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CELEBio

D.2.4

Summary report on the availability of biomass residues and biobased economy business opportunities for the CELEBio region

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Executive Summary

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This report was compiled with information from all country reports developed in CELEBio. An overview of the reports and authors is presented underneath. We thank them all for the valuable information provided in their reports!

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Summary

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in the 6 target countries and the neighbouring regions countries of the CELEBio project. The six target countries are Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia. The countries located in the neighbouring regions include Albania, Bosnia and Herzegovina, Greece, Montenegro, North Macedonia and Serbia.

To this end, twelve comprehensive reports for the target countries and the wider neighbouring region countries were developed which are all available through the CELEBio website at: https://CELEBio.eu/#

This report summarizes and benchmarks the information presented in these twelve country reports and makes a further analysis of the CELEBio region as a whole. The report presents information on the availability of biomass from agricultural, forest and waste sectors, logistics, and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT).

The information structure and analysis presented in the twelve country reports was developed by building on the method designed and applied by Van Dam et al. (2014) and specifies the key factors that guide the choice of setting up bio-based activities in countries. All the identified factors are important, but a system approach is a key requirement for being successful in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in the twelve country reports and were the basis for performing a SWOT analysis for development of bio-based production chains. A summary of the 12 reports, including the SWOT analyses is presented in this report.

This report is organised in 7 chapters. This chapter 1 gives an overview of the general characteristics of the central and eastern European region covered in the CELEBio project that consists of 12 countries. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In chapter 5 the factors that are important for setting up bio-based production chains, other than availability of feedstock, are summarized. These factors are current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options, Infrastructure, logistics, energy sector and the innovation potential, particularly in the context of bio-based research and development options, research and educational infrastructure and the potential for developing bio-based start-ups and Public-Private-partnerships, the policy framework and financing options for the biobased sector including regulations, legislation, taxes and tariffs and finally potential financing options related to the development of bio-based production chains. In chapter 6 considers potential bio-based value chains with the focus on bio-based products from biomass residues and bio-based industries. Chapter 7 presents key recommendations for the most promising biomass value chains that can be developed in the different countries covered by the CELEBio region.

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1 Introduction

This chapter gives an overview of the objectives and approach of the CELEBio Project and will directly pinpoint to the key and most typical characteristics of the 6 target countries and the neighbouring regions countries of the CELEBio project. The 6 target countries are Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia. The countries located in the neighbouring regions include Albania, Bosnia and Herzegovina, Greece, Montenegro, North Macedonia and Serbia.

1.1 Objectives, approach and structure of the report

The main objective of CELEBio is to contribute to strengthening Bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and the neighbouring countries. To this end one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in the central and eastern European region covered by the CELEBio project. This report summarizes and benchmarks the results of the 12 country reports that have been developed by the country experts in the CELEBio project. The country reports are very extensive reports which have all been written according to the same structure and all include an extensive SWOT analysis of all factors of relevance for building up the bioeconomy in a country. The information structure and analysis presented in the 12 country reports was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in the 12 country reports and were the basis for performing a SWOT analysis for development of bio-based production chains. A summary of the 12 reports, including the SWOT analyses is presented in this report.

This report is organised in 7 chapters. This chapter 1 gives an overview of the general characteristics of the central and eastern European region covered in the CELEBio project that consists of 12 countries. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In chapter 5 the factors that are important for

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setting up bio-based production chains, other than availability of feedstock, are summarized. These factors are:

- Current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options,
- Infrastructure, logistics, energy sector and the innovation potential, particularly in the context of bio-based research and development options,
- The research and educational infrastructure and the potential for developing bio-based start-ups and Public-Private-partnerships,
- The policy framework and financing options for the bio-based sector including regulations, legislation, taxes and tariffs,
- Potential financing options related to the development of bio-based production chains.

In chapter 6 considers potential bio-based value chains with the focus on bio-based products from biomass residues and bio-based industries. Chapter 7 presents the main conclusions of the SWOT analyses for the whole region and makes key recommendations for the most promising biomass value chains that can be developed in the different countries covered by the CELEBio region.

1.2 Overall characterisation of the region covered by the CELEBio project

The 12 countries covered by the CELEBio project are located in the central and eastern part of Europe (see Figure 1.1). The CELEBio region is bordering on the northern site with countries like Poland, Ukraine and Romania, on the western side with Austria and Italy and in the East with Turkey (see map in Figure 1.1). The biggest CELEBio target countries in terms of area and population size are Czech Republic and Hungary. The largest bordering CELEBio countries are Greece, Montenegro and Serbia.

The key characteristics of the CELEBio target and neighbouring countries are presented in Tables 1.1 and 1.2. The countries in the target country group are all member of the EU with Croatia as most recent EU member. For the countries in the neighbouring country group, only Greece is a member of the EU.

The 6 target countries together have a total population of 39 million and an area of 41 million hectares which means they make up 8% and 9% of the EU total respectively. Population density is generally much lower than the EU average, particularly for Bulgaria, Croatia and Slovakia, while it is above the EU average for Czech Republic. For all neighbouring CELEBio countries the population density is relatively low and far below that of the EU average (see Table 1.1).

The distribution of the population over urban and rural areas is very different between all CELEBio countries with more than 60% of the population living in urban areas in Bulgaria, Hungary and Serbia while in countries like Czech Republic, Croatia and Slovakia this does not even reach 30% of the population (See Table 1.1).

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Figure 1.1 The 6 target (orange colour) and 6 neighbouring (brown colour) countries covered by CELEBio

Most of these 6 target countries have either a relatively large agricultural or forest area (see Table 1.1). Bulgaria is the country with the largest per capita agricultural and forest area, the opposite is the case for Czech Republic. Hungary has a relatively large agricultural area per capita, but a relatively small forest area. Croatia and Slovenia have a relatively large forest area per capita, but not a large agricultural area.

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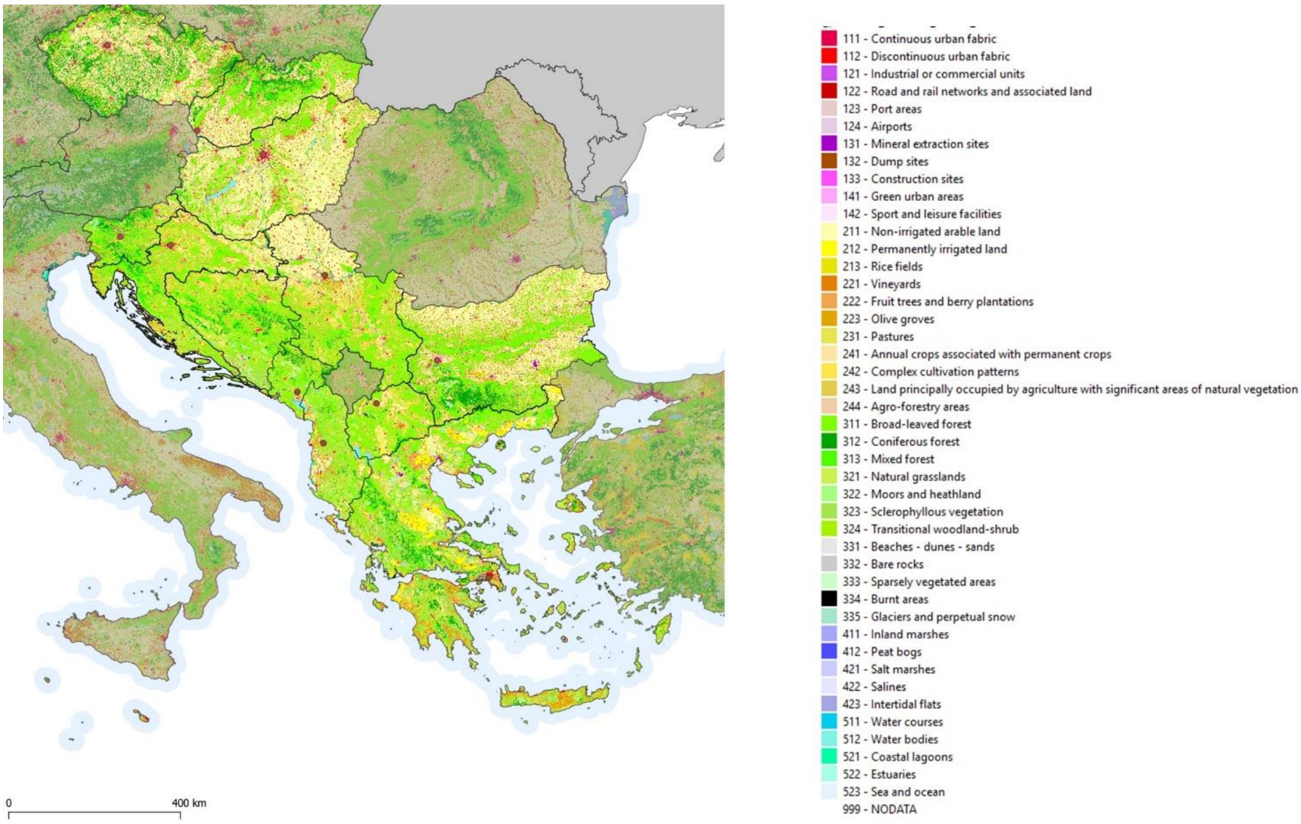

Figure 1.2 Land cover distribution in CELEBio target and neighbouring region countries

The most forested country of the neighbouring CELEBio countries is Bosnia and Herzegovina where the forest area per capita is at 0.91, while it is only at 0.32 ha/capita for the EU-28 average (see Table 1.2). A large per capita forest area is particularly seen in almost all neighbouring countries and especially in Greece, Montenegro and North Macedonia. In all neighbouring countries the agricultural area in hectares per capita is relatively large and far above the EU average. This is also reflected in the high proportion of Gross Value Added by the primary sectors in the neighbouring countries which is on average at 6%, ranging with 4% for Greece to more than 7% for North Macedonia (see Table 1.2). For the target countries the average GVA contribution for the primary sectors is on average 3% while for the EU this average is at 1.6% (see Table 1.1).

The GDP per capita is still below the EU average in all 6 target countries although differences are large between the countries with highest levels of GDP per capita found in Czech Republic and Slovenia and just above 15,000 € for Bulgaria, Hungary and Slovakia (See Table 1.1). The GDA per capita in the neighbouring CELEBio countries is much lower than in the target countries, except for Greece for which is just above the average of Croatia and two thirds of the EU-level average (see Table 1.2).

Table 1.1 Main population, land surface, GDP and trade characteristics of 6 CELEBio target countries benchmarked against EU average

			CELEBio focus countries						Total & average 6 CELEBio focus countries
Category	**Unit**	**EU**	**Bulgaria**	**Czech Republic**	**Croatia**	**Hungary**	**Slovakia**	**Slovenia**	
Population	*million (2018)*	512.2	7.1	10.6	4.1	9.8	5.4	2.1	39.1
Area (total)	*million ha (2018)*	447	11	8	6	9	5	2	41
% population in urban areas	*% of total population (2018)*	45%	71%	25%	20%	71%	19%	0%	41%
% territory predominantly rural	*% of total territory (2018)*	44%	22%	37%	63%	22%	22%	73%	40%
% territory predominantly urban	*% of total territory (2018)*	11%	1%	15%	1%	1%	1%	0%	3%
Agricultural Area	*million ha (2016)*	173.3	4.5	3.5	1.6	4.7	1.9	0.5	16.7
Forest area	*million ha (2016)*	164.8	4.6	2.67	2.5	1.9	2.2	1.3	15.2
Population density	*n°/km² (2018)*	115	64	135	73	105	64	102	95
Agricultural Area per capita	*ha/capita(2016)*	0.34	0.63	0.33	0.38	0.48	0.35	0.24	0.43
Forest area per capita	*ha/capita(2016)*	0.32	0.65	0.27	0.62	0.19	0.41	0.61	0.39
GDP/capita	*at current prices in 2018 €*	30,956	7,789	19,397	12,588	7,789	7,789	22,184	13,949
	GDP at purchasing power in 2018 €	30,956	15,934	27,483	19,275	15,934	15,934	26,595	21,044
GVA by Agriculture, forestry and fishing	*% of total GVA (2018)*	1.6%	4.2%	2.2%	3.6%	4.2%	4.2%	2.2%	3%

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area

Table 1.2 Main population, land surface, GDP and trade characteristics of 6 CELEBio target countries benchmarked against EU average

			CELEBio neighbouring countries						Total & average CELEBio neighbouring region countries
Category	**Unit**	**EU**	**Albania**	**Bosnia and Herzegovina**	**Greece**	**Montenegro**	**North Macedonia**	**Serbia (excl Kosovo and Metohija)**	
Population	*million (2018)*	512.4	2.9	3.5	10.7	0.62	2.1	7.0 [1]	23.9
Area (total)	*million ha (2018)*	447	2.7	5.1	13.2	1.38	2.6	7.8 [1]	30.1
% population in urban areas	*% of total population (2018)*	44.9%	61.4%	39%	40%	NA	58%	61%	50%
% territory predominantly rural	*% of total territory (2018)*	43.8%	82.2%	40%	63%	NA	42%	65% [2]	53%
% territory predominantly urban	*% of total territory (2018)*	10.7%	5.7%	20%	6%	NA	58%	3% [3]	22%
Agricultural Area	*million ha (2016)*	173.3	0.7	2.57	5.1	0.26	1.2	3.5 (2018)	12.6
Forest area	*million ha (2016)*	164.8	1.1	3.23	7.4	0.74	1.0	2.25	14.6
Population density	*n°/km² (2018)*	115	100	74	81	45	83	90.2	79.5
Agricultural Area per capita	*ha/capita(2016)*	0.34	0.24	0.53	0.48	0.42	0.6	0.50	0.53
Forest area per capita	*ha/capita(2016)*	0.32	0.37	0.92	0.69	0.74	0.48	0.32	0.61
GDP/capita	*at current prices in 2018 €*	30,956	4,446	4,200	17,264	4,663	4,827	6,140	7,419
	GDP at purchasing power in 2018 €	30,956	9,609	-	21,116	4,517	10, 900	6,140	10,591
GVA by Agriculture, forestry and fishing	*% of total GVA (2018)*	1.6%	21.1%	-	4.3%	6.7 %	7.2%	6.3%	6%

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area

1. Statistical Yearbook of the Republic of Serbia, ISSN 0354-4206, Statistical Office of the Republic of Serbia, Belgrade, 2019./Agriculture and rural development strategy of the Republic of Serbia for the period 2014-2024 ("Official Gazette of RS", No. 85/2014)/http://indicator.sepa.gov.rs/pretrazivanje-indikatora/indikatorilat/allfind/ecdba9bb36764756bcfd034e30ab8bb5

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Bio-based production chains require transportation of large volumes of materials, i.e. the supply of biomass and the export of (intermediate) products. The cheapest options for transportation of large volumes are waterways and railways. Also, the creation of hubs are essential for establishing successful bioeconomy activities, particularly if these are large scale installations.

Figure 1.3 Pan-European transport corridors in the CELEBio target countries and neighbouring regions

Several of the CELEBio countries are land locked and rely strongly on road, train and river transport. This is particularly the case for Czech Republic, Slovakia, Serbia, Bosnia and Herzegovina and North Macedonia (see Figure 1.1). The development of the European corridors is very important for these countries. Very important in the CELEBio region is east-west corridor IV, Danube – Rhine. Other important ones are the IV, VII, VIII, IX and X (see Figure 1.3). Bulgaria is one of the countries through which half of the European corridors pass (corridors IV, VII, VIII, IX and X), The entirely Bulgarian section on the Danube River is within the corridor VII. One of the busiest in its territory is Corridor X to Sofia and from there Corridor IV to Greece and Turkey and further to the Middle East. Budapest is really at the crossroads of all corridors runing through the CELEBio region.

For Czech Republic, that is bordering with Germany and Austria, and therefore good connections to the rest of western and southern Europe, the current national motorway

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network is due to be about 2.000 km before 2030. Although highway connection exist on routes to Nurnberg, Dresden, Bratislava, and Katowice, the highway connection to Vienna and Linz still remains to be built. For Slovakia three Trans- European corridors are important, namely the Baltic-Adriatic Corridor (V), The orient/ East – Mediterranean Corridor (V) and The Rhine- Danube Corridor (IV).

The countries with good harbour connections because of their coast locations of the Adriatic are Slovenia, Croatia, Montenegro, Albania and Greece. The only CELEBio country with access to the Black Sea is Bulgaria.

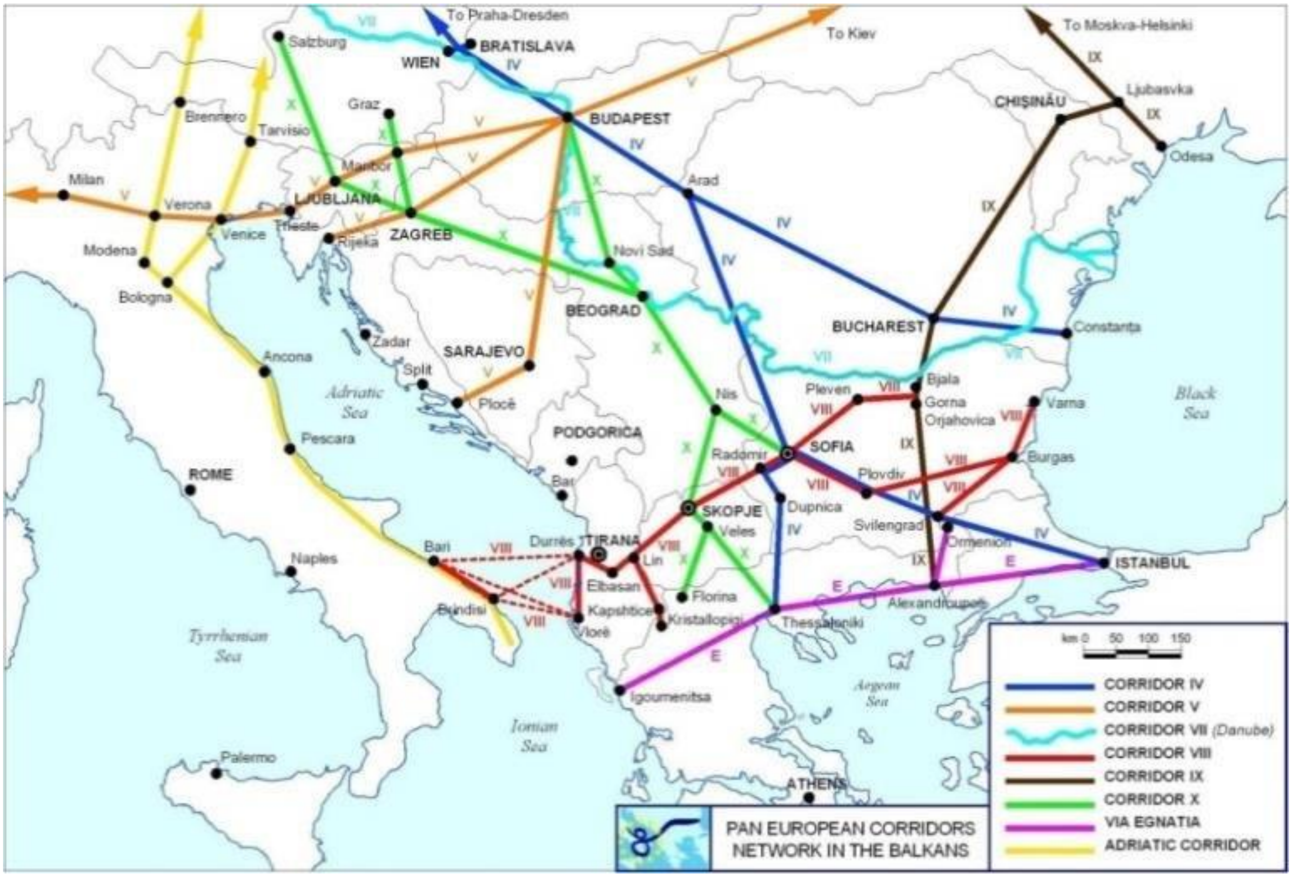

Figure 1.4 More detailed overview of the Trans-European Transportation Network in the bordering CELEBio countries (https://www.researchgate.net/figure/Position-of-Sarajevo-at-the-Pan-European-corridor-network-in-the-Balkans-Corridor-V_fig1_336374842

North to South road infrastructure is well defined with modern and fast highways in Croatia and Slovenia mostly from capitals to Adriatic coast locations e.g. Port of Koper, Dubrovnik and Ploče (industrial port), Rijeka (port), Istria to Italy, Osijek to Danube (port) and Serbia, and to Varaždin and Hungary. The port of Koper is the only Slovenian port which handles cargo. It is a part of the Trans-European Transport Network (TEN-T). The strategic geographical position of Slovenia and Croatia is extremely favourable for supplying markets in Central and Eastern Europe. Both countries are crossed by two priority railway freight corridors, namely the Baltic-Adriatic Corridor and the Mediterranean Corridor. Also, two important road corridor cross Slovenia's territory, namely the V Pan-European transport

Corridor (which links Lisbon via Barcelona and Ljubljana to Kiev) and the X Pan-European transport Corridor (links Munich via Jesenice and Ljubljana to Belgrade and Istanbul).

In general, train infrastructure needs modernisation in most of the target and neighbouring CELEBio countries but is well interconnected in most countries. In Slovenia recent investments have improved train transport particularly connecting the port of Koper to the hinterland.

Greece is a major entry point of cargo traffic from Asia into European space. Greece is part of the Orient / East-Med Core Network Corridors, linking by sea and through the port of Piraeus (corridor X and VIII), Cyprus. To the north, the land corridor links through Bulgaria to the Rhine-Danube Core Network (corridor IX). Through other networks and with focal points in the port cities of Thessaloniki and Alexandroupolis, Greece is also linked with Turkey to the east, Albania and North Macedonia to the northwest and north respectively. The ports of Patra and Igoumenitsa also serve as connections with the Italian mainland to the west (See Figure 1.4).

For the CELEBio neighbouring countries the development of the transport network was to be stimulated through the Memorandum of Understanding for the Development of the Basic Regional Transport Network in South East Europe (SEETO1 Memorandum). It was signed in Luxembourg on June 11, 2004, by the European Commission and the governments of Montenegro, Croatia, Bosnia and Herzegovina, Macedonia, Albania, Serbia and Kosovo. The mission of the Memorandum was the cooperation on the development of the main and auxiliary infrastructure on the multimodal basic regional transport network in South East Europe and the improvement of policies in this area in order to achieve faster progress in development. The successor to this Memorandum the Treaty establishing the Transport Community (in the Western Balkans region) was signed by the Prime Minister of the Western Balkans six in Trieste in 2017. This agreement will lead to better and faster integration of transport markets; adjustment of transport laws and related issues to EU law, including the future development of the Union's acquis and better environmental protection, including collaboration on climate change mitigation.

Albania is included in the extension of the Trans-European Transportation Network through the Mediterranean Corridor, running down from Rijeka along the Adriatic coast, passing through the ports of Durrës and Vlore and connecting to the International Airport of Tirana and finally reaching the Orient/East-Med corridor in Greece. The most important port in Albania is Durrës which is located about 36 km to the west of Tirana and serves as the entry way for Corridor VIII. In the future, major development of infrastructure is expected at the port of Shëngjin, close to the border with Montenegro. At the moment, Shëngjin handles only ships with a lower capacity than 5,000 tons. Investments promise to upgrade its operational capacity up to 60 million tons per year, surpassing Durrës as the main industrial port of Albania and upgrading into a major transportation hub for the whole region (see Figure 1.4).

Serbia, a land-locked country, has good road connections. The main traffic hub is the city of Belgrade. Two pan-European traffic corridors also pass through the Republic of Serbia: the road-rail Corridor 10 (going from Austria to Greece), with its branches B (the Budapest-Belgrade branch) and C (the Niš-Sofia_Dimitrovgrad_Istanbul branch) and the river corridor

7 (the Danube Corridor connecting the Central Europe with the Black Sea) (see Figure 1.4). Montenegro borders with the Adriatic Sea connected with European countries by road, rail, air and water traffic, but is not connected yet to the Trans-European Transportation network. The connection of Bosnia and Herzegovina with the rest of the Trans-Europe Transportation network goes through corridor V connecting Sarajevo with Belgrade and also the Adriatic coast in Croatia. North Macedonia completely landlocked and located at the crossroad of South-Eastern Europe, which makes the country an important transit route for inland road transport between Central Europe, the Aegean Sea, the Black Sea and the Adriatic Sea. This geographical position of the country has contributed to the development of international traffic on two trans-national axes: North South (Corridor X) and East-West (Corridor VIII) linked to the Trans-European Transport Network.

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2 Characterisation of agricultural sector in CELEBio countries

2.1 Introduction

In this chapter the agricultural sectors in the CELEBio target and neighbouring region countries is characterised. In this section we first describe the key characteristics of the agricultural sector in a benchmarking approach (See Tables 2.1 and 2.2). Unfortunately, for the non-EU countries not all data are available.

In the 6 target countries we see that the share of people employed in agriculture is still a bit above the EU average which illustrates the importance of the agricultural sector as a source of income. It is above 6.5% in Bulgaria and Croatia, but in Czech Republic and Slovakia this proportion is much lower, even below EU average. In the neighbouring countries this agricultural employment share is generally far above the EU average, except in Serbia where it is 5%. The highest share of agricultural employment is seen in Albania (38%), Bosnia and Herzegovina (18%), Greece (11%) and North Macedonia (16%).

In agriculture the cropping output dominates in all 6 target and neighbouring countries. This while the livestock activity is generally underrepresented also strongly below the EU average share, except for Albania and Slovenia. This also explains the relatively low per hectare livestock density in most of the countries.

Intensity of farming is illustrated by a couple of indicators in the Tables 2.1 and 2.2. The low input farms are the dominant farm group in Bulgaria, Hungary, Slovakia, Slovenia and North Macedonia. In the other countries the distribution is more even over high, medium and low input farms and more in line with the EU average. A higher share of high input farms in total also becomes clear from the nitrogen balance which is considerably above the EU average in Croatia and Czech Republic. The phosphates surplus is only high and above the EU average in Croatia and Slovenia. Very large irrigated UAA area shares are seen in Greece, Albania and North Macedonia only, while in all other countries it is below the EU average of 6%.

The proportion of High Nature Value farmland is an indicator of the presence of biodiversity of European conservation value which depends strongly for its survival on continuation of low input often traditional farming practices. On average in the EU this share is at 41%, but in several of the CELEBio countries this share is considerably higher such as in Croatia, Slovenia, Albania, Bosnia and Herzegovina and Montenegro. In the rest of the countries it is just or strongly below this EU average share.

Table 2.1 Key characteristics for the agricultural sector in 6 CELEBio target countries and neighbouring country Greece

Category	Unit	EU	Bulgaria	Croatia	Czech Republic	Hungary	Slovakia	Slovenia	Greece	Total & average
Agriculture in % of total employment	*% of total employment 2017*	3.9%	6.8%	6.4%	3.9%	5.0%	2.7%	4.6%	11%	**5.7%**
Agricultural area per capita	*ha/capita*	0.34	0.63	0.38	0.33	0.48	0.35	0.24	0.48	**0.43**
Cereal yield	*t/ha (Yield gap Atlas)*	5.2	4.6	5.1	9.3	5.9	4,9	4.7	4.38	**5.66**
Crop output in total output	*% of total agricultural output value (2018)*	56%	73%	60%	59%	63%	60%	56%	74.1%	**64%**
Livestock output in total output	*% of total agricultural output value (2018)*	44%	27%	35%	41%	37%	40%	44%	23.9%	**35%**
Agricultural income (2010=100)	*Index 2010=100 (2018)*	121	202	119	142	172	195	122	93.9	**149**
Livestock density	*LSU/ha UAA (2016)*	1.0	0.2	0.5	0.5	0.5	0,3	1.0	0.46	**1**
High input farms	*%/ total farms 2016*	29%	6%	29	28%	12%	6%	29%	30%	**20%**
Low input farms	*%/ total farms 2016*	39%	52%	25	28%	56%	49%	50%	34%	**42%**
Gross nutrient balance nitrogen	*kg of nutrient per ha (average 2011- 2015)*	51	28	60	98	35	34	53	55	**52**
Gross nutrient balance phosphorus	*kg of nutrient per ha (average 2011- 2015)*	1	-6	5	-2	-1	-5	3	0	**-1**
Irrigated utilised agricultural area	*% of UAA 2016*	5.9%	2.1%	1.0%	0.7%	2.6%	1.5%	0.7%	23.6%	**5%**
HNV farmland	*% of agricultural land*	41%	38%	90%	26%	29%	20%	76%	38.1%	**45%**
Soil erosion	*tonnes/ha/yr 2012*	2.4	2.03	3.04	1.62	1.57	2.12	7.42	4.19	**3**
Average farm size	*ha UAA/holding (2016)*	16.6	22.0	11.6	130.2	10.9	55.7%	7.0	6.6	**35**
% of agr. holdings < 5 ha	*%/total no. of holdings*	62.6%	82.6%	69.5%	18.7%	81.4%	2.7%	59.5%	77.3%	**56%**

Table 2.2 Key characteristics for the agricultural sector in CELEBio neighbouring countries

Category	Unit	EU	Albania	Bosnia and Herzegovina	Greece	Montenegro	North Macedonia	Serbia (excl Kosovo and Metohija)	Total & average CELEBio neighbouring countries
Agriculture in % of total employment	*% of total employment 2017*	4%	38%	18%	11%	7%	16%	5%	16%
Agricultural area per capita	*ha/capita*	0.34	0.24	0.53	0.48	0.48	0.61	0.50	0.47
Cereal yield	*t/ha*	5.2	4.1	3.3	4.4	3.3	3.4	4.6	4.0
Crop output in total output	*% of total agricultural output value (2018, *2012, **2010, ***2014)*	56%	46%*	63%**	74%	NA	69%	67%***	64%
Livestock output in total output	*% of total agricultural output value (2018, *2012, **2010, ***2014)*	44%	54%*	37%**	26%	NA	21%	33%***	34%
Agricultural income (2010=100)	*Index 2010=100 (2018)*	121	n/a	NA	94	NA	124	NA	
Livestock density	*LSU/ha UAA (2016)*	1.00	0.63	NA	0.46	NA	1.19	NA	
High input farms	*%/ total farms 2016*	29%	NA	NA	30%	NA	29%	NA	
Low input farms	*%/ total farms 2016*	39%	NA	NA	34%	NA	71%	NA	
Gross nutrient balance nitrogen	*kg of nutrient per ha (average 2011- 2015)*	51	NA	NA	55	NA	NA	NA	
Gross nutrient balance phosphorus	*kg of nutrient per ha (average 2011- 2015)*	1	NA	NA	0	NA	NA	NA	
Irrigated utilised agricultural area	*% of UAA 2016*	6%	43%	NA	24%	2%	24%	1%	17%
HNV farmland	*% of agricultural land*	41%	80%	93%	38%	99%	17%	27%	48%
Soil erosion	*tonnes/ha/yr 2012*	2.4	NA	NA	4.2	NA	NA		
Average farm size	*ha UAA/holding (2016)*	16.6	1.2	NA	6.6	NA	1.8	6.2	4.0
% of agr. holdings < 5 ha	*%/total no. of holdings*	63%	99%	NA	77%	NA	61%	72%	66%

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The largest farms in terms of area size are found in Czech Republic and Slovakia, with an average farm size of 130 and 56 hectares, respectively. The largest share of small farms is in Albania where average farm size amounts to only 1.2 hectares and 99% of the farms is smaller than 5 hectares. Strong domination of small farms under 5 hectares in the total farm population is also seen in Bulgaria, Hungary, Greece and Serbia. This is likely to also be the case in Bosnia and Herzegovina and Montenegro, but exact data are not available for these countries.

2.2 Farming sector structure

2.2.1 Cropping sector

The structure and importance of the cropping sector in the CELEBio countries is illustrated by Figure 2.1. The largest production area for crops is in Hungary, followed by Bulgaria, Greece, Serbia, Czech Republic. The smallest crop area is in Slovenia and Montenegro which are both small countries, but also countries with a relatively small agricultural area.

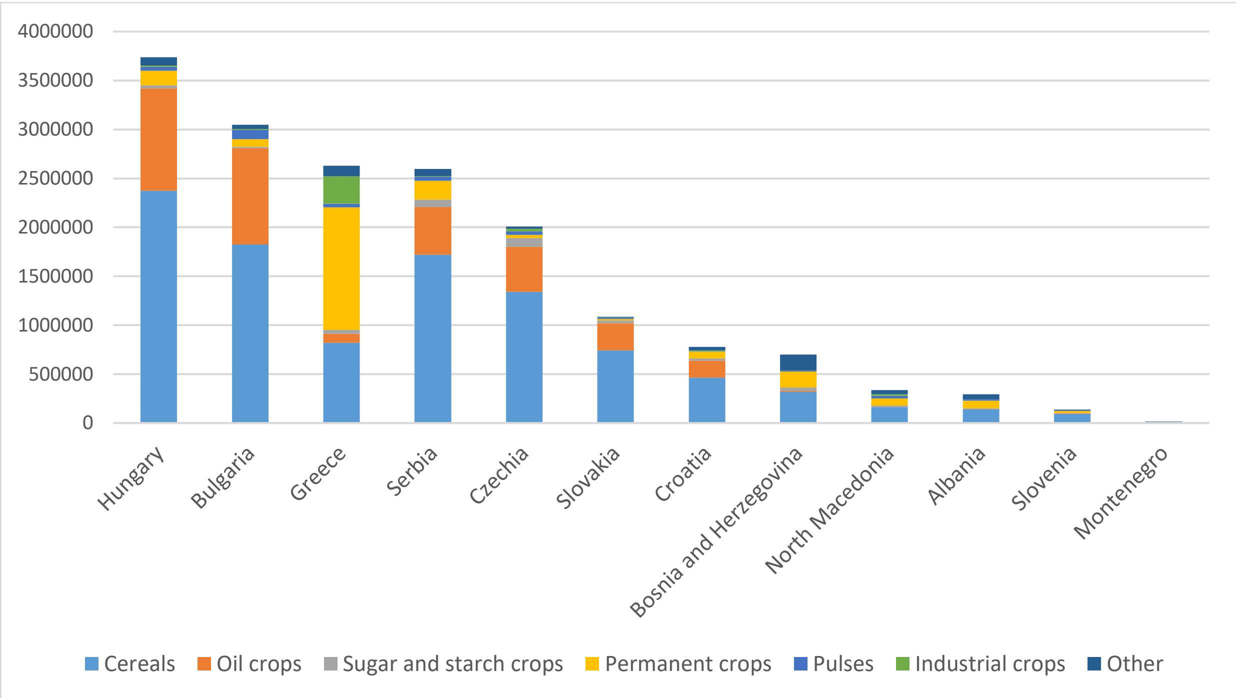

Figure 2.1 The main crop groups per CELEBio country, expressed in area (hectares, 2018) (source: FAOSTAT, 2018)

Cereal and oil crops are the largest crop groups in at least the larger countries. Greece is however an exception with a very large and dominant area covered by permanent crops and industrial crops. The latter is particularly caused by the large cotton production only seen in Greece. The large area coverage by crops is also reflected in large primary residual biomass potentials as will be discussed in next Section 2.3.

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The primary residual biomass potential is however also a function of the per hectare yields. For the Table 2.1 and 2.2 it can be concluded that these are generally still relatively law for most CELEBio target countries and certainly for the neighbouring countries. The only strong exception is the Czech Republic which has an average cereal yield level far above the EU average. In this country the straw potential is therefore very large, although under influence of climate change there is a lot of increasing uncertainty among farmers about future cereal and straw yields. Hungary also has cereal yields above the EU average although not as high as common in the Czech Republic. All other countries have lower cereal yields where changes in farming practices still give room for large yield gap closures[1] . Water availability is also a factor in this respect, and irrigated area is also relatively small in most countries. The influence of water deficits will continue to have effects on attainable crops yields in all countries of CELEBio.

In some countries the abandoned land potential is quite large which is largely related the collapse of socialism and subsequent institutional reforms. This went together with dismantling of large collective or state farms in the process of land privatisation resulted in land abandonment because property rights were not well established, or because co-ownership or lack of information on the landowner impeded the allocation of land. For example, in several of the CELEBio countries, the forced co-ownership of land parcels in communist times created inadequate property rights, inefficient land allocation and farmland abandonment. Returning land to previous owners has also proved to be complicated and slow by a lack of knowledge about who is the legal owner, incomplete cadastral registrations, lack of interest from some owners who had migrated to bring land again in production, and by a lack of start-up capital for agricultural investments. Also lack of capital forces landowners to leave part of their land outside agricultural use. A wide range of reasons and this results in quite large biomass potentials from dedicated biomass crops on unused lands in a selection of CELEBio countries, particularly in some of the neighbouring ones, as presented in Section 2.4 (Figure 2.4).

2.2.2 Animal sector

The animal sector in all CELEBio countries, except for Albania, is considerably smaller than the crop sector as already became clear from the former (see Tables 2.1 and 2.2). This is also related to the trend in livestock production decline which took place in many of the CELEBio countries after the shift to a market economy in the 1990s. In many countries the livestock sector never recovered from this collapse.

[1] See http://www.yieldgap.org/web/guest/europe

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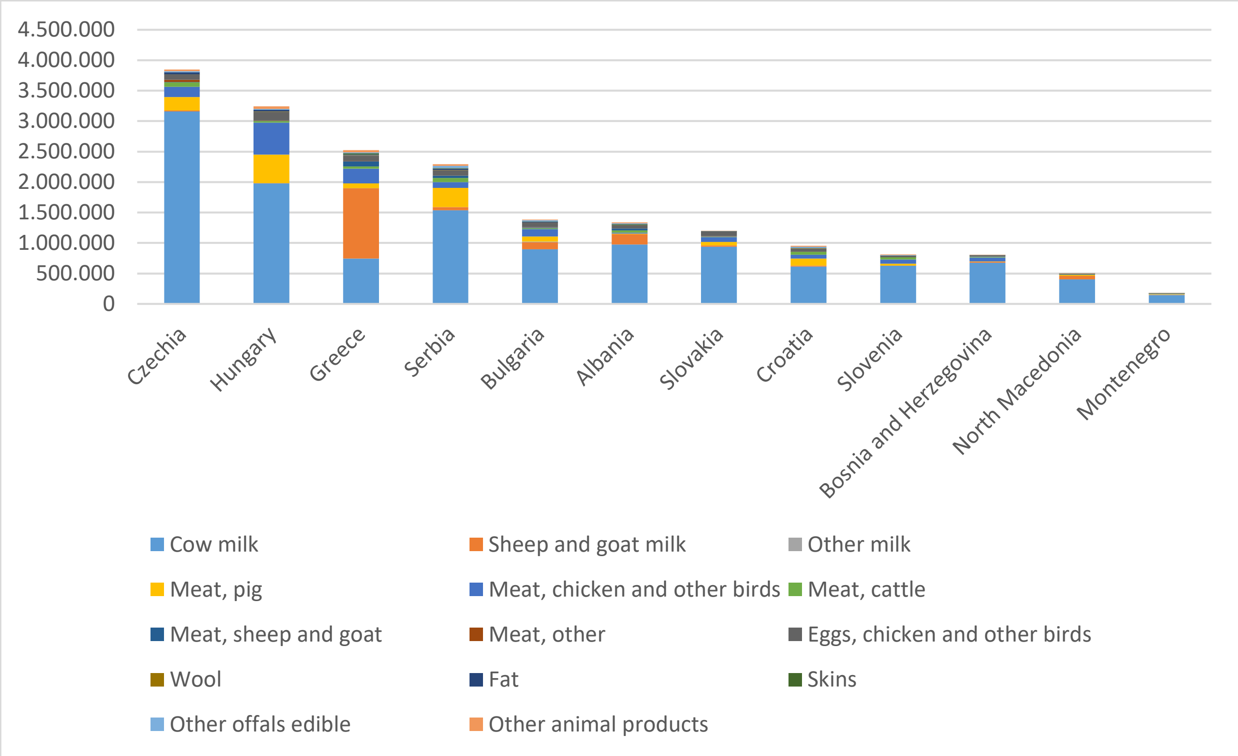

Figure 2.2 Main primary animal product volumes per CELEBio country, expressed in tonnes/ year (FAOStat data, 2018)

However, some countries do produce large amounts of animal products such as Czechia, Hungary, Greece and Serbia (see Figure 2.2). In Czechia, Serbia and all smaller countries the lion share of the livestock production is in dairy. In Hungary, it is more evenly spread over dairy and meat production. Hungary is a significant player in both chicken and pig meat production in Europe. In Greece, the production of sheep and goat milk and meat is most dominant, and this is typically an exception in most of the CELEBio countries. Bulgaria, Albania and North Montenegro also have sheep and goat production although these sectors are not as relatively large as in Greece. Slovenia has a small agricultural sector, but livestock is quite large as compared to the other countries with 43% of total agricultural output. In Albania the livestock production amounts 54% of the total agricultural output which implies that it is the only CELEBio country where livestock production is larger than crop production.

Given the size of the livestock production, Czechia, Hungary, Greece and Serbia also produce interesting quantities of manure which can and are sometimes already used in biogas as will also be discussed in Section 2.4. In this respect it is interesting to know that large spatial concentration of manure production is especially seen in Czech Republic where the size of dairy and other livestock farms is significant, also in broad EU perspective and certainly as compared to the rest of the region. In Hungary, the animal production is both distributed over a large amount of very small producers and also over a limited number of about 200 very large farming organisations.

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2.3 Agrifood industry sector

The agrifood processing sector is based on locally produced and imported crops. In Figure 2.3 an overview is presented of the crop processing volumes that are registered by FAO for the different countries. Not surprisingly the countries with the largest absolute crop production also have the highest processing volumes.

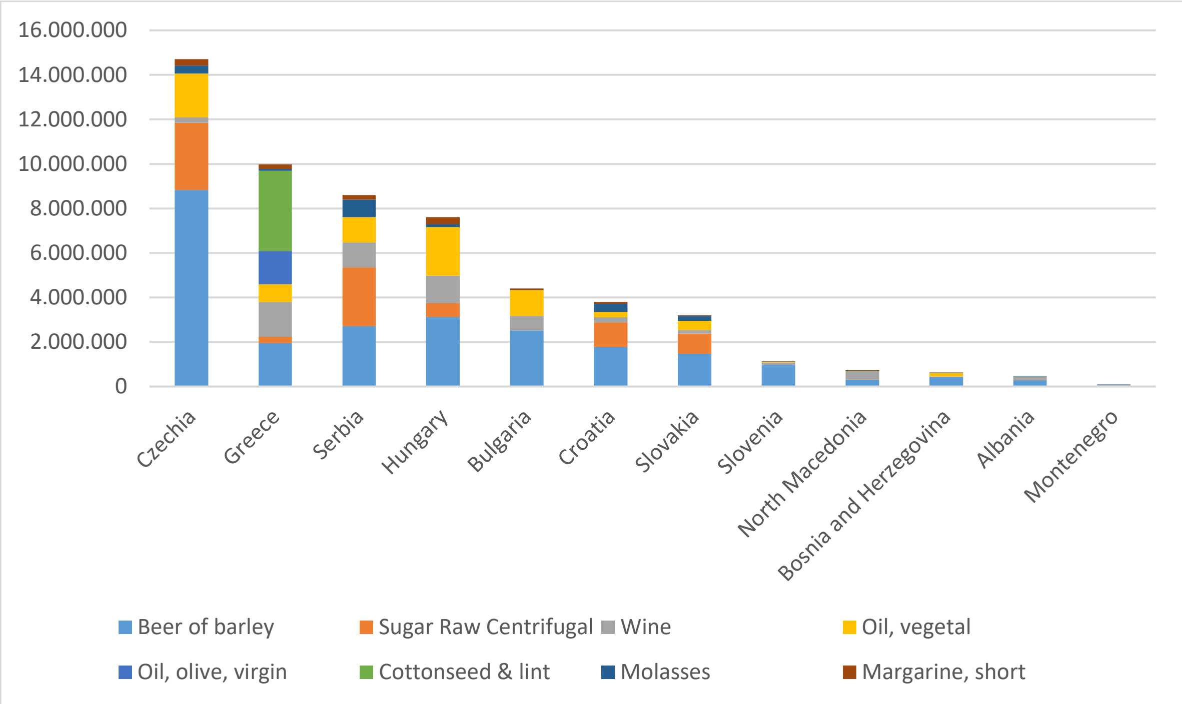

Figure 2.3 Crop processing volumes per CELEBio country, expressed in tonnes/ year only for products registered by FAO (FAO data, 2018)

The largest volumes of crop processing are seen in the Czech Republic. The largest volume comes from beer production based on barley, which is mostly produced domestically. Large volumes of sugar, based on domestically produced sugar beet, and vegetal oil from locally produced oil crops are also seen in this country. Beer production is also relatively large in most other countries, particularly Serbia, Hungary, Bulgaria, Croatia, Slovakia and Slovenia. Sugar production from sugar beet is also large in Serbia, Croatia and Slovakia. Oil from seed crops is produced in all countries with the largest absolute and relative quantities occurring in Czech Republic, Hungary, Bulgaria, Serbia, Slovakia, Greece and Bosnia and Herzegovina.

Olive oil is only produced in Greece, Croatia, Slovenia, North Macedonia, Albania and Montenegro. Cotton processing is only seen in Greece, where it is very large, and much more limited but present in Bulgaria and Albania. Wine production is occurring in all countries with largest production in Greece, Serbia, Hungary and Bulgaria.

Other agrifood processing activities based on crop products are generally much smaller in volume than the ones presented in Figure 2.3, but should certainly not be ignored.

Particularly those industries that process fruit and vegetables can be relevant in terms of creation of employment and income and providing residual biomass for existing and new bioeconomy activities. Fresh fruit and vegetable processing are important activities in several CELEBio countries, particularly Bulgaria, Greece, Serbia and Bosnia and Herzegovina where fruit and vegetable production is large and processing of these products has a long tradition and where labour is still relatively cheap in European perspective.

Large animal product processing industries are mostly seen in the countries where the livestock production sector is large. From the former section and Figure 2.3 it already becomes clear that this is particularly the case in the countries with large meat production. Slaughter activities are largest in countries like Hungary, Czech Republic, Serbia, Bulgaria and Albania. Slaughterhouses produce a lot of non-edible residues which can be used as feedstock for biobased activities.

Dairy industries processing milk into dairy products such as cheese and milk are by far the largest animal processing activities in Czech Republic, Greece, Serbia, Slovakia and Albania. But in all countries, it is the most important livestock production sector in terms of volumes processed. Also, from these industries large amounts of residual biomass such as whey from cheese making result.

2.4 Agricultural biomass potentials for the biobased sector

Based on the primary crop and livestock production data and the agrifood processing activities estimates could also be made of residual biomass potentials. These potentials were derived from different data sources which are specified in Annex I where a table is presented with all biomass potentials per country. In addition, data were also derived on biomass potentials from biomass cropping on unused lands. The summary of total agricultural potentials in presented in Figure 2.4.

It shows that in the four countries with the largest biomass potentials come from primary field residues from crops which are mostly cereals and oil crops. The largest secondary potentials from crop processing in the agrifood industry are found in Hungary, Czech Republic, Greece, Bulgaria, Serbia and Slovakia.

The manure potentials are of interest except for the small countries of Montenegro and North Macedonia.

The most uncertain potential, which is biomass from crops on unused lands is the only biomass source of significant size in countries like Bosnia and Herzegovina and North Macedonia. These countries have a large unused land potential. Setting up dedicated crop production on lands that have been out of use for a long time will only be interesting if there is a clear market demand for lignocellulosic biomass that delivers a prospect for a positive economic margin. Furthermore, this may only be advisable if new land uses deliver more environmental and economic benefits then when the land is left unused.

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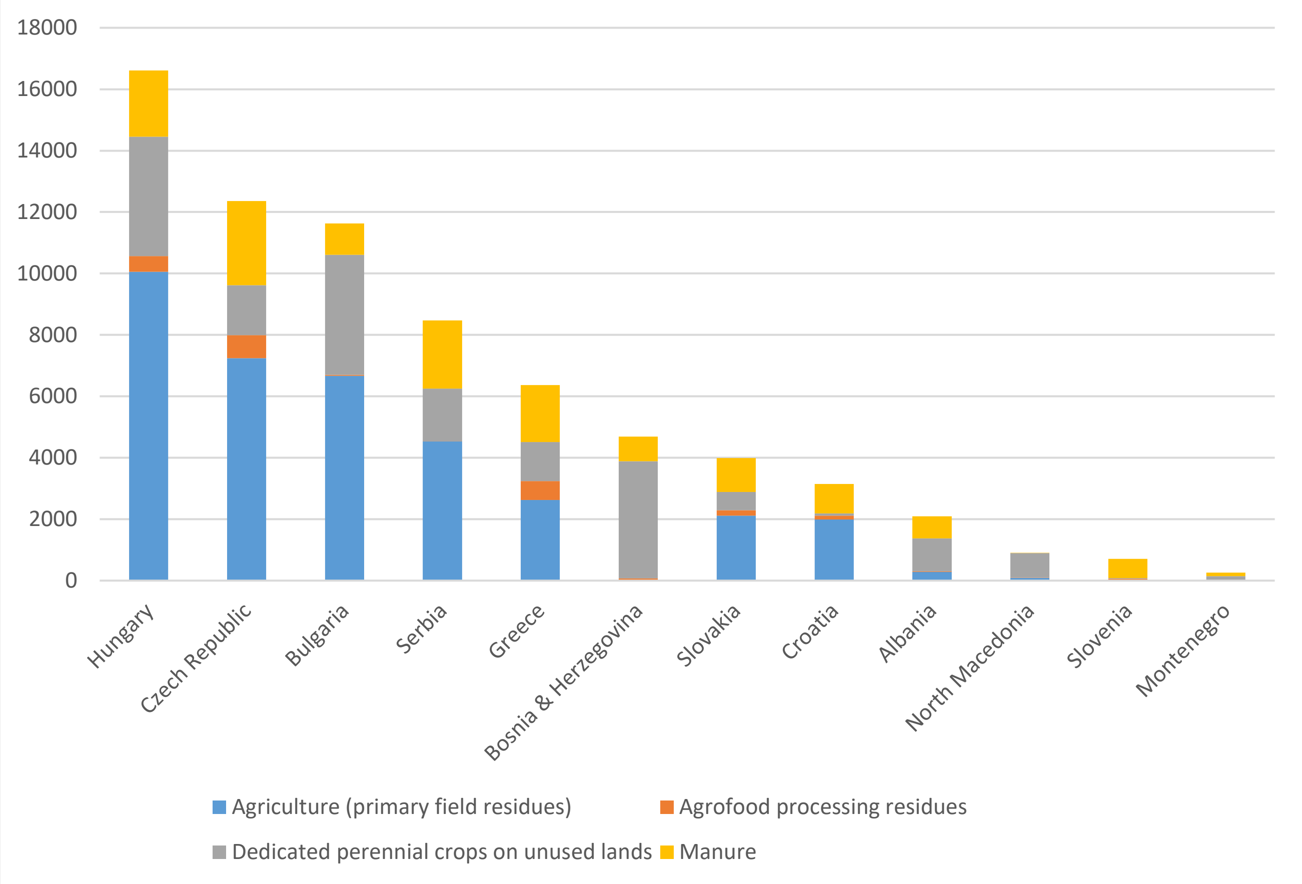

Figure 2.4 Residual biomass from agriculture and biomass from crop production on unused lands per CELEBio country, expressed in Kton/ year (Source: S2BIOM potential data 2020, CELEBio country report data, Scarlat et al., 2018 and FAOStat)

*Agrifood processing residues are entirely based on crop processing activities as presented in Figure 2.3. They are an underrepresentation as they do not include residual non-edible biomass from livestock product processing.

2.5 SWOT for characteristics of agricultural sectors

The SWOT observations per CELEBio country in relation to the agricultural' s sector capacity to source biomass is summarized in the Table 2.3. What becomes apparent is that in most countries there is unused biomass in agriculture and in certain countries this is clearly larger than in others.

A limitation for the collection is that the biomass is spatially dispersed, with relatively low density. Although in certain countries, e.g. Czech Republic and Hungary, there is clearly higher density of primary crop residues and/or livestock manure. In many of the regions the transport system, both the road network and the transport means are not optimally developed. This is also limiting the efficient collection of biomasses in regions where it is available. For the land locked countries this is even more challenging as security of supply cannot easily be increased through imports that enter most easily in seaports.

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For the mobilisation of primary residues from crops uncertainty arises about how much residual biomass can really be removed from the soil without losing the soil quality and how will this be affected by climate change. Climate change impacts are already seen in several regions in the CELEBio countries and in general increasing drought and extreme weather events are likely to decrease residue availability in the future.

Many countries have a long tradition of food production and agrifood processing. This is an advantage in that agrifood processing chains are already in place and experience with setting these up is also available. In the existing industries there is still a lot of room to improve the processing and more optimal uses of residual biomass.

Market demand for non-food biomass is still weakly developed in most CELEBio countries and this is not mobilising the potential supply. More investments need to be facilitated to get this off the ground. If there is demand, the supply will also be mobilised, particularly if the prices that can be paid are high enough. The latter will happen if the local biomass resources are not only used for heat and electricity generation but more for higher added value products such as advanced biofuels, bioproducts and biochemicals.

An interesting opportunity is a large land resource where there is still room to improve yields, close yield gaps, and also start using unused lands for dedicated cropping. A weakness however in relation to the latter is often unclear land rights, small and dispersed land ownership and lack of capital. Also, an overall lack of labour and population is certain regions is a weakness.

In Table 2.4 a summary overview is given of the main agricultural biomass resources expected to be available for mobilisation in a BBE in the CELEBio countries. These resources can also be the starting points for the setting up of new biomass delivery chains in the CELEBio countries. For these biomass types options for conversion pathways as discussed in chapter 6 of this report can be selected. The recommended combinations of biomass types and conversion pathways to focus on in further national action development (in Work package 3 of this CELEBio project) are presented at the end of this report.

Table 2.3 SWOT factors for biomass mobilisation for BBE from agricultural sector

	Strength	Weakness	Opportunities	Threats
Bulgaria	• Enough land to provide raw materials for BBE • Long tradition in agriculture and food processing • Unused potential available from primary residues, secondary residues and unused lands. • Cost of biomass resources are relatively low in comparison to other EU regions	• Spatial concentration of biomass is low (low yields), makes collection cost relatively high • Ownership of land is very dispersed, small farms and often still unclear land access • Capital for investments is scarce • BBE market demand for biomass not developed • Small agricultural field size • Lack of logistics centres to establish a stable and cost efficient biomass supply • Rural Development program is not supporting biobased projects and innovations.	• Still many biomass resources that can be mobilised • Many options to create BBE innovations based on local biomass resources • Opportunities to produce low-ILUC biomass on abandoned lands • Long tradition in agrofood processing and fresh and helathy food production with low environmental pressures. • Production of medical aromatic plans for medicines, food additives and cosmetic products	• Depopulation of rural areas, lack of labor in agriculture • No market for high added value BBE products, uses only low-quality chains for heat/electricity • Pollution through inefficient use of biomass, (firewood burned in low-efficient heating devices) • Import of value-added products • Risk for loss of HNV farmland when agricultural production becomes more efficient
Czech Republic	• Agriculture sector is highly developed, high yields, large farms, large plots, modern equipment, large farms • Relatively high spatial concentration of biomass • Robust aarofood processing value chains • Modern transport infrastructure	• Reduction in livestock production • Residual biomass sourcing security unclear, lack of interest among primary producers to mobilise biomass • BBE market demand for biomass not developed, lack of innovative industrial developments	• Relatively large utilizable biomass • Growth opportunity in development of Czech bio-organics market • Local bioeconomy hub development	• Climate change, more drought and high temperatures makes biomass sourcing uncertain • Agricultural practices leading to inadequate soil and water management • Monopolies in some value chains leading to competitive lock-out
Croatia	• Unused potential available from primary residues, secondary residues and unused lands • Roadside cost relatively low and good road connectivity • Long tradition in agriculture and food processing also in a planned economy • Rural Development Program	• The spatial concentration of biomass is low and absolute amounts of agricultural biomass are also limited in small country with many small fields and low yields • The facilities to collect, transport and pre-treat are not in the areas with the highest biomass concentration. • Ownership of land unclear and unused lands are very dispersed, • Lack of financial support for investments • Market demand for unused biomass not developed • Lack of logistics centers to establish a stable biomass supply	• Still many biomass resources that can be mobilised • Because of harbours (coastal and inland), local biomass resources can be combined with imported resources to strengthen security of supply • Unused land resource is significant • Expansion of family farms into tourism sector to generate additional income, entrance to new market - ecotourism • Production of healthy food for a healthy Europe is a trend the Croatian market can connect to.	• Risk loss of HNV farmland when demand for biomass takes off • Lack of rural population to produce and collect the biomass in the long term • No market for high added value biomass, uses only low-quality chains for heat/electricity • Pollution through inefficient use of biomass, pellets in local heat production • Increasing trend of labor outflow • Raising competitiveness makes future placement of Croatian value-added products challenging

	Strength	Weakness	Opportunities	Threats
				• Large land purchases for financial investment and industrial agricultural production, without stimulating local communities and creating jobs - Land-grabbing
Hungary	• Unused potential available from primary residues, secondary residues and unused lands • Diverse climate large suitability for different crops for bio-ethanol • Livestock sector well developed providing interesting residue source and biogas already well developed • Feedstock prices relatively low • Relatively high quality and well trained labour force • Standardization of biomass in place	• Long transportation distance • Low capacity of transport and transport network not well developed, transport cost high • Risks for ILUC effects and in worst case to deforestations • Agricultural production has still instable quality and also leads to lack of security of supply • Seasonally working industries are less sustainable from economical aspect • Risk for unsustainable residual biomass extraction	• Public support for the use of biomass • Discount on fuel oil tax on vegetable oil • There are official regulations for productions and the market • Clarified legal and ownership system • Low rates of loan (good CAPEX possibility)	• General organic matter deficiency in soils • Difficult to set up new BBE activities with low fossil process • The product range is scarce, only the biomass used for heating is widely known
Slovenia	• Gradual improvement of education in agriculture sector • Quality professional institutions and organizations in the field of research, education and consulting • Suitable conditions for irrigation (availability of water, precipitation) • Increased no. of complementary activities and establishing of micro and small enterprises in rural area	• Agriculture in general is not very attractive to younger generations • Poor economic and environmental performance and high exposure to climate change • High CAPEX and OPEX	• Promoting access to specialized advisory services • Increasing demand for sustainably produced local product of higher quality and products from above standard breeding. • Promotion of organic farming	• Too slow restructuring due to lack of own resources to co-finance investments • Lack of interest in taking over the farm and continuing farming in the younger generations
Slovakia	• Presence of relatively large farms, efficient production on large fields in many arable production regions. • Diverse climate large suitability for different crops for residues and dedicated for BBE uses • Large amount of unused biomass resources and land • High soil quality in the lowlands • Sufficient water supply • The possibility of growing organic agricultural products In Slovakia, • Advanced information systems and sources of information on supply assessment and control	• Low competitiveness and productivity of agricultural sector and processing industries also because of focus on low added value production • Lack of tradition in cooperation mechanisms in horizontal and vertical ways. • Lack of job opportunities • Migration of rural population to urban regions • Permanent loss of arable land, Indebtedness of farms • Decrease of agricultural and livestock production • Unresolved ownership relationships to agricultural and forestry land	• Space for improving agrifood chain (more added value) • Job conservation & creation • Diversification of the rural economic base • Further exploitation of local natural resources • Countryside capital inflow • Increase sale of local products • Targeted support through new CAP, Green Deal • Development of inter-communal and cross-sectoral cooperation • Increase local food processing to stop the negative balance of food export / import	• Aging rural population and an ongoing outmigration • Foreign competition tough • Unresolved land ownership relations & badly developed land market • Insufficient anti-erosion measures • Frequently changing legislation • Climate change • The reluctance of manufacturers to create sales organizations and to participate in the formation of shortened sales chains • No strategies for agrifood chain development

	Strength	Weakness	Opportunities	Threats
Greece	• Diverse climate and agricultural sector with multiple different products • Multiple well-established networks and enterprises	• Fragmentation of agricultural holdings • Lack of modernization • Lack of a coordinated bioeconomy policy focusing on residues • Many natural constraints/marginal agricultural lands	• CAP revision, F2F, Green Deal and increased emphasis on bioeconomy and paying for ecosystem services delivered by agriculture • Emergence of vertically integrated enterprises, with capacity to focus on by-product utilization • Major focus on the bioeconomy potential of the agricultural sector by various projects / activities	• Continuation of polluting practices (e.g. open-field burning) • Competition from other countries - shrinking of various sectors • Climate change threatening traditional crops and leading to desertification
Albania	• Varied agricultural sector • Cheap agricultural labour / Competitiveness of several products	• Fragmentation of agricultural holdings • Emphasis on subsistence farming • Lack of modernization • Many terrain constraints • Lack of a coordinated bioeconomy policy focusing on residues • Limited capacities for agrifood processing	• Increased export orientation, access EU markets • Possibilities to enhance agricultural supply • Increased emphasis on sustainability • Consolidation of farms	• Soil erosion • Abandonment of rural areas and land • Climate change effect on crops and leading to desertification
Bosnia & Herzegovina	• Diverse agri-climate zones, facilitating diverse agriculture • Available water resources for irrigation in many areas of BiH • Substantial areas of uncultivated land • Substantial grassland areas suitable for expansion of livestock production • Existence of tradition in different branches agriculture • Extensive capacity in R&D, consulting & education in agrifood sector • Pronounced trend of increase in the number of registered farms • Enhancement of competitiveness in some sectors of agriculture (wine, berries, fish, vegetables)	• Relatively low yields • Low knowledge & education level of farmers • Frequent damages on crops and plantations as a consequence of natural disasters (droughts, floods, hail, frost) • Disorganized land registries and cadastres • Fragmentation of land property • Low share of irrigated area • Low level of specialization and marketability of production • Low added value of in most agricultural products • Poor technical and technological equipment levels at farms • Instability and market prices oscillations most of agricultural sectors	• Promoting access to specialized advisory services • Better use of agricultural residues, • The potential for growing biomass crops on currently unused/abandoned lands is large • Increasing demand for sustainably produced local products of higher quality and products from above standard breeding • Natural predispositions for development of bio-refinery concept • Promotion of organic farming • Development and promotion of more niche market, higher value agriculture products • Transfer of knowledge and technologies • Technical and technological modernization of agriculture	• Too slow restructuring due to lack of resources • Lack of interest for continuing farming among young • High dependence of agricultural producers on direct budgetary support; • Increased share of abandoned arable land and decrease in livestock numbers • Undeveloped land market and outstanding issue of land restitution • Further property fragmentation • Climate change, increase in natural disasters, plant diseases and pests.

	Strength	Weakness	Opportunities	Threats
Montenegro	• High quality, preservation and fertility of soils and favorable climate for many types of products • Tradition in agricultural production practices • Biodiversity, presence of autochthonous species and varieties in agriculture, • Good conditions for organic production • Sufficient work force • Obvious changes in the institutional framework during the recent period • Obvious positive changes in production processes (adoption of new technology, standards etc.)	• Large part of production non-competitive in price • Poor mechanization • Low level of technology and specialization applied in production • Small and fragmented holdings • Relatively high input prices • Lack of organization and cooperation • Insufficient quality assurance in standards (hygiene & environment) • Inefficiency and non-competitiveness of processing industry • Unfavorable age and social structure in rural areas, • Poor infrastructure • Low budget support • Insufficiently developed IT systems, statistics and analyses in agriculture • Weak promotion and marketing • Lack of storage capacity • Low levels of education for farmers • Low levels of application of good agricultural and environmental practices	• Strengthening agriculture through tourism, additional (food) demand • Availability of state and EU support, • Increasing organic market • Strengthening local production, higher aded value products, markets and exports of competitive products (wine, lamb, vegetables) • Positive international market tendencies (incl. to Middle East) • Efficiency of additional budget support • Faster technological development, strengthening of professional skills and R&D institutions • Development of cooperation	• Opening of the market will increase competitiveness • The penetration of large trade systems will further endanger the economic position of certain sectors • Development of other economic branches in certain regions, may lead to further depopulation and the under-utilization of natural resources • Huge dependence on imports, • Lack of public awareness on benefits of local products • Difficulties in accessing finance for farmers (loans)
North Macedonia	• Long tradition in agrifood • The agrifood sector is represented by functional associations and chambers of commerce that are active stakeholders in the development of policies. • Educational facilities in the field of agriculture and food industry; • Favourable agri-environmental potential, rich biodiversity • Extensive experience with traditional sustainable practices; • Presence of road infrastructure also to smaller settlements • Introduced ICT technologies is rural areas; • Increased investments in rural infrastructure & services • In EU accession process already strongly aligned with EU requirements	• Dual structure with many very small farms and small parcels with bad access to water and roads • Low level of education and skills • Depreciated equipment • Lack of own capital • Poor integration of food chains • Low productivity in agriculture • Low value-added products– • Undeveloped training and R&D • Inefficient irrigation water use • Constant trend of soil degradation, • Reduction of pastures and degradation of mountain pastures; • Rural population and labour force decline, • High dependence on agriculture and poor alternative job opportunities • Rural poverty, social exclusion, poor access and low service levels • Lack basic infrastructure (roads, water supply and sewerage);	• New technologies in agriculture, food • Increasing revenues and increasing domestic demand • Improved access to EU markets and penetration of alternative markets; • Increasing domestic financial support and EU support • Increasing foreign investments • Increased interest in establishing cooperatives • More added value products • Increasing environmental awareness; • Interest in applying agri-environmental practices & organic • EU support for diversification of economic activities, improvement of basic services in rural areas	• Loss of population & specialized labour • Increasing the cost of inputs • Reduction available land; • Increase production cost to meet food safety and environmental standards; • Increased competition in the domestic market; • Climate change & risks for natural disasters • Loss of biodiversity and increase of pollution due to intensification industrial activities, transport and tourism; • Disappearance of traditional and indigenous varieties and breeds. • No qualitied workforce • Increasing disparities between rural and urban areas

	Strength	Weakness	Opportunities	Threats
Serbia	• Diverse agri-climate zones, facilitating diverse agriculture, large land resource and good quality and structure of agricultural • Low labour cost • Growing organic production sector & availability of foreign markets • Large processing capacity and technologies for agrifood products • Existence of horizontal structures of association (Cooperative union, various associations, chambers • R&D and education infrastructure well developed for knowledge creation and transfer; • Relatively low environmental pollution • Richness of biodiversity and the existence of genetic resources; • Large biomass production also on unused lands (low ILUC) • Preservation of traditional knowledge and technologies; Solid state of infrastructure in some rural areas;	• Lack of agricultural infrastructure (field roads, irrigation, drainage); • Low quality inputs and land degradation • Small size of farms and parcels; • Small percentage of irrigated areas; • Insufficiently improved breeds, small number of livestock; • Unsatisfactory condition of equipment and machinery; • Unfavourable age and educational structure workforce; • Social status agricultural employees; • Low technological and knowledge level • Agricultural production and processing chain underdeveloped & aged • Adverse demographic trends; • Inactive labour market; • Adverse social structure; • Unused farm income diversification opportunities; Low infrastructure; • unclear land rights on unused lands	• Increase in integral and organic production • Livestock growth and revitalization of cattle and livestock production; • Increase investors' interest • Production of products with geographical origin and export growth potential; • Alignment of domestic legislation with EU standards, regulations, quality requirements • Increase in R&D and education • More private-public partnerships • Wider use of wide range of renewable energy sources • Intensifying regional cross-border cooperation; • Utilisation of the pre-accession period to increase competitiveness	• Incomplete restitution process; • Inadequate response to climate change – • Inefficiency of land management • Lack financial capital investments • Lack of labour and bad working conditions • Increasing competition and unpreparedness of the agro-industrial sector to trade liberalization • Political and economic instability in country, region and globally; • Further decline of standard of life and purchasing power • Insufficient "branding" and innovated range; • Gray economy and monopoly on processing and trade; • Lack of banking products • Increasing disparities between rural and urban areas • Standstill in EU integration

Table 2.4 Most promising biomass types from agriculture (in Kton dm/year) for developing biobased delivery chains

	Biomass 1	Biomass 2	Biomass 3	Biomass 4
Bulgaria	Straw (cereals, maize stover, sunflower)(6660)	Prunings permanent crops (7)	Manure (1020)	Agrofood residues (vegetable & fruit processing) (578)
Czech Republic	Straw (Cereal& OSR) (7031)	Manure (2740)	Agrofood residues (7031)	
Croatia	Straw (Cereal straw & maize stover) (1992)	Dedicated perennial crops (74)	Manure (960)	Agrofood residues (vegetable & fruit processing) (268)
Hungary	Straw (Cereal straw & corn stover) (9927)	Dedicated perennial crops (3885)	Manure (2160)	Agrofood residues (meat industry, fruit processing) (1144)
Slovenia	Manure (620)			
Slovakia	Straw (Cereal) (2104)	Agrofood residues (meat & vegetable & fruit processing) (309)	Manure (1100)	
Albania	Dedicated perennial crops (1072)	Manure (720)		
Greece	Manure (1860)	Straw (cereals, maize stover, sunflower, OSR) & permanent crop residues (2625)	Agrofood residues (596)	Dedicated perennial crops (1267)
Bosnia Herzegovina	Dedicated perennial crops (3810)			
Montenegro	Dedicated perennial crops (130)	Manure (120)		
North Macedonia	Dedicated perennial crops (791)			
Serbia	Straw (cereals, maize stover, sunflower, OSR) (4362)	Manure (2220)	Dedicated perennial crops (1723)	

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3 Characterisation of forestry sector in CELEBio countries

3.1 Primary forestry sector

Of all CELEBio countries, Czech Republic has by far the largest primary wood production (see Figure 3.1). It is more than three times the size of the second largest wood production in Serbia. The smallest primary wood production Greece, Albania, Montenegro and North Macedonia. At the same time Czech Republic is not the country with the largest forest area as Bulgaria and Greece have both 3.9 million hectares of forest (Tables 3.1 and 3.2). Czech Republic only has 2.7 million of hectares as practically all consists of planted forest and 74% of the forest is designated or production. Czech Republic is in the top 10 countries with highest share of production forest. This share is even higher for Albania and Montenegro, but these countries are small and have a small absolute forest area.

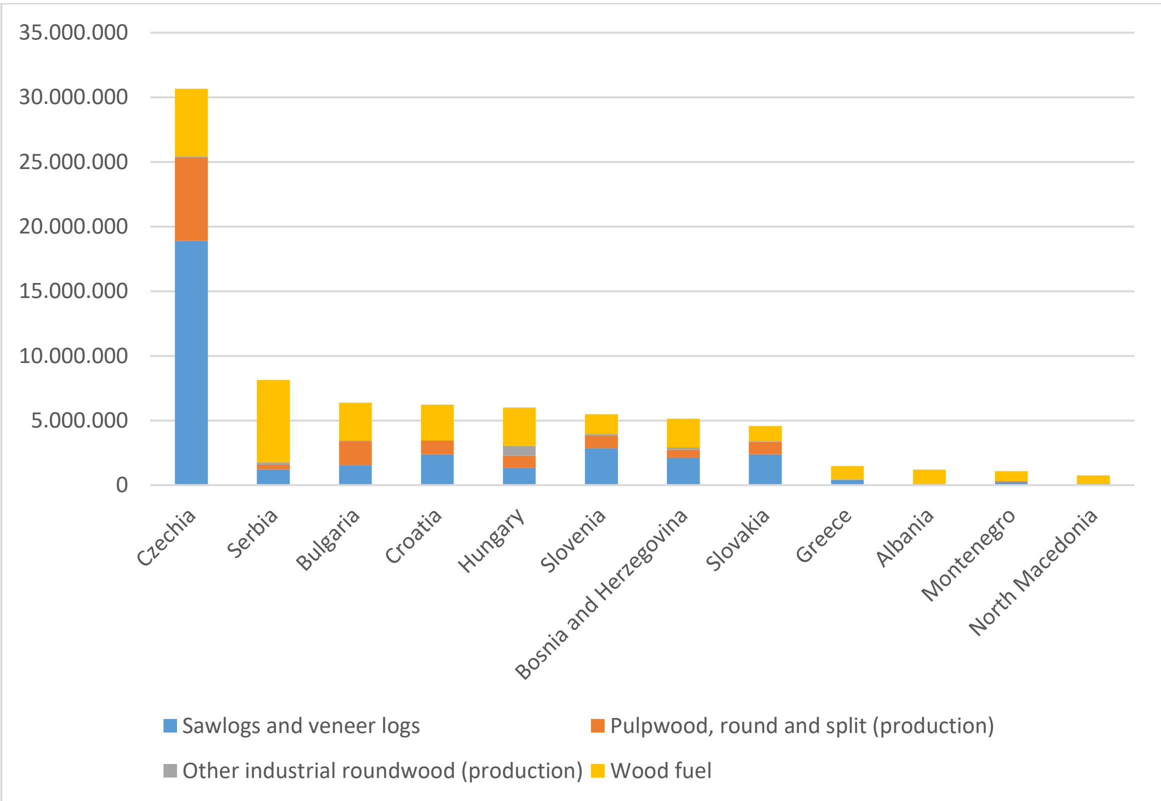

Figure 3.1 Primary wood production (M^3) (FAO data, 2019)

*Table 3.1 Overview of key forest sector characteristics per country of 6 CELEBio target countries (Note: Figures in this table may sometimes differ from the figures presented in the separate CELEBio country reports because these are mostly based on the most recent FAO Forest resources assessment report published in 2020***)**

		CELEBio focus countries					
Category	**Unit**	**Bulgaria**	**Czech Republic**	**Croatia**	**Hungary**	**Slovakia**	**Slovenia**
Population	*Million inhabitants*	7.1	10.6	4.1	9.8	5.4	2.1
Area (total)	*million ha (2018)*	11	8	6	9	5	2
Forest area*	*million ha (2020)**	3.893	2.677	1.939	2.053	1.926	1.238
Net annual change	*Average %/year for period 2010-2020**	0.41	0.07	0.10	0.03	0.04	-0.07
% forest area	*% forest/total area*	35%	33%	32%	23%	39%	62%
Forest area per capita	*ha/capita(2020)*	0.55	0.25	0.47	0.21	0.36	0.59
% primary forest sector contributing to GDP	*2012***	1.0%	0.5%	1.5%	0.9%	2.4%	1.8%
% employment in primary forestry of total employment	*2012***	1.4%	1.3%	2.1%	1.3%	2.2%	2.4%
% forest designated for production	*% of forest area**	39%	74%	69%	60%	23%	47%
% forest in public ownership	*% of total forest area**	88%	76%	71%	57%	48%	23%
Naturally regenerating forest*	*million ha (2020)**	3.116	0.138	1.871	1.264	1.177	1.192
Annual increment in naturally regenerating forest*	*Average %/year for period 2010-2020**	0.65	4.61	1.07	0.09	0.10	-0.02
Planted forest*	*million ha (2020)**	0.777	2.539	0.069	0.789	0.749	0.046
Annual increment in planted forest*	*Average %/year for period 2010-2020**	-0.5	-0.12	-0.87	-0.06	0.10	-3.78

**FAO Global forest resources assessment 2020*

*** FAO, 2012: http://www.fao.org/3/a-i4248e.pdf*

*Table 3.2 Overview of key forest sector characteristics per country of 6 CELEBio neighbouring countries (Note: Figures in this table may sometimes differ from the figures presented in the separate CELEBio country reports because these are mostly based on the most recent FAO Forest resources assessment report published in 2020***)**

		CELEBio neighbouring countries					
Category	**Unit**	**Albania**	**Bosnia and Herzegovina**	**Greece**	**Montenegro**	**North Macedonia**	**Serbia (excl Kosovo and Metohija)**
Population	*million (2018)*	2.9	3.5	10.7	0.62	2.1	7.0
Area (total)	*million ha (2018)*	2.7	5.1	13.2	1.38	2.6	7.8
Forest area	*million ha (2020)**	0.789	2.188	3.902	0.827	1.001	2.723
Net annual change	*Average %/year for period 2010-2020***	0.09	0.40	0.81	0.00	0.42	0.04
% forest area	*% forest/total area*	29%	43%	30%	60%	39%	35%
Forest area per capita	*Average %/year for period 2010-2020*	0.27	0.63	0.36	1.33	0.48	0.39
% primary forest sector contributing to GDP	*2012****	0.7%	1.6%	0.4%	0.5%	n.a.	1.1%
% employment in primary forestry of total employment	*2012****	0.2%	0.9%	0.6%	0.6%	n.a.	0.9%
% forest designated for production	*% of forest area**	80%	n.a.	n.a.	82%	n.a.	66%
% forest in public ownership	*% of total forest area**	97%	n.a.	n.a.	52%	89%	43%
Naturally regenerating forest*	*% forest/total area**	n.a.	n.a.	3.763	0.819	n.a.	2.607
Annual increment in naturally regenerating forest*	*ha/capita(2016)**	n.a.	n.a.	0.81	0.00	n.a.	0.29
Planted forest*	*million ha (2020)**	n.a.	n.a.	0.139	0.008	n.a.	0.116
Annual increment in planted forest*	*Average %/year for period 2010-2020**	n.a.	n.a.	0.00	0.00	n.a.	-4.33

**FAO Global forest resources assessment 2020*

***Refers to 2010-2020 average except for Greece where it refers to 2000-2010 period*

**** FAO, 2012: http://www.fao.org/3/a-i4248e.pdf*

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The countries with the lowest share of forest area designated for production are Bulgaria and Slovakia. In countries like Bosnia and Herzegovina, Greece and North Macedonia this share is expected to be even lower, but official figures on this are not reported. Striking is also that Greece has the largest forest area in absolute terms of all CELEBio countries but is among the 4 countries with the lowest primary forest production (Figure 3.1 and Table 3.2). We can conclude therefore that it is certainly the country with the largest unexploited forest potential.

Also, the quality of the primary wood production is high in Czech Republic as the largest production share consists of saw and veneer logs production (Figure 3.1). In practically all other countries, with the exception of Slovenia and Slovakia, pulpwood and wood fuel production dominate.

The relative forest area share is by far the highest in Slovenia and Montenegro with respectively 62% and 60% of their territory covered by forest. In Montenegro the share of forest designated for production is also extremely high with 82% and in Slovenia this is more modest to 47%. The net annual increment of the forests in both countries is practically zero. All these factors illustrate forestry is a very important economic sector in these two countries and that it is also a growing sector removing in the 2010-2020 period as much biomass from their forest as is produced.

In Czechia in the last 50 years the forest area grew by 3%. Still it only accounts for 0.5% of the Czech GDP and 1.3% of employment. In other countries the contribution of the forest sector to the GDP is mostly higher ranging from 2.4% in Slovakia to 0,4% in Greece (Tables 3.1 and 3.2). Also, in terms of employment this sector can be quite important in some countries such as in Slovenia (2.4%), Slovakia (2.2%), Croatia (2.1%) while it is very small in Albania, Greece and Montenegro.

Lately in Czechia particularly this sector is also encountering important challenges which are related to climate change and the large-scale recent infestations by the bark beetle. In 2018 this led to a 33% higher logging ratio then the year before of 25.7 mil. m^3 of wood. Around 90% of this harvest was salvage felling (See Country report for Czech Republic). The infestation continues and is not expected to be easily stopped. Because of it the price of round timber decreased because of excess supply and decreased quality in recent years.

The negative effects of the bark beetle infestation are large in Czech Republic because of high concentration of spruce forests in combination with climate change effects on temperature and extreme whether events. It is of course also a problem in other CELEBio countries, but particularly Czech Republic is heavily affected where the area covered with coniferous species, particularly Norwegian Spruce, is very high and production of saw and veneer logs is dominant which is more sensitive to good quality trees.

The countries with the largest absolute and relative share of naturally regenerating forest are Bulgaria, Croatia, Greece and Serbia. In Bulgaria this share is at 80% of the forest area and in the other it is even more then 95%. In these countries active forest management is limited, with relatively small primary forest production, leading to a high net annual increment in wood. Exceptions are however Serbia and Montenegro where the annual increment remains very low. This is because production forests are mostly overlapping with the naturally regenerating forests in these countries.

It is also obvious to see that state (public) ownership of forests is very common in most of the CELEBio countries. Albania has by far the highest share with 97%, followed by North Macedonia (89%) and Bulgaria (88%). The only countries where less than half of the forest area is still in public ownership are Slovenia, Slovakia and Serbia, which goes together with most of the forest spread over a large number of small forest owners. This makes the exploitation of forest biomass more challenging.

The CELEBio country with the smallest forest exploitation opportunities is Albania. It is the country with the smallest forest area of all CELEBio countries and at the same time the exploitation of Albanian forests has reached dramatic levels in recent years. As explained in the CELEBio country report for Albania (Karampinis, 2020b) the European Environmental Agency performed a study and showed that the forest utilization rate (annual fellings as a percentage of annual increment) in Albania were consistently higher than 200% since the 1990s, compared to the suggested rate of 70%. In 2005 the utilization rate was 550%, while in 2010 it was 440%. Very few hectares (around 400 thousand hectares) of true forests remain in Albania, while the rest have been transformed into low forests, bushes and barren land. Because of this the importance of forests in Albania's economy has declined since the 1990s, with the share of employment in the total workforce dropping to 0.2% from 4.7% in 1990. This situation made the Albanian government to impose in 2016 a national moratorium on forest logging operations, effectively banning the exporting of roundwood and forcing wood processing companies to rely mostly on imported wood. An exception is granted for the harvesting of firewood for the use of local populations, which anyway corresponded to the majority of fellings in Albania. Reforestation and sustainable forest management awareness raising, and replanting projects are now the main focus.

The forest production situation in Greece is also most exceptional in that it is the country with the largest forest area of all 12 countries (3902 million hectares) and at the same time also practically having the lowest primary forest production of all. The direct economic impact is therefore limited to only 0.2% of the national GDP. Furthermore, forest production has been steadily declining in the last three decades. Indicative is the fact that 2,979 thousand cubic meters of felling were recorded in 1990, decreasing to 50% after 20 years. Currently, roundwood removal is mostly geared towards the production of firewood (and charcoal), with industrial roundwood being a minority in total removals.

Not surprisingly, in Greece a new National Forest Strategy was adopted in 2018 for the next 20 years period, aiming to increase the forests' contribution to the GDP to 1%. Experts think however this may become challenging for several reasons as Karampinis (2020) indicates in the CELEBio country report for Greece. Firstly, because the updating, publication and approval of forest maps is a major work that is coordinated by the Hellenic Cadastre (land registry); up to now, 55% of the country has been covered, however the process is facing numerous legal issues and challenges. Secondly, most of the Greek forests are located in mountainous areas at altitudes of 600-1200 m and with steep slopes which makes forest operations inefficient often using lumberjacks and mules for transportation. Thirdly, forest

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fires have become a major issue for the preservation of Greek forests, affecting 0.57% of their total area.

Firewood/wood fuel production in many of the neighbouring CELEBio countries is large but it should be made clear that what is presented in Figure 3.1 in terms of wood fuel volumes is likely to be an underestimation. This is due to the lack of a reliable recording of firewood production. In Serbia for example the statistically recorded production of firewood was almost five times lower than real production as was concluded in a FAO project implemented in Serbia in the period 2009-2011[2] .

3.2 Forest industries

Given the large primary forest production it is also to be expected that the forest processing industry is largest in Czech Republic followed by Serbia, Bulgaria, Croatia and Hungary. However, this is not entirely the case as is shown in Figure 3.2. Czechia is the largest, followed by Croatia, Serbia, Slovakia and Hungary. This implies that particularly Croatia, Slovakia, Slovenia and Hungary have a well-developed forest processing industry and are therefore able to add more value to their forest products. This is not the case for Serbia for example where most of the primary forest production goes straight to fuel wood and little is processed locally in secondary products. The only secondary processing activity that is quite large in Serbia is paper production which is displayed in Figure 3.3 separately. What is also striking in that figure is that Croatia produces relatively little paper and cardboard, certainly as compared to other secondary wood products.

Still, the forest processing industries in all CELEBio countries remain relatively small. This is also the case for Czechia where timber-processing capacity is far below the primary production of wood products. This is because at least one third of primary wood production is exported directly as round and pulpwood, sawn wood and wood chips (see Figure 3.4). This also applies particularly to countries like Croatia, Slovakia, Slovenia where half or more of the roundwood and sawn wood produced is directly exported. These countries are also important producers and exporters of wood chips and particles and overall, together with Czechia they are the countries that export relatively large amounts of their forest products. Countries like Bulgaria and Hungary are able to add more value to the forest products before exporting them such as in plywood, OSB and fibre boards, their export volumes are much smaller though. Bosnia and Herzegovina, Serbia and Montenegro export only forest products of low added value such as sawn wood and wood fuel directly.

[2] Ocena tržišta drvnih goriva i uredjaja na čvrsta goriva za grejanje i kuvanje u Srbiji, GIZ DKTI Održivo tržište bioenergije u Srbiji, E4tech, juli 2017., http://www.bioenergy-serbia.rs/images/documents/studies/2017_market_of_wood_fuels__appliances_in_Serbia_srp_final.pdf

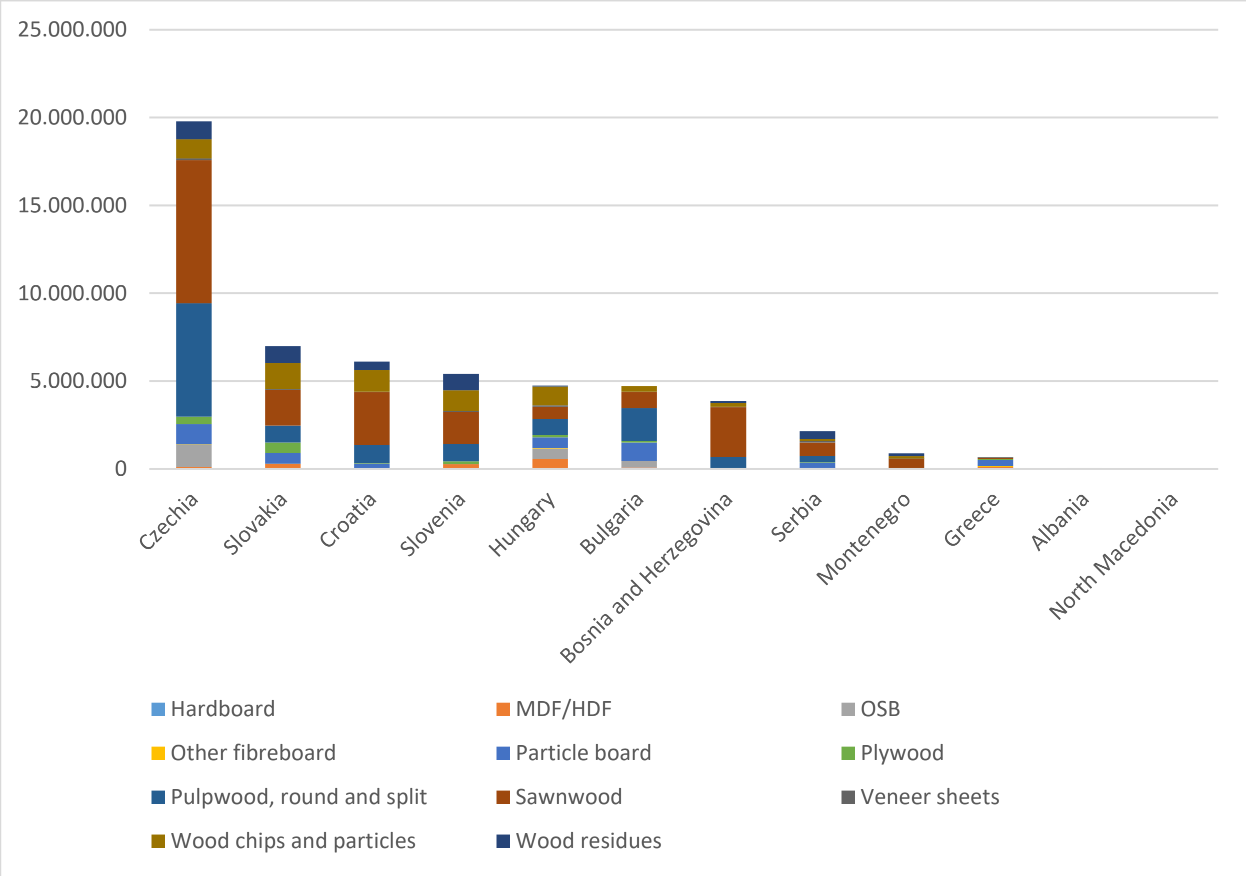

Figure 3.2 Wood processing (M3) (FAO data, 2019)

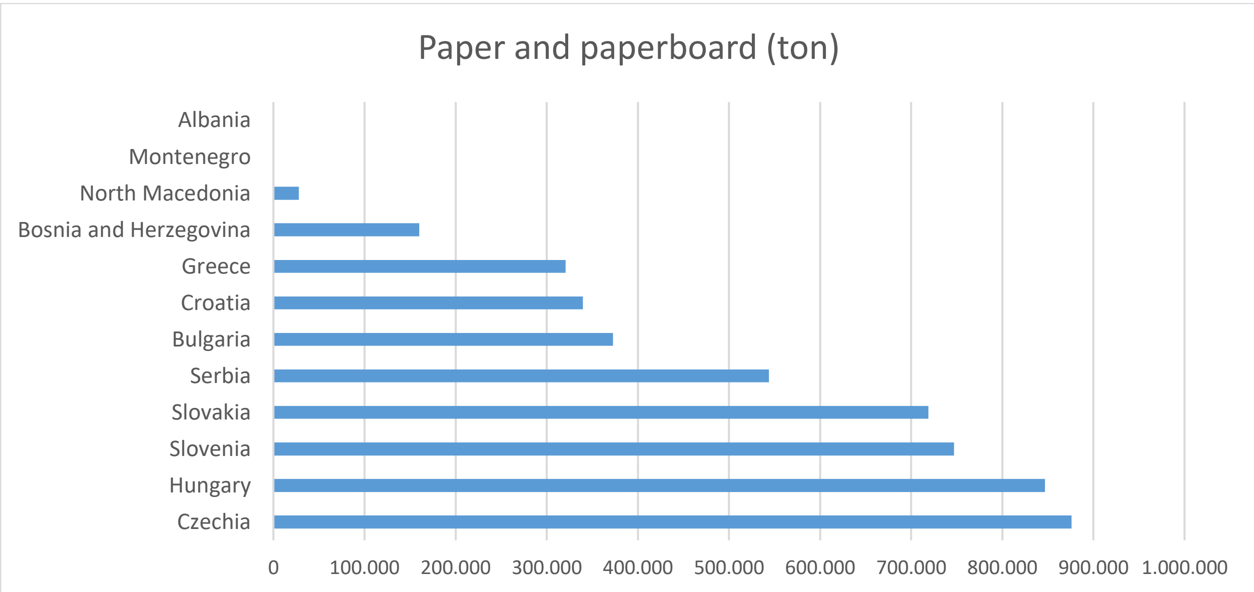

Figure 3.3 Paper and cardboard production (ton) in CELEBio countries

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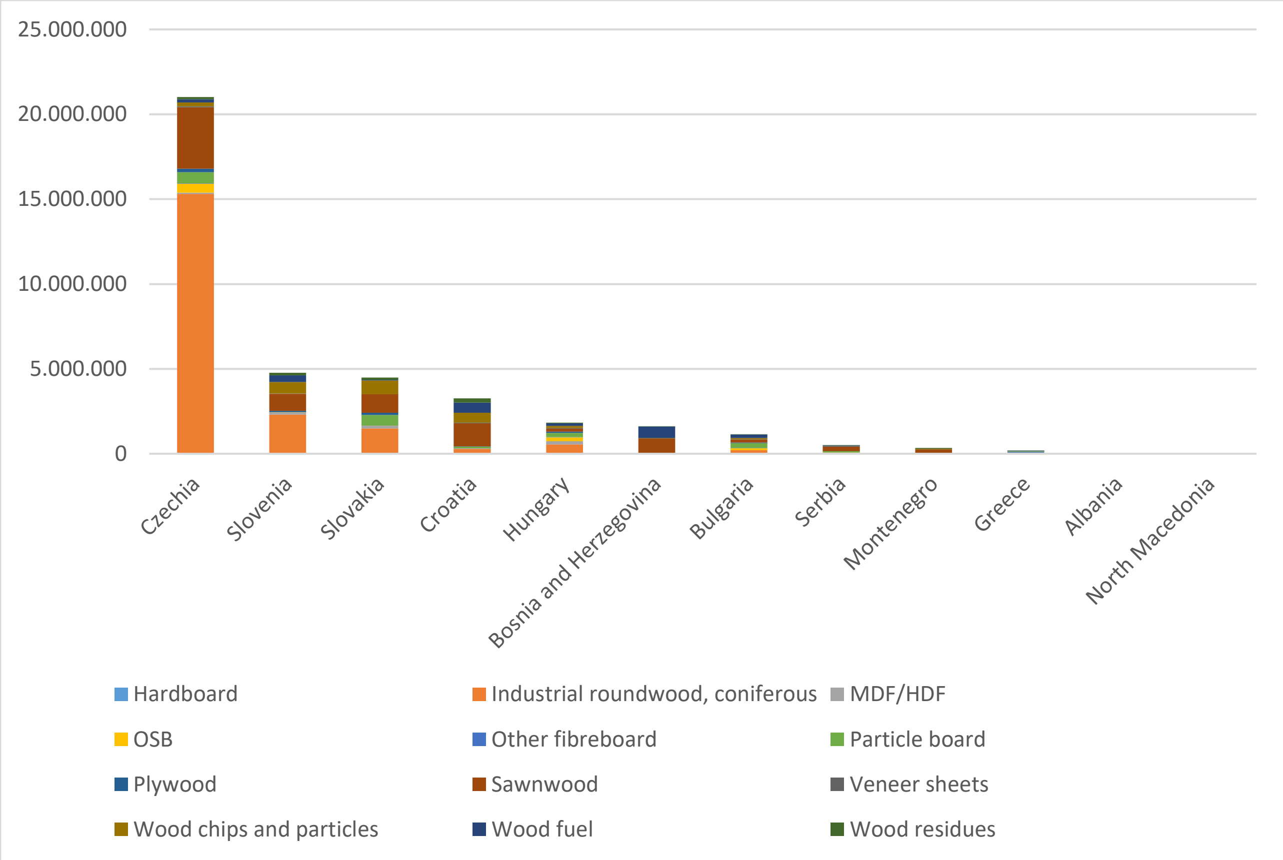

Figure 3.4 Export volumes and types of forest products for CELEBio countries

In addition to the secondary wood processing activities presented in former graphs there is also quite some wood furniture industrial activities in many of the CELEBio countries, such as in Serbia, Croatia and Bosnia and Herzegovina. Detailed figures about the size of this industry are difficult to find, but some information is available in the country reports.

3.3 Biomass potential from forestry for BBE

Given the importance of the forestry sector in many of the CELEBio countries there must also be large quantities of residual biomass sources generated. In Figure 3.5 an overview is presented of the primary and secondary residues produced in the primary collection of wood biomass from forest and as secondary products in the wood processing activities.

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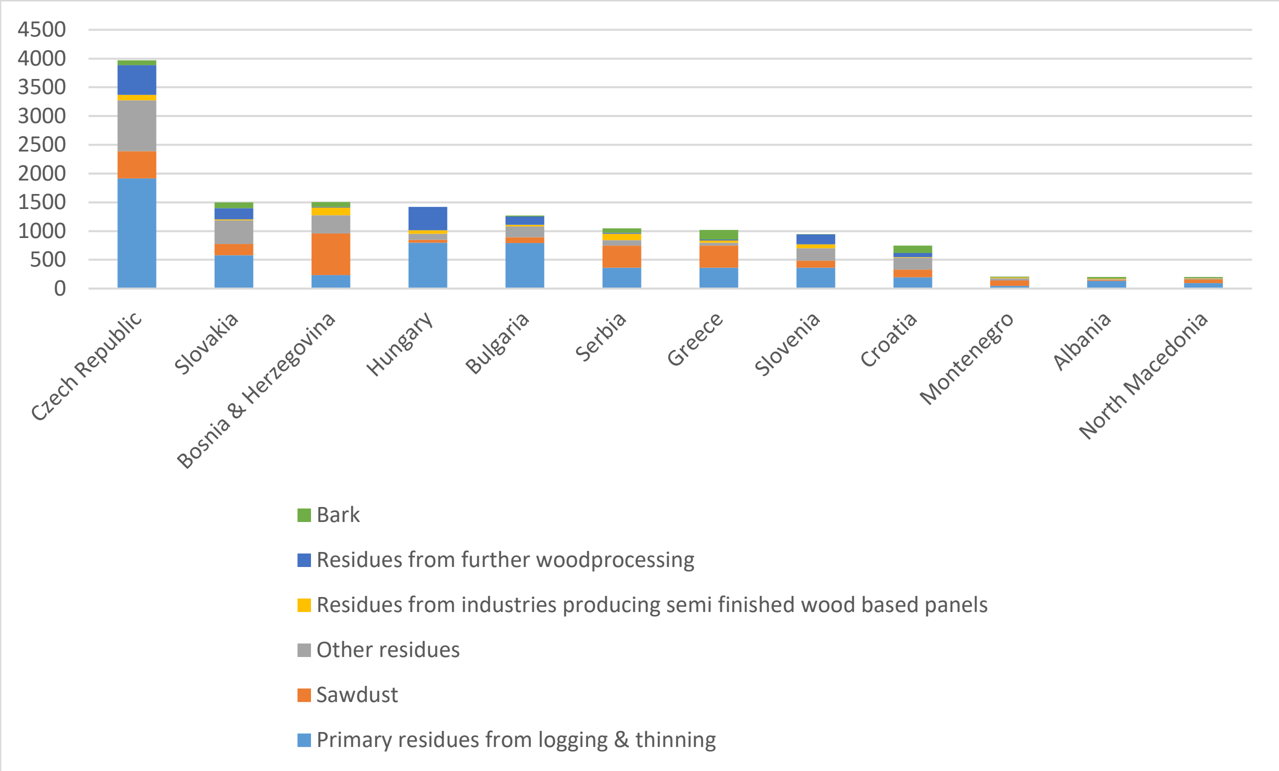

Figure 3.5 Residual biomass from primary and secondary forestry sources, expressed in Kton dm/year (Source: S2BIOM potential data 2020, CELEBio country report data).

Note: Bark data for Hungary not available.

The overview of residual biomass sources is mostly based on S2BIOM baseline potential assessments. It is not known for these sources whether and how they are used currently. What we do know is that large amounts of primary residues from forest largely remain in the forest, although this will depend on the location. The potential presented for primary residues refers to the potential that can sustainably be removed from the forest as was assessed by the EFISCEN model using national forestry inventory data as an input and taking account of spatially explicit data on terrain, soil, climate, forest roads and protected forests data (see Annex III). The secondary forestry residues from sawmills and wood processing industries build on the potentials assessed in EUWood and S2BIOM in combination with some updated data from national sources.

Overall, the primary residues are not the best quality biomass as it consists of stem and crown biomass with relatively high bark contents and generally high ash content. As long as there is no well-developed market demand for this biomass it is not economical to remove it from the forest. Furthermore, as with straw removal in agricultural soils, it is important to follow maximum sustainable removal rates that ensure maintenance of nutrients and corban in the soil and provide enough food and shelter to biodiversity. The primary residue potential presented in Figure 3.5 can therefore expected to be largely unused at this moment.

Wood processing by-products as presented in Figure 3.5 can be expected to be mostly already utilized for energy production, either in-house or sold as such or after upgrading into pellets as wood fuel. However, whether this use is the most efficient from a climate and or economic perspective is to be challenged. It is therefore certainly a group of forestry residues for which the optimal use options could still be further reviewed. Interesting examples of this were presented in the Czech country report for bark which is already used to produce dyes, resins, flavorings, and medicinal products from. Bark is also commonly used in mulching or as a soil amendment or in building materials such as fibre, chip board or insulation board. Also, pellets are made in almost all CELEBio countries from secondary residues, e.g. sawdust or residues from other wood processing activities. To make the process more circular the remaining ash when the pellets are burned can be used as fertilizer.

The potentials presented in Figure 3.5 show interesting quantities of primary residues, particularly in Czechia, Slovakia, Bulgaria and Hungary. Sawdust production is particularly large in Czechia, Bosnia and Herzegovina, Serbia and Greece. In these countries the sawn wood production and processing of wood products also based on imported wood is large producing these amounts of sawdust. The latter particularly applies to the Greek situation where domestic industrial roundwood production is very small, or not meeting the right quality. In the CELEBio country report for Greece (Karampinis, 2020) it is reported that wood imports amounted to 65 million EUR a year.

It should be mentioned that the data presented in Figure 3.5 give some indication of the available residual wood potentials but should still be interpreted with care simply because these type of data are not or in-completely registered in most countries.

A residue not included in Figure 3.5, because of inconsistent and incomplete information availability is black liquor a residue from the pulp and paper industry. This residue is usually used as an important source of energy used for the mill where it is produced. From the size of the paper and cardboard production presented in Figure 3.3. is can be concluded that the largest amount of black liquor is produced in Czech Republic, Hungary, Slovenia, Slovakia, Serbia and Bulgaria. The use of black liquor for own energy needs in pulp and paper mills is logical, but options could be invested to add more value to this residue by using it for generation of advanced biofuels for example. This, however, should not lead to an increase in fossil energy use in paper and pulp industries however, so other renewable energy sources should be available first before making this switch.

3.4 SWOT for characteristics of agricultural and forestry sectors

From the former the diverse character of the forestry sectors in the 12 CELEBio countries became clear. In this section the types of biomass potentials that can be mobilised further in terms of valorisation in the BBE and a final summary of the SWOT is presented. The selection of the most interesting forest biomass sources is presented in Table 3.4. In practically all countries the primary forestry residues could be further mobilised, except in Albania and Greece. In Albania the forest resource should entirely be focused on reforestation and harvesting of forest biomass is no priority on the short run. In Greece, the country with the largest forest area, but almost the smallest industrial roundwood production. The large majority of the forests are not maintained nor exploited. The forest processing sector relies strongly on imported wood. The most interesting sources of forest biomass to be further mobilised are therefore thinning from unmanaged forests to bring them back in production and increase the biomass development in these forests and develop long term sustainable exploitation where this is an option. The other source would be secondary forestry residues from the processing industries that rely strongly on imported wood sources but do generate residual biomass. It should be reviewed where further optimal use of these resources can be created from a GHG mitigation, carbon capture and economic added value perspective.

What also becomes clear is that increasing the added value in the forest sector, which implies that investments should be made to further process own harvested forest resources rather than exporting them only as roundwood or sawn wood.

Another challenging aspect is the large exploitation of forest resources for fuelwood. This practice is often badly monitored and often leads to rather sub-optimal uses of wood resources in terms of GHG mitigation, carbon capture, air pollution and economic added value. More coordination in the exploitation for fuel wood and also addressing access to de-central efficient heat and power installations at the same time is needed in many of the CELEBio target countries. This particularly applies to those countries in the neighbouring countries group.

In all CELEBio countries, with the only exception of Albania, further mobilisation of forest resources from primary residues and thinning, from the wood processing and paper industry for supply to new biobased industry activities should be possible.

Table 3.1 SWOT factors forestry sector

	Strength	Weakness	Opportunities	Threats
Bulgaria	• Large forest area publicly owned which ensures sustainable management • Long tradition in forest management • Availability of 10-years local/regional forest plans, good planning of biomass flow balance, • Possibilities for additional mobilisation of primary forest resources • Forest processing industry is growing and leads to more secondary forestry residues • Well-developed industry for glued boards and chipboard, pulp, paper • High percentage of firewood in energy balance	• Short and vertical value chains • Illegal logging and harvesting • Inefficient utilisation of firewood for heating • Attitudes and ambitions of investors towards wood for electricity instead of production of efficient solid fuels, heat & bioproducts • Unsustainable wood harvesting due to the energy poverty (in rural areas and even in the larger cities) • Inefficient burning of wet firewood in primitive stoves and high emissions of PM • Difficult access certain forest areas on steep slopes, lack forest roads • Insufficient human resources for exploitation of forest resources	• Mobilisation of unused biomass for future bio-based materials production • Development of new bio-based products on lignocellulosic base • Biomass production for low ILUC biofuels • Add more value to current forest products	• Climate change - erosion of forest terrains, probability for fire occurrences, insects infestation threat) • Concerns for overharvesting • Primary (unprocessed) wood export to Turkey and Greece
Czech Republic	• Strong tradition of forestry management • Monitoring and surveillance of forest status in place	• Customer demand and appreciation for wood products is low • Labor force in forestry is depleted • Low level of in-country processing of wood and timber products – processing is exported	• Much under-utilized wood biomass • Relatively open market for wood product development • Lack of competition of novel technological solutions to the forestry-derived products and service • Establish local sawmills and collective wood and timber processing centres in country	• Climate change effects lead to increasing drought and mild winters • Weak containment of the bark beetle • Lack of urgency in prioritizing forestry as a potential industry • Decrease ground water due to current agricultural practices, leading to the forest drying

	Strength	Weakness	Opportunities	Threats
Croatia	• Long tradition in forestry and wood processing • Sustainable management of most forests (150 wood processing companies have FSC COCs) • Skilled and qualified workforce • Large state-owned forest • Knowledge of cascading use • Significant additional mobilisation of primary forest resources possible and planned • Forest processing industry is growing and leads to more secondary forestry residues	• Short and vertical value chain • Inconsistent forest potential statistics and lack of data needed for planning & monitoring • Lack of industry for glued boards and chipboard, pulp, paper… • High percentage of firewood in energy balance • Lack of bio-hubs for storage, pre-treatment and processing • Poor management of private forests	• Mobilisation of unused biomass • Development of new bio-based products on lignocellulosic base • Private forest owners can mobilise resources • Biomass production for low ILUC biofuels	• Climate changes effects lead to more forest fires, drought, prolonged vegetation season, more diseases and pests • Energy poverty leads to unsustainable management of private forests
Hungary	• New Forestry Act • Biomass increase in forests and growth in forest production • Wood-based industries with high capacity present • Long expertise forest industry • Worker training and engineer education, R&D in forestry skills • Efficient heat and electricity appliances in the market • Clarified legal and ownership system • Opportunities for further mobilisation of biomass from forest	• Low harvest levels in forests • Difficulty in forest biomass harvesting • Fragmented ownership distribution • Transport, road network not well developed and expensive • Lack of decentralized smaller power plants • Fossil alternatives for fuels cheap • High demand for equipment and machinery	• Public support for the use of biomass in BBE • Stable internal market • Available regulations for productions and the market • Reduce soil erosion • More employment opportunities • Low interest rates of loan (good CAPEX possibility)	• Climate change leading to more drought and pests • Biomass is not competitive with other sectors • Investor interested in biggest investments • General organic matter deficiency in soils • Additional land use might lead to in- direct land use changes, in worst case to deforestations
Slovenia	• Forestry abundance (58 % of surface is covered by forest) • Good accessibility (forest roads) • Availability of up-to-date data on forests (Slovenian Forest Service, Slovenian Forestry Institute, WoodChainManager) and strong support at sustainable management of forests	• High dispersion and fragmentation of forest ownership hampering devoted management • Extensive export of wood instead of creating high value-added products within the county	• Development of innovative and high-added value products • Job creation • Consolidation of local markets • Increased competitiveness of the country	• Lack of owners' willingness to mobilise forest feedstock

	Strength	Weakness	Opportunities	Threats
Slovakia	• Large woody biomass potential from forests, landscape elements and forest with a multifunctional use • Large state forest area aimed at protection • Non-state forest owners own up to 52.3% and are well organised and manage forest efficiently • Dynamic development in BBE and well connected in EU networks • National Forest Centre is a powerful instrument in the national forest management,	• Strong political involvement in forestry management • The inability to diversify goods and add value to forest products • Insufficient and unsystematic funding • A high proportion of adult and old forests, which are much more vulnerable to pests and diseases, than the young ones. • Lack of processing capacity for highest quality coniferous and hardwood round sorbents. • Illegal logging • Fragmentation forest ownership	• Increasing demand for forestry products • Support through RDP • External financial resources • New legislation (explicit division into state and non-state forests) • Investment in applied forestry and timber research • Increasing share of renewable energy sources (RES) from forestry in RES & R&D • The development of rural business activities in new value chains in circular bioeconomy	• Negative persistent public view of foresters • NGOs and forest sector conflicts • Governance not optimal • Lack of financial resources from the state, • Slow solution to the fragmentation of forest ownership • Demanding bureaucratic barrier for access to EU funds • Economic restriction by nature protection without financial compensation • Low law enforcement • Climate change threats
Greece	• Large forest area	• Difficult terrain for operations • Outdated harvesting methods • Limited funding allocated to forestry sector • Largely state forest, but no resources or action to mobilise forest resources better	• Drafting of new management plans for forests • New forest strategy • Extraction of biomass as a way of reducing risk of forest fires	• Illegal logging operations • Competition from neighbouring countries in the wood supply sector • Public opposition against major forest-based economic activities
Albania	• Some past tradition in forest sector	• Difficult terrain • Lack of infrastructure (e.g. forest roads) and machinery • Very small share of forest sector in the GDP • Focus on extraction of firewood	• Reforestation projects • Revitalization of rural settlements through forest management schemes	• Massive deforestation through very high utilization • Continuation of illegal loggings • Additional loss of forest areas through wildfires

	Strength	Weakness	Opportunities	Threats
Bosnia and Herzegovina	• Forestry abundance large (unused) production potential • Competitive advantages for exploitations of biomass (land, forest, climate, etc.) • Relatively good accessibility (forest roads) • Very close perspective of promotional measures for bioenergy production and use.	• Lack of cross-sectoral communication, collaboration, professional education • Non-adequate system of actual data management regarding to forests and forestry • Non-adequate forest management • Lack of transparency in biomass market • Challenging logistics for collecting and transporting biomass to pre-processing centres • Large unmanaged forest area • Ownership of forest land unclear	• Development of innovative and high-added value products • Rural development and employment opportunities in BBE • Consolidation of local markets • Increased competitiveness of the country • Development of ESCO companies or other forms of the PPP • Options for biomass logistics and trade centers Transfer of knowledge and technologies in agricultural production • Technical and technological modernization options	• Unsystematic and unsustainable exploitation of forests • Lacking investment in rural areas • Non-implementation of legislation • Missing communication with other sectors • Lack of owners' willingness to mobilise forest feedstock • Low level of R&D and technological development • Some big biomass consumers (DHS) and disturbance on the market
Montenegro	• Significant biomass potential from relatively large forest area • Accessibility of unused land for fast-growing plantations • Decrease in CO2 emissions, • Support of development of forestry and wood-processing industry, • Generation of significant amount of energy from RES, • Generating energy surplus • Proximity to raw materials • Availability of medium and high skilled labor force • Excellent wood quality	• Unclear ownership structure • Lack of research for BBE uses • Poorly developed forestry and wood-processing industry • Lack of own financial resources and investors • Lack of regulatory stimulation, • Lack of knowledge and public information about energy potential of biomass and opportunities & threats • Low level of processing • Obsolete technology • Little diversity of products	• Improving energy stability, • Direct replacement for fossil fuels, • Export of energy, • Increase of national product: • New employment options • Development of local businesses • Use of investment from Kyoto protocol • Market proximity	• Fossil fuel might be cheaper • Intensive energy generation from: sun, wind or geo potential • No conducive concession system • Poor road infrastructure for transport
North Macedonia	• Closeness and connection to European borders and markets • Favourable climatic conditions • Productive and prosperous SMEs • Human resources • Existence of economic zones	• Underdeveloped infrastructure • Insufficient utilization of natural resources • Fragmentation of forest ownership • Brain drain • Insufficient education • Lack of direct investment & adverse financial environment	• Opportunities for new economic zones • Possibility of regional infrastructure connectivity • Rural development opportunities • New income opportunities	• Threat to environment - large industries that would pollute, • Globalization and market liberalization threaten domestic production as it is not yet ready for new competition • Outflow of human resources • Lack of own energy sources

	Strength	Weakness	Opportunities	Threats
	• Commitment of municipalities to common economic development • Developed civil sector • Brands from Southeast Region • Euroregion of the Balkan area and one of the very few Euroregion composed of European member states (Greece and Bulgaria) and non-member states	• Grey economy • Significant share of old low-stemmed forests; • High risk of damage to forests from natural disasters;	• Opportunity to access foreign markets	
Serbia	• Enough forest cover to meets domestic needs • Principle of sustainability and multifunctionality in forest management is respected • Favorable ownership structure • Continuity in the supply of the wood market, with slight growth. • Long-term opportunities to increase the raw material potential for wood processing. • The privatization process in the wood processing sector is completed. • A large number of companies and entrepreneurs. • Skilled workforce (tradition, experience, knowledge). Developed network of educational institutions. • Increase in exports of wood products. • Employment opportunities • Production of energy from renewable sources. • System of certification of forests and a chain of supervision (COC) in state-owned forests is applied in a significant number of wood processing companies.	• Unmanaged forest, insufficient exploitation of valuable roundwood. • Insufficiently known condition of forests and extent of felling in private forests. • Low representation of technical roundwood in sales. • Dispersed ownership over small contractors, without technical capacity • Fragmentation of production • Low added value in forest processing & export • Unrecorded employment in certain activities. • Inadequate spatial distribution of wood processing plants • Too many primary processing with high demand for rough log. • Private forest owners' associations are not present on the market. • Insufficient control, strategic planning of wood flows by state authorities. • Lack of strict forest management & control • Low know how, R&D, Technical capacity	• Forest richness & biodiversity • Increasing forest biomass. • Development of domestic wood industry demand for wood • Development of BBE sector • Non-wood forest products • Positive ecological effects reduction of the GHG • Economic and rural development, jobs, diversification • Sustainable forest biomass production • Organizing private forest owners • Certification of private forests. • Increased budget to improve the condition of forests. • Establishment and development of new partnerships in sector. • Strengthening competitiveness in the international market. • Changes and adjustments of the personnel education	• Decreasing roundwood and increase of firewood production. • Decrease in the value of total income from forest use. • The impact of the economic crisis on business. • Increase in undeclared employment. • Inadequate qualitative structure of employees • Large number of employees with minimum wages • Insufficient cross-sectoral cooperation • Lack of an integrated information system • Economic policy measures are not adjusted to more dynamic development. • Impossibility of processing rough log due to the lack of local processing capacities. • More competition • Insufficient effects of budget support for work on improving the condition of forests due to reduced benefits.

Table 3.2 Most promising biomass types from forestry

	Biomass 1	Biomass 2	Biomass 3
Bulgaria	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor
Czech Republic	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor
Croatia	Primary residues from thinnings & logging	Secondary residues from wood processing industry	
Hungary	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor
Slovenia	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor
Slovakia	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor
Albania	None		
Greece	Thinnings from unmanaged forests (coppices)	Secondary residues from wood processing industry	Black liquor
Bosnia and Herzegovina	Secondary residues from wood processing industry	Secondary residues from wood processing industry	
Montenegro	Primary residues from thinnings & logging	Secondary residues from wood processing industry	
North Macedonia	Secondary residues from wood processing industry		
Serbia	Primary residues from thinnings & logging	Secondary residues from wood processing industry	Black liquor

4 Characterisation of waste sector in CELEBio countries

4.1 Characterisation of current waste sector

In the CELEBio countries waste production and treatment levels differ strongly as becomes clear from the key waste characterisation figures in Table 4.1. Total waste production per head amounts to 1,826 kg/head/yr in the EU-28, but only amounts to 458 kg/head/yr in North Macedonia to 3,097 kg/head/yr in Bulgaria. This is a large difference but may also be related to incomplete registration of waste generation in North Macedonia because not all waste is collected via official waste management and/or registered. As to waste generated by households the average EU-28 level amounts to 0.42 tonnes/head/yr. The lowest levels per head is registered at 0.09 for Bosnia and Herzegovina and at 1.32 tonnes/head/yr for Greece. Again, this large difference may be related to incomplete registration levels particularly in Bosnia and Herzegovina. But at the same time, it does tell us that waste generation levels in Greece are very high.

The incomplete registration of waste generation figures in North Macedonia is confirmed by the report on current waste deposition in the CELEBio country report. It tells us that there are 55 active landfills without any permit, but only Drisla landfill (serving the Skopje Region) is well managed and has a working permit. It is estimated that the number of illegal landfills (dumpsites), especially in rural municipalities, is about 1 000. Regional integrated management of municipal solid waste is planned to be established in the upcoming period. Seven regional landfills are planned for the territory of N. Macedonia. The total amount of municipal solid waste in N. Macedonia reaches 700 thousand tons per year, of which around 200 thousand tons belong to the regional landfill Drisla, and the other regional landfills make 50 - 100 thousand tons for which waste deposition levels are likely not to be registered at this moment.

Also, in Bosnia and Herzegovina there is likely to be an underestimation of the waste generation level as the CELEBio country report tells us that only 74 % of waste generated is collected by a waste collection services (2016), 66 % of the population was accessed by a solid waste collection service (2015) and 33 % of the waste collected is disposed on sanitary landfills, while 67 % is disposed on uncontrolled municipal landfills (2015).

Table 4.1 Key characteristics for the waste sectors in all CELEBio target countries as compared to EU average

Category	Unit	EU	BG	HR	CZ	HU	SK	SL	Al	EL	B&H	MO	MK	RS
Population	*Million (2018)*	512.2	7.1	10.6	4.1	9.8	5.4	2.1	2.9	3.5	10.7	0.6	2.1	7.0
Waste generated by households	*mln tonnes/yr (2018)*	216.3	3.1	3.7	1.3	2.7	2.3	0.6	n.a.	4.6	0.9	0.3	0.5	1.9
Waste generated by households	*tonnes/head yr (2018)*	0.42	0.44	0.35	0.32	0.28	0.42	0.31	n.a.	1.32	0.09	0.44	0.21	0.27
Hazardous & non-hazardous Waste (excl. major mineral wastes)	*Million tonnes/yr (2018)**	2364	119	24	4	17	9	8	1	43	n.a.	1	1	51
Hazardous & non-hazardous Waste (excl. major mineral wastes)	*Kilograms/head yr (2018)*	1826	3097	1271	922	1099	1579	1479	n.a.	1478	1607	1202	458	1704
Waste-landfilled	*% total waste (2018)**	24%	85%	19%	42%	24%	39%	4%	63%	82%	n.a.	98%	6%	96%
Waste-incinerated	*% total waste (2018)**	1%	0.0%	0%	0%	0%	0%	0%	3%	0%	n.a.	0%	0%	0%
Waste-incinerated with energy recovery	*% total waste (2018)**	6%	1%	5%	2%	6%	7%	2%	0%	1%	n.a.	0%	0%	0%
Recovery - recycling & backfilling	*% total waste (2018)**	49%	3%	76%	56%	69%	53%	93%	22%	14%	n.a.	0%	87%	4%
Sludge production total	*1000 tonnes (2018)***	2262	57	19	228	218	56	38	94	120	10	n.a.	n.a.	10

Source: Eurostat: Treatment of waste by waste category, hazardousness and waste management operations [ENV_WASTRT dataset]. Extracted 27/11/2020
***For Albania data are for 2014 instead of 2018**
****Eurostat-ESTAT: Sewage sludge production and disposal [ENV_WW_SPD], Extracted 04/12/2020. Data refer to 2018 except for Bulgaria (2015), Greece (2015)**

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Also in Serbia, waste generation statistics record very different figures (see also CELEBio country report for Serbia) as the Serbian Environment Protection Agency (SEPA) data report 9.2 million ton of waste generated for 2018, while the Statistical Office of the Republic of Serbia (SORS) reports 49 million tons of waste generated in Serbia for 2017. The waste generation reported for Serbia in the Eurostat statistics is 51 million tons of waste for 2018 which is likely to be in line with the SORS data. The main reason for the differences of the figures of SORS and SEPA is, that the statistics of SORS (and Eurostat) include approximately 38 million tonnes of waste from mining and quarrying.

Greece waste characteristics are also quite different from the other countries with a very high household waste generation level to start with. The total waste production per head per year is however, still under the EU average, but the most striking is the high share of waste still being landfilled. This level is at 82% while the EU-28 level is at 24%. The only countries that have a higher landfill share are Bulgaria and North Macedonia and Serbia with 85%, 98% and 96% respectively. So, Greece and Bulgaria are the countries with the highest landfill rates in the EU-28. Greece is also 25th in the EU-28 in recycling and still has 53 illegal landfills operating in the country.

The EU CELEBio countries with the highest recycling rates and lowest landfill rates are Croatia, Hungary and Slovenia. Slovenia is even among the EU countries with the highest percentage of separately collected waste and management of recycling; 71% of municipal waste was collected separately and also managed to recycle 42% of all waste collected in the country in 2018. The amount of waste being landfilled was only 1% in Slovenia. Nearly 8 million tons of waste was recovered through final recovery processes. Improvements of waste recovery go also faster in Slovenia as in 2018 42% more waste was recovered than in 2017 due to a higher amount of recovered construction and demolition waste and waste disposal was 10% lower than in 2017.

Already for a long time Greece has no integrated plan for the management of other major categories of waste (e.g. agricultural, demolition / construction, etc.) and, unlike most EU countries, has been using very few resources from the EU Structural Funds for improving the waste treatment facilities. Only very recently, the Greek Ministry has announced a series of policy interventions /measures, which are expected to be documented in an updated National Waste Management Plan. Important measures in relation to bio-waste to be included in this new plan are an implementation of source collection of biowaste with application of the brown bin throughout the country by 2023, an expansion of the Biowaste Treatment Plants, with tendering procedures for 31 new facilities by 2023 (currently only 4 operate) and an increase of recovery of biowaste from the current 6% to 12% and up to 20% -22% within the next 4 and 10 years, respectively.

The waste management in Bulgaria is even more behind then in Greece, particularly because the amount of waste produced in the country per head is twice that of Greece and an even higher share is being landfilled and less waste is being recycled or incinerated with energy recovery. Lately many measures are introduced in Bulgaria to improve the waste collection system, increase waste separation and improve the waste treatment infrastructure making use of co-financing options of the structural funds.

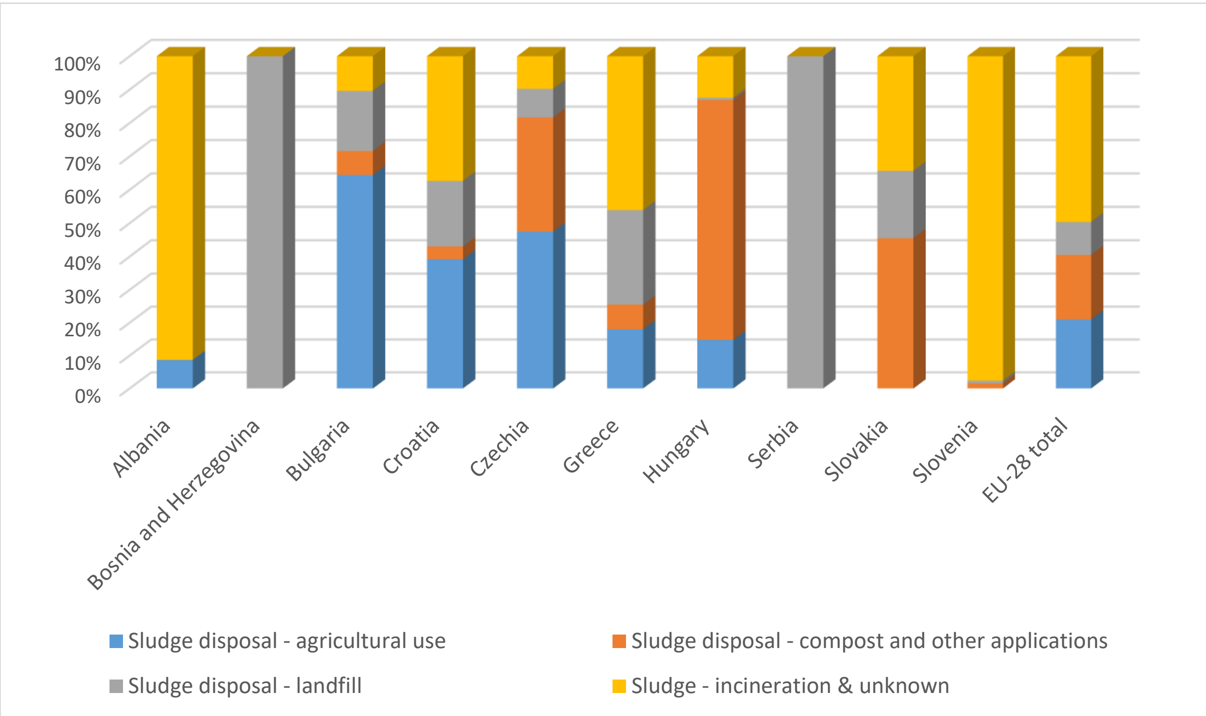
Of the non-EU countries both Montenegro and Serbia still have very high landfill rates. Actually, practically all waste generated in these countries is still being landfilled. In the CELEBio country report for Serbia several major reasons are given for this lack of waste treatment. The first is the organisation of waste management which is the responsibility of local self-government units. Waste management is therefore not taken up in every municipality in the same way and intensity. Because of this, a waste collection service is not available to a large part of the population in Serbia. Collection is organized primarily in urban areas, whereas rural areas are significantly less covered. Thus, the service ranges from only 25% to 100% in some municipalities. It has been estimated that the collection rate of organized municipal waste amounts to ~82% in the Republic of Serbia. Secondly, there are only 10 sanitary landfills complying with EC sanitary landfill standards and three regional sanitary landfills are under construction (2017). According to latest data from SEPA in 2017, 460,488 tonnes of waste was landfilled into compliant sanitary landfills. The three largest cities in Serbia (Belgrade, Novi Sad and Niš) do not have a sanitary landfill. Furthermore, there are 123 controlled not-compliant municipal landfill sites in Serbia and about 3,450 dumpsites. Due to the poor service coverage in rural areas it is likely that large amounts of waste fall into non-compliant landfills or dumpsites. Thus about 20 % of generated municipal waste in Serbia is disposed in wild landfills, outside control of the public utility companies. Thirdly, there is no systematically organized separate collection, sorting and recycling of municipal waste in the Republic of Serbia. Although the primary waste selection in Serbia has been set forth under the Law which envisages which separation of paper, glass and metal in specially labelled containers should take place, in practice recycling is not functioning. Fourthly, Serbia does not have the necessary infrastructure to reduce the disposal of biodegradable waste. Currently, composting sites exist only in Subotica and partially in Sremska Mitrovica regions. The biodegradable waste generated falls into a mixed municipal waste stream and is not further treated before disposal. Al these reasons together will make it impossible for Serbia to achieve environmentally, economically as well as financially beneficial treatment of biodegradable waste in the short run.

For Bosnia and Herzegovina the situation is rather similar to that of Serbia. Data for this country are not reported by Eurostat but the data of the Agency of Statistics Bosnia and Herzegovina for 2015 tell us that the total amount of municipal waste generated annually is around 1.3 million tons, 74 % of waste generated is collected with waste collection services (2016), 66 % of population is covered with a solid waste collection service, 33 % of the waste collected is disposed on sanitary landfills, while 67 % is disposed on uncontrolled municipal landfills and only 1 % of waste is recovered.

A non-EU country with a very high waste recycling rate of even 87% is North Macedonia. We suspect however that these high recycling figures reported by Eurostat are an overestimation because the total amount of waste produced is underestimated. This is likely to be related with the fact that large amounts of wastes are still going to illegal landfill sites. In the country report for North Macedonia it is reported that there are 55 active landfills without any permit, but only Drisla landfill (serving the Skopje Region) is well managed and has a working permit. The total amount of municipal solid waste in North Macedonia reaches 700 thousand tons per year, of which around 200 thousand tons belong to the regional landfill Drisla, and the other regional landfills make 50 - 100 thousand tons. It is estimated that the number of illegal landfills (dumpsites), especially in rural municipalities, is about 1,000. Improvements are taking place though as seven regional landfills are planned for the territory of North Macedonia at this moment.

For Albania both waste collection and recycling rates of waste are fairly low. The waste collection is largest in Tirana and other county capitals ranging between 80 and 85%, while in suburban areas it is at 65% and rural areas even 33%. As to the recycling rates of waste they are around 19% in 2018 according to official sources, but the Albanian Recycling Association estimates that these rates are even lower (10% in 2016), but the informal economy plays a major role in supplying recycling industries with raw materials, e.g. manual workers. The Albanian government has become much more active and ambitious in waste management and treatment in the last couple of years, however. Since 2013, the Albanian government has reversed its initial position towards waste incineration, as set out by the National Strategy for Waste Management, for the 2010-2025 period, and started to actively promote the concept through the planned construction of Waste-to-Energy (WtE) plants in Elbasan, Fier and Tirana. The Albanian government allocated 178 million EUR for the construction of these three WtE incinerators. At the same time, the emphasis on WtE plants has been challenged by several NGOs, experts, citizen groups and, reported, even by the European Commission. One fundamental aspect of disagreement is that the capacity of the incinerators is oversized if one considers the recycling targets set by Albania, which will simply not leave enough combustible waste for continuous plant operation.

Figure 4.1 Sludge disposal in CELEBio counties (No data for Montenegro & North Macedonia)



Beside waste countries also generate sludge from wastewater treatment. The size of the sludge production is a function of the size of the population, particularly of the population living in large urban areas. The largest sludge production in the CELEBio countries is seen in Czechia, Greece, Hungary and Albania. In countries like Croatia, Bosnia and Herzegovina and Serbia where populations are quite large, the sludge production is still small which indicates towards an underdevelopment of wastewater treatment, low connection rates of the population to sewage systems and wastewater treatment installations and/or incomplete data on sludge production and treatment.

In Albania for example the Water Regulatory Authority reports that 53% of the country's population were served by wastewater sewage systems. So, the 94 thousand tonnes of sludge come from this share, while the waste water produced by the remaining 47 % of the population remains untreated. Because of this a European delegation in Albania has announced support for new projects of wastewater treatment. At the moment, no energetic valorization of sewage sludge is recorded for Albania for example. Most of the sludge is now going to agricultural applications and the majority to unknown applications (see Figure 4.1).

Also, in Slovakia the share of population with connection to wastewater treatment is among the lowest in the OECD. Only 65% of the Slovak population benefit from a connection to a wastewater treatment plant.

When looking at the treatment of sludge in the other countries it becomes clear that of the sludge produced in Bosnia and Herzegovina and Serbia is completely landfilled. In other countries, the landfilling of sludge is significantly smaller. In Albania, Bulgaria, Croatia, Hungary and Slovenia in remains under 5% but in Greece it is 28%, Slovakia at 20% and in Bosnia and Herzegovina it is at 14%. In Bulgaria, Czechia and Hungary the majority of the sludge is currently going to agricultural or forest lands and/or to conversion into compost. Incineration and unknown treatments are highest in Albania, Croatia and Greece but which part is going to incineration or other uses is not known.

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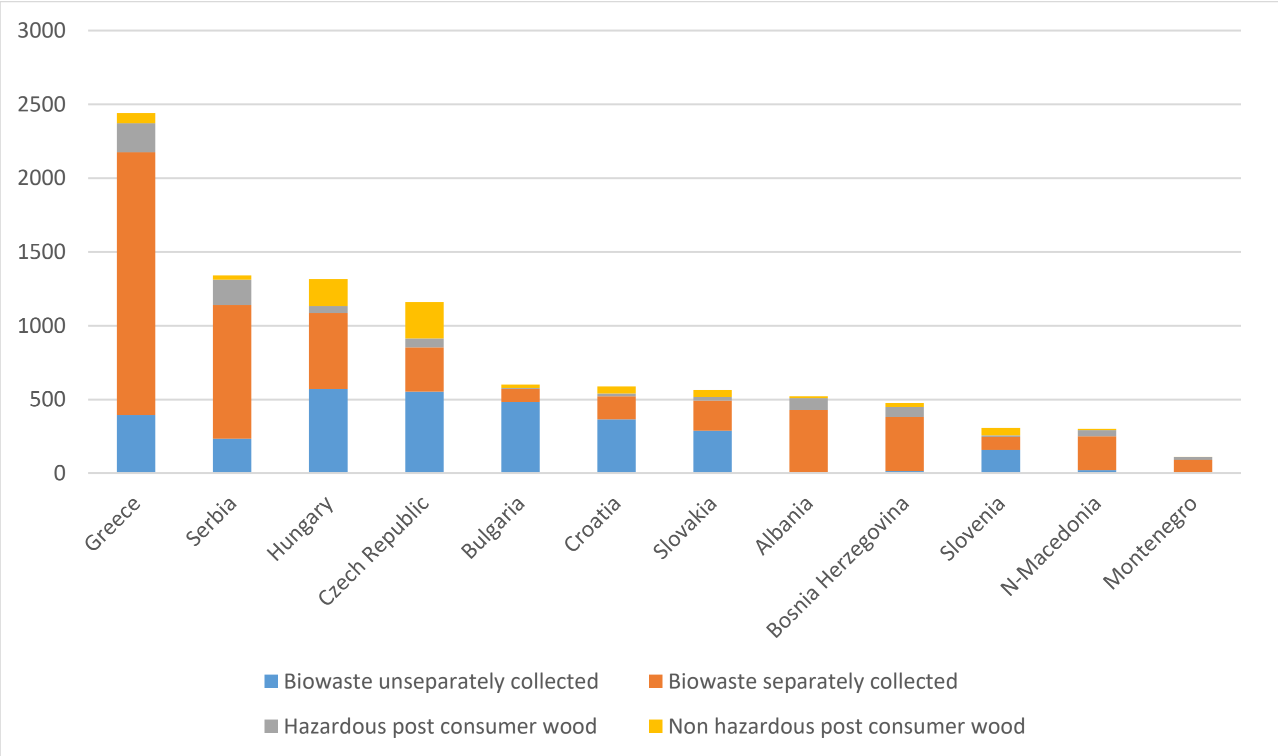
4.2 Current biowaste potentials

An important biomass source for the bioeconomy is organic waste. In order to move to a more circular bioeconomy it is very important that the optimal use of biowaste is stimulated. This starts with separation of the waste in an organic and non-organic fraction. From the former it already became clear that waste separation is still insufficiently developed in several of the CELEBio countries. On the other hand, there are also countries that are very advanced in waste collection, separation and treatment, but this does not necessarily apply to biowaste.

Potentials of biowaste, grouped in separately and unseparately collected fractions and post-consumer wood, classified in hazardous and non-hazardous fractions, for the year 2020 were assessed in the scope of the S2BIOM project. Figure 4.2 summarises the major findings. Countries with the largest biowaste potentials are Greece, Serbia, Hungary and Czech Republic. These countries have a relatively large population and also a relatively large proportion of the population living in larger urban centres where organic waste needs to be collected, while in rural areas this waste is often directly re-used by households and farms themselves. In urban areas most of the biowaste quantities in municipal solid waste (MSW) consists of household food waste, and waste from the commercial / service sector as well as "green" waste from gardens and parks.

Figure 4.2 Biowaste potentials in the CELEBio countries (Source: S2BIOM base potential data for 2020)



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From Figure 4.2 it can be derived that very large quantities of organic waste are already separately collected, particularly in Greece, Serbia, Hungary, Albania and Bosnia and Herzegovina, although there is still room for further separation of waste. The latter is particularly the case in Czech Republic, Hungary, Slovakia and Slovenia.

At the same time, there are also countries that still have incomplete coverage of waste collection and also treatment but do apply an efficient separation of organic waste. This is for example the case in Albania, Bosnia and Herzegovina, North Macedonia and Montenegro that have relatively high shares of separately collected biowaste.

Postconsumer wood includes all kinds of wooden material that is available at the end of its use as a wooden product, like packaging materials (e.g., pallets), demolition wood, timber from building sites, and used furniture. The quality in terms of hazardous substances largely determines the possibilities to utilize postconsumer wood for material applications beyond combustion with energy application. Large quantities of post-consumer wood are particularly found in Greece, Hungary, Serbia and Czech Republic. In Greece and Serbia this largely consists of a hazardous fraction, which makes energy recovery one of the view treatment options. The opposite is the case for the post-consumer wood in Hungary and Czech Republic, where recycle and material use options of this fraction are still an option.

4.3 Conclusions in SWOT for Waste

It is quite clear that the current situation in waste management in several of the CELEBio countries is far from optimal and certainly behind the EU targets. On the other hand, there are also CELEBio countries that have an efficient waste collection and treatment system in place with practically no waste being landfilled anymore, high recycling and recovering rates. The latter applies to for example to Slovenia, Hungary and Czech Republic. Very high landfill levels are still found in Bulgaria, Albania, Greece, Montenegro, Bosnia and Herzegovina and Serbia. Beside this, another challenge is still in several countries that the waste collection rate is still very low and that because of that a lot of waste is still burned by households and dumped in illegal landfill sites. The latter is particularly still seen in Albania, Serbia, Bosnia and Herzegovina, Montenegro and North Macedonia.

Main challenges in municipal waste management in particularly most of the neighbouring CELEBio countries involve ensuring good coverage and capacities for collection and transport of waste and sanitary and circular waste disposal. The main issues are still that most of the municipal waste still goes to landfills untreated, as well as a significant proportion of municipal waste is still being disposed of in non-sanitary of illegal landfills because it is the cheapest way to handle waste. Since it is cheap to do this there is no incentive to prevent waste, separate and/or recycle it. This also applies for hazardous waste which is still mostly mixed with unhazardous waste when disposed of.

The overall goal should be to develop as much as possible sustainable waste management systems in order to reduce environmental pollution and reuse, recycle, and recover waste. This applies to all waste categories, including sludge and hazardous and non-hazardous waste streams.

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Biological waste treatment should be focussed as much as possible to adding value to the waste and keeping the nutrients in the waste in the cycle as long as possible. This implies that composting and conversion into materials should be the preferred treatment. Energy production from organic waste for example through biogas generation is attractive, but sub-optimal if this is not combined with generation of compost from the digestate. Such routes are more optimal, but also require large investments in waste collection, waste separation at source or after collection and treatments. Also, education and stimulation measures need to be introduced widely to make households participate in sustainable waste separation and disposal.

From Table 4.2 it becomes clear that the CELEBio countries have similar SWOT elements to be addressed in the road towards improving their waste management systems, but that they also have country specific challenges and opportunities.

Further improvements in optimal collection treatment and use for biobased application of waste biomass can still be developed in all CELEBio countries. Some countries have little hurdles to take, while others are still in the beginning and have many improvements to make.

Table 4.1 SWOT factors waste sector

	Strength	Weakness	Opportunities	Threats
Bulgaria	• Development of waste management infrastructure that can be used for energy and/or material recovery • High existing potential for utilization which is currently still going to landfill • Development of separate waste collection on household level • Utilisation of manure in agriculture • Utilisation of sewage sludge	• Still small share of recycled waste • Bad practices for implementation of separation of wastes collection • Landfilling practices - significant amount of waste that could be energy/materially recovered ends up in landfills and unused • Relatively slow implementation of legislation framework • Bad examples of waste management and utilisation of wastes • High collection and operational costs for waste management • Lack of knowledge on bioeconomy principles and its possibilities • Poor public awareness of waste separation/ management • Lack of proper regulation on by-products and end-of-waste status	• Opportunities for improvement of performance of waste management under the guidance of the EU directives. • Turning bio-waste, residues and discards into valuable resources and creation the innovations and incentives • Knowledge-based production and utilisation of biological resources, biological processes and principles • Knowledge transfer from more advanced countries in EU • Introduction of innovative technologies for biodegradable waste utilization • EU support/funding for improvement of waste management infrastructure and waste management system • Utilization of currently landfilled biodegradable waste • Implementation of "Waste Market"	• Lack of public willingness for waste separation, utilization for energy/recovery purposes • Lack of recognition for the opportunities in waste utilization within bioeconomy principles • Backwardness and lack of change within legislation and strategic framework • Indifference of sector stakeholders
Czech Republic	• Sludge is controlled by the municipalities, the accounting for its production and usage is likely to be reliable. • There is a trend to decrease landfilling	• Food waste, the majority of this biomass remains unused. • The recording of waste materials is extensive for Czech Republic, however these data are dependent on the reporting of the individual actors which can be variable.	• A key opportunity will be the installation of new infrastructures within and around municipalities to harness both sludge and recycled food waste. • New legislation will need to put in place to recycle organic waste and use of the biomethane for public transport vehicles in cities.	• The main threat is political inaction and unwillingness to incorporate measures which may undercut existing business interests, even though the social, environment, and/or economic benefits favour a changed approach.

	Strength	Weakness	Opportunities	Threats
Croatia	• Development of waste management infrastructure that can be used for energy and/or material recovery • High existing potential for utilization which is currently still going to landfill • Development of separate waste collection on household level	• Implementation of legislation framework slow • High collection and operational costs for waste management • Lack of knowledge on Bioeconomy principles and its possibilities • Significant amount of waste that could be energy/materially recovered ends up in landfills and unused • Poor public awareness of waste separation/ management	• Implementation of "Waste Market" • Innovative ways of biodegradable waste utilization are possible given that this still needs to be largely build up • Knowledge transfer from more advanced countries in EU • Utilization of biodegradable waste that is currently landfilled • Financing from EU funding, aligned with financing of waste management system (waste management centers)	• Lack of recognition for the opportunities in waste utilization within Bioeconomy principles • Backwardness and lack of change within legislation and strategic framework • Negative public opinion in terms of waste separation, utilization for energy/recovery purposes • Indifference of sector stakeholders
Hungary	• Well-organised solid communal waste collection • Infrastructure are available most areas of land (Biomass-industries and depos) • Collection of hazardous household waste • Collection of green household waste • Container supply is also organized for individuals and industry. • There are waste incinerators throughout the country (24) • Both civil society and business organizations are becoming increasingly aware of need for waste separation at source and separated collection and waste management	• Lack of selective waste collection • The problem of special waste (e.g. car batteries, green waste) partly unsolved • Poor awareness of the environment among households, companies • The amount of solid waste is constantly increasing • There is little interest in recycled products • Expensive waste sorting (after collection) while waste separation at source is still weakly developed	• Developing integrated waste management through national and EU financing. • Developing the waste utilization industry • The waste management sector has become a public organization	• Biomass is s competitor with other sectors • Increased transportation costs can occur due to rising fuel prices • Infrastructure are available just a few areas of land (Biomass-industries and depos) • Low price of biomass-based energy in value-change 0,1 Eur/kWh-(OPEX min.0,13 kFh)

	Strength	Weakness	Opportunities	Threats
Slovenia	• Awareness and willingness of citizens to separately collecting waste • Presence of the most modern regional waste management centre in Europe (RCERO)	• Lack of better capabilities to treat broader spectrum of waste	• Development of innovative and high-added value products • Job creation • Increased competitiveness of the country • Reduction of landfill costs • Extension of landfill's lifetime	• Waste accumulation
Slovakia	• Has substantially reduced its greenhouse gas emissions and the energy intensity of its economy • More progress has been achieved in the management of industrial waste, where 39% now goes for recycling, while only 36% is landfilled. • Positive changes in the legislation (growing landfilling costs) • New policy and regulations on returnable PET & aluminium cans	• Low sorting rates • Low awareness among citizens and companies to separate, treat and produce less waste • Frequent changes and lots of exceptions in waste legislation (apartment buildings are not obliged to separate biological waste, if municipality provides detached houses with composting container, they are not obliged to collect bio-waste etc.) • Low landfilling fees (they should grow continuously in next couple of years) • High transportation costs • Low state stimulations/ interventions • The current policy framework is incomplete and lacks coherence • Waste management is in hands of high number of small municipalities and their capacity adequately design and procure high quality collection services is very limited	• Still an enormous amount of waste that is not separated and that can be recycled, reused, used for energy generation once the separation and waste treatment system become further developed • Empowering bioeconomy through circular economy. Good opportunity to invest in and improve the circular economy. • Increasing the efficiency of metal processing and of electricity generation from lignite could immensely increase the overall resource efficiency of the economy • Gradually increase the landfill tax. • Consider ICT for useful recycling.	• Insufficient municipal solid waste recycling. (now only 15% MSWrecycled). • Municipal waste management is underperforming, lacks appropriate economic signals that would divert waste from landfills and stimulate recycling and reuse • Wastewater sludge insufficiently recycled (treatment levels are among the lowest in the OECD); • Water use is under-priced; • the user pays principle is not applied to all types of users. • Illegal dumping • Bad air quality • Low law enforcement

	Strength	Weakness	Opportunities	Threats
Greece	• Major centres of concentrated MSW production • High potential for valorization of biogenic waste currently going to landfilling • New, modern infrastructure already available in a few regions (e.g. West Macedonia, Epirus)	• Beyond the urban areas, challenges in collecting / transporting waste to treatment centres (e.g. islands)	• New waste management plan in preparation • Resources to be allocated • Increase of landfilling costs • New, independent schemes for management of various biogenic waste fractions on local / regional / national level • Interest in renewable gases might prompt new utilization opportunities for biomethane from anaerobic digestion of biowaste • Waste incineration plants might allow valorization of various solid waste fractions, including biogenic	• Funding gap for new projects • Delays in implementation • Social acceptance issues for the positioning of new waste management infrastructure • Limited to no attention on novel technologies for biowaste management beyond the anaerobic digestion / incineration • Uncertainties as to compost properties for agricultural use
Albania	• Legal framework mostly harmonized with European Directives and Regulations	• Incomplete collection rate of MSW • Landfilling still prevailing, low recycling rates, no source separation of organic waste • Data inaccuracies due to uncoordinated efforts or lack of technical means (e.g. weighting stations)	• Funding and resources allocated to waste management • Possibility to transfer latest technological developments	• Improper implementation of waste-to-energy schemes may lead to distortions
Bosnia and Herzegovina	• System of regional landfills which is suitable to development waste-to –energy projects • Some waste separation activities in the process of collection and in landfills • Modern and adequate waste management legal framework exist	• Low level of separation and recycling of waste • Significant percentage of population which is still not covered by landfills • Limited amounts of industrial and hazardous waste are recovered or reused • Low level of awareness and willingness of citizens to separately collecting waste • Lack of capabilities to treat broader spectrum of waste • Lack of capacities for adequate disposal of hazardous waste • Non-systematic monitoring of the parameters for environmental assessment	• Large potential in waste recycling industry exist • Possibility of energy recovery • Development of innovative and high-added value products • Job creation • Increased competitiveness of the country • Reduction of landfill costs • Extension of landfill's lifetime • Option to introduce polluter pays principles	• Waste accumulation • Significant percentage of waste in rural areas which is not covered by waste collection system • No separate collection system for hazardous materials, so everything ends up in landfills or dumpsites • Environmental and health risks related to non-adequate disposal of certain hazardous wastes • Increased GHG emissions from waste sector

	Strength	Weakness	Opportunities	Threats
		• Cost recovery problems related to unpaid fees		
Montenegro	• Landscape (coast, mountains) • Tourist centers (e.g. The Bay of Kotor, Ulcinj) • Preventive and improved environmental protection • Recycling • Increasing awareness of environmental protection • • Existence of national waste management strategy; • Adopted key laws on waste management harmonized with EU Directives; • Existing of recycling yards and sanitary landfills; • Unused potential for waste recycling	• Lack of sufficient infrastructure for treatment and disposal of waste • Absence of facilities for treatment of hazardous waste • Ununiform waste collection • Degraded areas due to inadequate waste disposal • Absence of organized collection and disposal of waste in rural areas • Lack of accurate data on quantity of waste	• Introduction of the EU waste management standards • Integration process and use of the EU and other funds • Reduction of industrial waste generation • Expansion of network infrastructure • Contribution to employment and opening of new jobs • Charging by quantity of generated municipal waste	• Lack of investment for development of waste management infrastructure • Capacity Planning • Insufficiently developed public awareness of necessity to treat waste properly • Environment as a public good, is in constant conflict with growth • Inability of citizens to pay the real, economic price for municipal services
North Macedonia	• Regional waste management plans have been developed	• Most of the waste is mixed waste and land filled • Political and legal framework; organization of institutions and human resources, • Covering costs and financing services and investments, • The consciousness of the entities involved and informing them, • All stages of technical management from collection to waste disposal, • Existence / remediation of animal loads environment, • Impacts on human health and the environment / natural environment with potential impact on the Macedonian economy	• There is still large room for improving the waste separation, collection and treatment and processing of waste. Now almost all household waste is going to landfill • Harmonization of policy and legislation • Establishing effective institutional and organizational set-up • Strengthening human resources and capacities • Introduction of stable financial resources and appropriate economic mechanisms • Raising public awareness and awareness of all parties involved • Establishment of a data / information collection system • Establishment of a technically modern waste management system	• To maintain control over all flows of generated waste, • To reduce the amount of waste generated, • To use the material and energy value of the waste, • To reduce the amounts of hazardous substances in the waste, • To ensure acceptable disposal from the aspect of environmental protection, • To prevent the formation of new environmental burdens that will have to solve future generations, • To repair the environmental burdens that are negative environmental and human health impacts • Large investments need to be made to make the waste

	Strength	Weakness	Opportunities	Threats
			• Application of efficient and cost-effective techniques for managing the separated flows of • Waste through private sector participation in order to achieve a 100% collection rate • Waste and optimal level of waste material / energy utilization; • Introduction of landfills for hazardous and non-hazardous waste • Gradual closure and / or repair of existing municipal waste dumpsites and / or industrial ecological hotspots	sector more circular, avoid land fill.
Serbia	• Existence of national waste management strategy; • Adopted key laws on waste management harmonised with EU Directives; • Started construction of several regional sanitary landfills – regional centres for waste management; • Unused potential for waste recycling • Possibility of waste incineration in cement plants, thermal power plants	• Lack of infrastructure for treatment and disposal of waste (regional landfills – regional centres for waste management, facilities for recycling, composting etc.); • Absence of facilities for treatment of hazardous waste; • Absence of central storage for hazardous waste; • Pollution of waters, soil and air due to poor waste management practice; • Degraded areas due to inadequate waste disposal and numerous dumps and wild landfills; • Absence of organized collection and disposal of waste in rural areas; • Lack of accurate data on quantity of waste that disappears; • Lack of public awareness/willingness of how to handle waste sustainably	• Introduction of the EU waste management standards; • Integration process and use of the EU and other funds • Rehabilitation of unregulated dumps and remediation of contaminated soil; • Reduction of industrial waste generation; • Contribution to employment and opening of new jobs; • Charging by quantity of generated municipal waste	• Lack of investment for development of waste management infrastructure; • Areas burdened by uncontrolled and unhygienic landfills – dumps; • Insufficiently developed public awareness of necessity to treat waste properly; • "Not in my backyard" principle; • Inability of citizens to pay the real, economic price for municipal services

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5 Factors that are important for setting up bio-based value chains

5.1 Identification of factors

One of the objectives of the CELEBio project is to map opportunities in the target and surrounding countries for setting up bio-based value chains. This includes not only the mapping of the biomass feedstock potential, but also other factors that are important for setting up bio-based value chains, e.g., business activities, what bio-based products can be generated, and what is the market demand of these products.

To be able to perform a Strength, Weakness, Opportunity and Threat (SWOT) analysis and generate action plans, the first step was the identification of which factors are important. The factors were determined and ranked based on the perspective of the stakeholders in the target countries.

Highest ranked factors:
- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:
- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO_2, fodder, lignin

Lowest ranked factors:
- Infrastructure: what part of the chain is already available (harbours, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the stakeholders mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

5.2 Generalized SWOT analyses of CELEBio target and surrounding countries

The identified factors were subsequently mapped in the country reports and for each factor a SWOT analysis was performed. A generalised overview of these SWOT analyses of all target and surrounding countries is given in de next paragraphs.

5.2.1 Bio-based industries, products and markets

A clear strength for setting bio-based value chains is the fact that various biomass processing industries are established in the CELEBio region. Main biomass processing industries are wood, furniture, pulp, paper, food, beverage, essential oils, pharmaceuticals. Besides the biomass processing industries, a significant number of anaerobic digestion plants are established. Furthermore, it is mentioned that laboratories for testing of biofuels, compost, and bio-wastes are accredited and competence centers for the development of the bio-based industry are established.

As a weakness it is mentioned that often the processing of bio-based products with a higher added value is lacking, e.g., the processing of wood is low and the export of wood to countries in western Europe is high. Furthermore, food waste is not separately collected and there is a tendency to incinerate and landfill waste. Industrial scale biorefineries are generally lacking.

Opportunities are the currently underexploited potential of biomass residues and the circumstance that these biomass residues can be mobilized or are available at existing processing industry.

Major threats are the lack of markets for bio-based products and, related to that, bio-based products are not competitively priced.

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Table 5.1 Summarized SWOT analysis of biobased industries, products and markets

Strengths	**Weaknesses**
Established processing industry: wood, furniture, pulp, paper, food, beverage, essential oils, pharmaceuticals Existing anaerobic digestion and composting plants Established competence centers for the development of bio-based industry Accredited laboratories for testing of biofuels, compost and bio-wastes Following European and global trends related to bio-based industries	Processing capacities for agricultural products are insufficient or lacking, e.g. low wood processing, high export/import of wood Lack of industrial scale biorefineries Food waste is not recycled, tendency to incinerate and landfill Lack of willingness to try innovative solutions and new concepts
Opportunities	**Threats**
Growing interest in bio-based products Underexploited potential of biomass residues Biomass residues are available at existing industry Current expansion of food processing, pharmaceutical, and cosmetic industry towards bio-based products and markets EU funding for waste management Development of bioplastics / alternative packaging market The engineering of new machinery for the bio-based industry	No developed markets for bio-based products Bio-based products are not competitively priced Limited focus on agricultural and forest residues No adequate management of food processing residues The loss of start-up companies due to lack of recognition of the legislative framework

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5.2.2 Infrastructure, logistics and energy sector

In the CELEBio countries several industrial hubs are established, which is a large strength for setting up biobased value chains. However, only a few countries have access to sea and therefore the number of seaports is limited in the CELEBio region. Slovenia, Croatia, Montenegro, Albania, and Greece have coastal ports at the Mediterranean Sea and Bulgaria has ports at the Black Sea coast. Another considered weakness is the underdeveloped railway system.

An opportunity is the well-developed road network with central positions in the Trans-European Transport Networks (TEN-T) (Baltic-Adriatic and Mediterranean corridors). Another opportunity emerges from the EU Green Deal, which may unlock the energy sector. This is strongly required because the energy sector is considered a threat.

The energy sector is dominated by natural gas and nuclear power. The existing infrastructure (with large investments) does not allow investments in biobased alternatives. Furthermore, there is Insufficient investments in renovation, modernization of existing energy facilities and infrastructure. Besides, bio-based energy is currently economically not competitive to its fossil and/or renewable (wind, solar) alternatives.

Table 5.2 Summarized SWOT analysis of infrastructure, logistics and energy sector

Strengths	**Weaknesses**
Established industrial hubs Good connection with European countries Well-developed road network Several existing ports and/or railway connections to foreign ports Potential in energy production from biomass (biomass and biogas plants)	Limited number of seaports due to limited access to sea Underdeveloped railway system Lack of inland waterway network Limited utilization of agricultural residues and food waste for biogas production
Opportunities	**Threats**
Increasing investments in ports, railways, airports and other transportation infrastructure Central position in Trans-European Transport Networks (TEN-T) (Baltic-Adriatic and Mediterranean corridors) The EU Green Deal may unlock the energy sector	Worrying condition of the road and railway network Competition from foreign ports Increasing congestions during tourist seasons Road transport strongly depends on cheap fossil fuels The energy sector is dominated by natural gas and nuclear power, the existing infrastructure does not allow investments in bio-based alternatives Insufficient investments in renovation, modernization and construction of energy facilities and infrastructure Biomass based energy is economically not competitive to its fossil and/or renewable (wind, solar) alternatives

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5.2.3 Skills, education, research and innovation potential

A clear strength is the existence of an educated labour force with good language skills. Moreover, the presence of a strong academic community is mentioned.

Despite, the development of technologies is lacking. The connection between academia, and both the public and private sector is insufficient. There is limited financing for research and development of laboratory scale experiments (TRL 1-4) to pilot and demo scale processes (TRL 5-6), and to develop pilot and demo scale processes to industrial scale.

An opportunity is the increasing awareness for the bio-based economy and the related potential growth of expertise, skills, and employment opportunities. There is EU and BBI funding to encourage biobased initiatives. Several multi-country stakeholder programs on bio-based initiatives are developed. Advantage can be gained by the transfer of knowledge from more advanced countries in the EU.

A threat is formed by the loss of (young) experts due to better work conditions in other countries, i.e. the so called "brain drain".

Table 5.3 Summarized SWOT analysis of skills, education, research and innovation

Strengths	**Weaknesses**
Educated labor force with good language skills Strong academic community Universities and other higher education institutes have well-equipped laboratories Existing bio-based research projects Established competence centers	Insufficient connection between academia, public, and private sector Limited financing for research and development of laboratory scale experiments (TRL 1-4) to pilot and demo scale processes (TRL 5-6) Limited financing for research and development to get pilot and demo scale processes to industrial scale and to bring products on the market Limited support for bio-based initiatives
Opportunities	**Threats**
Increasing awareness for bio-based economy Potential growth of expertise and skills, i.e. job creation Pilot projects to connect the academic community with public and private investors Multi-country stakeholder programs on bio-based initiatives EU and BBI funding for bio-based initiatives Knowledge transfer from more advanced countries in EU Programs to keep (young) experts in the region, i.e. prevention of "brain drain"	The loss of (young) experts due to better work conditions in other countries, i.e. "brain drain" High level of bureaucracy Limited number of hi-tech centers for bio-based initiatives

5.2.4 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

A strength for setting up bio-based value chains is the growing awareness of the economic potential of the agricultural sector and the bio-based economy in general. Besides, there is a growing awareness that structural changes in policies are required for the development of the bio-based economy.

However, an important weakness is the lack of or limited strategy for the development of the bio-based economy. This is partly caused by the limited or slow policy-making framework.

Realized policies for improved biomass managing and increasing use of biomass residues are opportunities for the realization of other bio-based policies.

A threat is the lack of willingness to change to the bio-based economy within the public sector.

Table 5.4 Summarized SWOT analysis of the policy framework

Strengths	**Weaknesses**
Growing awareness of the economic potential of the agricultural sector and bio-based economy in general Growing awareness that structural changes in policies are required for the development of the bio-based economy Strong policy framework for biodiversity conservation and sustainable use Strong agri-food sector Development of energy and climate action plans Development of national bioeconomy strategies and action plans	Lack of or limited strategy for the development of the bio-based economy Limited or slow policy-making framework No explicit legislative support for the bio-based economy Lack of financial incentives or subsidies to foster bioeconomy development Slow implementation of directives of the EU, a general anti-EU climate Fragmented institutional leadership on bio-based economy strategy development
Opportunities	**Threats**
Established committees for the development of bio-based economy strategies Policies for improved biomass managing and increasing use of biomass residues Stimulation of the use of recognized certificates Removing exhaustive administrative regulations	No willingness to change to bio-based economy within the public sector Ignoring the need for structural changes in policy-making framework Continuous relying on voluntary pledges from companies High level of bureaucracy

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5.2.5 Financing

A number of country reports mention the availability of various venture capital schemes or voucher programs for bio-based initiatives as a strength.

On the other hand, other country reports emphasize as weaknesses the lack of targeted financing for bio-based initiatives and insufficient support of financial institutions (e.g., venture capital funds) for bio-based initiatives.

A clear opportunity is enhancing the utilization of EU, national, and/or state funding and subsidies for bio-based initiatives.

Most important threats are the lack of agencies providing equity and loans for bio-based initiatives, the lack of tax advantages and subsidies for bio-based initiatives, and the (too) large investment costs of industrial scale biorefineries.

Table 5.5 Summarized SWOT analysis of financing

Strengths	**Weaknesses**
Established competence centers related to bio-based economy Various venture capital schemes or voucher programs are available for bio-based initiatives Availability of EU and BBI funding	Lack of motivation to start new initiatives Lack of targeted financing for bio-based initiatives Insufficient support of financial institutions (e.g., venture capital funds) for bio-based initiatives Poor knowledge of public procurement procedures Low level of trust in public institutions
Opportunities	**Threats**
Enhance the utilization of EU, national, or state funding and subsidies for bio-based initiatives Regional resource connecting (Research, Development and Innovation (RDI), production, logistics)	Rising competitiveness of bio-based industries in neighboring countries Lack of agencies providing equity and loans for bio-based initiatives Lack of tax advantages and subsidies for bio-based initiatives Investment costs of industrial scale biorefineries are too high and/or too risky Investors and agencies are not presented with sufficient bio-based initiatives, the academic centers do not connect well with the public and private sector

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6 Considered bio-based value chains

6.1 Bio-based products from biomass residues

In all reports of the target and surrounding countries, it was concluded that large quantities of biomass residues are potentially available at relatively low costs to produce bio-based products. Agricultural residues are widely available. With improvement of forest management and exploitation, also residual wood biomass is potentially available. Furthermore, improvement of (separate) municipal waste and food waste collection is a third potential source of residual biomass.

Despite these potentially available biomass sources, it was indicated in the country reports that there is currently no significant demand for bio-based products and a strategy for setting up bio-based value chains is still lacking. However, several potential bio-based value chains and bio-based products were considered in the reports. A generalised overview of potential bio-based products is given below.

<u>Specialty chemicals</u> that can be obtained from biomass residues are for example bioactive components. The added value of specialty chemicals is generally high compared to other bio-based products. However, these bioactive components usually are present in low concentrations in the raw material and require mild processing to maintain their bioactivity. This means that large volumes of raw material need to be processed to obtain small amounts of product. Valorisation of side streams might be required to be economically profitable. Processing usually is separation and/or extraction, which can be mechanical or chemical, followed by concentration and/or purification. Because of the diversity of bioactive components, research and development is usually required to be able to set up a processing line for each individual component.

<u>Functional food ingredients</u> are other potential bio-based products with a high added value which can be obtained from biomass residues. It is for example possible to obtain functional proteins from sugar beet leaves. Because the functionality determines the added value, it is essential to maintain the functionality while processing. Mild processes are usually required. Because of the diversity of both the raw materials and the functional ingredients, research and development is required to develop these processes.

<u>Base chemicals and materials</u> can be obtained by separation and/or extraction of biomass. Also recycling, upcycling, and downcycling of residual material is possible. Lignocellulosic biomass is potentially a raw material for value added products, e.g. construction materials, furniture, fibre board, packaging materials, pulp and paper.

<u>Bio-based fuel</u> can be obtained by a large number of routes. The most obvious are refining pyrolysis oil or vegetable oil, hydrolysis of biomass and fermentation to ethanol, and upgrading biogas from anaerobic digestion to biomethane. However, despite exhaustive research and development, biobased fuels are economically not competitive with fossil fuels.

<u>Basic food ingredients and feed</u> can be obtained from biomass residues, for example from agricultural residues or residues from the food processing industry, by separation processes

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or by hydrolysis followed by fermentation. Logically, safety is an issue regarding both food and feed products, especially, when they are produced out of residual or waste material. However, food and feed safety can be controlled by, for example, sterilization or acidification. Biomass can be hydrolysed into a sugar crude, which can be used in fermentation processes. Enzyme or other pre-treatment (i.e. acid, heat, pressure) costs significantly contribute to the costs for hydrolysis. Furthermore, the obtained sugar crude usually has a relative low concentration and therefore a concentration step prior to fermentation might be required.

Electricity and heat can be generated by burning biomass in a power plant. Biomass or biomass pellets can (partly) replace coal. Furthermore, electricity and heat can be generated by burning biogas produced in anaerobic digestion plants. However, despite the low raw material costs, electricity produced from bio-based resources can in general economically not compete with electricity from fossil, nuclear, and renewable (wind and solar) resources.

6.2 Bio-based industries

A schematic overview of the considered bio-based value chains is given in Figure 6.1. The bio-based products are top-down sorted on their expected added value. However, as there is a wide variety of bio-based products, this order is just indicative. For example, some bio-based fuels have a higher added value compared to some base chemicals and materials.

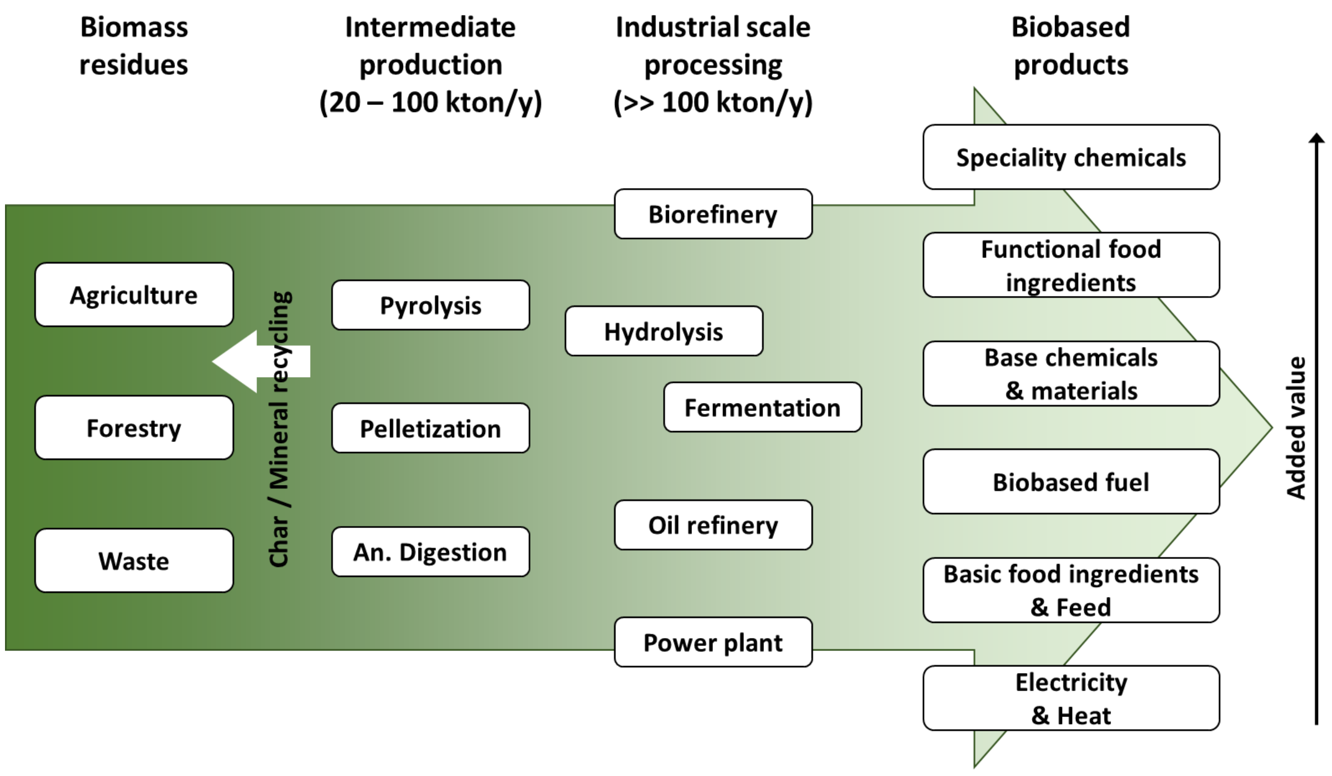

Figure 6.1 Schematic overview of the considered bio-based value chains

An important aspect of the considered value chains is the actual plant size and its processing capacity. For these types of processes, the so-called "economy of scale" applies. This means that the production costs per unit decrease with increasing scale, because investment, maintenance, and labour costs do not linearly increase with the production capacity. As a result, biorefineries should have an annual capacity well above 100 kton to be economically profitable. This means that large amounts of biomass should be year-round available locally at the biorefinery or large amounts of biomass should be transported to the biorefinery.

In a number of country reports, it is mentioned that industrial scale biomass biorefineries may not be feasible for the target and/or surrounding countries, because the required amount of biomass is not available or cannot be mobilized by cheap transportation. If this is the case, it might be an option to process biomass residues into intermediate products, which can be mobilized by cheap transport. Possible options for these intermediate products are biomass pellets and pyrolysis oil. Although pyrolysis can be considered as a high-tech process, both pyrolysis and pelletization can be economical profitable at relatively small scale, especially if these processes are added to existing plants with the required infrastructure and utilities available.

Concerning the circularity of bio-based products, minerals should be returned to the field as much as possible. In general, the minerals have no or a negative value in the biobased products. In a pyrolysis process the minerals mostly end up in the char, which can easily be returned to the field. Prior to pelletization, the minerals can be washed or extracted from the biomass and returned to the field in the form of an aqueous solution. These processes are however still in development.

In the reports is mentioned that in the target and surrounding countries already a large number of anaerobic digestion plants are established. Most of these plants are located on farmlands and run on manure, crop residues, and energy crops. The digestate, containing the minerals, is brought back to the field. Most anaerobic digestion plants strongly rely on some form of subsidy. Main reasons are the relatively small scale of the plants with relatively high investment and operational costs and the fact that prevented methane emissions to the atmosphere are not credited. Beside manure and crop residues, anaerobic digestion of municipal biodegradable waste and food waste is a considered value chain. The economic potential of these plants should carefully be studied using the experience of already established plants.

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7 Conclusions and recommendations

7.1 Conclusions per country and for the region

In the target and surrounding countries, the biomass residues that are available are dominated by lignocellulosic biomass, i.e. straw (cereals, corn, sunflower, oilseed rape), forestry residue, dedicated perennial crops, and prunings from permanent crops. An obvious biobased product from lignocellulosic residues is energy in the form of electricity and heat. These products can be obtained by co-firing of lignocellulosic residue with coal in power plants. To increase the transportability and applicability of lignocellulosic biomass, pyrolysis and pelletization are intermediate processing options. For energy pellets, the ash content is a point of attention. Washing the biomass and return the minerals to the field is and option. Alternatively, straw can be mixed with forestry residue to lower the ash content of the energy pellets. Demineralized pellets can, besides the production of energy, also be hydrolysed and fermented into base chemicals or bio-based fuel.

Bio-based products with a higher added value that can be produced from lignocellulosic biomass are fibre-based products, e.g., construction materials, furniture, fibre board, packaging materials, pulp and paper. As the quality of the fibre structure is essential in these applications, not all lignocellulosic biomass residues are suitable.

Manure, organic waste, and agrifood residues can be fed into anaerobic digesters and converted into biogas and digestate. Biogas can be used to produce electricity and heat or upgraded into bio-based fuel. Digestate can be used as mineral fertilizer for crops. Especially for manure, a large advantage of anaerobic digestion, is the prevention of methane emission to the atmosphere. Drawbacks of anaerobic digestion are the relatively high cost price of electricity compared to electricity from fossil, nuclear, and renewable (wind and solar) resources and the diluted residue digestate.

Another processing option for organic waste and agrifood residues is composting. The compost can be used as fertilizer. More optimal solutions are recommended in which a combination of energy extraction in anaerobic digestion and production of compost fertilisers of the digestate is done.

Bio-based products with a higher added value which can be obtained from agrifood residues are specialty chemicals, functional food ingredients, and feed. These products usually require selective and separate collection of biomass residues and one or more processing steps, e.g. mechanical and/or chemical separation, concentration, purification, conservation.

In Table 7.1 an overview is given of the key biomass types that can be further mobilised in the CELEBio countries and recommendations on possible conversion routes to be developed.

Table 7.1 Recommended biomass delivery chains to be developed in CELEBio countries

	Top 6 biomass type (largest, unused/mobilisable, low risk)						**Top 3 BBE conversion options**					
Country	**Biomass 1**	**Biomass 2**	**Biomass 3**	**Biomass 4**	**Biomass 5**	**Biomass 6**	**Food & Feed**	**Energy**	**Energy**	**Energy**	**Chemicals & bioproducts**	**Chemicals & bioproducts**
Czech Republic	Cereal& OSR straw	Manure	agrifood residues	Primary & secondary forestry residues	Organic waste			4. Primary and secondary forest residues to electricity & heat	1. Manure + organic waste to digesters (biomethane) and compost	3. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets	2. Primary and secondary forestry residues to materials	5. Agrofood waste to specialty chemicals
Hungary	Cereal straw & corn stover	Dedicated perennial crops	Manure	Agrifood residues (meat industry, fruit processing)	Primary & secondary forestry residues	Organic waste	3. Agrofood waste to functional food ingredients	1. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets	2. Manure + organic waste to digesters (biomethane) and compost		3. Primary and secondary forestry residues to materials	4. Agrofood waste to specialty chemicals
Slovenia	Manure	Primary & secondary wood residues	Organic waste					2. Primary and secondary forest residues to electricity & heat			1. Primary and secondary forestry residues to materials	
Croatia	Cereal straw & maize stover	Dedicated perennial crops	Manure	Agrifood residues (vegetable & fruit processing)	Primary & secondary forestry residues	Organic waste		2. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets			1. Primary and secondary forestry residues to materials	
Slovakia	Cereal straw	Agrifood residues (meat & vegetable & fruit processing)	Manure	Primary & secondary forestry residues	Organic waste			2. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets	3. Primary and secondary forest residues to electricity & heat	4. Manure + organic waste to digesters (biomethane) and compost	1. Primary and secondary forestry residues to materials	
Bulgaria	Straw (cereals, maize stover, sunflower)	Prunings permanent crops	Manure	Agrifood residues (vegetable & fruit processing)	Primary & secondary forestry residues	Organic waste	3. Agrofood waste to functional food ingredients	1. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets			2. Primary and secondary forestry residues to materials	4. Agrofood waste to functional food ingredients & specialty chemicals

	Top 6 biomass type (largest, unused/mobilisable, low risk)						Top 3 BBE conversion options					
Country	**Biomass 1**	**Biomass 2**	**Biomass 3**	**Biomass 4**	**Biomass 5**	**Biomass 6**	**Food & Feed**	**Energy**	**Energy**	**Energy**	**Chemicals & bioproducts**	**Chemicals & bioproducts**
Albania	Dedicated perennial crops	Biowaste	Primary & secondary forestry residues					2. organic waste to digesters (biomethane) and compost	3. dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets		1. Primary and secondary forestry residues to materials	
North Macedonia	Primary & secondary forestry residues	Dedicated perennial crops	Organic waste					2. organic waste to digesters (biomethane) and compost	3. dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets		1. Primary and secondary forestry residues to materials	
Bosnia and Herzegovina	Dedicated perennial crops	Primary & secondary forestry residues	Organic waste					2. organic waste to digesters (biomethane) and compost	3. dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets		1. Primary and secondary forestry residues to materials	
Serbia	Straw (cereals, maize stover, sunflower, OSR)	Primary & secondary forestry residues	Organic waste	Manure	Dedicated perennial crops			1. Straw & dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets	3. Manure & organic waste to digesters (biomethane) and compost		2. Primary and secondary forestry residues to materials	
Montenegro	Dedicated perennial crops	Primary & secondary forestry residues	Organic waste					2. organic waste to digesters (biomethane) and compost	3. dedicated perennials to biofuels via intermediates as pyrolysis oil and pellets		1. Primary and secondary forestry residues to materials	
Greece	Manure	Biowastes & post-consumer wood	Straw (cereals, maize stover, sunflower, OSR) & permanent crop residues	Agrofood residues	Primary & secondary forestry residues	Dedicated perennial crops	3. Agrofood waste to functional food ingredients	1. Organic waste to digesters (biomethane) and compost	2. Primary permanent crop residues and primary and secondary forest residues to electricity & heat		4. Agrofood waste to functional food ingredients & specialty chemicals	

Although in almost all CELEBio countries BBE conversion routes to energy are recommended it should be kept in mind that preferential chains should first be those that provide the best carbon mitigation and the highest added value. Bioenergy generation is one of them but not necessarily the best in this perspective. For example, the large exploitation of forest resources for fuelwood are currently the more sub-optimal uses of wood resources in terms of GHG mitigation, carbon capture, air pollution and economic added value. More coordination in the exploitation for fuel wood and other residual biomass sources also addressing access to de-central efficient heat and power installations at the same time is needed in many of the CELEBio target countries. This particularly applies to those countries in the neighbouring countries group.

7.2 Recommendations for bio-based value chains

In the target and surrounding countries large quantities of biomass residues from agriculture, forests, and waste are potentially available to produce bio-based products at relatively low costs. Despite these potentially available biomass sources, it was indicated in the country reports that there is currently no significant demand for bio-based products and a strategy for setting up bio-based value chains is still lacking. Based on the SWOT analyses and the considered bio-based value chains general recommendations are compiled.

- Define clear strategies and/or government policies concerning bio-based value chains and also optimal uses of biomass from a wider sustainability perspective.
- Create a demand for bio-based products and ensure a stable (long-term) market.
- Provide an inventory of available feedstocks from agriculture, forests, and waste with quantity and quality aspects.
- Create and provide clear guidelines on minimal sustainability principles to be applied to uses of different types of biomass and create and make biomass suppliers and users aware of certification options
- Determine if industrial scale processing is feasible. Otherwise, determine if the production of intermediate products (e.g. biomass pellets or pyrolysis oil) is feasible.
- Reward prevented methane emission in anaerobic digestion of agricultural residues and/or municipal waste.
- Provide federal funding for pilot and demo scale projects related to bio-based value chains.
- Provide (federal) support to lower the risk to invest in bio-based initiatives.
- Promote better use of available EU funding in the field of bio-based economy.

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Annex I - Overview of biomass potential per country

Table A.1 Per CELEBio country biomass potentials from agriculture, forestry and waste sectors

Biomass availability 2020 (Kton d.m.)	Forest (primary & secondary sources)*	Agriculture (primary field residues)*	Agrofood processing residues* & **	Biowastes & post-consumer wood*	Dedicated perennial crops on unused lands*	Manure ***	Total
Czech Republic	18301	7242	747	1161	1633	2740	31824
Hungary	6365	10058	511	1315	3885	2160	24294
Bulgaria	4612	6667	32	601	3907	1020	16838
Serbia	4078	4531	1	1341	1723	2220	13894
Greece	2610	2625	618	2822	1267	1860	11802
Slovakia	6511	2116	175	1108	596	1100	11606
Bosnia & Herzegovina	3193	1	75	475	3810	800	8354
Croatia	3819	1992	124	564	74	960	7533
Slovenia	5407	3	58	308	24	620	6421
Montenegro	1096	10	1	110	3810	120	5147
Albania	1097	281	20	521	1072	720	3711
North Macedonia	1189	93	11	301	791	4	2389

Sources:

* S2BIOM (Dees et al, 2018) and CELEBio country reports

** FAOSTAT for agrifood processing residues only referring to crop based agrifood residues. Data are for 2013

*** Scarlat et al. (2018)

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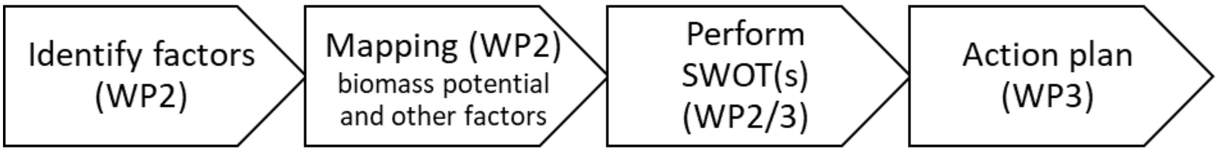
Annex II - Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.

The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

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Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbours, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

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Annex III - Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and waste

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

To consult and download biomass cost-supply data from the S2BIOM toolbox see: https://s2biom.wenr.wur.nl/web/guest/biomass-supply#_48_INSTANCE_nYA0VqOhoRGM_%3Dhttps%253A%252F%252Fs2biom.wenr.wur.nl%252Fbiomasscostsupplyviewer%252Findex.html%253Fclassic%2526

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and

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sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of ‘maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials, the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints). Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A.1 Overview of agricultural residual biomass potential types and considerations

	Area/ Basis	**Yield, Growth**	**Technical & environmental constraints on the biomass retrieval (per area)**	**Consideration of competing use**	**Mobilisation**
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None

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User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed. For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So, the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

Table A.2 Overview of woody biomass potential types used in S2BIOM

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobili-sation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stem wood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None

Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

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Table A.3 Overview of potentials calculated for biowaste and wood waste

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood and assumes that this material application remains constant in 2020 and 2030.
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stem wood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps'). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016).

National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stem wood potential removed as logs was estimated by subtracting harvest losses from the stem wood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stem wood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agrifood industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agrifood industries see Table A.5.

Table A.4 Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran

Biomass type	Area / Source	Residue factor	Technical & environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	**Base=** pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (*FABbiogas (2015)- Italian country report*)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). So, the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

Domestic production cereals – export cereals + import cereals

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see Figure A.1).

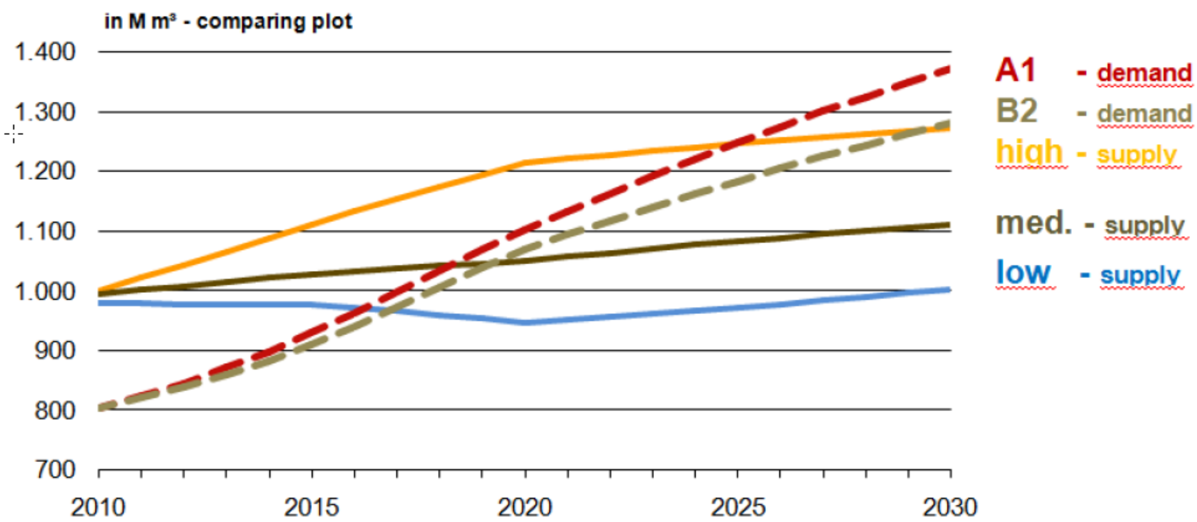

Figure A.1 Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010). Source EUWood 2010

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see Figure A.2

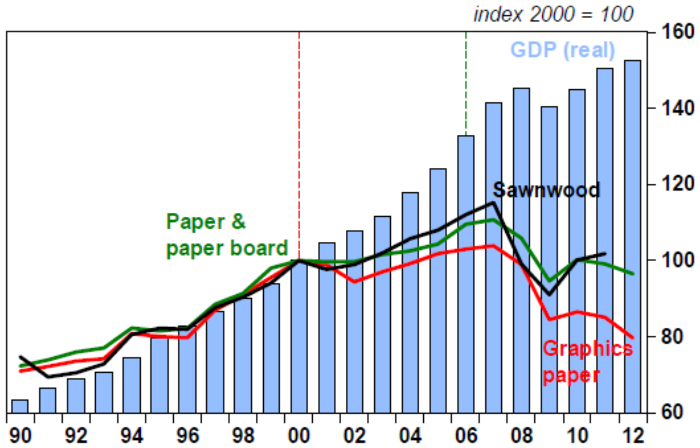

Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A.2 EU GDP and forest products consumption index[3]

An alternative is to use predicted future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures A.3 and A.4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

[3] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

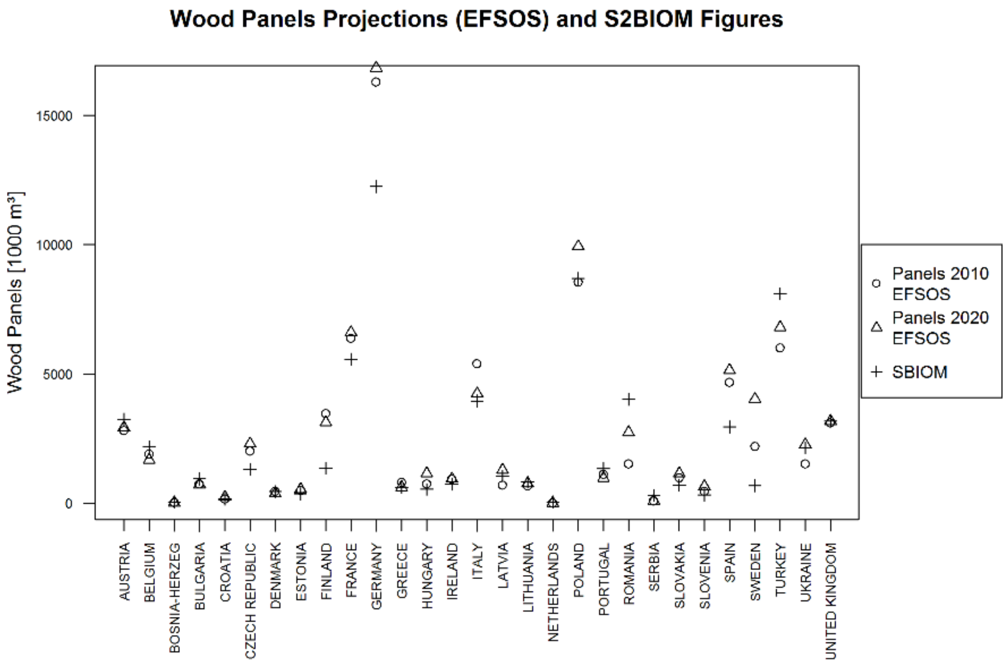

Figure A.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawn wood and wood-based panel production. For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

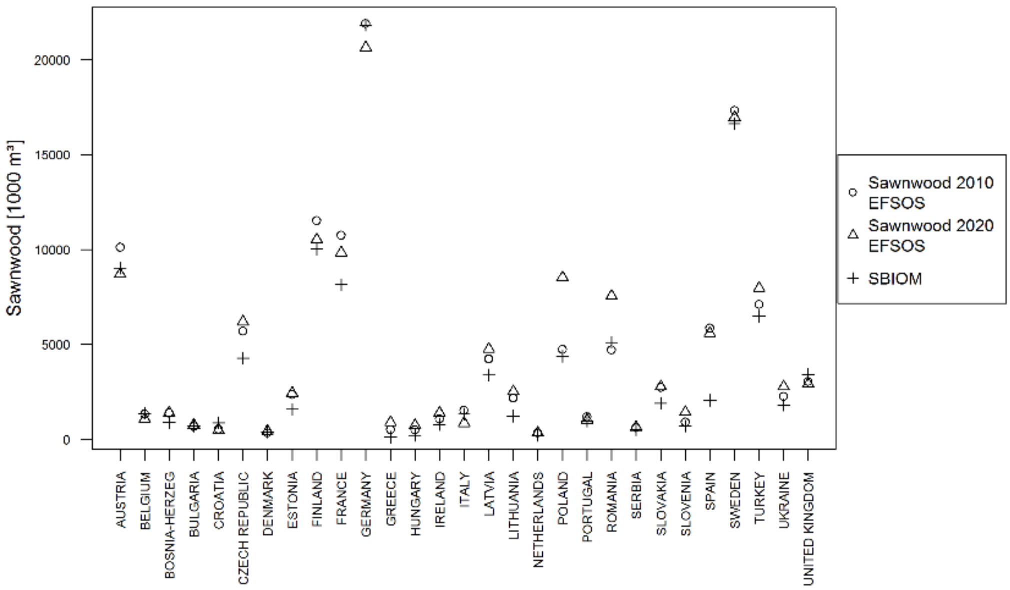

Figure A.4 Sawn wood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

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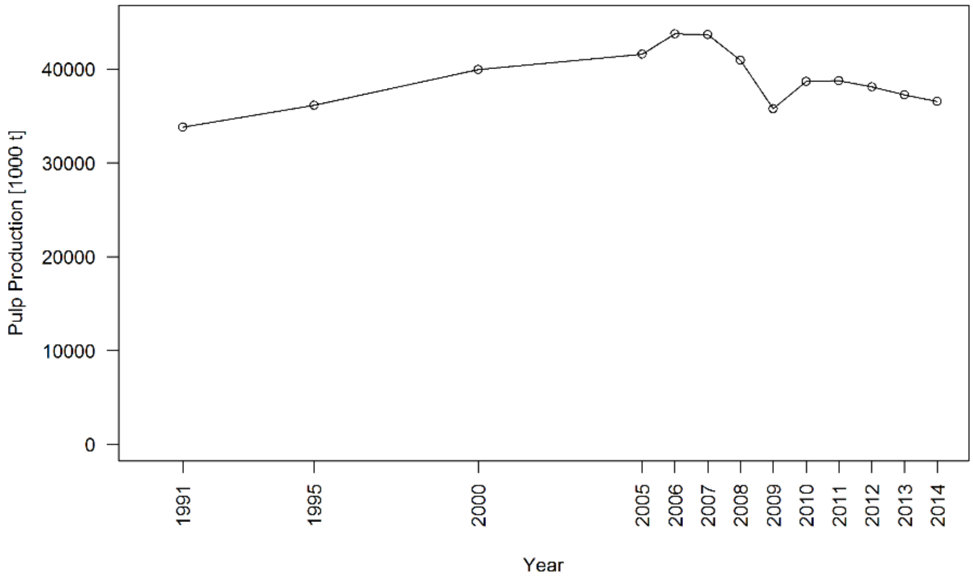
The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure A.5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.



FigureA.5 Development of Pulp production, CEPI data

The approach used is summarised by category in Table A.6.

Table A.5 Approach used to estimate future production amount in the wood industry

Sector	Approach
Sawmill residues, conifers	EFSOS II sawn wood, reference scenario
Sawmill residues, non-conifers	
Residues from industries producing semi -finished wood-based panels	EFSOS II wood-based panels production, reference scenario
Residues from further wood processing	EFSOS II sawn wood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

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Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x biowaste fraction (%) x

population of the NUTS3 area (persons)

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$$PCW_{\text{technical potential}} = PCW_{\text{material}} + PCW_{\text{energy}} + PCW_{\text{disposed}}$$

$$PCW_{\text{base potential}} = PCW_{\text{energy}} + PCW_{\text{disposed}}$$

in which:
$PCW_{\text{recovered}}$ = *PCW used for materials like panels and chipboards*
PCW_{energy} = *PCW used for energy production*
PCW_{disposed} = *landfilled and/or incinerated with MSW.*

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource assessment done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[4]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood but covers Europe as a whole instead of EU28. In

[4] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva

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order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[5], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil-based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for lignocellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to roadside/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

The cost assessed in S2BIOM are limited to the roadside cost. So, the cost from roadside for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the roadside. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

[5] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

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The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.

As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:

$$NPv = Fv / (1+i)^n$$

Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:

$$NPVa = \Sigma NPv * (1 / ((1-(1+i)^{-n}) / i))$$

Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allows for national differentiation of cost according to main inputs having national specific prices levels. The is organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in

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one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or bio-based products, i.e., in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e., cuttings of landscape elements or grass from roadside verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g., for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the roadside cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of dedicated crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole lifetime of a plantation as harvest levels are very low in the first years and increase in time.

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The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.

The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).

The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general workflow is illustrated in Figure A.6.

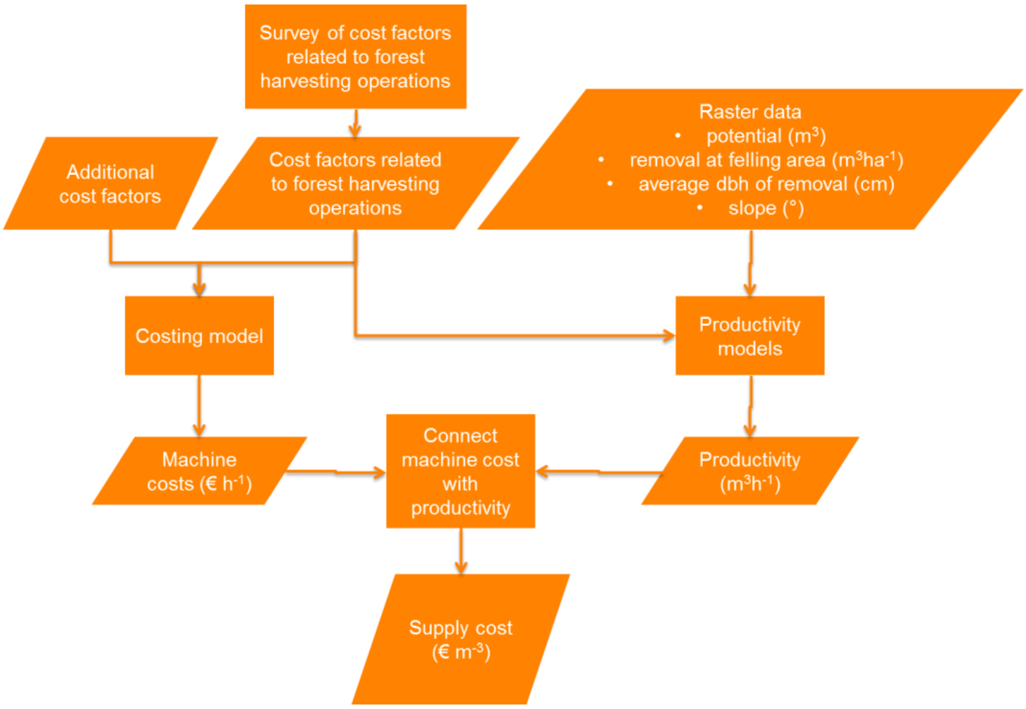

Figure A.6 General workflow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.