following the COVID pandemic in the period 2020-2022 in order to shed some light on other events and interactions at play between different stages of the global forest products markets. We found:

- lockdown and stimulus measures related to the COVID-pandemic led to an increased demand for wood for construction and renovation;
- lockdowns at the same time constrained the supply of wood products;
- resulting price increases in wood products have been more pronounced for processed products than for primary forest products;
- apparent imperfect transmission of price signals from processed wood products markets to roundwood markets could increase price volatility;
- as a result of geopolitical issues (see ***Box 5***), price volatility is still ongoing at the end of 2022.

Box 5. Focus on wood trade between EU, Ukraine, and Russia.

The JRC monitored bilateral trade flows of wood products between the EU-27, Ukraine and Russia in the last six years using the United Nation Comtrade dataset to identify potential criticality in the supply of wood products in the EU-27 as a consequence of the conflict. We found that before 2022, the monetary value of the import from Russia was larger than that from Ukraine, with variable import patterns between countries. Concerning the bilateral trade between Ukraine and EU countries, Poland is the main importer of particle board and a large importer of sawnwood oak; Romania, Italy and Hungary are the main import partners of coniferous sawnwood.

Finland is the main importer in the EU-27 of roundwood birch from Russia. Other relevant importers of wood products from Russia are Latvia, for roundwood birch and sawnwood pine, and Estonia for sawnwood spruce and pine. Germany is an important importer of sawnwood conifer, plywood, and sawnwood spruce from Russia.

9 Deforestation and forest biomass embodied in traded bio-commodities and products

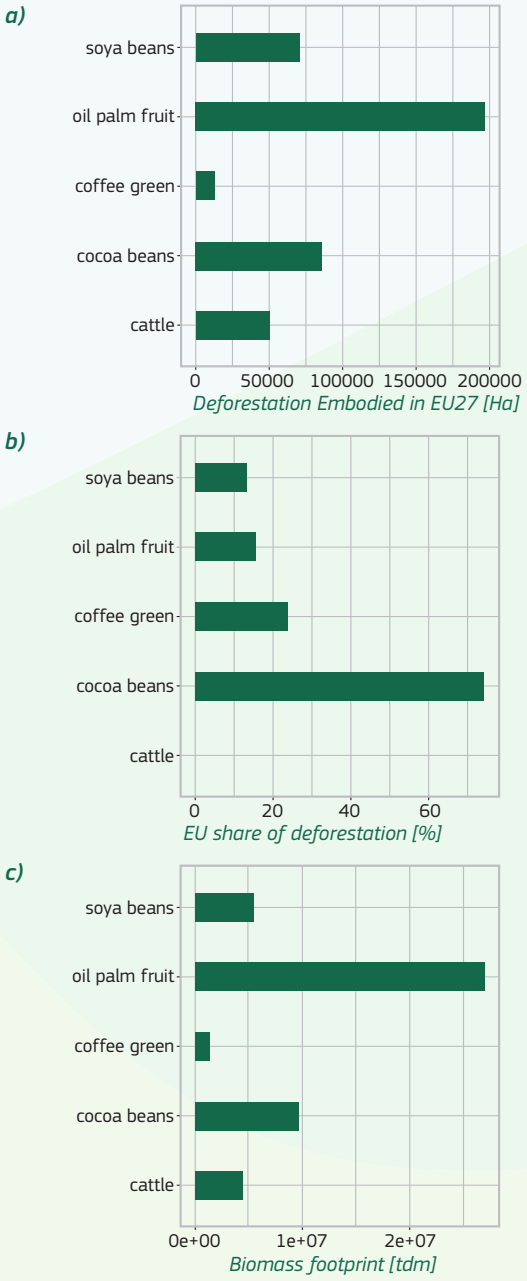
The JRC gathers statistics and trends on the production of four agricultural commodities associated with deforestation, the bilateral trade flows of commodities and products between EU-27 and the producing countries and reports the share of deforestation attributed to the EU-27. Data sources include satellite observation of tree cover loss and vegetation biomass, and FAO statistics on production, trade, and land use change.

The EU-27 plays a major role in the import of coffee and cocoa beans, palm oil, and soybean cake. According to our modelling based on land use change and trade flows, the imports of EU-27 between 2014 and 2019 contributed to 74.2 % of the deforested area between 2010 and 2015 related to the production of cocoa, 23.7 % for coffee, 15.9 % for palm oil, 13.6 % for soybeans, and less than 1 % for cattle and the total forest biomass loss in 2010-2015 of the products traded in 2014-2019 was 48.04 Mtdm.

The importing of palm oil, cocoa, cattle, and soybeans shows a significant impact in terms of deforested area, followed by imports of coffee. Palm oil shows the largest impact in terms of loss of forest biomass. The cattle footprint includes both the conversion of forest to pasture and for the production of fodder.

The results show that the EU-27 import-contribution to deforestation in the producing country compared to the rest of the world and internal consumption varies according to the commodity, with the highest share for cocoa beans and the lowest share for cattle (***Figure 5***). For commodities such as cocoa and coffee, EU-27 imports therefore play an important role, while for the other commodities, the rest of the world and the internal domestic consumption of the producing countries are also extremely relevant drivers. The impacts of EU-27 imports of the selected commodities and products are felt in South America (mainly through the soybean and beef supply chain), Central and Western Africa (due to cocoa production), and Southeast Asia, where palm oil is mainly produced.

Figure 5. *a) **Total deforested area per year (2010-2015) embodied in mean annual trade volumes (2014-2019) of the selected commodities and related products;** b) **EU-27 share (in percentage) of deforestation per commodity; and** c) **total biomass lost for the production of product imported by the EU-27 (tdm) of deforestation per commodity.** (Source: JRC 2023)*



10 Uses of Biomass

As a central element of the EU's Bioeconomy Strategy, bio-based products[8] and related processing plants, biorefineries at scale, could play an important role in transforming industrial facilities to support the environmental ambitions of the EU, while creating jobs and growth in rural areas (EC, 2022).

Bio-based products can also contribute to a sustainable economy by reducing dependency on fossil resources, and can bring new functionalities (Spekreijse et al., 2019). The bio-based products market comprises established products, which have been in the market for long time, as well as some novel products that are not yet fully commercialised.

The EU is well-positioned in the world market for bio-based chemical products.

While Asia is the global leader in fossil-based chemical production (comprising chemicals, plastics and pharmaceuticals) with a 58 % share, Europe and N. America follow with roughly 15 % each. In terms of bio-based chemical markets, Europe, Asia and North America have very similar shares, of around 30 % each (Spekreijse et al., 2021).

Since higher cost shares in (bio-based) feedstock have been identified as the main difference between fossil and bio-based chemical products – particularly in the plastics sector and for the use of vegetable oil – the EU's competitiveness is very much linked to costs for feedstock.

The combination of agrifood modelling with the detailed depiction of the feedstock used to produce bio-based materials, as developed in the H2020 BioMonitor project (Leeuwen et al, 2022; Sturm et al, 2023), made it possible, for the first time, to quantify the different feedstocks used (see **figure 6**). The total amount is around 55 million tonnes, including imports. It is mainly in the form of plant oil (30 %) and starch (20 %), which enters the conversion process. The total physical quantity of bio-based chemicals (including biofuels) is estimated according to the C20 NACE classification[9]. Manufacture of chemicals and chemical products, with biofuels[10] accounting for approximately 42 % of the total output, followed by agrochemicals (21 %) and bio-based surfactants (12 %) (Sturm et al., 2023).

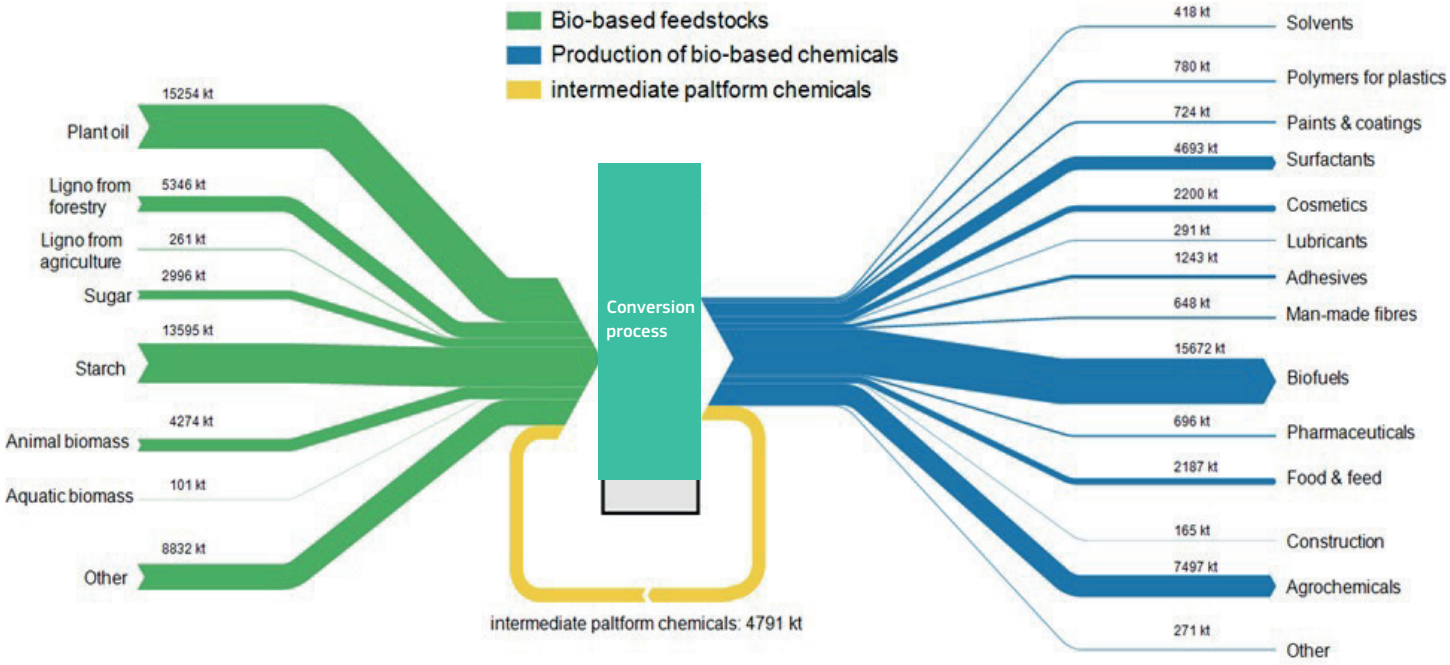
Further differentiating by primary agriculture (arable crops), the share of total agricultural products for material use, (mainly non-food/non-biofuels), is estimated at 8 % in the EU-27. This is much lower than the use for food (27 %) and animal feed (56 %). While under unchanged policies the share of arable crops for material use in the EU is projected to rise only slightly, from 8 % in 2020 to 10 % in 2050, it can be expected that the import of feedstock for material use could rise more significantly, to allow for the intended growth of bio-based industry – especially those products not produced in the EU, e.g. palm oil. To this end, targeted policies and the deployment of technologies to value unused biomass from waste streams, residues and other sustainable sources, would be needed to increase domestic production.

(8) The European Commission defines bio-based products as products that are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised.

(9) NACE is the statistical classification of economic activities Overview - NACE Rev. 2 - Eurostat (europa.eu).

(10) Details on EU funding of research for advanced biofuels can be found here: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-5-climate-energy-and-mobility_en.

Figure 6. Flow chart for the feedstocks for the selected bio-based industrial products (C20), (EU-27+UK, 2018) (Source: Sturm et al., 2023)



Box 6. Innovative uses of wood.

The need to achieve EU climate mitigation goals and to increase resource use efficiency are driving innovation across various industries. A new way of using natural resources is also seen within the wood-based industry. There is an increasing production of innovative wood-based products, such as bioplastics, wood-based composites, and cross-laminated timber, indicating that technologies are improving. Moreover, the use of innovative wood products as a functional alternative to non-renewable-based products, in some cases, might create a positive substitution effect (Leskinen et al. 2018).

The four innovative wood products whose quantities are most significant or have potential to increase are cross-laminated timber, man-made cellulosic fibres, bioplastics and wood-based composites. Global production capacity of cross laminated timber in 2020 is estimated at 2.8 Mm^3, of which 48 % is produced in Europe. The global production is expected to double by 2025.

The manmade cellulosic fibre lyocell is considered to be environmentally friendly compared to synthetics and cotton. Even though lyocell is an apparently environmentally friendly fibre, the market share of this fibre is relatively small (0.3 percent of the total fibre production volume).

The estimated production of crude tall oil, which can be used in the production of biodiesel and bioplastics, is around 650 thousand tonnes in Europe, and production is expected to increase due to heightened demand.

In Europe there are roughly 30 major producers of wood-based composites in nine different countries. In 2018, the production was nearly 470 thousand tonnes.

To read more about innovative uses of wood, see Chapter 11 of the main report.

11 Conclusions and way forward

When assessing all biomass production, supply, uses, demand, flows and impact at once, we find that, in many cases, we are making progress in terms of resource efficiency (e.g. increased wood, food and other bio-waste re-use), but that we are also producing and consuming more overall. This is expected given the increased substitution of the non-renewable resources for bio-based, however, we caution that a focus on higher efficiency may also generate lock-in and low adaptability to change. Whereas efficiency is important in the short term, adaptability is important in the long term, for example to foster resilience (Holling and Gunderson, 2002).

Furthermore, when combined with a rebound effect, whereby there is an overall increased use of biological resources – because they are more efficiently produced, less expensive, and their diversification in uses is encouraged (Jevons, 1865) – we conclude that our impact on biomass-producing systems is increasing. Thus, in our quest to produce and use biomass more efficiently, there may be an apparent side effect of consuming more overall. This can only be assessed through a holistic monitoring of our whole consumption to understand the share of penetration of bioeconomy.

12 JRC data and knowledge resources

The JRC disseminates data and tools on the basis of the JRC's open data principles. In this way, readers may derive their own studies using our data. This is fundamental to advancing knowledge of biomass production, supply, flows and uses in the European Union and beyond. Here we present the URLs at which the data and maps can be downloaded. These are divided into three main categories: 1) In the individual sector-specific pages, 2) In the pages of JRC data and metadata portals; 3) Data curated by the Knowledge Centre for Bioeconomy (KCB), where data, reports and dashboards are made available: https://knowledge4policy.ec.europa.eu/bioeconomy_en.

The JRC Biomass Mandate contributes to the EU Bioeconomy Monitoring System with data on biomass production, supply, uses and flows. The EU Bioeconomy Monitoring System provides a comprehensive overview of European trends in indicators related to the EU Bioeconomy. As a whole, the set of indicators is organised according to a conceptual framework that allows for full coverage of the EU Bioeconomy from different angles: value chain steps, sustainability dimensions, and primary production sectors. The indicators may be browsed according to the EU Bioeconomy Strategy Objectives, the SDGs or the European Green Deal priorities.

Knowledge Centre for Bioeconomy: https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en

Topic	Native distribution	JRC data portal	Knowledge Centre for Bioeconomy
All biomass in dry units	Technical report on methods Data-Modelling platform of resource economics biomass flows	JRC Data catalogue	1. Infographics 2. Translated to indicator: Bioeconomy Monitoring system - Total biomass for food purposes, including feed 3. Translated to indicator: Bioeconomy Monitoring system - Biomass directly consumed by EU citizens as food 4. Translated to indicator: Bioeconomy Monitoring system - Biomass production in EU from primary production systems (agriculture, forests, fisheries) 5. Translated to indicator: Bioeconomy Monitoring system - Total biomass consumed for materials 6. Translated to indicator: Bioeconomy Monitoring system - Total biomass consumed for energy 7. Translated to indicator: Bioeconomy Monitoring system – Share of biomass used by primary sector
Algae	Technical report on the algae industry in Europe	Dataset, algae producing industry Dataset, socioeconomic data for European algae industry	1. Algae production industry in Europe pages 2. The bioeconomy in different countries dashboards
Agriculture	Technical report on methods Data-Modelling platform of resource economics biomass flows	JRC Data catalogue	
Fisheries	STECF website		1. Translated to indicator: Bioeconomy Monitoring system - Fishing mortality of commercially exploited fish and shellfish exceeding fishing mortality at maximum sustainable yield 2. Translated to indicator: Bioeconomy Monitoring system - Fish stock biomass in NE Atlantic & Mediterranean, forthcoming
Forestry Reference database of forest biomass statistics at sub-national scale statistics for biomass stock, FAWS, BAWS, GAI and NAI Wood Resource Balance	Technical report on methods to derive forest biomass Science for Policy report on The use of woody biomass for energy production	Forest biomass: JRC Data catalogue NAI, GAI, FAWS, BAWS • metadata • maps	1. Translated to indicator: Bioeconomy Monitoring system - Ratio of annual fellings (m3/ha/year) to net annual increment (m3/ha/year) 2. Translated to indicator: Bioeconomy Monitoring system – Roundwood removals
Wood Resource Balance	Technical report on methods		1. Translated to indicator: Bioeconomy Monitoring system -share of woody biomass used for energy **Country reports:** 2. https://knowledge4policy.ec.europa.eu/publication/wood-resource-balances_en 3. Interactive web-based diagrams: https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries_en#wrb
Woody Biomass Flows	Technical report on methods		1. Translated to indicator: Bioeconomy Monitoring system - cascading factor of wood resources 2. Country reports: https://knowledge4policy.ec.europa.eu/publication/forestry-sankey_en 3. Interactive web-based diagrams: https://knowledge4policy.ec.europa.eu/visualisation/interactive-sankey-diagrams-woody-biomass-flows-eu-member-states_en
Waste	Technical report on methods to derive food waste		1. Translated to indicator: Bioeconomy Monitoring system - biowaste generated by source 2. Translated to indicator: Bioeconomy Monitoring system - biowaste recovered by source 3. Translated to indicator: Bioeconomy Monitoring system - food waste along the supply chain 4. Translated to indicator: Bioeconomy Monitoring system - food waste by food category

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pp. 25–62.

List of abbreviations and definitions

CFP	Common Fisheries Policy
EBIT	Earnings before interest and taxes
EC	European Commission
ENFIN	European National Forest Inventory Network
EU-27	European Union countries (in 2023)
FMSY	Reference fishing mortality
FTE	Full time equivalents
H&P	Heating and power
ha	Hectare
JRC	Joint Research Centre of the European Commission
KCB	Knowledge Centre for Bioeconomy
LULUCF	Land Use, Land-Use Change and Forestry
Mtdm	Million tonnes dry matter
Mtww	Million tonnes wet weight
NAI	Net Annual Increment
NFI	National Forest Inventory
SoEF	State of Europe's Forests
SWE	Solid wood equivalent
tdm	Tonnes dry matter
tww	Tonnes wet weight
WFD	Waste Framework Directive
y	Year

List of boxes

List of figures

List of tables

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