BioTheRoS

Collaborative actions to bring novel **BIO**fuels **THE**rmochemical **RO**utes into industrial **S**cale

DELIVERABLE 2.1

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Disclaimer

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List of abbreviations

AGB	Above Ground Biomass
BAWS	Biomass Available for Wood Supply
d.b.	Dry Basics
FAO	Food and Agricultural Organization of the United Nations
IPCC	Intergovernmental panel on climate change
JRC	Joint Research Centre
MToe	Million Tonnes of Oil Equivalent
NUTS0	Nomenclature of Units for Territorial Statistics nivel 0 (country)
NUTS1	Nomenclature of Units for Territorial Statistics nivel 1
NUTS2	Nomenclature of Units for Territorial Statistics nivel 2
RFNBO	Renewable Fuels of Non-Biological Origin
RPR	Residue to Product Ratio

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Executive Summary

This report provides a comprehensive assessment of the Global and European biomass potential for advanced biofuels production, using a methodology based on the categories outlined in Annex IX of the Renewable Energy Directive (RED II and recently updated to RED III). The evaluation covers a wide range of biomass sources, focusing on agricultural residues, forestry by-products, and other non-food feedstocks, offering a detailed insight into the geographic distribution of biomass resources and their suitability for biofuels production.

At the global level, the report identifies key regions with significant biomass potential. Southeast Asia, Latin America, and Northern Europe emerge as the regions with the highest biomass availability, driven by agricultural residues like straw, husks, and bagasse, as well as forestry by-products such as wood residues and biomass from forest-based industries. The report highlights Brazil, Mexico, and parts of Southeast Asia as major contributors due to their abundant crop residues, particularly rice husks and sugarcane bagasse. Additionally, the Nordic countries are recognized for their substantial forest biomass resources, which provide large quantities of ligno-cellulosic materials suitable for biofuels.

In Europe, the assessment shows that the northern regions of Spain, western France, and parts of Central and Eastern Europe have the highest biomass potential, particularly from e) straw, m) husks, and o) forestry residues. The report also emphasizes the importance of forestry by-products from countries like Sweden, Finland, and Poland, which contribute significantly to the biomass pool in Europe. Notably, e) straw is identified as the most abundant biomass resource, playing a central role in the biofuel potential across many regions.

The innovative categorization of biomass resources according to Annex IX allows for different way of present the resource assessment, aligning with European regulations and facilitating informed decision-making regarding biomass utilization for biofuels production. However, the report acknowledges that the results presented are based on initial estimates, and local variations in biomass availability due to factors like the Residue to Product Ratio (RSP) and regional agricultural practices should be considered in more detailed studies.

When transforming these tons of biomass into energy and comparing them with the current consumption levels in the aviation and maritime sectors, a clear difference emerges between Global and European contexts. At the Global scale, biomass resources appear sufficient across all scenarios to achieve full

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decarbonization, with straw being particularly prominent as it could largely meet the demand for advanced biofuels. In contrast, at the European level, none of the scenarios (not even those considering theoretical potential) offer enough biogenic feedstock to fully decarbonize these sectors. This highlights the importance of incorporating other resources, such as those from other categories of Annex IX, alongside advanced technologies like HVO and renewable fuels of non-biological origin (RFNBO) for e-fuel production, to ensure a comprehensive and effective decarbonization strategy.

Looking forward, BioTheRoS plans to integrate this evaluation methodology into a data visualization interface, as part of Task 2.4 of the project. This interface will allow users to adjust key variables such as RSP and availability percentages, providing more accurate, locally tailored biomass estimates for advanced biofuels production. By offering this dynamic tool, the project aims to support better decision-making in the optimization and development of biomass-based biofuels.

Finally, it is important to note that this report has played a key role in guiding the decision on which biomass types to use in WP3 and WP4 for a detailed study on the production of advanced fuels for the aviation and maritime sectors, utilizing pyrolysis and gasification technologies.

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1. Introduction

The transition to sustainable energy sources is a critical challenge for the aviation and maritime sectors, where decarbonization options are limited. Biomass feedstocks, when sourced and managed sustainably, offer a promising solution for producing renewable fuels via advanced conversion technologies such as pyrolysis and gasification. However, for these technologies to be effectively scaled and integrated into the global and European energy systems, it is essential to accurately assess the availability and sustainability of biomass resources.

Understanding the potential of biomass feedstock is a key to ensuring that sufficient, reliable, and sustainable supplies are available to meet the growing demand for renewable fuels. Without this foundational knowledge, large-scale initiatives risk facing supply chain bottlenecks, unsustainable resource extraction, or logistical challenges, which could undermine the environmental goals set by the Renewable Energy Directives (RED II and RED III). Previous studies have underscored the critical role of comprehensive resource assessments in facilitating informed decision-making within the bioenergy sector. For example, this point was further emphasized during the inaugural technical workshop conducted by BioTheRoS, which highlighted the necessity of detailed evaluations to address challenges and optimize bioenergy strategies effectively.

This deliverable begins by explaining the methodology employed in the study. Next, it highlights the selected feedstock and provides an overview of the global potential of biomass resources, offering a broad perspective on feedstock availability. The focus then narrows to Europe, presenting a more detailed assessment using comprehensive datasets. Finally, Section 4 discusses the geographical distribution of biomass potential at the global level (NUTS 0) and within Europe (NUTS 2). In all cases, the data are categorized according to Annex IX of RED II and RED III.

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2. Methodology

The methodology employed in this deliverable is designed to assess the potential of biogenic sustainable biomass feedstocks for renewable fuel production using gasification and pyrolysis technologies. The assessment is grounded in the feedstock categories defined in Annex IX of the Renewable Energy Directives (RED II and RED III), ensuring that only eligible and sustainable resources are considered. The process is structured around three main steps:

1. Identification of biogenic suitable feedstock.

The first step focuses on selecting feedstock that meet the criteria outlined in Annex IX of RED II and RED III, ensuring their sustainability. These feedstocks must be of biogenic origin, which includes agricultural residues, forestry by-products, certain waste streams, and other biomass sources listed in Annex IX, Parts A and B. In addition to being sustainable, the selected feedstocks must also be technologically compatible with the gasification and pyrolysis processes used in the project (considering factors such as energy content, chemical composition, etc). This ensures that the chosen feedstocks are not only compliant with EU regulatory standards but are also suitable for conversion into renewable fuels through the specific technologies being employed.

2. Data collection and quantification of biomass potential.

Building on the selected feedstocks from the previous step, this phase involves analysing the current production of these feedstocks using publicly available reports and databases such as FAO, EUROSTAT, and other credible sources. The aim is to quantify the potential of each feedstock by understanding its current production levels and associating this with the type of biomass it represents. For each selected resource, the potential biomass yield is estimated based on the production data. This assessment is conducted in two stages:

- Global analysis: Initially, the feedstock availability is evaluated on a global scale to provide a broad perspective on potential supply. This global overview helps identify general trends and large-scale opportunities for biomass utilization.
- European analysis: Following the global analysis, a more detailed assessment is conducted at the European level. Here, production data is examined with higher precision, considering regional specifics and resource potential within Europe. This stage allows for a more granular

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understanding of the biomass potential in alignment with European sustainability targets and the regulatory frameworks of RED II and RED III.

3. Geospatial mapping and feedstock categorization.

In the final step, the potential biomass resources are visually represented using Geographic Information Systems (GIS) to map their availability and distribution. The biomass resources are categorized according to the categories indicated in Annex IX of RED II and RED III, differentiating between the various types of sustainable feedstocks (Parts A and B). This enables stakeholders to easily understand the geographical distribution of resources, facilitating the development of supply chains for renewable fuels.

2.1 Identification of suitable feedstock

The first step in the methodology involved a thorough analysis of the different categories of biomass feedstocks listed in Annex IX of the Renewable Energy Directive (RED II), and subsequently those introduced in RED III. These categories define which feedstocks are considered sustainable for the production of renewable fuels and are critical for ensuring that the selected biomass complies with European sustainability standards.

Annex IX is divided into two parts, Part A and Part B, which categorize the eligible feedstocks:

- Part A includes advanced biofuels and biogas feedstocks that are deemed highly sustainable. These feedstocks do not directly compete with food production, as they are typically derived from waste, residues, and non-food cellulosic materials. Examples include agricultural residues like straw, forestry residues, and certain types of industrial waste. Feedstocks in Part A can count double towards the renewable energy targets set for the transport sector.
- Part B includes a narrower range of feedstocks, such as used cooking oil (UCO) and animal fats, which can also be used to produce renewable fuels. However, these are capped in their contribution to the renewable energy targets because their availability is more limited, and concerns over market saturation or indirect land use changes could arise.

RED III builds upon the framework established in RED II and updates the list of eligible feedstocks by further refining sustainability criteria and adding new potential feedstocks. The inclusion of these updates is essential to ensure compliance with the latest regulatory framework.

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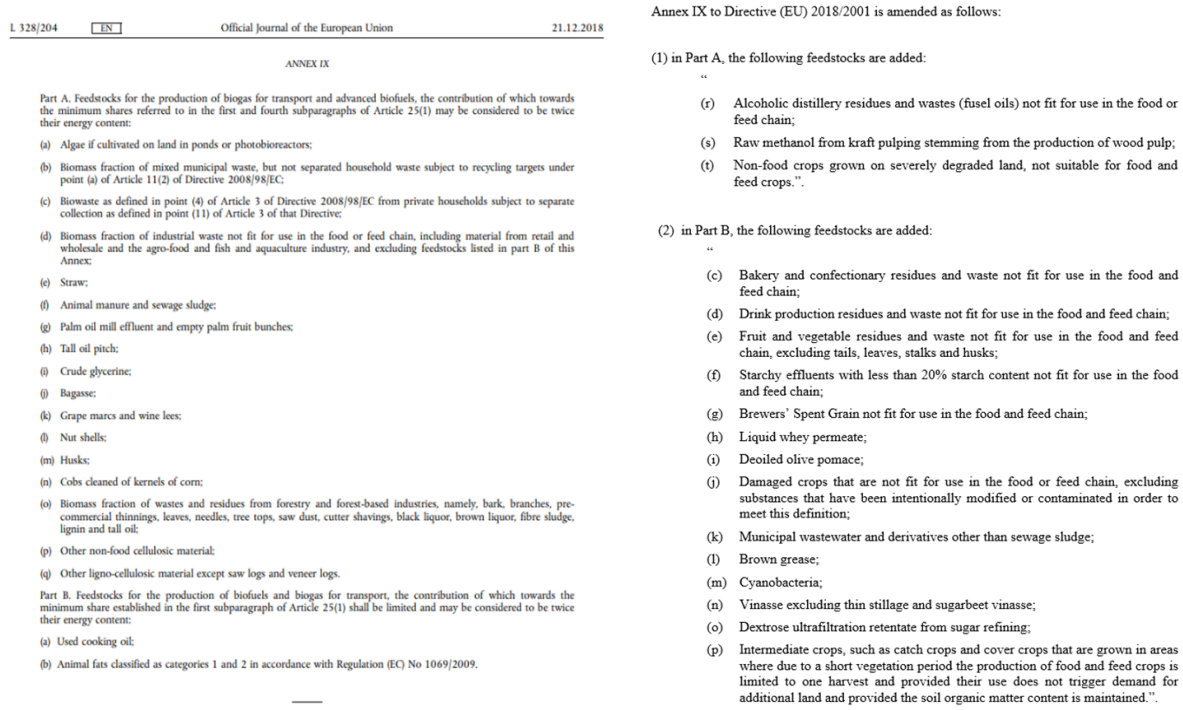

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ANNEX IX

Part A. Feedstocks for the production of biogas for transport and advanced biofuels, the contribution of which towards the minimum shares referred to in the first and fourth subparagraphs of Article 25(1) may be considered to be twice their energy content:

(a) Algae if cultivated on land in ponds or photobioreactors;

(b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC;

(c) Biowaste as defined in point (4) of Article 3 of Directive 2008/98/EC from private households subject to separate collection as defined in point (11) of Article 3 of that Directive;

(d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale and the agro-food and fish and aquaculture industry, and excluding feedstocks listed in part B of this Annex;

(e) Straw;

(f) Animal manure and sewage sludge;

(g) Palm oil mill effluent and empty palm fruit bunches;

(h) Tall oil pitch;

(i) Crude glycerine;

(j) Bagasse;

(k) Grape marcs and wine lees;

(l) Nut shells;

(m) Husks;

(n) Cobs cleaned of kernels of corn;

(o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely, bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil;

(p) Other non-food cellulosic material;

(q) Other ligno-cellulosic material except saw logs and veneer logs.

Part B. Feedstocks for the production of biofuels and biogas for transport, the contribution of which towards the minimum share established in the first subparagraph of Article 25(1) shall be limited and may be considered to be twice their energy content:

(a) Used cooking oil;

(b) Animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009.

Annex IX to Directive (EU) 2018/2001 is amended as follows:

(1) in Part A, the following feedstocks are added:

"

(r) Alcoholic distillery residues and wastes (fusel oils) not fit for use in the food or feed chain;

(s) Raw methanol from kraft pulping stemming from the production of wood pulp;

(t) Non-food crops grown on severely degraded land, not suitable for food and feed crops.".

(2) in Part B, the following feedstocks are added:

"

(c) Bakery and confectionary residues and waste not fit for use in the food and feed chain;

(d) Drink production residues and waste not fit for use in the food and feed chain;

(e) Fruit and vegetable residues and waste not fit for use in the food and feed chain, excluding tails, leaves, stalks and husks;

(f) Starchy effluents with less than 20% starch content not fit for use in the food and feed chain;

(g) Brewers' Spent Grain not fit for use in the food and feed chain;

(h) Liquid whey permeate;

(i) Deoiled olive pomace;

(j) Damaged crops that are not fit for use in the food or feed chain, excluding substances that have been intentionally modified or contaminated in order to meet this definition;

(k) Municipal wastewater and derivatives other than sewage sludge;

(l) Brown grease;

(m) Cyanobacteria;

(n) Vinasse excluding thin stillage and sugarbeet vinasse;

(o) Dextrose ultrafiltration retentate from sugar refining;

(p) Intermediate crops, such as catch crops and cover crops that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land and provided the soil organic matter content is maintained.".

Figure 1.Categories of feedstocks included in Annex IX of RED II (left) [1] and RED III (right). [2]

With the aim of analysing the current consumption of these categories feedstocks, in the "State of the Energy Union Report 2023" [3] elaborated by the European Union it can be seen the trend of Annex IX biofuel demand from 2017 to 2021 (Figure 2) and the Annex IX biofuel consumption per feedstock for each Member State in 2021 (Figure 3).

In Figure 2 an overall increase is observed in Annex IX biofuels use, from 2,317 ktoe in 2017 to 5,474 ktoe in 2021. Consumption of biofuels produced from used cooking oil (UCO, Annex IX Part B (a)) is the highest of all Annex IX feedstocks. When it comes to Annex IX Part A feedstocks, consumption of biofuels derived from feedstocks listed in points (d) biomass fraction of industrial waste not fit for use in the food or feed chain and (g) palm oil mill effluent and empty palm fruit bunches is the highest. In contrast, biofuels from the following Annex IX Part A feedstocks are not used at all or used less than 1 ktoe throughout the whole EU in all considered years: (a) algae if cultivated on land in ponds or photobioreactors; (l) nut shells; (m) husks; (n) cobs cleaned of kernels of corn and; (q) other ligno-cellulosic material except saw logs and veneer logs.

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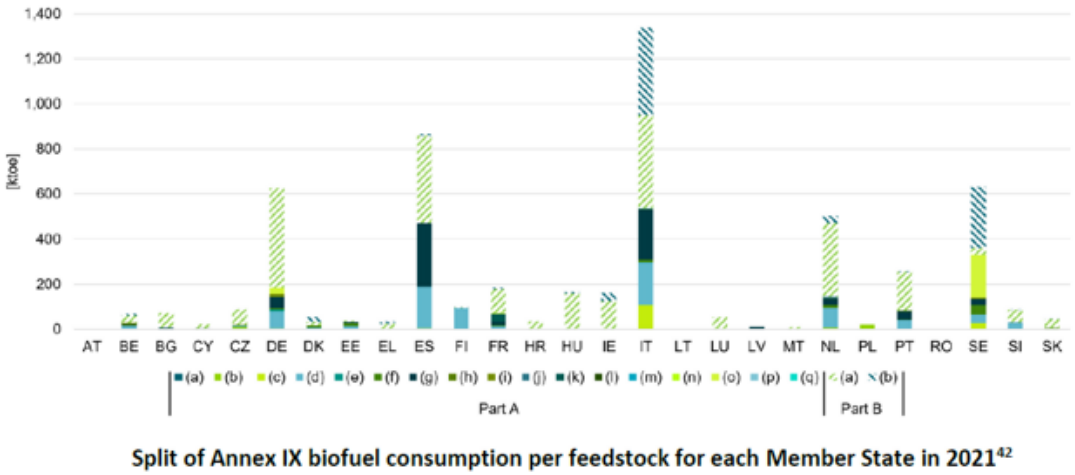
Figure 2. Trend of Annex IX biofuel demand for EU-27 from 2017 to 2021.

In Figure 3 can be seen that Italy is the largest consumer of Annex IX biofuels and, along with Spain, the largest user of Annex IX Part A biofuels. Italy is also the largest consumer of Annex IX Part B biofuels, followed by Germany, Spain, the Netherlands, and Sweden. Other Member States (Romania and Latvia) did not consume any Annex IX feedstocks, while Austria consumed only a small amount (<1 ktoe).



[41] Source: Eurostat SHARES database.
[42] Ibid.

Figure 3. Split of Annex IX biofuel consumption per feedstock for each Member State in 2021.

Once the categories of feedstocks were identified based on their classification in Annex IX of RED II and RED III, the next step was to ensure their suitability for the gasification and pyrolysis technologies that are

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central to the project. To this end, several meetings were held with project partners responsible for developing and implementing these conversion technologies.

These discussions focused on defining the specific biomass characteristics (presented in Table 1) that are crucial for the efficient operation of gasification and pyrolysis processes.

Table 1.Optimal, not ideal, and K.O. characterization that of the feedstocks according to the technology selected.

Parameter	Unit	Biomass requirements gasification			Biomass requirements pyrolysis		
		Optimum	Not ideal	K.O.	Optimum	Not ideal	K.O.
Proximate analysis							
Moisture	% a.r.	10-25	< 10 or > 25	-	5,0	<5 or >10	50,0
Volatile matter	% d.b.	50-90	< 50 or > 90	-	75 - 99	<75	
Ash	% d.b.	< 5	5-50	> 50	0-1	1-5	>5
Ultimate analysis							
C	% d.b.				40-60		
H	% d.b.				5-12		
N	% d.b.	< 1.0	1.0-3.0	> 3.0	0-2		
S	% d.b.	< 0.1	0.1-0.5	>0.5			
Cl	% d.b.	<0.5	0.5-2.0	>2.0			
Heating value							
Low heating value	kJ/kg d.b.	> 10,000	5,000-10,000	< 5,000	15,000-30,000	<15,000	
Bulk density and size distribution							
Bulk density	kg/m3 d.b.				100-500		
Size distribution	mm	5-50	< 5 or > 50		2-5	0,5-2	<0,5
Ash fusibility temperatures							
Ash fusibility temperature	ºC	1000	900-1000	<900	800-950		<800

Table 1 shows that, in general, the requirements for feedstock are somewhat more demanding for pyrolysis technology than for gasification. As critical aspects could be mentioned:

- Moisture contents above 50 % are not recommended
- Ash contents above 5 % in pyrolysis or 50 % in gasification (very unlikely for most feedstocks)

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- Certain N (>3 %), S (>0.5)) and Cl (>2.0) content in gasification can be critical
- Low calorific value of the feedstock (below 5000 kJ/kg)
- Low melting temperatures (below 800 ºC for pyrolysis, and 900 ºC for gasification)

The categories to be considered from now on for the resource evaluation have been selected taking into account this information given by the partners, together with the fact that the resource should be biogenic (goal of BioTheRoS project), and an additional desk research to see in previous studies which type of category of feedstock from Annex IX is recommended for this type of technologies (an example is showed in Figure 4).

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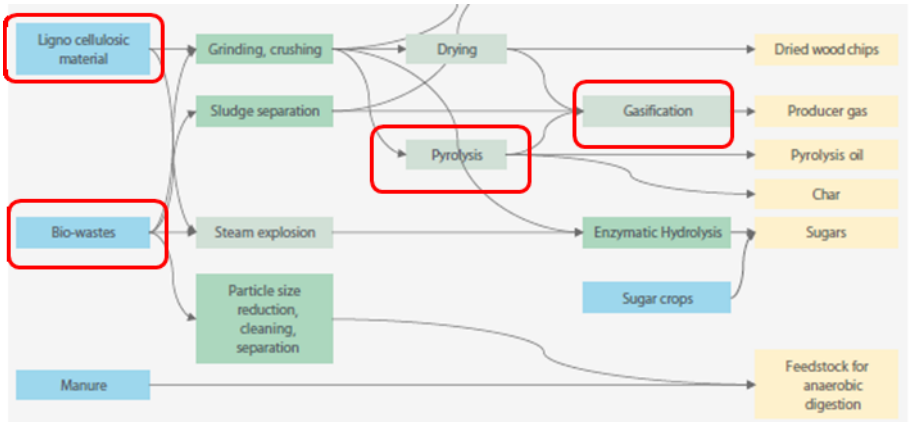
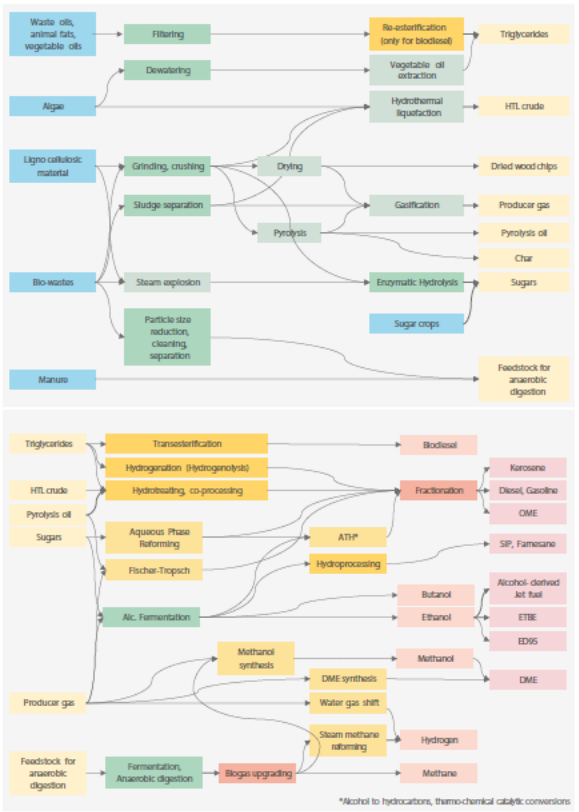


Annex I – Selected pathways for producing Annex IX biofuels



Source: Hurtig O., Buffi M., Scarlat N., Motola V., Georgakaki A., Letout S., Mountraki A., Joanny G., *Clean Energy Technology Observatory: Advanced biofuels in the European Union – 2022 Status Report on Technology Development, Trends, Value Chains and Markets*, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/938743, p. 2.

Figure 4. Scheme of production routes of SAF according to raw materials and technologies selected. Lignocellulosic material and biowastes are selected for gasification and pyrolysis technologies. [4]

In Figure 4 is indicated that the lignocellulosic material and biowastes are the categories of feedstocks selected for gasification and pyrolysis technologies, even though these categories are not specifically mentioned in Annex IX but are part of different categories of that Annex. In any case, this group of

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feedstocks corresponds to those identified through the information provided in the questionnaires carried out in BioTheRoS about the characterization that should fulfil the feedstocks (Table 1).

Based on this, the categories of feedstock that form part of Part B of Annex IX are discarded, because most of them are not of biogenic origin and are feedstock with high moisture content. As for the categories of feedstock indicated in Part A, it is proceeded to select the following categories that form part of what can be called lignocellulosic materials and biowastes (of biogenic origin).

It is true that the categories listed in Annex IX are sometimes abstract and may raise a number of doubts as to which type of product is to be included. For this purpose, the document prepared by Transport & Environment has been taken as a reference, named "RED II and advanced biofuels" [5], in which the feedstock categories of Annex IX are described, indicating "What it is and how it is produced" and "Existing practice or use". Considering all these considerations, the following categories were initially selected (Table 2).

Table 2. Categories of feedstock selected from Annex IX.

Feedstocks	What it is and how it is produced	Existing practice or use (or its current function i.e. soil carbon)
e) Straw	Dry stalks of crops that remain following the removal of the grain and chaff during the harvesting of grains.	Large amounts of straw are left on field or incorporated into the soil to maintain soil health. If extracted, it can be used for animal bedding and fodder. Used also for heat & power, horticulture, mushroom production, frost protection and a wide range of products (bottles, bags, etc.).
j) Bagasse	The fibrous residue from the sugarcane crushing process, after the removal of sugar juices.	Used as a fuel for on-site heat and power (50%), incinerated without energy recovery (40%), or in paper and board manufacture (10%).
k) Grape marcs and wine less	Grape marc, or 'pomace', is the residue that remains after the pressing of fresh grapes to extract juice for wine making. Wine less is the sediment remaining in the vessels used in wine fermentation.	Increasingly used for other alcoholic beverages, grape seed oil, food colourings, sweeteners, preservatives, and health products. Originally used for mulch.
l) Nut shells	Shells of nuts such as almonds, walnuts, hazelnuts etc.	Largely used for energy, though material uses exist.

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m) Husks	Husks are the protective outer covering of seeds, nuts, grains or fruit	Mainly energetic use, but could be also a component of animal feed.
n) Cobs cleaned of kernels of corn	The central, fibrous core of a maize ear to which the maize kernels are attached.	Typically left to field during harvesting.
o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely, bark, branches, pre-commercial thinnings, leaves, needles, tree tops, sawdust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil;	The bark of trees. Wood from uneconomic forestry management practices. Needles and leaves of trees. Would be usually collected together with treetops /branches. Primary residues of forest harvesting operations. Secondary residues from the processing timber at saw mills.	Depending on the material. Examples: -The wood is usually small diameter and left to forest floor. -Tree tops and branches, in some regions, collected on selected sites for energy. -Paper, wood products, energy (heat and power).
p) Other non-food cellulosic material	This is a very broad category. The definition in REDII includes agricultural residues, energy, cover, and ley crops.	Depending on the material. Examples: -These energy crops are grown on agricultural land, and are perennial, thus with one seeding, it will yield biomass for multiple years. - The "normal practice" now is leaving land without a crop in winter, or grow a winter crop. -Intermediate crops could in some cases be added to the rotation, with the aim to produce fodder for livestock and improve soil fertility.
q) Other ligno-cellulosic material except saw logs and veneer logs.	This is a very broad category and could include almost anything, from recycled paper to pulp wood, to tree stumps.	Depending on the material. Examples: -Energy crops are grown on agricultural land, and are perennial, thus with one planting, the plantations will grow 20-30 years. Harvested every 2-5 years. -Tree stumps keeps organic carbon sequestered in the biomass for decades/centuries and increases soil carbon levels. Makes forest more biodiverse as provides dead wood habitat for insects.

Among these selected categories, it can be seen that some are very specific, while others are very ambiguous and include very different feedstocks. In conclusion, it can be stated that the feedstock under

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study will be all those coming from agricultural or forestry sources, whether of primary origin (field/forest) or secondary origin (by-product of agro-industries/wood industry).

2.2 Data Collection and Quantification of Biomass Potential.

The second step of the methodology focuses on calculating the potential availability of the selected feedstocks, identified in Annex IX of RED II and RED III, specifically those of agricultural and forestry origin. This step relies on analyzing publicly available data from reliable sources such as FAO (global level analysis), EUROSTAT (EU level analysis), and public reports (to complement the data from FAO and EUROSTAT). These feedstocks are further divided into two primary categories based on their origin:

- Primary biomass: Directly sourced from fields or forests, such as agricultural residues (e.g., straw, husks) and forestry residues (e.g., branches, wood chips, and bark).
- Secondary biomass: By-products generated from agro-industrial and wood-processing activities, such as sawdust from sawmills or husks from food processing industries.

The overall aim of this phase is to estimate the potential amount of biomass that can be used for the production of advanced biofuels. The following steps outline the methodology used for calculating the potential biomass resources.

2.2.1 Global and European Assessment

This analysis is conducted at two scales:

- Global Level: The first stage of analysis assesses biomass potential on a global scale to provide a broad overview of potential feedstocks. Global databases such as FAO are used to estimate the overall potential for agricultural and forestry residues, as well as industrial by-products, across different regions. The accuracy of this analysis is at the country level (NUTS 0).
- European Level: After the global assessment, the analysis is refined with a more detailed focus on Europe, using databases such as EUROSTAT and European reports. This stage provides a more accurate estimate of biomass potential within the EU. The accuracy of this analysis is at the NUTS 2 level (except for Germany and United Kingdom, since public data are reported in NUTS 1).

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2.2.2 Collection of Production Data

The first task in this phase involves gathering production data for each selected feedstock from global and European databases. The sources used for data collection include:

- FAO [6]: (Food and Agriculture Organization): Provides comprehensive global data on crop and forestry production, allowing for the estimation of primary biomass, such as agricultural and forestry residues, from field and forest sources.
- EUROSTAT [7]: Offers detailed European-level data on agricultural and forestry outputs, as well as industrial by-products from wood processing and agro-industries. EUROSTAT is especially useful for obtaining more detailed, region-specific data within the EU.
- Reports from industry and research institutions: Studies from organizations like the Joint Research Centre (JRC), the International Renewable Energy Agency (IRENA), the European Space Agency (ESA), and national forestry/agricultural agencies provide insights into production trends and the potential availability of secondary feedstocks.

2.2.3 Estimation of biomass potential

Once the production data has been collected, the potential biomass yield is calculated for both primary subproducts and secondary biomass. The following methodological approach is applied for each category (the data is reported in ton dry basics, d.b):

Methodology for evaluating the potential of primary forest residual biomass

The assessment of primary forest residual biomass potential was based on a review of different bibliographic sources to gather and analyze the data they provide on this subject. This approach ensured the inclusion of diverse perspectives and datasets, allowing for a more comprehensive evaluation. As part of this process, data from the FAO's Forest Resources Assessment (FRA) Platform [8] were utilized. This resource provides information on annual forest area and biomass stock, specifically related to above-ground biomass (AGB), which was used to estimate global forest AGB biomass quantities.

Additionally, biomass maps from the European Space Agency (ESA) [9] and the Joint Research Centre (JRC) [10] were incorporated. The ESA biomass maps offer global-scale data on AGB biomass derived from

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remote sensing technologies, while the JRC datasets, including AGB and BAWS (Biomass and Wood Stock), and provide high-resolution data with a focus on European forests.

To align the data with administrative boundaries [11], the biomass estimates from the ESA and JRC maps were aggregated using NUTS 0 administrative boundary layers. This process allowed for the integration of biomass data with regional and national units, facilitating comparisons and regional analyses.

A comparison of the datasets from FAO, ESA, and JRC was conducted to evaluate their consistency and to identify potential variations. The FAO and ESA datasets provided a global perspective, while the JRC data offered a more detailed view specific to Europe. This comparative analysis serves as the starting point for estimating the amount of primary forest residual biomass. By establishing a baseline of forest biomass quantities, subsequent evaluations will focus on determining the fraction that can be considered as residual biomass for potential use.

The next steps involve refining the analysis with additional variables essential for assessing sustainable biomass extraction. The data on AGB derived from the FAO FRA Platform were compared for the years 2015 and 2020. For the same period, and in parallel, data on removals were analyzed to understand historical patterns of wood extraction. These include wood fuel and industrial round wood removals, which will be differentiated between coniferous and non-coniferous species. This data, sourced from the FAO database [12], was analyzed on a country-by-country basis to capture regional differences in forest management practices and extraction rates.

Data from wood fuel was also considered in certain quantities for the production of advanced biofuels. On the other hand, industrial round woods (sawlogs and veneer logs, pulpwood (round and split), and other industrial round wood) are associated with the stump of the tree, and in order to estimate the potential for residual biomass, a crown biomass expansion coefficient (CBEF) was applied. This coefficient accounts for the biomass in the tree crown, which is typically left behind after stump removals and is a key component in the assessment of residual biomass. To do so, different crown biomass expansion factors (CBEF) were considered by differentiating between the different subregions of each continent and the type of tree species (coniferous or non-coniferous), Table 3. These values have been estimated from different bibliographic sources consulted, the main resources are IPCC [13] (Intergovernmental panel on climate change) and FAO [14] (Food and agriculture Organization of the United Nations).

Table 3. Range and selected value of CBEF considered according to the different world regions.

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Region	Range CBEF coniferous	Range CBEF non-coniferous	CBEF coniferous selected	CBEF non-coniferous selected
Northern Africa	0.15–0.35	0.3–0.5	0.25	0.4
Southern Asia	0.2–0.4	0.35–0.55	0.3	0.45
Eastern Asia	0.2–0.4	0.3–0.5	0.3	0.4
Southern Europe	0.2–0.35	0.3–0.45	0.275	0.375
Polynesia	0.2–0.35	0.4–0.6	0.275	0.5
Middle Africa	0.15–0.35	0.4–0.6	0.25	0.5
Caribbean	0.2–0.35	0.4–0.6	0.275	0.5
South America	0.2–0.35	0.4–0.6	0.275	0.5
Western Asia	0.15–0.35	0.25–0.4	0.25	0.325
Central America	0.2–0.35	0.4–0.6	0.275	0.5
Western Europe	0.2–0.4	0.3–0.5	0.3	0.4
Eastern Europe	0.15–0.35	0.25–0.4	0.25	0.325
Northern Europe	0.2–0.4	0.3–0.5	0.3	0.4
Southern Africa	0.2–0.35	0.3–0.45	0.275	0.375
Western Africa	0.2–0.35	0.4–0.6	0.275	0.5
Eastern Africa	0.2–0.35	0.4–0.6	0.275	0.5
South-Eastern Asia	0.2–0.35	0.4–0.6	0.275	0.5

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Northern America	0.1–0.3	0.3–0.5	0.2	0.4
Australia and New Zealand	0.2–0.35	0.3–0.5	0.275	0.4
Micronesia	0.2–0.35	0.4–0.6	0.275	0.5
Melanesia	0.2–0.35	0.4–0.6	0.275	0.5
Central Asia	0.15–0.35	0.25–0.4	0.25	0.325

By combining these datasets, it was possible to determine the annual percentage increment for each country. This percentage was then used to estimate the theoretical potential for residual biomass and wood fuel. In cases where the percentage increment was negative, it was assumed that sustainable harvesting would not allow for additional biomass extraction. This follows the key principle of sustainable forest management, which states that "the long-term annual fellings do not exceed the net annual increment."

The calculated annual increment percentages were then multiplied by the AGB data from the four statistical sources considered (FAO, ESA, JRC AGB, and JRC BAWS). This approach enabled the estimation of the theoretical residual biomass potential across the datasets, which was then compared to evaluate consistency and identify variations.

Finally, three scenarios were developed to assess how much of this potential could be utilized for advanced biofuels production. These scenarios consider the harvesting loses, also differentiated between coniferous and broadleaf species and the previous CBEF considered in each subregion of each continent, providing insight into the possible contributions of each type of biomass to advanced biofuels production under varying assumptions. Table 4 shows the percentage of the theorical potential considered in each scenario for primary residual forest biomass and Table 5 for the wood fuel.

The differences in forest residual biomass potential between coniferous and non-coniferous species can be explained by harvesting practices and forest composition. Coniferous species are more commonly harvested for commercial purposes, and therefore residues, such as branches and treetops will be generated. In contrast, non-coniferous species are often harvested less intensively. Additionally,

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coniferous forests tend to be more extensive and accessible, making biomass collection more efficient, while non-coniferous forests are often more fragmented or located in areas with logistical challenges.

The differences across Scenarios A, B, and C, basically intend to make a sensitivity analysis on the amount of biomass that would be available for the production of advanced fuels (being scenario A the most optimistic and C the lowest), as this can be very particular to each area (that is why as indicated in the executive summary it is intend to make a web interface to be able to evaluate more concretely this data with specific knowledge of each area).

Table 4. Parameters considered to assess the theorical potential of primary forest residual biomass and the tree different scenarios of availability for advanced biofuels production.

Parameter	Coniferous	Non-coniferous
Scenario A (%)	72%	50%
Scenario B (%)	52%	30%
Scenario C (%)	32%	10%

Table 5. Parameters considered to assess the tree different scenarios of availability for advanced biofuels production from forestry wood fuels.

Parameter	Wood fuel
Scenario A (%)	50%
Scenario B (%)	30%
Scenario C (%)	20%

Methodology for evaluating the potential of primary agricultural residual biomass

The evaluation of the potential of agricultural residual biomass began with an analysis of agricultural crop production data for the period from 2018 to 2022. This timeframe was chosen to account for inter-annual variability in agricultural yields, which are strongly influenced by climatic and other external factors. Production data were sourced from the FAO database (for global assessments at the country level, NUTS 0) and Eurostat (for European data at NUTS 2). The Eurostat data at the NUTS 0 level were compared with FAO data to ensure consistency, revealing similar results.

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Using these production data, the next step involved selecting the crops that account for more than 80% at global level and 90 % at European level of total agricultural production. For each of these major crops, the primary type of residual biomass generated was identified. For example, in the case of herbaceous crops, straw is often the dominant agricultural residue.

To estimate the quantity of agricultural residual biomass associated with these crops, bibliographic sources were consulted to determine ranges for the Residue-to-Product Ratio (RSP). The RSP defines the relationship between the crop production data available in the databases and the potential quantity of residual biomass that can be derived. For each selected crop, a range of RSP values was identified based on the literature, and an average value within this range was established to provide a balanced estimate. This average RSP was then applied to the production data to calculate the theoretical biomass potential at both Global and European scales.

Finally, as in the case of forest biomass, scenarios were developed to evaluate the portion of this theoretical agricultural residual biomass that could realistically be utilized for advanced biofuels production. These scenarios consider variations in biomass availability based on different assumptions, including regional practices, accessibility, and the type of agricultural residues, providing an adaptable framework for assessing the potential contributions of agricultural biomass to advanced biofuels production, Table 6.

The potential availability percentage for pruning is assumed to be slightly higher than for straw due to the diverse and competitive uses of straw as mentioned in Table 2, being mainly pruning left on the field as organic matter or directly burnt in the open air. With respect to the 3 scenarios indicated, the same criterion has been applied, being A the most optimistic and C the lowest.

Table 6. Parameters considered to assess the tree different scenarios of availability for advanced biofuels production from primary agricultural residual biomass.

Parameter	Pruning	Straw/Stalk
Scenario A (%)	60%	50%
Scenario B (%)	40%	30%
Scenario C (%)	20%	10%

Methodology for evaluating the potential of forestry secondary biomass

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To assess the potential of secondary biomass, a methodology was developed based on data from the FAO database. The analysis focused on publicly available data related to imports and exports of industrial round wood. Industrial round wood, as defined in this context, includes the combined categories of sawlogs, veneer logs as well as pulpwood. Due to data availability limitations, these categories were not analysed separately, as detailed breakdowns of import and export are not currently provided by the FAO.

The evaluation considered the period from 2015 to 2020, consistent with the timeframe used for analysing removals in the assessment of primary biomass. For each country, the quantity of industrial roundwood processed domestically was calculated by considering the total harvested volume, adjusted for imports and exports. Specifically, the processed volume was determined as the difference between the total harvested quantity within a country and the net trade balance (imports minus exports) of industrial roundwood.

From this processed volume, an estimated percentage of potential secondary biomass was calculated separately for coniferous and non-coniferous species. Additionally, the volumes were converted from cubic meters to tonnes using average wood density values specific to coniferous and non-coniferous wood. This calculation provides the theoretical maximum potential of secondary biomass that could be available for energy purposes. The calculated value is based on FAO data and has been divided by the AGB data obtained from FAO. This allows to obtain a percentage of secondary biomass to be obtained for energy purposes with respect to the AGB data, which has been used to determine this value with respect to the other sources consulted (ESA and JRC).

As with the estimation of primary residual biomass, three scenarios were advanced biofuels production. These scenarios reflect varying levels of availability and accessibility while distinguishing between coniferous and non-coniferous sources, providing a general framework for assessing the possible contributions of secondary biomass under different assumptions, Table 7.

Table 7. Parameters considered to assess the tree different scenarios of availability for advanced biofuels production from secondary forestry biomass.

Parameter	Wood fuel
Scenario A (%)	80%
Scenario B (%)	50%
Scenario C (%)	30%

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Methodology for evaluating the potential of secondary agricultural biomass

The evaluation of secondary agricultural biomass follows a similar methodology to that used for agricultural residual biomass, as described earlier. The analysis is based on production data for the main products derived from agricultural crops during the period 2018 to 2022, sourced from the FAO (global, NUTS 0) and Eurostat (European, NUTS 2) databases. The consistency between the two datasets was confirmed at the NUTS 0 level.

For the crops contributing to over 90% of total agricultural production, the industrial transformation processes were identified, and the main secondary residues generated (e.g., rice husks, sugarcane bagasse) were analysed. Conversion factors relating the production of these primary products to the generation of secondary residues were derived from bibliographic sources, consistent with the approach outlined in the previous section.

The resulting estimates provide the theoretical maximum potential of secondary agricultural biomass, expressed in tonnes (d.b.). As with agricultural residual biomass, three scenarios were developed to evaluate the realistic availability of secondary agricultural biomass for advanced biofuels production, taking into account different scenarios of availability (Table 8). This approach ensures consistency across the assessment of different biomass streams.

Table 8. Parameters considered to assess the theorical potential of secondary agricultural residual biomass and the tree different scenarios of availability for advanced biofuels production.

Parameter	Pomace	Bagasse	Cob	Husk
Scenario A (%)	70%	70%	70%	70%
Scenario B (%)	40%	40%	40%	40%
Scenario C (%)	20%	20%	20%	20%

2.2.4 Final Quantification and Integrations of the Results

The final step in this phase involves consolidating all the data collected in the previous stages to provide a comprehensive estimate of biomass potential. The objective is to aggregate and classify the identified feedstocks based on the categories outlined in Annex IX, Part A of RED II and RED III. The process follows these key steps:

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- Classify feedstocks: Once the total biomass availability is determined, the next step is to categorize the feedstocks according to the relevant classifications in Annex IX, Part A. This ensures that all selected feedstocks meet the regulatory requirements for sustainable biofuel production.
- Aggregate data: All the calculated potential biomass volumes, from both primary (agricultural and forestry residues) and secondary (by-products of agro-industries and the wood industry) sources, are aggregated in the different categories.
- Analysis: In all categories, a comparison will be carried out to analyse their contribution in relation to the total, and what is the percentage that provides each of the biomasses considered within each category.

By following this process, the results will be organized according to the RED II and RED III categories, which has not been commonly addressed in other biomass potential analysis studies, providing a notable point of distinction.

2.3 Geospatial Mapping and Feedstock Categorization.

The third phase of the methodology focuses on geospatial mapping of the different categories of the Annex IX selected, as described in the point 2.2. This step is critical for understanding where biomass resources are most abundant and accessible, and for having the geographical distribution of feedstock availability across different regions.

For the representation of the data at global level it will be done at country level (NUTS 0), whereas for the European level it will be done at the regional level (NUTS 2), except for Germany and UK which will be at NUTS1 level due to lack of data. Additionally, desk research has been carried out to identify maps of biomass potentials elaborated by other types of entities (as for instance the European Space Agency and the Joint Research Centre). Some of these maps, as was previously mentioned, has been taken as starting point, especially in the case of forest biomass (more studied than agricultural biomasses).

These geospatial mapping will allow the identification of logistical and infrastructure considerations necessary for the deployment of biomass conversion technologies like pyrolysis and gasification which is fundamental for the development of predictive biomass demand models with AI.

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3. Biomass assessment

This section shows the feedstocks selected for the study, the categories in Annex IX into which they have been grouped, and the overall results obtained at both Global and European level.

3.1 Biomass selected

Section 2.1 concluded that the analysis would focus on biogenic and sustainable forestry and agricultural biomass groups. Specifically for primary forest biomass, only residual forest biomass and wood fuel will be considered, for secondary forest biomass, residual biogenic materials generated by the wood industry will be included. In the case of agricultural biomass, the scope is much broader due to the diversity of agricultural crops. To address this, the analysis identified the crops representing 80% of global agricultural production and 90% of European production. This allowed the classification of the predominant types of primary and secondary biomass. Additionally, bibliographic sources were consulted to determine residue-to-product (RSP) ratios, which were then used to select the specific types of biomass to be studied.

Table 9 and Table 10 show the average production of each crop in the period analysed (2018 to 2022) at both global (80%) and European (90%) level, ordered from highest to lowest production. At the global level, the top 5 are sugar cane, maize, rice, wheat and oil palm fruit, while at the European level they are wheat, sugar beet, maize, potatoes and barley.

Table 9. Average global agricultural crop production (2018-2022). Source: FAO [6]

Crops	Value (Tons)	% worldwide
Sugar cane	1,909,763,357	18.70%
Maize (corn)	1,157,860,499	11.34%
Rice	771,505,467	7.55%
Wheat	766,930,904	7.51%
Oil palm fruit	417,058,157	4.08%
Potatoes	369,753,097	3.62%

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Soya beans	351,665,745	3.44%
Cassava, fresh	315,600,145	3.09%
Other vegetables, fresh n,e,c,	295,225,039	2.89%
Sugar beet	266,972,790	2.61%
Tomatoes	184,941,061	1.81%
Beer of barley, malted	184,705,006	1.81%
Raw cane or beet sugar (centrifugal only)	177,764,549	1.74%
Barley	151,337,667	1.48%
Bananas	126,753,652	1.24%
Onions and shallots, dry (excluding dehydrated)	103,993,136	1.02%
Watermelons	100,984,227	0.99%
Apples	90,733,249	0.89%
Cucumbers and gherkins	90,248,988	0.88%
Sweet potatoes	88,951,643	0.87%
Yams	82,514,369	0.81%
Grapes	77,134,538	0.76%
Palm oil	77,013,304	0.75%
Oranges	75,866,437	0.74%
TOTAL	8,235,277,027	80.64%

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Table 10. Average European agricultural crop production (2018-2022). Source: FAO [6]

Crops	Value (Tons)	% at European level
Wheat	263,036,227	21.48%
Sugar beet	178,756,398	14.60%
Maize (corn)	125,829,463	10.28%
Potatoes	102,599,337	8.38%
Barley	90,780,088	7.41%
Beer of barley, malted	50,525,130	4.13%
Sunflower seed	39,980,856	3.26%
Grapes	28,060,913	2.29%
Raw cane or beet sugar (centrifugal only)	27,342,588	2.23%
Rape or colza seed	25,332,497	2.07%
Tomatoes	22,833,990	1.86%
Apples	18,418,343	1.50%
Wine	16,967,120	1.39%
Sunflower-seed oil, crude	14,861,769	1.21%
Oats	14,041,498	1.15%

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Olives	13,522,995	1.10%
Triticale	13,010,984	1.06%
Soya beans	11,686,790	0.95%
Rye	11,118,297	0.91%
Rapeseed or canola oil, crude	10,927,648	0.89%
Onions and shallots, dry (excluding dehydrated)	9,962,419	0.81%
Cabbages	9,287,862	0.76%
Carrots and turnips	8,359,065	0.68%
TOTAL	1,107,242,275	90.42%

The data presented in Table 9 represents the global level, while Table 10 focuses exclusively on the European level. For insights into global crop production excluding the impact of Europe, please see Table 11. When compared with Table 9, the crops listed are nearly the same, with differences primarily in the production quantity and therefore the ranking of certain crops, corresponding mainly to the top five European crops (Table 10). As these crops are not reflected in this table, their production decreases to some extent at the global level.

Table 11. Average global agricultural crop production (2018-2022) without Europe. Source: FAO [6]

Crops	Value (Tons)	% worldwide (without Europe)
Sugar cane	1,909,763,323	21.25%
Maize (corn)	1,032,031,036	11.48%
Rice	767,723,406	8.54%

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Wheat	503,894,677	5.61%
Oil palm fruit	417,058,157	4.64%
Soya beans	339,978,346	3.78%
Cassava, fresh	315,600,145	3.51%
Other vegetables, fresh n.e.c.	290,454,073	3.23%
Potatoes	267,153,759	2.97%
Tomatoes	162,106,651	1.80%
Raw cane or beet sugar (centrifugal only)	150,421,501	1.67%
Beer of barley, malted	134,177,503	1.49%
Bananas	125,059,272	1.39%
Watermelons	95,244,429	1.06%
Onions and shallots, dry (excluding dehydrated)	94,030,717	1.05%
Sweet potatoes	88,943,621	0.99%
Sugar beet	88,214,814	0.98%
Cucumbers and gherkins	84,277,894	0.94%
Yams	82,512,142	0.92%
Palm oil	77,013,304	0.86%
Seed cotton, unginned	73,362,428	0.82%
Apples	72,314,906	0.80%

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Oranges	69,541,060	0.77%
TOTAL	7,240,877,165	80.58

Taking into account these crops (Table 9 and Table 10), the characteristics that the biomasses derived from them must fulfil to be suitable for the technologies proposed in BioTheRoS, as mentioned in section 2.1, and the availability of RSP (residue to product ratio) data, the following crops were selected at World and European level in this study (Table 12).

Table 12.Selected crops at World and European level.

Crops selected at World level	Crops selected at European level
Sugar cane	Wheat
Maize (corn)	Sugar beet
Rice	Maize (corn)
Wheat	Potatoes
Potatoes	Barley
Soya beans	Sunflower seed
Sugar beet	Grapes
Barley	Rape or colza seed
Apples	Apples
Yams	Wine
Grapes	Oats

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Oranges	Olives
	Triticale
	Soya beans
	Rye

After identifying the agricultural crops to be included in the study, the types of primary and secondary biomass that can be derived from each crop were determined. Furthermore, as previously stated, one of the objectives of this study is to assess the potential of these biomasses according to the categories outlined in Annex IX of RED II and RED III. Consequently, the identified biomasses were classified based on their corresponding categories within those specified in the Annex IX, Table 13.

Table 13. Primary and secondary biomass derived from each agricultural crop and their corresponding category in Annex IX.

Food crops	Primary residues	Category of Annex IX for primary residue	Secondary residues	Category of Annex IX for secondary residue
Sugar cane	Straw	e) Straw	Bagasse	j) Bagasse
Maize (corn)	Stalk	n) Cobs cleaned of kernels of corn	Cob	n) Cobs cleaned of kernels of corn
Rice	Straw	e) Straw	Husk	m) Husks
Wheat	Straw	e) Straw	Husk	m) Husks
Potatoes	Stalks	p) Other non-food cellulosic material	Peel	p) Other non-food cellulosic material
Soya beans	Straw	e) Straw	-	-
Sugar beet	Leaves	p) Other non-food cellulosic material	-	-
Barley	Straw	e) Straw	-	-

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Apples	Prunings	p) Other non-food cellulosic material	-	-
Yams	Stalks	e) Straw	-	-
Grapes	Prunings	p) Other non-food cellulosic material	Pomace	p) Other non-food cellulosic material
Oranges	Prunings	p) Other non-food cellulosic material	-	-
Sunflower seed	Stems	p) Other non-food cellulosic material	Pomace	p) Other non-food cellulosic material
Rape or colza seed	Straw	e) Straw	Pomace	p) Other non-food cellulosic material
Oats	Straw	e) Straw	-	-
Olives	Prunings	p) Other non-food cellulosic material	Pomace	p) Other non-food cellulosic material
Triticale	Straw	e) Straw	-	-
Rye	Straw	e) Straw	-	-

Finally, considering also the forestry biomass considered, the specific biomass considered in each of the categories at World and European level are indicated in Table 14.

Table 14.Summary of feedstock and categories of Annex IX selected for the assessment.

Categories Annex IX	Biomass considered at World level	Biomass considered at European level
e) Straw	Maize Stalk	Maize Stalk
	Barley Straw	Barley Straw
	Wheat straw	Wheat straw
	Rice straw	Soya straw
	Sugar cane straw	Rye straw
	Soya beans straw	Oats straw

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	Yams straw	Triticale straw
	-	Rape seed straw
j) Bagasse	Sugar cane bagasse	-
m) Husks	Wheat husk	Wheat husk
	Rice husk	-
n) Cobs cleaned of kernels of corn	Maize cob	Maize cob
o) Biomass fraction of wastes and residues from forestry and forest-based industries	Primary residual forestry biomass	Primary residual forestry biomass
	Secondary forestry biomass	Secondary forestry biomass
p) Other non-food cellulosic material	Apples pruning	Fruits pruning
	Grape pruning	Grape pruning
	Grape pomace	Grape pomace
	Orange pruning	Potatoes leaves
	Potatoes leaves	Potatoes peel
	Potatoes peel	Sugar beet leaves
	Sugar beet leaves	Rape seed pomace
	Sweet potatoes leaves	Sunflower seed leaves
	Sweet potatoes peel	Olive pruning
	Yams peel	Olive pomace
q) Other ligno-cellulosic material except saw logs and veneer logs.	Forestry wood fuel	Forestry wood fuel

3.2 Biomass potential

The methodology followed has been the same for carrying out the study at both Global and European level, as detailed in section 2.2.3.

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In the case of the agricultural potential, a comprehensive bibliographic review was conducted to identify the RPR ranges typically reported. This analysis culminated in the determination of a specific RPR value for each type of biomass, Table 15.

Table 15. RPR of the selected agricultural biomass.

Food crops	Eurostat Code	Primary residues	Secondary residues	Range of RPR for primary residues	RPR selected for primary residues [1]	Residue to product ratio (RPR) consider for secondary residues [1]
Sugar cane	I9000	Straw	Bagasse	0.05-0.32 [15] [16]	0.22 [16]	0.23 [16]
Maize (corn)	C1500	Stalk	Cob	0.77-2.50 [15] [17] [18]	2 [18]	0.3 [18]
Wheat	C1110	Straw	Husk	0.5-1.75 [15] [16] [17] [18]	1.5 [18]	0.3 [18]
Rice	C2000	Straw	Husk	0.45-1.75 [15] [16] [17] [18]	1.5 [18]	0.2 [18]
Sugar beet	R2000	Leaves	Pulp	0.1-0.3 [17] [19]	0.2 [19]	-
Soya beans	I1130	Straw	-	0.76-3.5 [15] [16] [17]	1.7 [15]	-
Potatoes	R1000	Leaves / Stalks	Peel	0.05-0.76 [15] [16] [17]	0.76 [16]	
Barley	C1300	Straw	Bagasse	1.08-1-36 [16] [17] [18]	1.3 [18]	-
Rape or colza seed	I1110	Straw	Pomace / cake	1.10-1.8 [16] [17] [18]	1.8 [18]	2 [2] [20]
Grapes	W1000	Prunings	Pomace / cake	0.11 [18]	0.11 [18]	0.168 [3] [21]
Sunflower seed	I1120	Stems and leaves	Pomace / cake	0.7-3.5 [18]	3 [18]	-

[1] The values are selected taking the mean from the range provide from the literature, if the literature can provide a unique value, this is selected from it.
[2] This value refers to the production of Rapeseed oil only.
[3] This value refers to production of wine: "for 6 liters of wine production generates around 1 kg of grape pomace"

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Olives	O1000	Prunings	Pomace / cake	1.14-1.25 [17]	1.2 [17]	2 [4] [22]
Triticale	C1600	Straw	-	1.3 [5]	1.3 [5]	
Oats	C1410	Straw	-	1-2 [15] [16] [17]	1.4 [16]	
Apples	F1100	Prunings	-	0.14-0.3 [6] [17]	0.22 [17]	
Oranges	T1000	Prunings	-	0.2-0.5 [17]	0.35 [17]	
Yams	V4900	Leaves / Stalks	Peel	0.5 [16]	0.5 [16]	0.23 [16]
Rye	C1210	Straw	-	0.99 [17]	0.99 [17]	

In the case of the forestry biomass, all the potentials and scenarios were calculated according to the different sources indicated in section 2.2.3 (FAO, ESA, JRC BAWS and JRC AGB). The data gathered from these sources reveal significant differences in certain countries or regions, although the overall discrepancies are less pronounced. Annex I present the some of the data obtained for different countries based on each source.

Nevertheless, this section focuses on the global data obtained from the ESA, while at the European level, it relies on data from the JRC BAWS. These sources were selected because they are based on very detailed georeferenced maps, which subsequently facilitate more effective use of geographic information systems (GIS) in the following task of BioTheRoS.

The following sections outline the theoretical potential, and the three distinct availability scenarios proposed at both Global and European levels.

3.2.1 Global level

Figure 5 illustrates the availability of biomass, measured in tonnes, for the production of advanced biofuels across different scenarios (A, B, and C) and its theoretical potential. The theoretical potential

[4] This value refers to the production of olive oil only, Olive mil solid wastes (OMWS).
[5] The ratio that is used is the same of the wheat because of the similarity between crops.
[6] This value refers a Pome fruit.

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(blue bars) is significantly higher than any of the scenarios for all biomass categories, representing the maximum potential without constraints. In contrast, scenarios A (orange bars), B (green bars), and C (light blue bars) show progressively lower availability as restrictions such as technical, economical, and competition with other uses are considered. Among the biomass categories, straw (e) and forestry residues (o) stand out as the largest contributors across all scenarios, highlighting their importance for biofuel production. Conversely, categories such as bagasse (j), husks (m), and cobs cleaned of kernels of corn (n) have comparatively smaller contributions. This figure emphasizes the substantial gap between theoretical potential and realistic availability under various constraints, with straw and forestry residues emerging as the most promising resources for advanced biofuels.

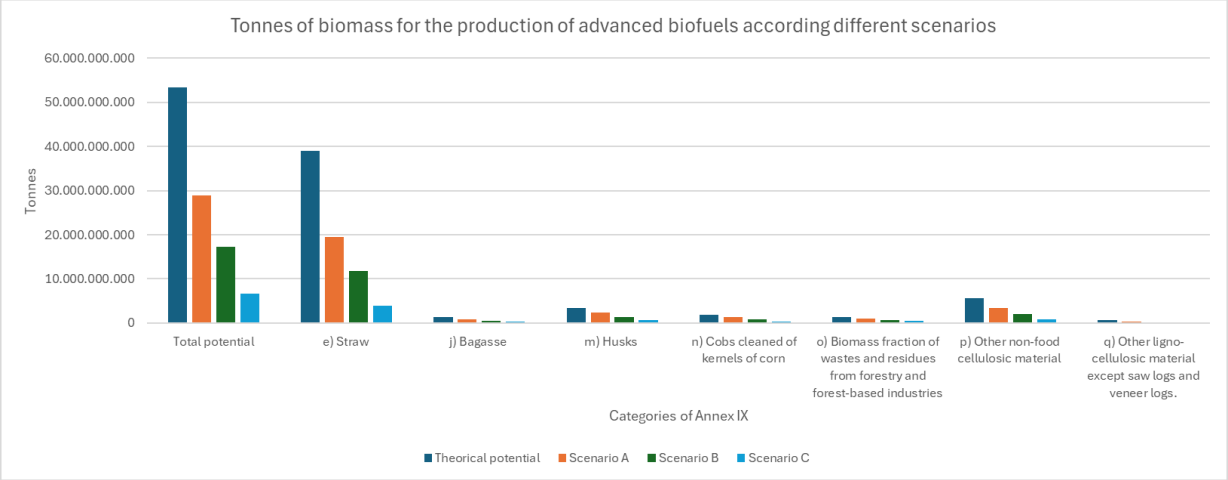

Figure 5. Tonnes of biomass to produce advanced biofuels at Global level according to different scenarios grouped in the different categories of Annex IX.

Figure 6 focus on the theoretical potential of biomass resources for advanced biofuel production, emphasizing the variety of resources contributing to each category from Annex IX. The "Potential" category, dominated by straw (e), includes significant contributions from resources such as rice straw, maize stalks and wheat straw. Similarly, forestry residues (o) consist of primary and secondary forestry biomass, being the primary forest residual biomass the dominant.

For smaller categories, bagasse (j) comprises barley and sugarcane bagasse, while husks (m) primarily include wheat husk and rice husk. Cobs cleaned of kernels of corn (n) consist of maize (corn) cobs. Additionally, non-food cellulosic materials (p) incorporate resources like grape pomace, apple and orange pruning, and sugar beet leaves and ligno-cellulosic materials (q) the wood fuel.

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These diverse resources showcase the wide array of biomass feedstocks available, with agricultural residues such as straw playing a pivotal role, supplemented by contributions from forestry and specialized materials like pruning and pomace. This variety underlines the importance of optimizing resource use within each category to achieve the theoretical biomass potential.

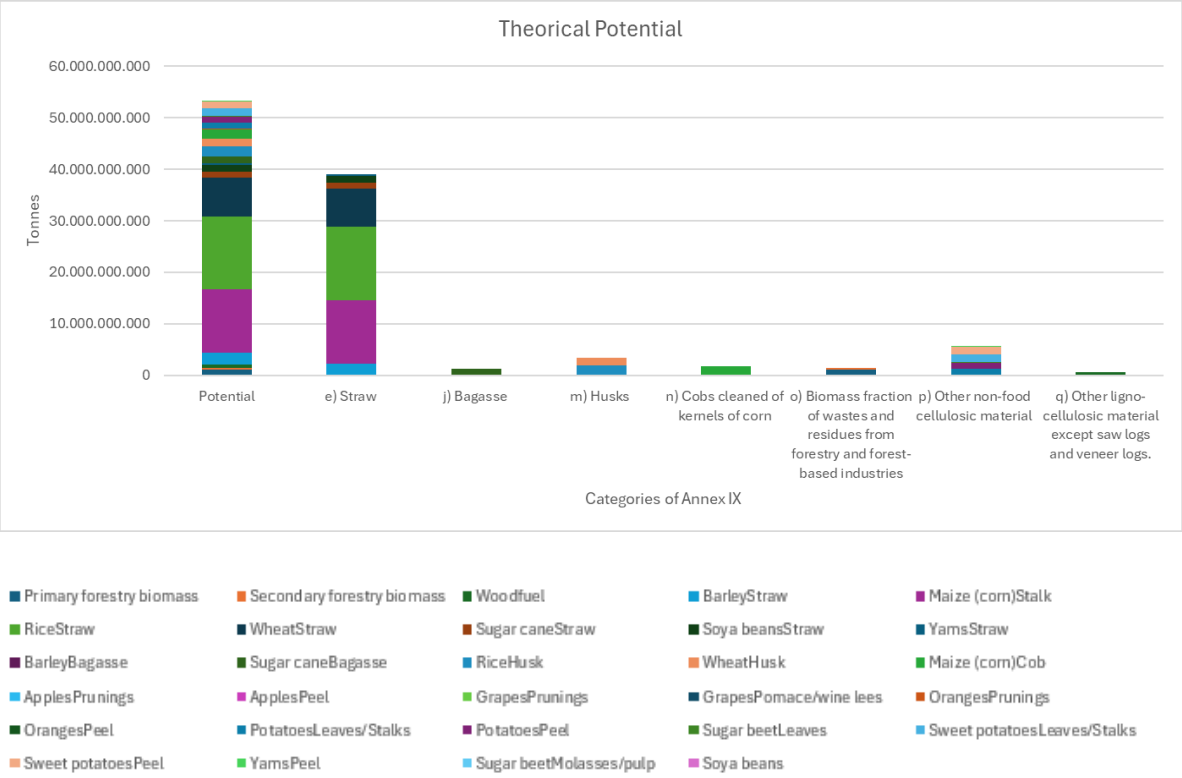

Figure 6. Tonnes based on the theorical potential at Global level, classified by categories, and quantification the contribution of each of the biomasses.

Figure 7, Figure 8 and Figure 9 shows the same information than Figure 6, but in this case for the Scenario A, B and C (respectively). It can be observed that the major biomass types and categories remain consistent across scenarios. However, category (p), which includes forestry resources, gains a larger proportional share as availability decreases in the more restrictive scenarios.

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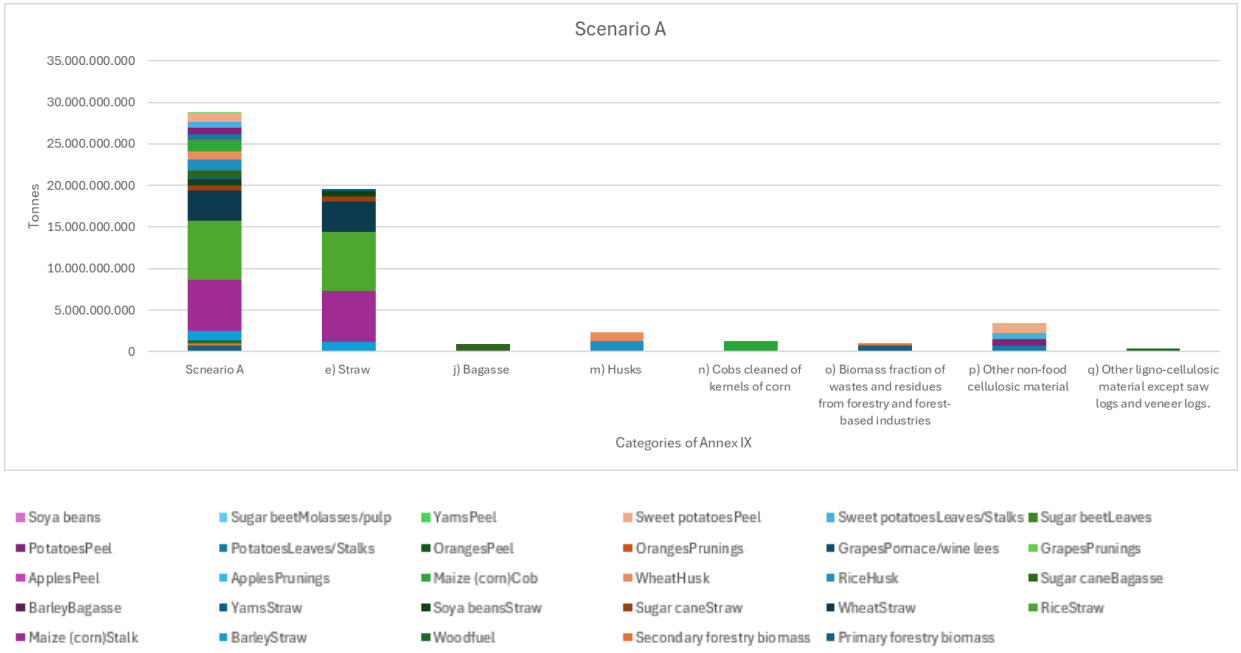

Figure 7. Tonnes based on the Scenario A at Global level, classified by categories, and quantification the contribution of each of the biomasses.

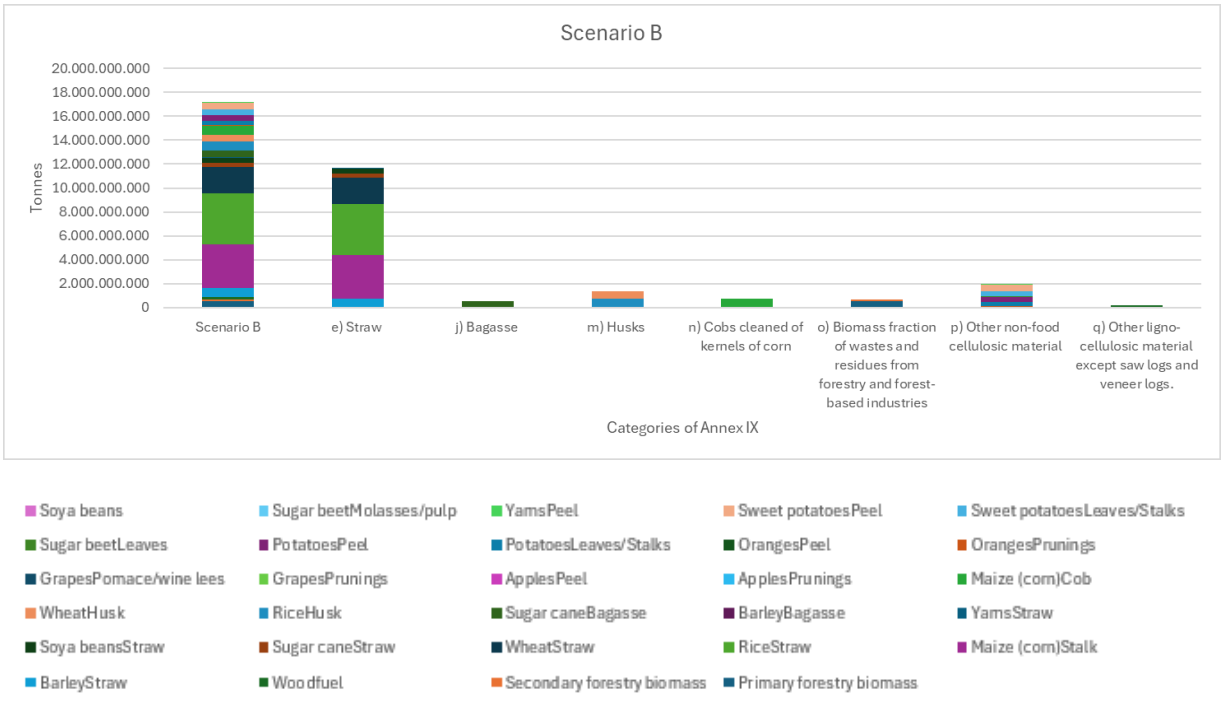

Figure 8. Tonnes based on the Scenario B at Global level, classified by categories, and quantification the contribution of each of the biomasses.

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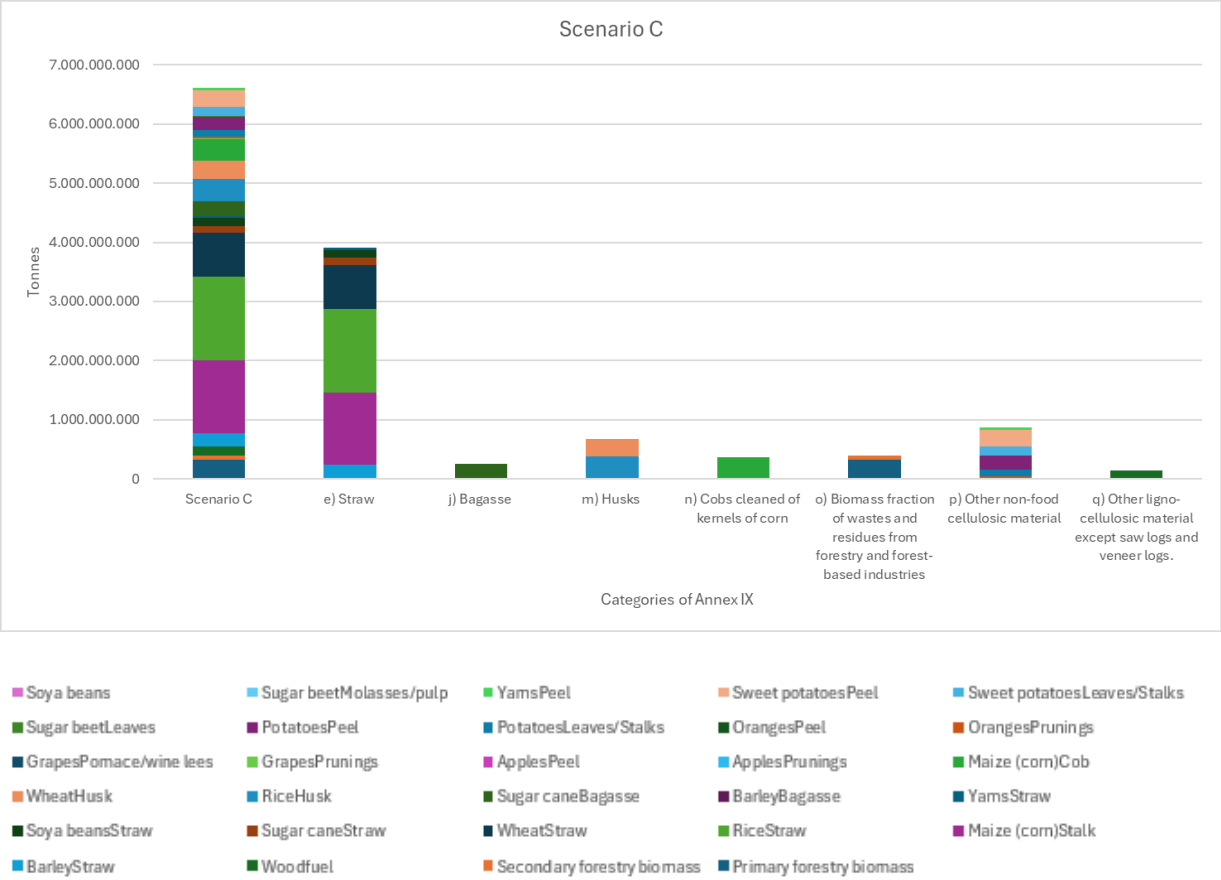

Figure 9. Tonnes based on the Scenario C at Global level, classified by categories, and quantification the contribution of each of the biomasses.

Scenario B, the intermediate scenario, is considered the most realistic baseline. The percentage distribution of each biomass within each category is then detailed, initially presented in Figure 8 but displayed more visually in Figure 10 (only the distribution of those categories that consist of two or more biomasses is shown.).

In the Figure 10 is shown how in the category of e)straw, the majority of the biomass is coming from the rice straw, followed by maize stalk and wheat straw, in o) biomass fraction of wastes and residues from forestry 82 % is coming from primary forestry residues, in m) husk the distribution is more equitable between the two biomasses that are included, and finally in p) other non-food cellulosic material the majority come from the biomass derived from the potatoes crop.

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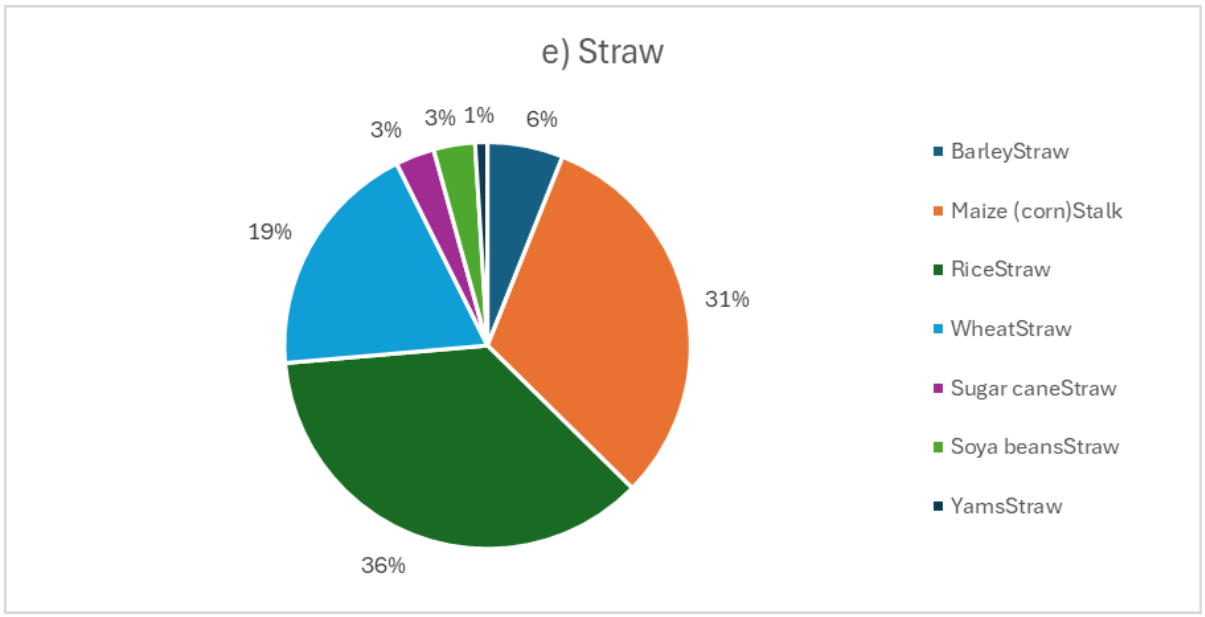

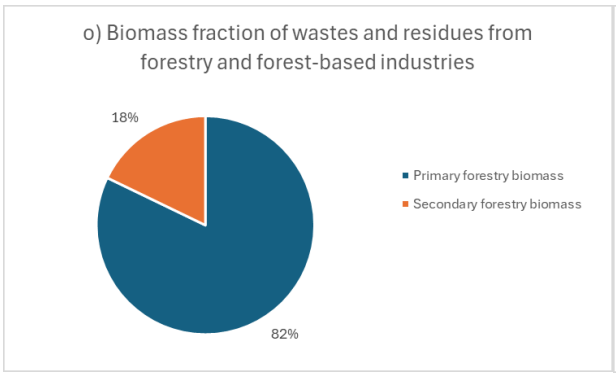

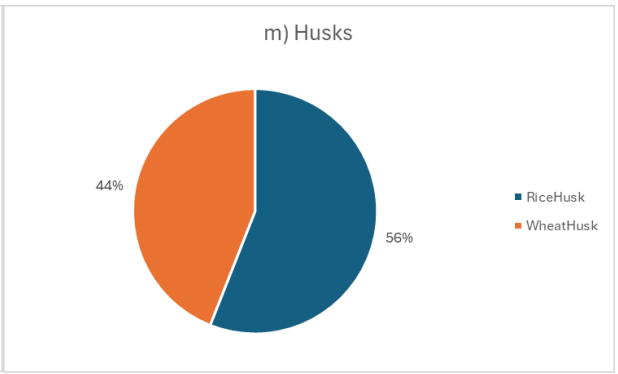

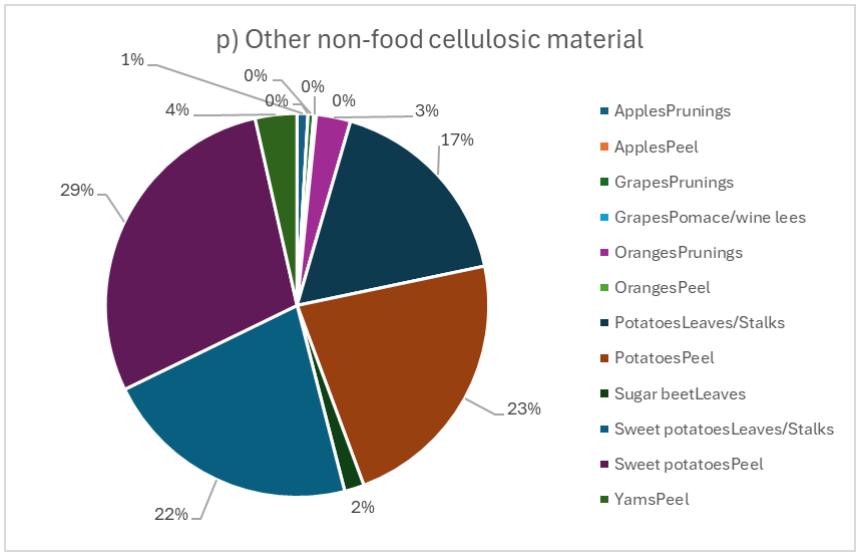

Figure 10. Distribution in the Scenario B of the different types of biomass at Global level in each categories of the Annex IX.

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Finally, these biomass quantities (expressed in dry basic ton) for each scenario have been compared with the global amount of fossil fuels consumed in the aviation and maritime sectors. For this purpose, the report of the International Transport Forum 2023 [23] has been consulted and an estimated data of kerosene for the aviation sector (320 MToe) and fossil fuels for the maritime sector (310 MToe) per year was obtained. These data have been converted into ton of oil equivalent, and compared with data on biomass potentials, which have also been converted into ton of oil equivalent. To carry this out, a preliminary estimate has been made, assuming an average dry basics PCI of 4.5 MWh/t and a conversion efficiency to the desired final product of 15-30% (Table 16 and Table 17). Clearly, these figures are preliminary, and the sole purpose is to enable an initial comparison between the indicated biomass quantity (in tons) and the consumption of the aviation and maritime sectors. Therefore, if the PCI or conversion efficiency ultimately proves to be higher or lower, the final values will change proportionally.

Table 16 shows the percentage represented by each category to cover the total energy required to decarbonize the aviation and maritime sectors (considering an efficiency of 15 %). From this table, it can be concluded that, except in scenario C, there would be sufficient resources to achieve decarbonization if biogenic feedstock were utilized. Regarding the categories, e) straw is the most significant and indicates that it alone could supply the entire production of advanced biofuels, except in scenario C, where it would only meet 40% of the demand.

Table 16. Contribution of biomass categories to meet energy demand for decarbonizing aviation and maritime sectors at Global level, considering an efficiency of 15 %.

Categories of Annex IX	Theorical potential	Scenario A	Scenario B	Scenario C
e) Straw	400%	200%	120%	40%
j) Bagasse	13%	9%	5%	3%
m) Husks	35%	24%	14%	7%
n) Cobs cleaned of kernels of corn	19%	13%	8%	4%
o) Biomass fraction of wastes and residues from forestry and forest-based industries	14%	10%	7%	4%
p) Other non-food cellulosic material	58%	35%	20%	9%
q) Other ligno-cellulosic material except saw logs and veneer logs.	7%	4%	2%	1%

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Total	491%	266%	159%	61%

Table 17 shows the same data considering an efficiency of 30 %. In this case, it can be concluded that, in all the proposed scenarios, there would be sufficient resources to achieve decarbonization if biogenic feedstock were utilized, being the e) straw clearly the most significant.

Table 17. Contribution of biomass categories to meet energy demand for decarbonizing aviation and maritime sectors at Global level, considering an efficiency of 30 %.

Categories of Annex IX	Theorical potential	Scenario A	Scenario B	Scenario C
e) Straw	800%	400%	240%	80%
j) Bagasse	26%	18%	10%	5%
m) Husks	69%	48%	28%	14%
n) Cobs cleaned of kernels of corn	38%	26%	15%	8%
o) Biomass fraction of wastes and residues from forestry and forest-based industries	29%	20%	14%	8%
p) Other non-food cellulosic material	116%	70%	41%	18%
q) Other ligno-cellulosic material except saw logs and veneer logs.	15%	7%	4%	3%
Total	983%	531%	317%	122%

3.2.2 European level

As with the global level, the same approach has been applied to the European level, following the methodology outlined in Section 2. In this case, the Figure 11 illustrates the availability of biomass, measured in tonnes, for the production of advanced biofuels across different scenarios (A, B, and C) and its theoretical potential. The theoretical potential (blue bars) is significantly higher than any of the scenarios for all biomass categories, reflecting the maximum potential without constraints. In contrast, Scenarios A (orange bars), B (green bars), and C (light blue bars) show progressively lower availability as factors such as technical, economic, and competitive constraints are considered. Among the biomass categories, straw (e) and forestry residues (o) emerge as the largest contributors across all scenarios,

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highlighting their key role in biofuel production. Other categories like husks (m), non-food cellulosic material (p), and cobs cleaned of kernels of corn (n) contribute comparatively less.

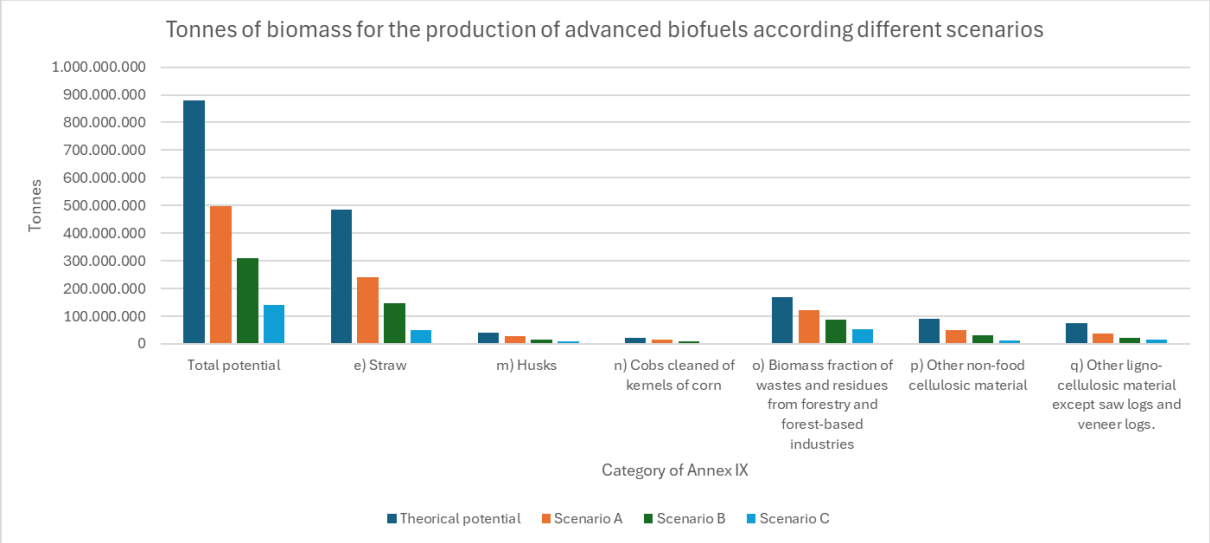

Figure 11. Tonnes of biomass to produce advanced biofuels at European level according to different scenarios grouped in the different categories of Annex IX.

Figure 12 focus on the theoretical potential of biomass resources for advanced biofuel production at European level, highlighting the contributions of different feedstocks from Annex IX categories. The "Theoretical Potential" category, which is the highest across all scenarios, is primarily driven by resources such as straw (e), particularly wheat straw and maize stalks, as well as forestry residues (o), which include both primary and secondary forestry biomass, with primary forest biomass being the dominant contributor.

For smaller categories, husks (m) it is composed of wheat husk, while cobs cleaned of kernels of corn (n) are derived from maize cobs. Non-food cellulosic materials (p) include resources like grape pomace, apple and orange pruning, and sugar beet leaves, while ligno-cellulosic materials (q) are primarily represented by wood fuel.

The graphs highlight the wide variety of biomass feedstocks available for biofuel production, with agricultural residues such as straw being the most significant contributor. Forestry residues also play a vital role, followed by other materials like husks, pruning, and pomace.

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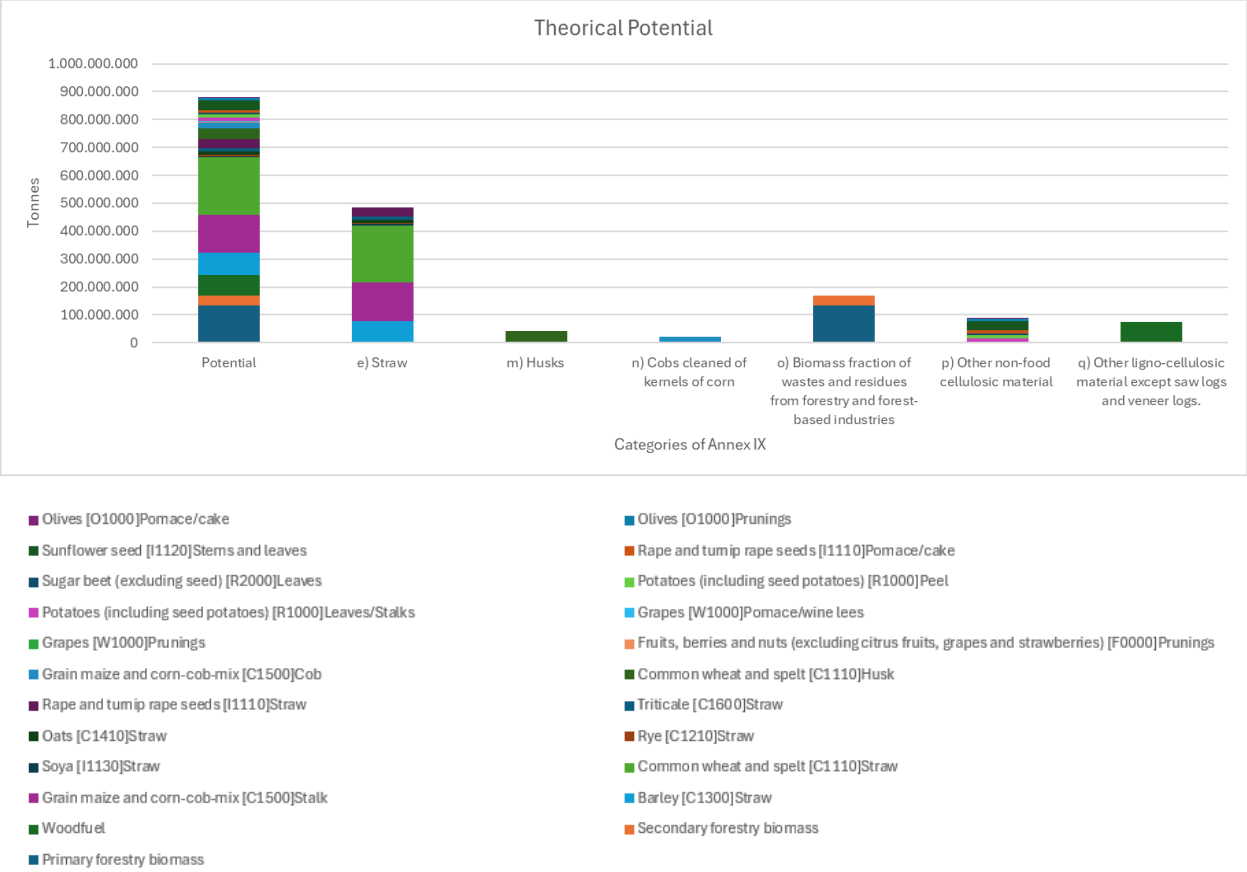

Figure 12. Tonnes based on the theorical potential at European level, classified by categories, and quantification the contribution of each of the biomasses.

Figure 13, Figure 14 and Figure 15 present the same data as Figure 12, but for Scenarios A, B, and C, respectively. It is evident that the main biomass types and categories stay consistent across these scenarios. However, as the availability of biomass diminishes in the more restrictive scenarios, category (p), which encompasses forestry resources, increases its proportional share, being in Scenario C the main category of biomass availability (overcoming the straw).

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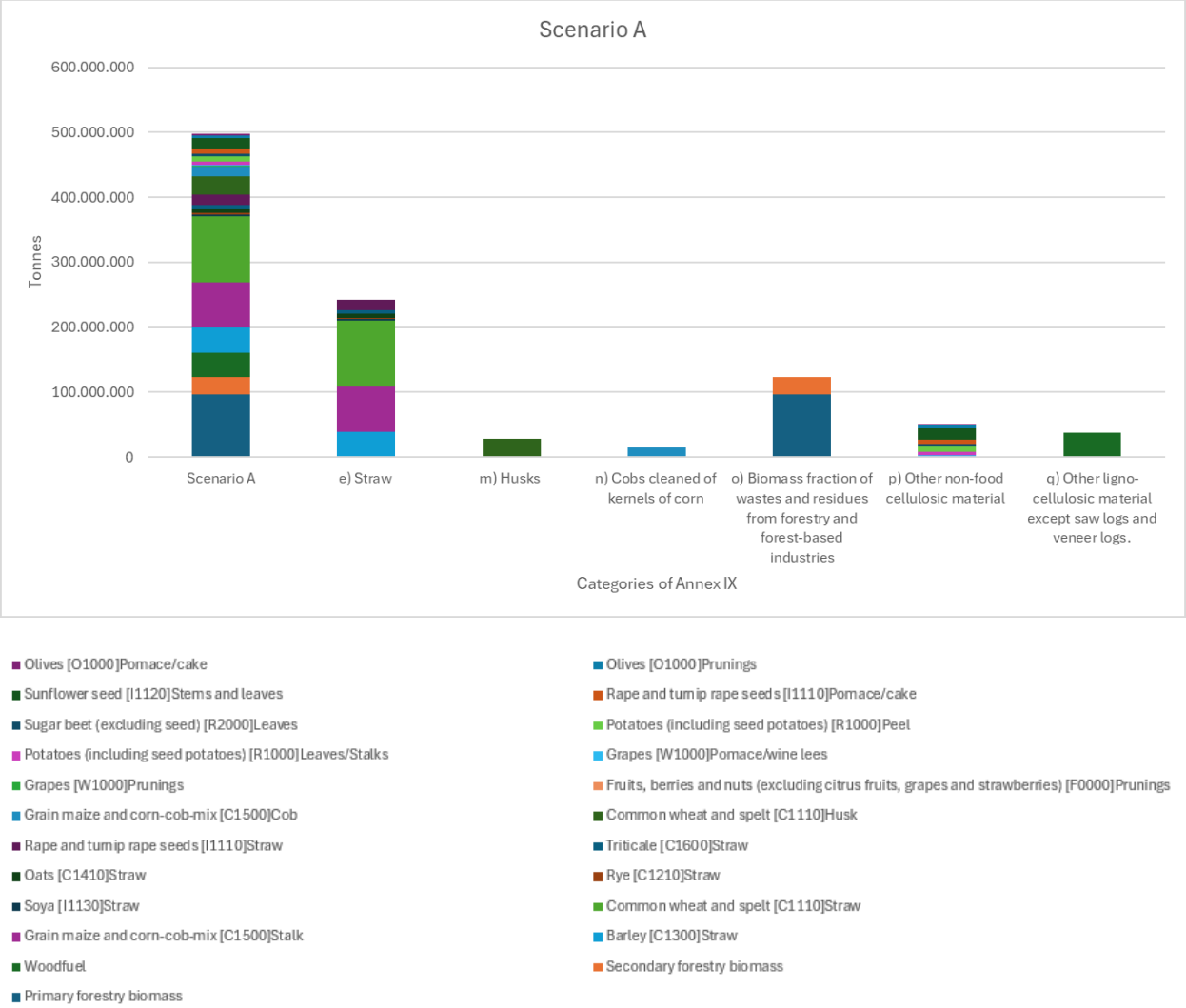

Figure 13. Tonnes based on the Scenario A at European level, classified by categories, and quantification the contribution of each of the biomasses.

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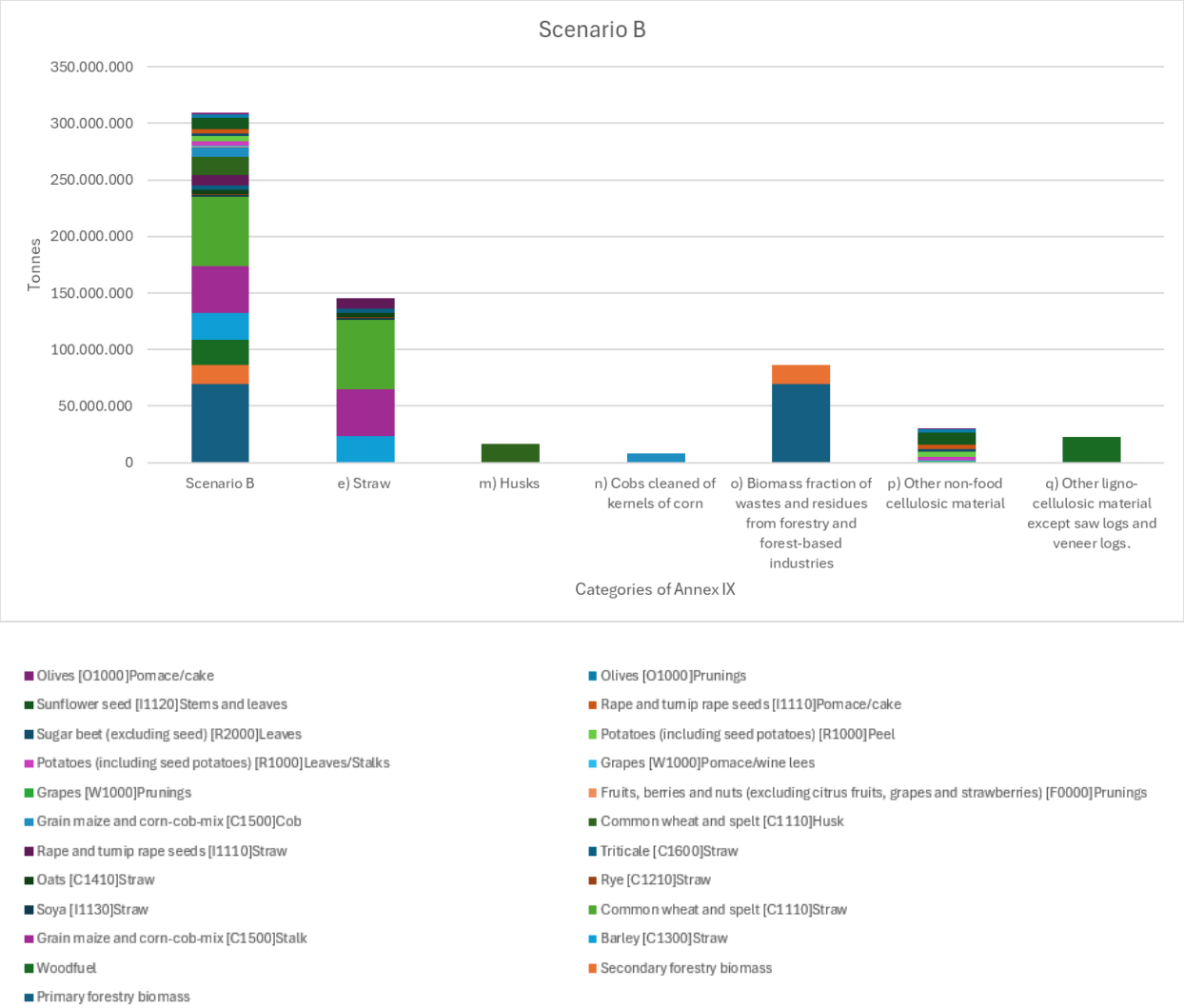

Figure 14. Tonnes based on the Scenario B at European level, classified by categories, and quantification the contribution of each of the biomasses.

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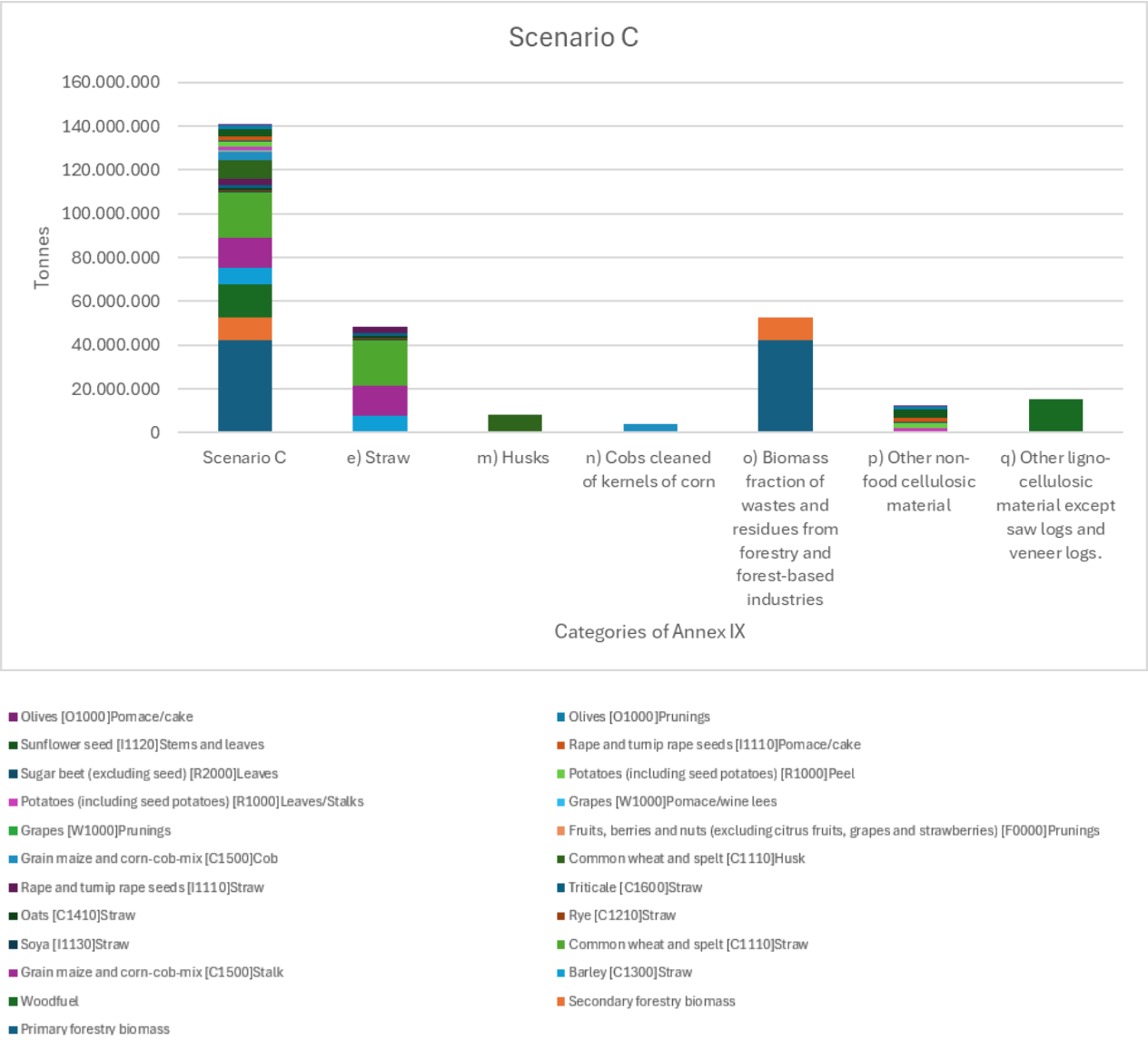

Figure 15. Tonnes based on the Scenario C at European level, classified by categories, and quantification the contribution of each of the biomasses.

Scenario B, considered the most realistic baseline, provides a detailed breakdown of the biomass distribution within each category, initially presented in Figure 14 but more visually represented in Figure 16 (only categories with two or more types of biomass are shown).

In Figure 16, the distribution reveals that in the e) straw category, most of the biomass comes from wheat straw, followed by maize stalks and barley straw. In the o) biomass fraction of wastes and residues from forestry, 80% of the biomass is derived from primary forestry residues. Finally, in p) other non-food cellulosic material, the majority of the biomass comes from the sunflower leaves and the potato crop.

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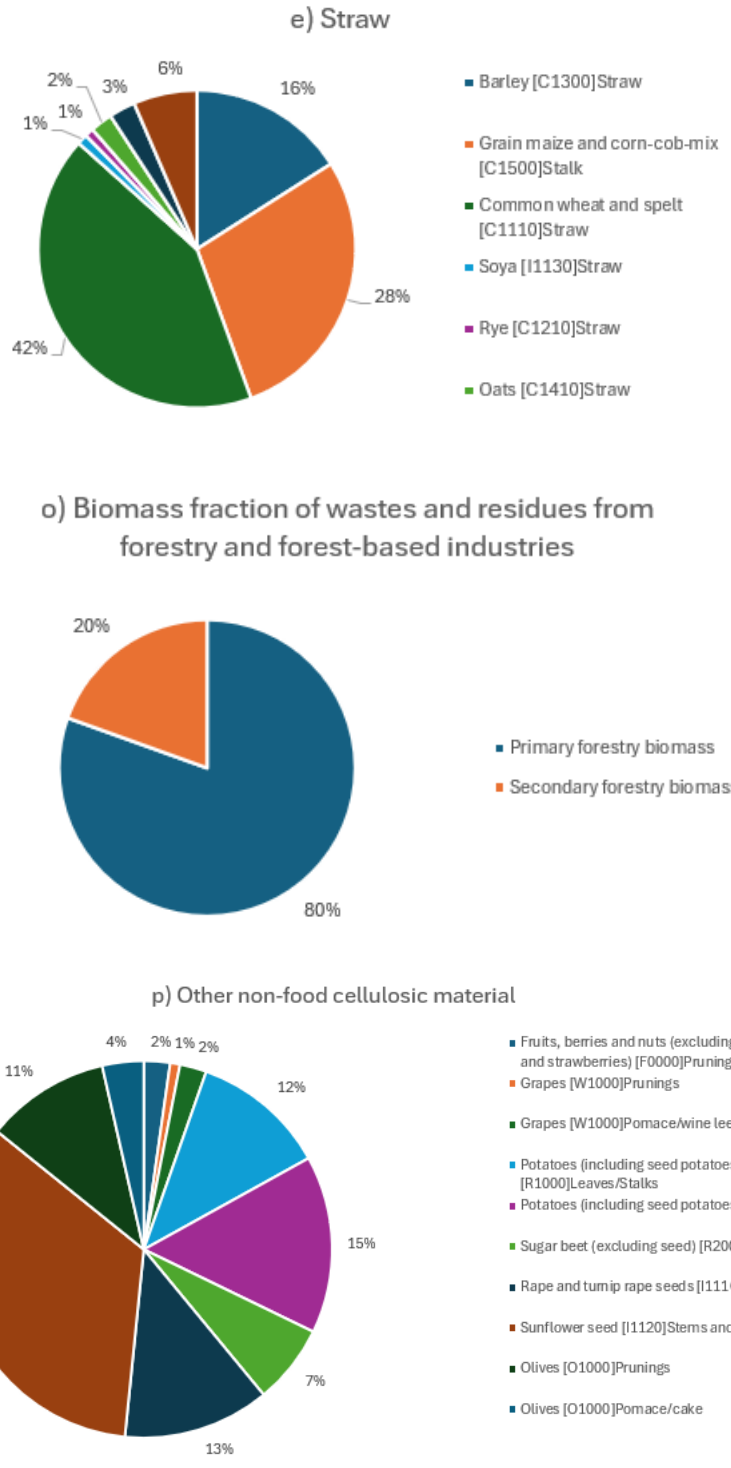

Figure 16. Distribution in the Scenario B of the different types of biomass at European level in each categories of the Annex IX.

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Finally, these biomass quantities (expressed in dry basic ton) for each scenario have been compared with the global amount of fossil fuels consumed in the aviation and maritime sectors. For this purpose, the report of the International Transport Forum 2023 and the European Energy Agency [24] have been consulted and an estimated data of kerosene for the aviation sector (50 MToe) and fossil fuels for the maritime sector (65 MToe) per year was obtained. These data have been converted into ton of oil equivalent, and compared with data on biomass potentials, which have also been converted into ton of oil equivalent. A preliminary estimate has been conducted, considering an average dry PCI of 4.5 MWh/t and a 15-30% conversion efficiency to the final product (Table 18 and Table 19). These figures are provisional and intended solely to facilitate an initial comparison between the biomass quantity specified (in tons) and the consumption of the aviation and maritime sectors. Accordingly, if the PCI or conversion efficiency is ultimately found to be higher or lower, the final values will adjust proportionally.

Table 18 and Table 19 shows the percentage represented by each category to cover the total energy required to decarbonize the aviation and maritime sectors at European level. From these two tables, it can be concluded that, contrary to the global context, at the European level, none of the scenarios (not even when considering theoretical potential and at efficiency of 30 %) provide enough biogenic feedstock (within the constraints outlined in this report) to fully decarbonize the aviation and maritime sectors. This highlights the need to consider other resources in Europe, such as those from the remaining categories in Annex IX, as well as alternative technologies (as for instance HVO) and the use of renewable fuels of non-biological origin (RFNBO) for the production of e-fuels.

Table 18. Contribution of biomass categories to meeting energy demand for decarbonizing aviation and maritime sectors at European level, considering an efficiency of 15 %.

Categories of Annex IX	Theorical potential	Scenario A	Scenario B	Scenario C
e) Straw	24%	12%	7%	2%
m) Husks	2%	1%	1%	0%
n) Cobs cleaned of kernels of corn	1%	1%	0%	0%
o) Biomass fraction of wastes and residues from forestry and forest-based industries	9%	6%	4%	3%
p) Other non-food cellulosic material	5%	3%	2%	1%

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q) Other ligno-cellulosic material except saw logs and veneer logs.	4%	2%	1%	1%
Total	44%	25%	16%	7%

Table 19. Contribution of biomass categories to meeting energy demand for decarbonizing aviation and maritime sectors at European level, considering an efficiency of 30 %.

Categories of Annex IX	Theorical potential	Scenario A	Scenario B	Scenario C
e) Straw	49%	24%	15%	5%
m) Husks	4%	3%	2%	1%
n) Cobs cleaned of kernels of corn	2%	1%	1%	0%
o) Biomass fraction of wastes and residues from forestry and forest-based industries	17%	12%	9%	5%
p) Other non-food cellulosic material	9%	5%	3%	1%
q) Other ligno-cellulosic material except saw logs and veneer logs.	8%	4%	2%	2%
Total	89%	50%	31%	14%

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4. Geospatial mapping

In section 3 an overall analysis of the data at Global and European level has been made for each of the selected categories, this section goes further and shows the amount (in thousands of tonnes) of each category, at country level (Global) and NUTS 2 level (Europe).

4.1 Global level

In addition to this global analysis, as mentioned in section 2, the theoretical potential has been quantified by country and for each of the scenarios for all the biomasses considered and the categories to which they belong. However, in this section it will only show the resulting maps for Scenario B (intermediate).

From Figure 17 to Figure 24 the amount of biomass that could be used for the production of advances biofuels according to scenario B has been represented with a gradient of different colours. There is a specific figure for each category (from Figure 18 to Figure 24), and one that compile the total of all the categories (Figure 17).

Figure 17 shows the countries with the highest biomass potential are concentrated in Asia and the Americas, particularly in regions like Southeast Asia and Central/South America. Vietnam, Mexico, Indonesia, China, and the Philippines lead the list, showing significant biomass potential due to their large agricultural and forested areas. Africa, especially the Eastern and Western regions, also has notable biomass potential, with countries like Ethiopia, Kenya, and Uganda standing out. Oceania, while less prominent, has significant biomass in Australia, which contributes to the region's potential. Europe, though home to countries like Russia and Kazakhstan, has a more limited biomass distribution, especially when compared to the tropical regions of Asia and the Americas. In summary, Asia and the Americas have the largest biomass potential, driven by vast natural resources and favourable climates, with Africa and Oceania also playing important roles but to a lesser extent.

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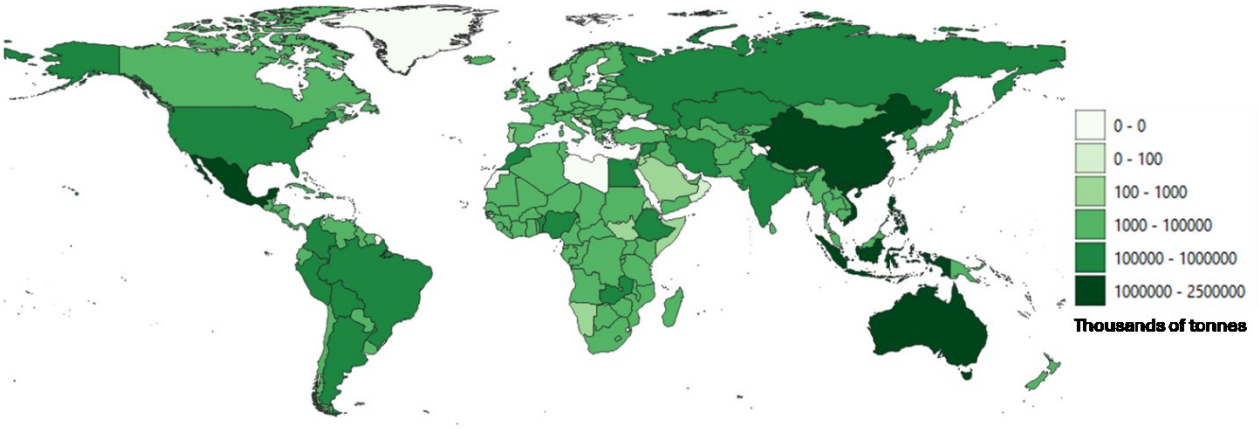

Figure 17. Geographical distribution of global biomass potential of sustainable biogenic feedstock for the production of advanced biofuels according to the Scenario B.

Figure 18 show the biomass potential from the category e) straw and it can be seen that mainly is concentrated in Asia and the Americas, with some notable contributions from Africa. Vietnam leads the list with nearly 1.92 thousand million tonnes of straw, followed by Mexico and Indonesia, with 1.35 thousand million and 1.31 thousand million tonnes, respectively. Other significant contributors in Asia include China, the Philippines, and India, while Brazil in South America also stands out with a considerable amount of straw biomass potential. Africa shows moderate potential, with Ethiopia, Nigeria, and Morocco contributing substantial quantities of straw biomass. Oceania, represented mainly by Australia, also contributes, although its overall impact is smaller compared to other continents. In general, Southeast Asia (including Vietnam, Indonesia, and the Philippines) is the region with the highest straw biomass, reflecting the large-scale agricultural production of rice and other crops. The Americas have notable contributions as well, especially from Mexico and Brazil, largely due to their extensive production of crops like corn and sugarcane.

In conclusion, Asia dominates the global straw biomass potential, followed by the Americas, with regions like South-Eastern Asia and Central America showing the most promise for biomass generation from herbaceous crop residues.

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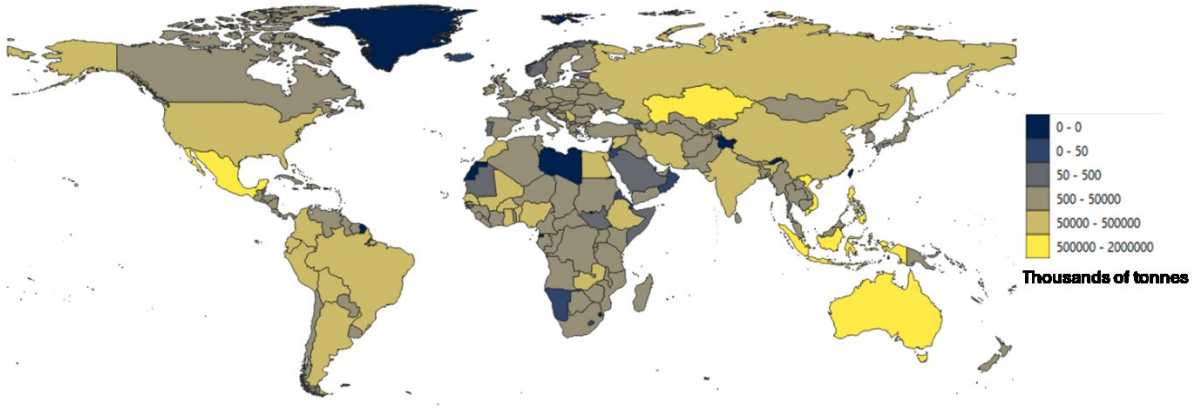

Figure 18. Geographical distribution of global biomass potential of the category "e) straw" for the production of advanced biofuels according to the Scenario B.

Figure 19 shows the biomass potential from the category j) bagasse, which indicates that Mexico is the largest producer of sugarcane bagasse with 104,486 tons, followed by Colombia, the Philippines, and Vietnam. South American countries like Argentina and Peru also contribute significantly. In Asia, India and Vietnam are key producers, though Indonesia's output is notably low at 702 tons. African countries like Nigeria and Egypt produce moderate amounts, but many European nations have no production. Overall, sugarcane bagasse is primarily produced in tropical and subtropical regions, with little contribution from Europe and Oceania.

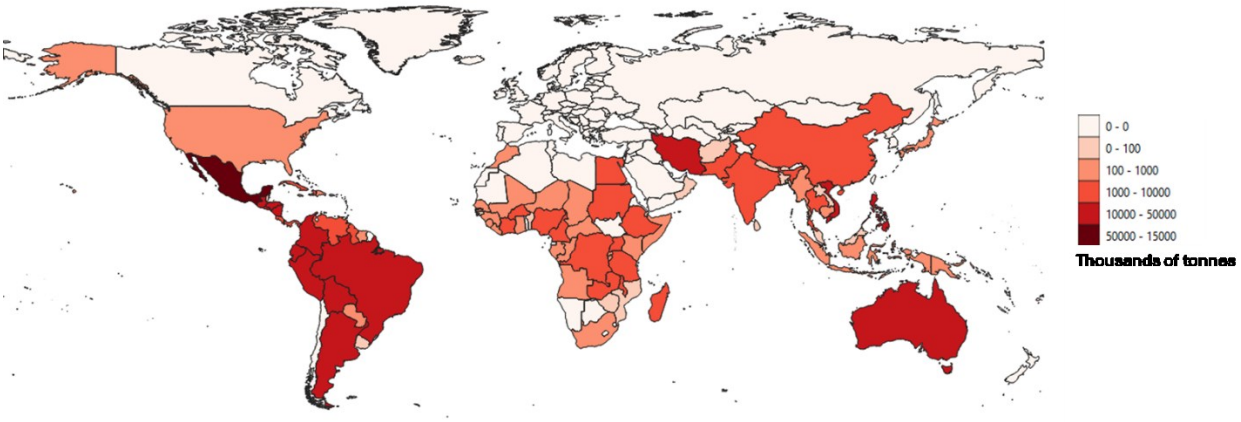

Figure 19. Geographical distribution of global biomass potential of the category "j) Bagasse" for the production of advanced biofuels according to the Scenario B.

Figure 20 shows the production of m) husks is spread across various regions globally, with significant contributions from both developed and developing countries. In Asia, countries such as Vietnam, Indonesia, and the Philippines are leading producers, particularly in Southeast Asia. In Oceania, Australia

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is a major contributor. Kazakhstan in Central Asia and Iran in Southern Asia also add considerable volumes to the global husk supply. Europe's production is more modest, with Russia being the largest producer in Eastern Europe, while countries like Morocco, Egypt, and Ethiopia are key players in Africa, particularly in Northern and Eastern Africa. In the Americas, Mexico and Peru are significant contributors, with the United States also having a notable presence.

Overall, Asia is the largest producer of husks, accounting for a substantial share, particularly from Southeast and Eastern Asia, followed by Africa, Oceania, and the Americas. Europe remains a smaller but consistent player in this market.

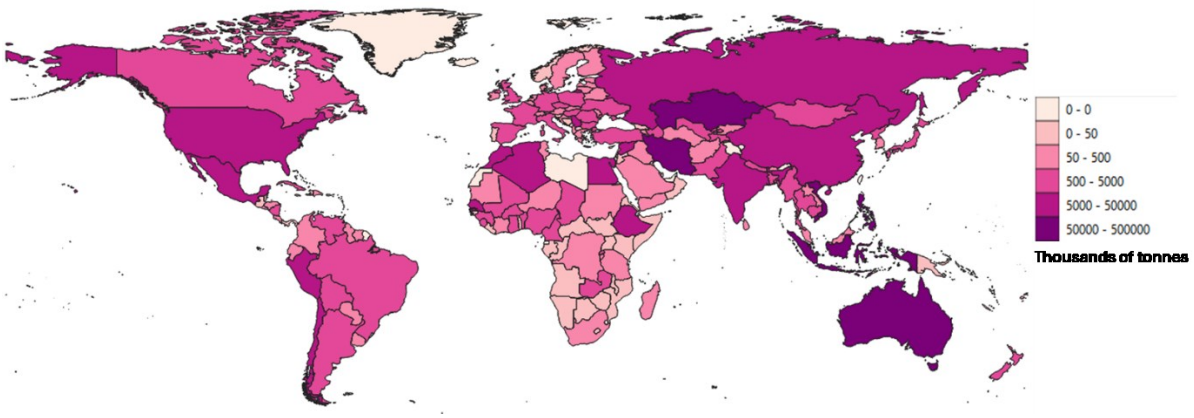

Figure 20. Geographical distribution of global biomass potential of the category “m) Husks” for the production of advanced biofuels according to the Scenario B.

Figure 21 reflects the data from the category n) Cobs cleaned of kernels of corn, Mexico leads, with strong contributions from nations in the Americas, including the Philippines, Colombia, and the United States. In Europe, Serbia and Russia are significant producers, while Africa is represented by Ethiopia and Zambia. Asia also plays a key role, with countries like Vietnam, China, and the Philippines contributing substantial amounts. Overall, while the Americas and Asia are the primary players in corn cob production, Europe and Africa have their own important contributions, creating a diverse global landscape for this agricultural product.

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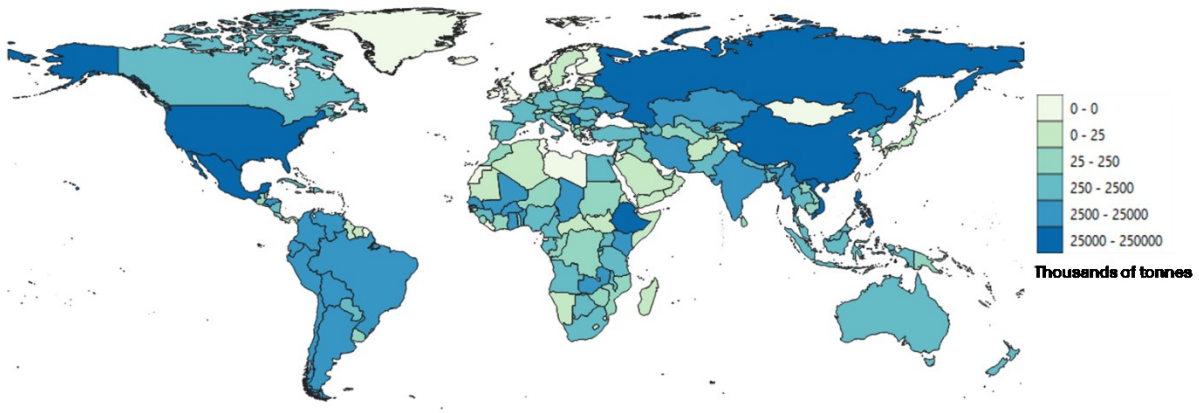

Figure 21. Geographical distribution of global biomass potential of the category "n) Cobs cleaned of kernels of corn" for the production of advanced biofuels according to the Scenario B.

Figure 22 based on o) Biomass fraction of wastes and residues from forestry and forest-based industries indicates that Russia, China, and the U.S. dominate the list, reflecting their extensive forest industries and infrastructure. Northern Europe, including Finland and Sweden, also stands out as a major contributor. In contrast, many regions in Africa, Central America, and smaller countries show minimal biomass production, likely due to limited forest resources, industrial capacity or sustainability management of the forest. This uneven distribution underscores the challenges and opportunities in utilizing residual forestry biomass as a sustainable energy source globally.

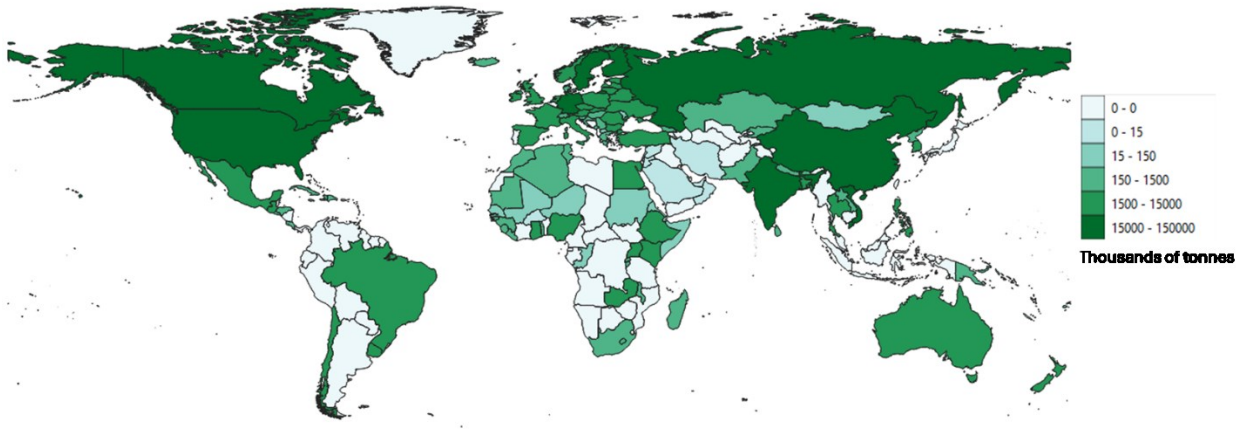

Figure 22. Geographical distribution of global biomass potential of the category "o) Biomass fraction of wastes and residues from forestry and forest-based industries" for the production of advanced biofuels according to the Scenario B.

Figure 23 shows the data of the category p) Other non-food cellulosic material, which indicate that China leads by far with 993,935 thousand tons, followed by Nigeria with 114,807 thousand tons. Asia, especially countries like China, India, and Indonesia, dominates in production, likely due to large agricultural sectors.

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Africa also plays a significant role, with Nigeria and Ethiopia showing high figures. Developed nations like the U.S. and European countries report much lower numbers, possibly reflecting more efficient use or less reliance on agricultural byproducts. Overall, Asia and Africa are the main contributors, while developed countries have a smaller role.

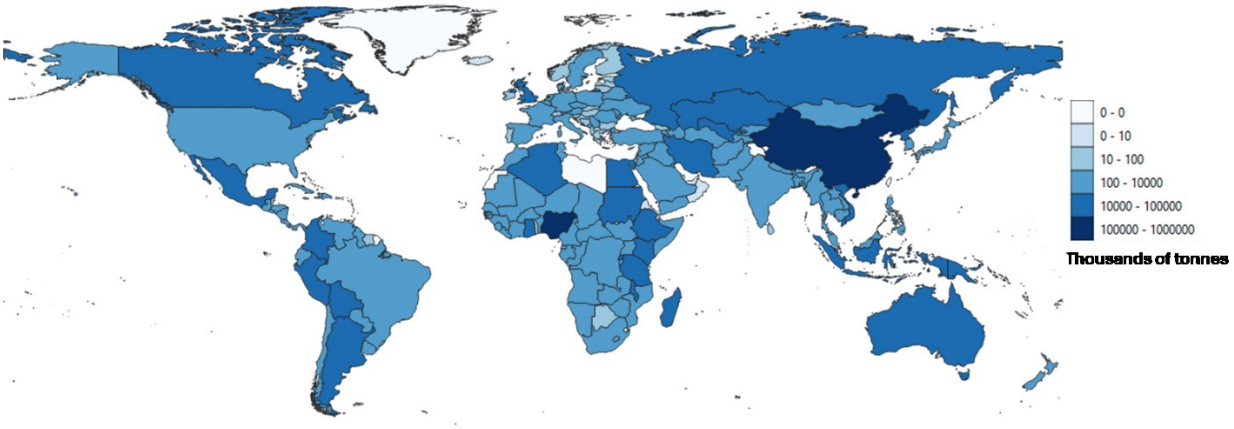

Figure 23. Geographical distribution of global biomass potential of the category "p) Other non-food cellulosic material" for the production of advanced biofuels according to the Scenario B.

Figure 24 reveals a significant global variation in the potential of q) Other ligno-cellulosic material except saw logs and veneer logs based on wood fuel production across different countries. China leads by a large margin with over 49 million tons of potential biomass, followed by India, the United States, and Egypt. These countries have robust forest industries and infrastructure to support large-scale biomass production. Many African countries, such as Uganda, Ethiopia, and Ghana, show notable biomass potential, highlighting regional strengths in certain areas. Conversely, many smaller or less developed nations, particularly in Oceania, the Caribbean, and parts of Asia, report zero or negligible potential, suggesting a lack of infrastructure or suitable resources for large-scale biomass production.

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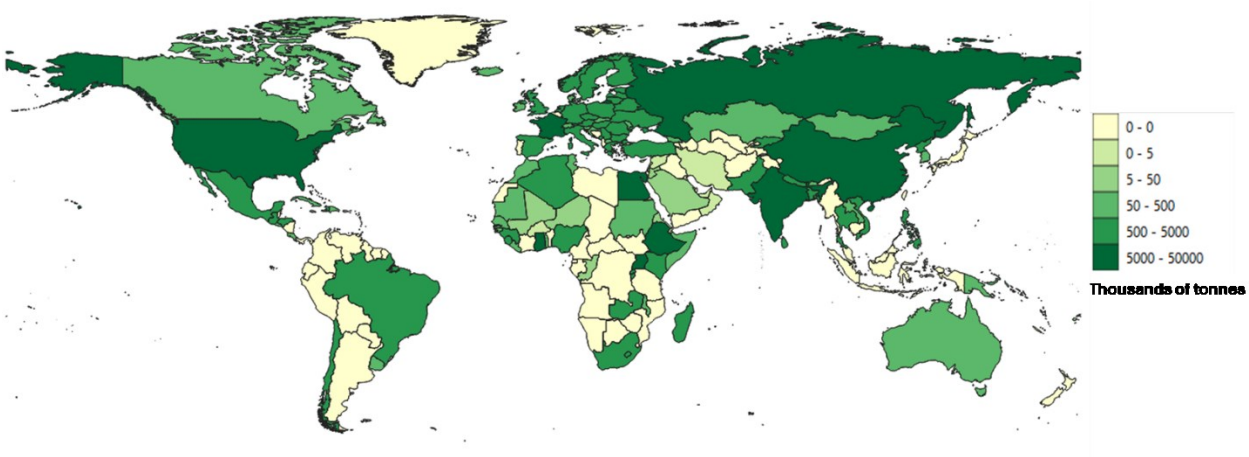

Figure 24. Geographical distribution of global biomass potential of the category "q) Other ligno-cellulosic material except saw logs and veneer logs" for the production of advanced biofuels according to the Scenario B.

4.2 European level

Building on the global analysis presented in section 2, the theoretical potential at European level has been assessed by NUTS 2, NUTS 1 and NUST 0 and for each scenario, considering all biomass types and their respective categories. In this section, we will focus on the maps corresponding to Scenario B and NUTS 2 (just in the case of Germany and UK the data are presented in NUTS1, since Eurostat does not provide information at NUTS 2 level), which represents the intermediate scenario.

From Figure 25 to Figure 31 the amount of biomass that could be used for the production of advances biofuels according to scenario B has been represented with a gradient of different colours. There is a specific figure for each category (from Figure 26 to Figure 31), and one that compile the total of all the categories (Figure 25).

Figure 25 shows the geographical distribution of the amount of biomass (included all the categories) that could be used for the production of advanced biofuels in Europe. The top-ranking regions are primarily concentrated in Central and Northern Europe, with several areas in France, Germany, and Finland showing significant biomass potential. This suggests that these regions possess more amount of agricultural, forestry, and industrial biogenic feedstock that are crucial for the development of advanced biofuels. On the other hand, regions with smaller biomass availability are located in certain areas in Southern and Eastern Europe, although it depends on the specific location.

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This data underscores the importance of regional efforts in meeting the EU's renewable energy targets, with some areas having a higher potential to scale up biofuel production based on available biomass.

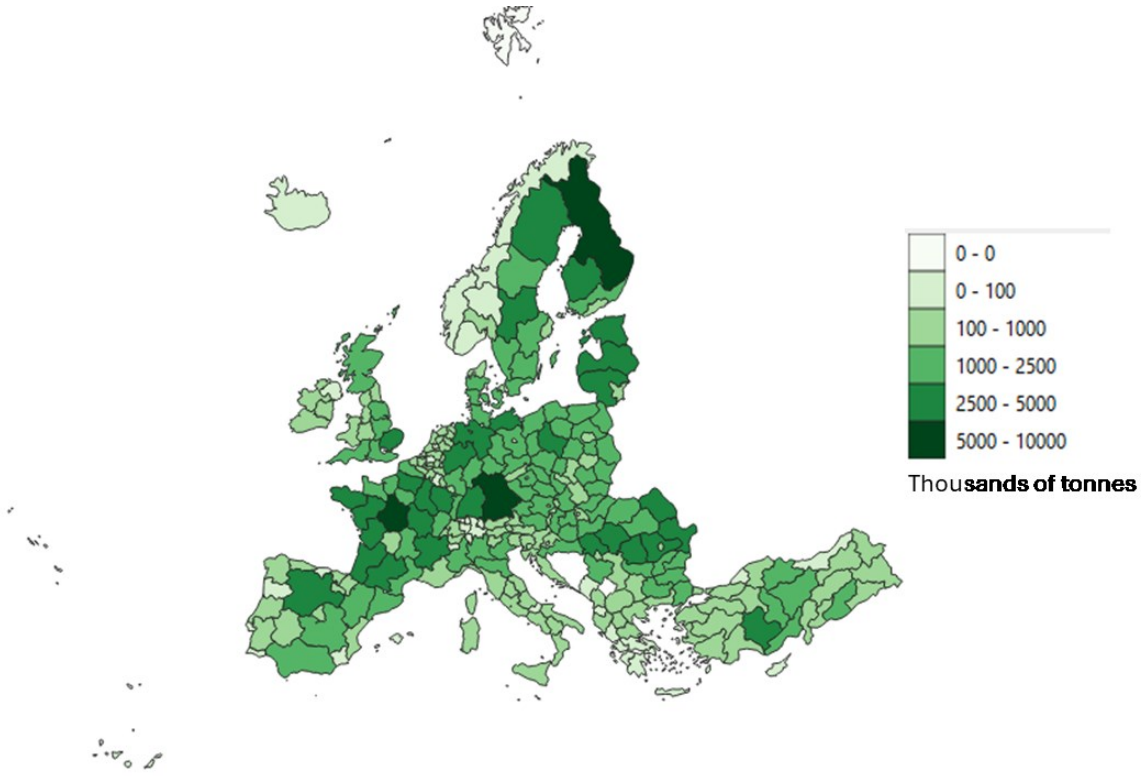

Figure 25. Geographical distribution of European biomass potential of sustainable biogenic feedstock for the production of advanced biofuels according to the Scenario B.

Figure 26 reflects the amount of the category "e) straw, and it is observed that the areas with the highest biomass availability for advanced biofuel production are located in northern Spain, the western part of France, central Europe, and Eastern Europe. These regions show significant potential in terms of biomass availability, which could be key to boosting renewable energy production in these areas. On the other hand, northern and south-eastern Europe have the lowest potential.

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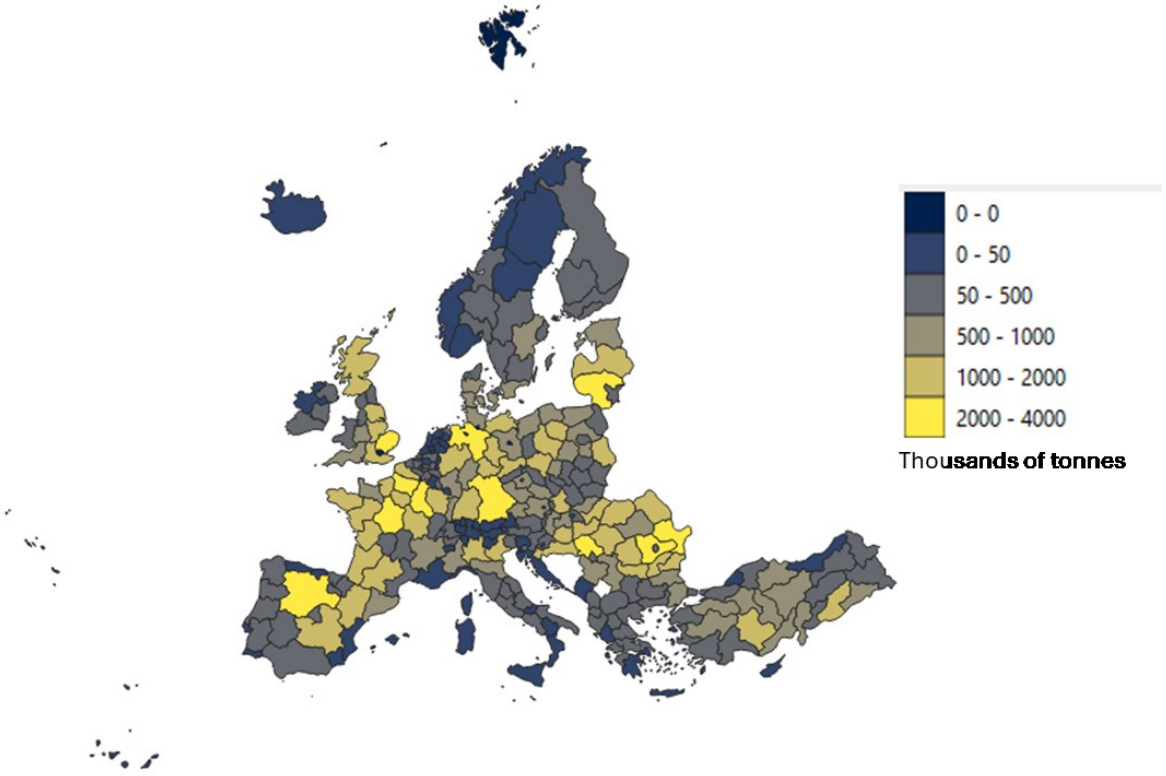

Figure 26. Geographical distribution of European biomass potential of the category "e) Straw" for the production of advanced biofuels according to the Scenario B.

Figure 27 presents the biomass availability of the category m) Husks, in general, the biomass resources are more concentrated in certain central and northern parts of Europe. Regions in Western Europe, particularly in France, Germany, and the UK, dominate the table in terms of biomass quantities. On the other hand, countries in Southern and Eastern Europe tend to have lower biomass values.

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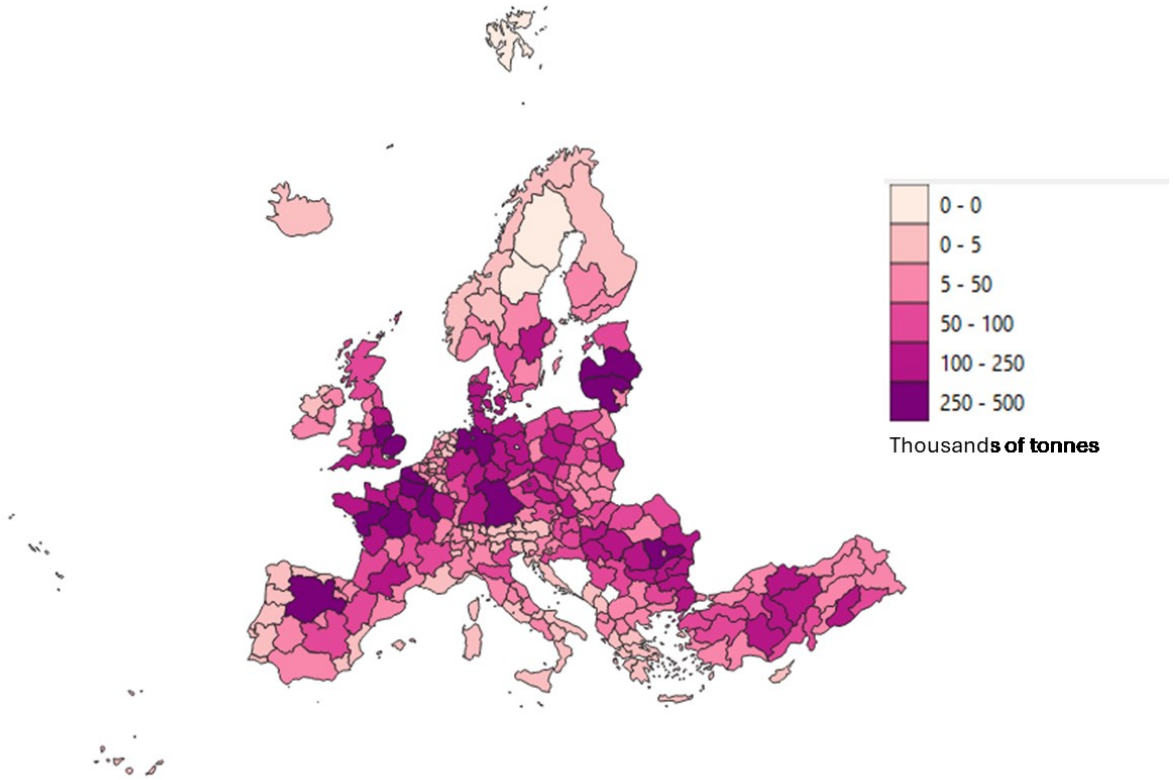

Figure 27. Geographical distribution of European biomass potential of the category "m) Husks" for the production of advanced biofuels according to the Scenario B.

Figure 28 indicates the biomass availability of the category n) Cobs cleaned of kernels of corn in Europe, according to the Scenario B. The data reveals that the most abundant regions are located in central and southeastern Europe. In contrast, northern and western parts of Europe show significantly lower amounts of maize corn cob biomass.

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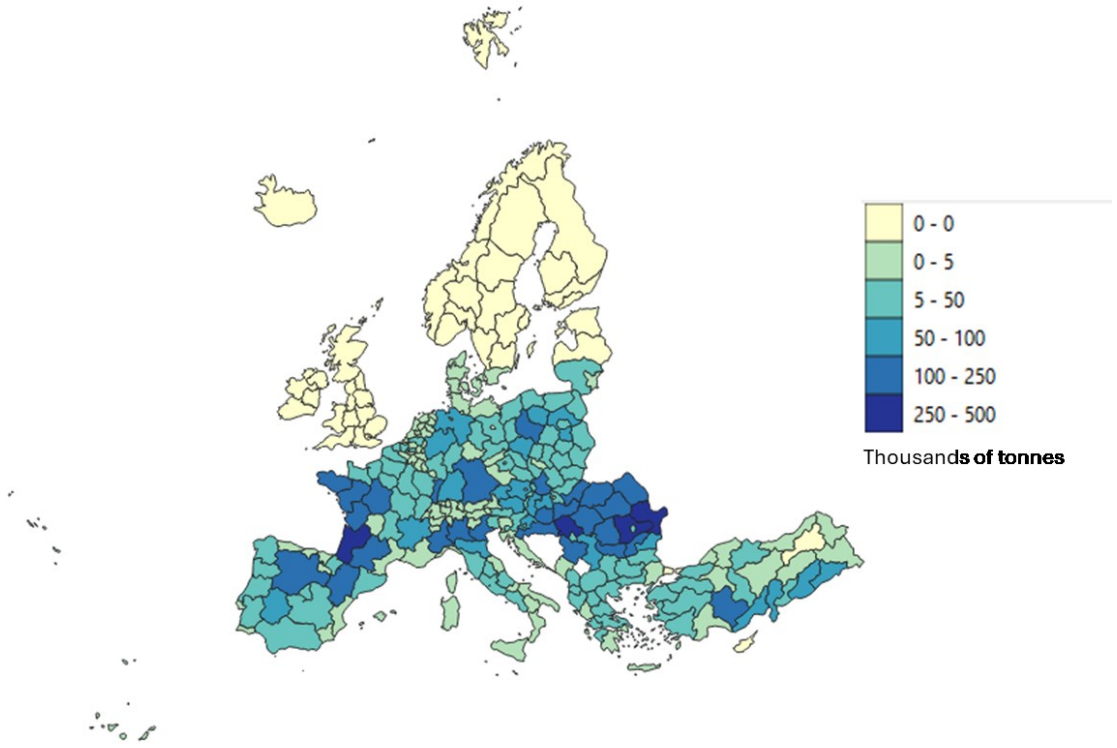

Figure 28. Geographical distribution of European biomass potential of the category "n) Cobs cleaned of kernels of corn" for the production of advanced biofuels according to the Scenario B.

Figure 29 shows the biomass availability of the category o) Biomass fraction of wastes and residues from forestry and forest-based industries. A few key takeaways can be observed from this data. Firstly, biomass availability is particularly high in certain northern and eastern parts of Europe, where large, forested areas and robust forestry industries contribute to significant biomass production. There is also a noticeable concentration of biomass in central Europe, which reflects the region's well-established industrial activities linked to forestry.

Furthermore, regions with a combination of forest cover and strong industrial bases, such as parts of Scandinavia and Germany, show the highest figures. In contrast, southern and some western European regions report lower biomass quantities, which could be attributed to both lesser forest resources and different industrial practices. Interestingly, many areas in southern Europe and some parts of Eastern Europe report negligible biomass production, likely due to both ecological and economic factors.

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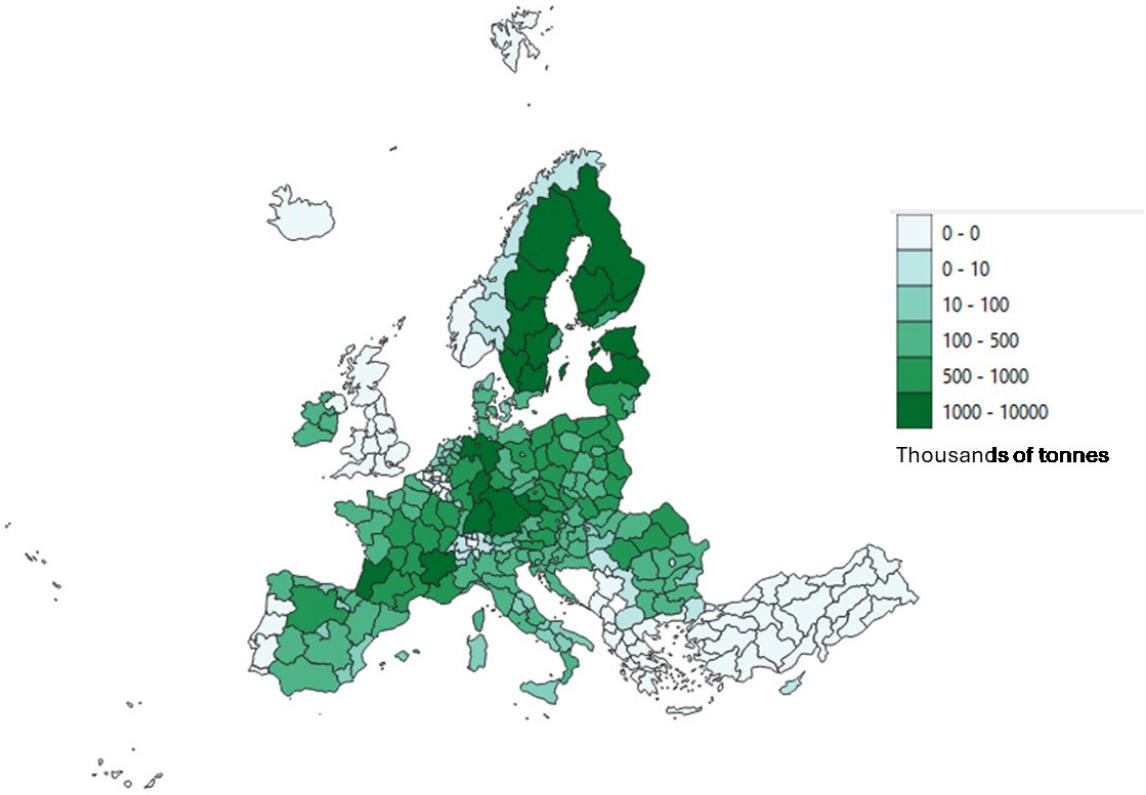

Figure 29. Geographical distribution of European biomass potential of the category "o) Biomass fraction of wastes and residues from forestry and forest-based industries" for the production of advanced biofuels according to the Scenario B.

Figure 30 provides data on available biomass from the category p) Other non-food cellulosic material across the different NUTS 2 regions of Europe, presented in Scenario B. The regions with the highest biomass levels are primarily concentrated in the north of Spain, the west of France, and in Central and Eastern Europe. Leading regions include parts of Germany, Turkey, and Romania, which are at the forefront in terms of available biomass, followed by certain regions in France and Serbia. Biomass availability tends to be higher in regions with intensive agricultural activity, such as certain areas in northern Spain and France. In contrast, southern and peripheral regions, including many Mediterranean areas, show lower biomass availability, with minimal contributions in some coastal and Mediterranean zones. This geographical pattern reflects the varying levels of the biomass from the "category p)" generated across Europe, influenced by both regional climate and agricultural practices.

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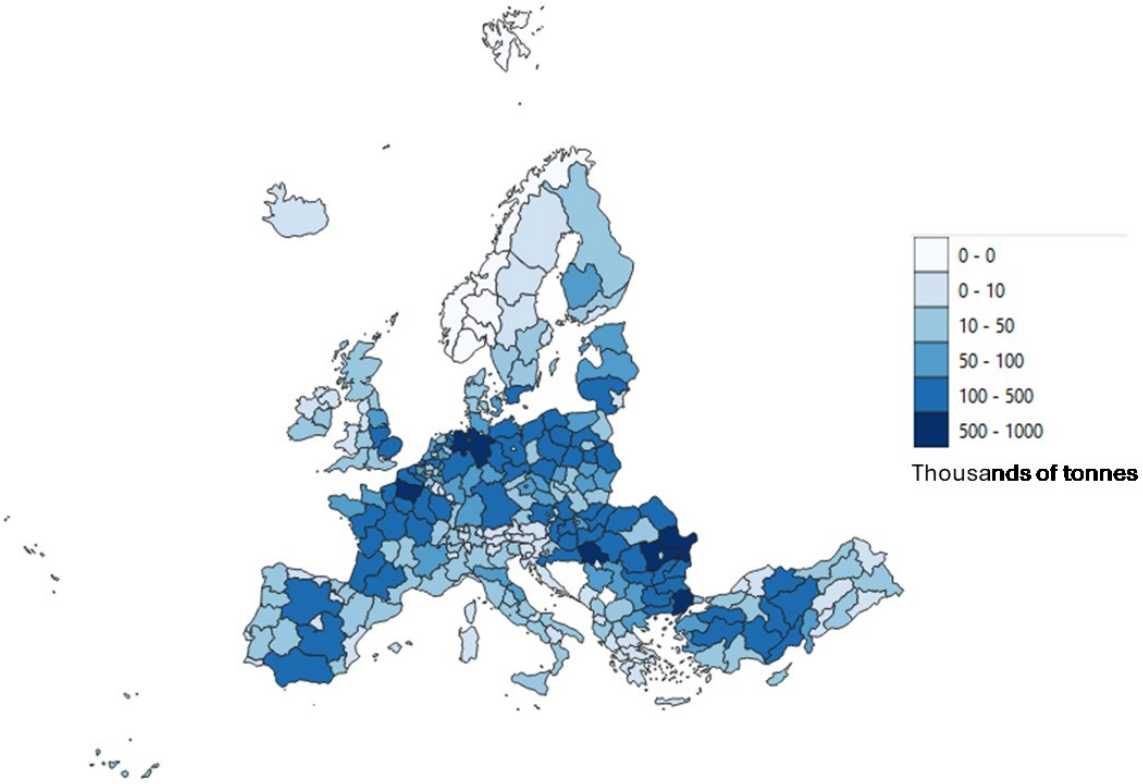

Figure 30. Geographical distribution of European biomass potential of the category "p) Other non-food cellulosic material" for the production of advanced biofuels according to the Scenario B.

Figure 31 indicates the biomass available according to the category q) Other ligno-cellulosic material except saw logs and veneer logs, which in this study is only represented by the wood fuel as indicated in Table 12, the regions with the highest biomass values are located in central and northern Europe, followed by certain areas in France and the Baltics. The largest biomass contributors often correspond to regions with dense forests and strong forestry industries. In contrast, some southern and eastern regions show much lower biomass figures, reflecting variations in local forestry resources.

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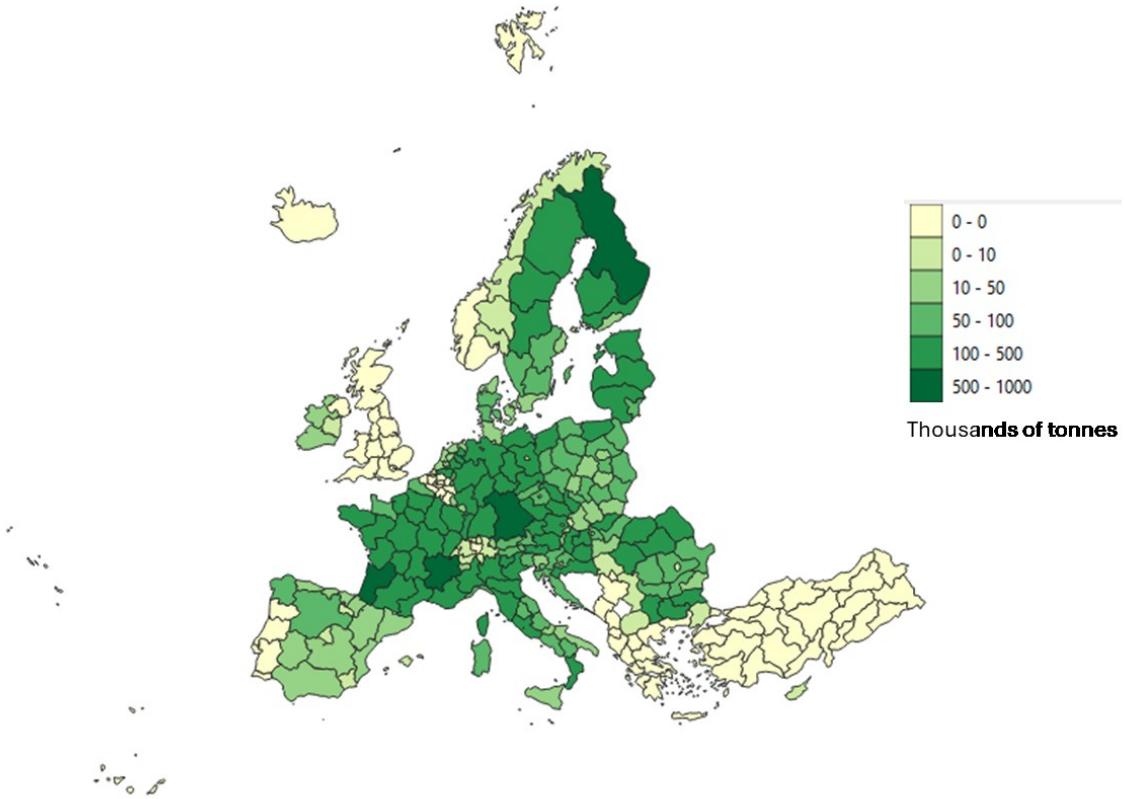

Figure 31. Geographical distribution of European biomass potential of the category “q) Other ligno-cellulosic material except saw logs and veneer logs” for the production of advanced biofuels according to the Scenario B.

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5. Conclusions

This report presents a comprehensive assessment of the potential for advanced biofuels production from biomass, both at a global level and within Europe. By categorizing biomass resources according to Annex IX of the Renewable Energy Directive (RED II and updated in RED III), the report provides valuable insights into the geographic distribution and suitability of biomass for biofuels production.

At the global level, it has been identifying several regions with significant biomass potential for advanced biofuels production. Southeast Asia and Latin America, particularly Brazil and Mexico, are prominent due to the large availability of agricultural residues, especially the straw which is the category more abundant. In contrast, Sub-Saharan Africa shows relatively limited potential for advanced biofuels production from biomass, as it lacks the same level of agricultural and forestry residues compared to other regions. However, certain areas within Africa may still offer opportunities for specific types of biomass, particularly related to crop residues. Europe has an intermediate position compared to the rest of the continents in terms of potential.

Being more specific regarding Europe, the northern part of Spain and the western region of France stand out as areas with substantial biomass availability. These regions are particularly rich in agricultural residues such as (e) straw and (m) husks, as well as forestry residues. Central and Eastern Europe, including countries like Poland, Romania, and Hungary, also show significant potential with abundant (e) straw and (j) bagasse from agricultural activities, in addition to (o) biomass fractions from forestry residues. The Nordic countries, particularly Sweden, Finland, and the Baltic States, contribute a major share of forest-derived biomass, primarily (o) biomass from forestry and (q) other ligno-cellulosic material.

One of the most striking findings of the report is the significant contribution of (e) straw to the overall biomass potential at Global and European level. This category (e) straw, with its widespread availability in regions with intensive agricultural activity, such as northern Spain, France, and large parts of South America, stands out as the largest contributor to biomass potential for advanced biofuels production. Its abundance and relatively easy accessibility make it a highly valuable resource in these regions, driving a substantial portion of the overall biofuels potential.

The report also emphasizes the importance of organizing biomass resources by their Annex IX categories, which allows for a detailed and systematic evaluation, offering a clearer understanding of the types of

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biomass that are most suited for biofuels production. This approach aligns with European regulatory frameworks and provides valuable insights for policymakers and stakeholders in the biofuels industry.

On the other hand, transforming these tons of biomass into energy and comparing it with the current consumption in the aviation and maritime sectors this report reveals a stark contrast between Global and European contexts. At the Global level, there appear to be sufficient biomass resources across all scenarios to fully decarbonize these sectors, with straw playing a particularly significant role. However, in Europe, none of the scenarios, even under theoretical potential, provide adequate biogenic feedstock to meet the energy demands for complete decarbonization. This discrepancy underscores the necessity of exploring alternative resources, including other Annex IX categories, advanced technologies like HVO, and renewable fuels of non-biological origin (RFNBO) to produce e-fuels, as part of a diversified strategy to achieve decarbonization goals.

However, it is important to note that the results presented are based on initial estimates and that local conditions can significantly influence biomass availability. Factors such as the Residue to Product Ratio (RSP), the percentage of material availability, and regional differences in agricultural and forestry practices can lead to variations in the actual biomass potential. While the results are informative, they are preliminary and should be refined by local data and further studies.

Looking ahead, BioTheRoS is considering integrating this biomass evaluation methodology into a data visualization interface under Task 2.4 of the project. This interface would allow users to adjust key variables, such as RSP and availability percentages, enabling more precise and regionally tailored biomass potential estimates. By providing a dynamic tool for stakeholders to modify key assumptions, this interface will facilitate better-informed decision-making and help to optimize biomass use for advanced biofuels production.

This study serves as a basis for the following WP2 activities, based on the logistics of these resources, the design of the value chain, and the development of AI models to facilitate the decision-making process of where to locate new plants. For all this, this initial analysis was necessary, and having the data geo-referenced will also be very useful. Lastly, it is worth mentioning that this report has also contributed to the decision-making process regarding which types of biomass to select for WP3 and WP4, in order to conduct a detailed analysis of advanced fuel production for the aviation and maritime sectors, using pyrolysis and gasification technologies.

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Annex I

This Annex show some examples of tables that have been elaborated to obtain the forestry biomass potential according to the different bibliographic sources (FAO, ESA and JRC). In this particular case, the final tables (theoretical potential, scenario A, scenario B and scenario C) are shown for the primary forestry biomass which is one of those forming part of Annex IX (o). Similarly, tables have been prepared for all the other biomasses analysed, for each of the scenarios established.

Primary forestry residual biomass in 1000 (T). Theorical Potential.

Name	Continent	Region	FAO	ESA	JRC BAWS	JRC ABG
Abyei	Africa	Northern Africa	0	0	0	0
Afghanistan	Asia	Southern Asia	0	0	0	0
Aksai Chin	Asia	Eastern Asia	0	0	0	0
Albania	Europe	Southern Europe	0	0	0	0
Algeria	Africa	Northern Africa	1,112	1,696	0	0
American Samoa	Oceania	Polynesia	0	0	0	0
Andorra	Europe	Southern Europe	0	0	0	0
Angola	Africa	Middle Africa	0	0	0	0
Anguilla	Americas	Caribbean	0	0	0	0
Antigua & Barbuda	Americas	Caribbean	0	0	0	0
Argentina	Americas	South America	0	0	0	0
Armenia	Asia	Western Asia	0	0	0	0
Aruba	Americas	Caribbean	0	0	0	0

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Arunachal Pradesh	Asia	Eastern Asia	0	0	0	0
Australia	Oceania	Australia and New Zealand	7,090	2,846	0	0
Austria	Europe	Western Europe	4,106	5,056	4,371	4,929
Azerbaijan	Asia	Western Asia	0	0	0	0
Azores Islands	Europe	Southern Europe	0	0	0	0
Bahamas	Americas	Caribbean	9	9	0	0
Bahrain	Asia	Western Asia	0	0	0	0
Bangladesh	Asia	Southern Asia	5,574	7,870	0	0
Barbados	Americas	Caribbean	0	0	0	0
Belarus	Europe	Eastern Europe	8,377	12,094	14	15
Belgium	Europe	Western Europe	0	0	0	0
Belize	Americas	Central America	0	0	0	0
Benin	Africa	Western Africa	0	0	0	0
Bermuda	Americas	Northern America	0	0	0	0
Bhutan	Asia	Southern Asia	1,360	394	0	0
Bolivia	Americas	South America	0	0	0	0
Bosnia & Herzegovina	Europe	Southern Europe	0	0	0	0
Botswana	Africa	Southern Africa	0	0	0	0
Bouvet Island	Antarctica		0	0	0	0

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Brazil	Americas	South America	3,550	3,537	0	0
British Indian Ocean Territory	Africa	Eastern Africa	0	0	0	0
British Virgin Islands	Americas	Caribbean	0	0	0	0
Brunei Darussalam	Asia	South-Eastern Asia	0	0	0	0
Bulgaria	Europe	Eastern Europe	5,242	4,055	2,766	3,173
Burkina Faso	Africa	Western Africa	130	5	0	0
Burundi	Africa	Eastern Africa	1,958	2,476	0	0
CÃ´te d'Ivoire	Africa	Western Africa	0	0	0	0
Cambodia	Asia	South-Eastern Asia	0	0	0	0
Cameroon	Africa	Middle Africa	0	0	0	0
Canada	Americas	Northern America	19,283	35,509	0	0
Cape Verde	Africa	Western Africa	57	17	0	0
Cayman Islands	Americas	Caribbean	0	0	0	0
Central African Republic	Africa	Middle Africa	0	0	0	0
Chad	Africa	Middle Africa	0	0	0	0
Chile	Americas	South America	22,578	19,030	0	0
China	Asia	Eastern Asia	180,887	210,647	0	0
Christmas Island	Asia	South-Eastern Asia	0	0	0	0

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Cocos (Keeling) Islands	Asia	South-Eastern Asia	0	0	0	0
Colombia	Americas	South America	0	0	0	0
Comoros	Africa	Eastern Africa	103	429	0	0
Congo	Africa	Middle Africa	46	66	0	0
Cook Islands	Oceania	Polynesia	0	0	0	0
Costa Rica	Americas	Central America	2,978	1,887	0	0
Croatia	Europe	Southern Europe	1,923	2,291	1,711	1,855
Cuba	Americas	Caribbean	1,178	1,132	0	0
Cyprus	Asia	Western Asia	29	39	9	24
Czech Republic	Europe	Eastern Europe	4,489	6,804	6,442	6,817
Democratic People's Republic of Korea	Asia	Eastern Asia	1,209	1,707	0	0
Democratic Republic of the Congo	Africa	Middle Africa	0	0	0	0
Denmark	Europe	Northern Europe	858	1,218	825	833
Djibouti	Africa	Eastern Africa	134	4	0	0
Dominica	Americas	Caribbean	0	0	0	0
Dominican Republic	Americas	Caribbean	638	789	0	0
Ecuador	Americas	South America	0	0	0	0

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Egypt	Africa	Northern Africa	4,856	19,803	0	0
El Salvador	Americas	Central America	1,412	1,479	0	0
Equatorial Guinea	Africa	Middle Africa	0	0	0	0
Eritrea	Africa	Eastern Africa	256	89	0	0
Estonia	Europe	Northern Europe	2,534	5,092	2,306	2,516
Ethiopia	Africa	Eastern Africa	32,131	23,357	0	0
Falkland Islands (Malvinas)	Americas	South America	0	0	0	0
Faroe Islands	Europe	Northern Europe	0	0	0	0
Fiji	Oceania	Melanesia	613	404	0	0
Finland	Europe	Northern Europe	17,398	41,074	17,175	20,268
France	Europe	Western Europe	22,118	24,701	23,218	24,841
French Guiana	Americas	South America	0	0	0	0
French Polynesia	Oceania	Polynesia	6	0	0	0
French Southern and Antarctic Territories	Antarctica		0	0	0	0
Gabon	Africa	Middle Africa	0	0	0	0
Gambia	Africa	Western Africa	217	117	0	0
Gaza Strip	Asia	Western Asia	0	0	0	0

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Georgia	Asia	Western Asia	397	502	0	0
Germany	Europe	Western Europe	20,623	26,316	18,025	18,688
Ghana	Africa	Western Africa	22,040	19,296	0	0
Gibraltar	Europe	Southern Europe	0	0	0	0
Glorioso Islands	Africa	Eastern Africa	0	0	0	0
Greece	Europe	Southern Europe	577	1,835	818	904
Greenland	Americas	Northern America	0	0	0	0
Grenada	Americas	Caribbean	0	0	0	0
Guadeloupe	Americas	Caribbean	0	0	0	0
Guam	Oceania	Micronesia	0	0	0	0
Guantanamo	Americas	Caribbean	0	0	0	0
Guatemala	Americas	Central America	4,423	6,136	0	0
Guernsey	Europe	Northern Europe	0	0	0	0
Guinea	Africa	Western Africa	2,015	1,568	0	0
Guinea-Bissau	Africa	Western Africa	697	380	0	0
Guyana	Americas	South America	0	0	0	0
Haiti	Americas	Caribbean	621	1,591	0	0
Hala'ib Triangle	Africa	Northern Africa	0	0	0	0
Heard Island and	Antarctica		0	0	0	0

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McDonald Islands						
Holy See	Europe	Southern Europe	0	0	0	0
Honduras	Americas	Central America	1,601	1,706	0	0
Hong Kong	Asia	Eastern Asia	0	0	0	0
Hungary	Europe	Eastern Europe	1,663	2,179	2,267	2,439
Iceland	Europe	Northern Europe	16	1,700	0	0
Ilemi Triangle	Africa	Northern Africa	0	0	0	0
India	Asia	Southern Asia	113,560	47,961	0	0
Indonesia	Asia	South-Eastern Asia	0	0	0	0
Iran (Islamic Republic of)	Asia	Southern Asia	145	21	0	0
Iraq	Asia	Western Asia	0	0	0	0
Ireland	Europe	Northern Europe	1,161	2,668	1,023	1,032
Isle of Man	Europe	Northern Europe	0	0	0	0
Israel	Asia	Western Asia	0	0	0	0
Italy	Europe	Southern Europe	5,184	6,076	4,482	5,352
Jamaica	Americas	Caribbean	247	196	0	0
Jammu-Kashmir	Asia	Eastern Asia	0	0	0	0
Japan	Asia	Eastern Asia	0	0	0	0
Jarvis Island	Americas	Northern America	0	0	0	0

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Jersey	Europe	Northern Europe	0	0	0	0
Jordan	Asia	Western Asia	80	8	0	0
Kazakhstan	Asia	Central Asia	452	963	0	0
Kenya	Africa	Eastern Africa	10,134	5,896	0	0
Kiribati	Oceania	Micronesia	0	0	0	0
Kuril Islands	Asia	Eastern Asia	0	0	0	0
Kuwait	Asia	Western Asia	0	0	0	0
Kyrgyzstan	Asia	Central Asia	403	948	0	0
Lao People's Democratic Republic	Asia	South-Eastern Asia	680	543	0	0
Latvia	Europe	Northern Europe	3,686	6,675	3,411	3,709
Lebanon	Asia	Western Asia	15	15	0	0
Lesotho	Africa	Southern Africa	543	1,902	0	0
Liberia	Africa	Western Africa	407	422	0	0
Libyan Arab Jamahiriya	Africa	Northern Africa	0	0	0	0
Liechtenstein	Europe	Western Europe	0	0	0	0
Lithuania	Europe	Northern Europe	2,255	3,857	2,088	2,275
Luxembourg	Europe	Western Europe	126	170	120	126
Macao	Asia	Eastern Asia	0	0	0	0

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Madagascar	Africa	Eastern Africa	3,984	3,011	0	0
Madeira Islands	Europe	Southern Europe	0	0	0	0
Malawi	Africa	Eastern Africa	1,001	749	0	0
Malaysia	Asia	South-Eastern Asia	0	0	0	0
Maldives	Asia	Southern Asia	5	0	0	0
Mali	Africa	Western Africa	2,238	152	0	0
Malta	Europe	Southern Europe	0	0	0	0
Marshall Islands	Oceania	Micronesia	0	0	0	0
Martinique	Americas	Caribbean	31	11	0	0
Ma'tan al-Sarra	Africa	Northern Africa	0	0	0	0
Mauritania	Africa	Western Africa	939	725	0	0
Mauritius	Africa	Eastern Africa	5	5	0	0
Mayotte	Africa	Eastern Africa	0	0	0	0
Mexico	Americas	Central America	9,800	10,057	0	0
Micronesia (Federated States of)	Oceania	Micronesia	0	0	0	0
Midway Is,	Americas	Northern America	0	0	0	0
Moldova, Republic of	Europe	Eastern Europe	283	353	1	1
Monaco	Europe	Western Europe	0	0	0	0

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Mongolia	Asia	Eastern Asia	131	99	0	0
Montenegro	Europe	Southern Europe	1,824	1,858	0	0
Montserrat	Americas	Caribbean	0	0	0	0
Morocco	Africa	Northern Africa	1,993	645	0	0
Mozambique	Africa	Eastern Africa	0	0	0	0
Myanmar	Asia	South-Eastern Asia	0	0	0	0
Namibia	Africa	Southern Africa	0	0	0	0
Nauru	Oceania	Micronesia	0	0	0	0
Nepal	Asia	Southern Asia	4,882	1,841	0	0
Netherlands	Europe	Western Europe	797	4,625	2,702	3,040
Netherlands Antilles	Americas	Caribbean	0	0	0	0
New Caledonia	Oceania	Melanesia	2	2	0	0
New Zealand	Oceania	Australia and New Zealand	7,107	4,042	0	0
Nicaragua	Americas	Central America	0	0	0	0
Niger	Africa	Western Africa	3,896	59	0	0
Nigeria	Africa	Western Africa	16,001	6,091	0	0
Niue	Oceania	Polynesia	1	0	0	0
Norfolk Island	Oceania	Australia and New Zealand	0	0	0	0

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Northern Mariana Islands	Oceania	Micronesia	0	0	0	0
Norway	Europe	Northern Europe	4,909	9,976	4	9
Oman	Asia	Western Asia	8	1	0	0
Pakistan	Asia	Southern Asia	8,677	2,961	0	0
Palau	Oceania	Micronesia	0	0	0	0
Panama	Americas	Central America	0	0	0	0
Papua New Guinea	Oceania	Melanesia	654	752	0	0
Paracel Islands	Asia	South-Eastern Asia	0	0	0	0
Paraguay	Americas	South America	0	0	0	0
Peru	Americas	South America	0	0	0	0
Philippines	Asia	South-Eastern Asia	4,771	4,929	0	0
Pitcairn Island	Oceania	Polynesia	0	0	0	0
Poland	Europe	Eastern Europe	13,029	17,615	13,312	13,734
Portugal	Europe	Southern Europe	0	0	0	0
Puerto Rico	Americas	Caribbean	0	0	0	0
Qatar	Asia	Western Asia	0	0	0	0
Republic of Korea	Asia	Eastern Asia	6,929	5,861	0	0
Reunion	Africa	Eastern Africa	58	60	0	0

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Romania	Europe	Eastern Europe	6,237	5,715	4,537	5,294
Russian Federation	Europe	Eastern Europe	99,251	196,813	4	4
Rwanda	Africa	Eastern Africa	2,189	2,580	0	0
Saint Kitts and Nevis	Americas	Caribbean	0	0	0	0
Saint Lucia	Americas	Caribbean	34	21	0	0
Saint Vincent and the Grenadines	Americas	Caribbean	2	1	0	0
Samoa	Oceania	Polynesia	2	0	0	0
San Marino	Europe	Southern Europe	0	0	0	0
Sao Tome and Principe	Africa	Middle Africa	3	3	0	0
Saudi Arabia	Asia	Western Asia	65	8	0	0
Senegal	Africa	Western Africa	1,317	189	0	0
Serbia	Europe	Southern Europe	2,041	1,647	6	8
Seychelles	Africa	Eastern Africa	5	0	0	0
Sierra Leone	Africa	Western Africa	1,347	2,777	0	0
Singapore	Asia	South-Eastern Asia	3	2	0	0
Slovakia	Europe	Eastern Europe	1,802	2,569	2,352	2,590
Slovenia	Europe	Southern Europe	940	780	738	847
Solomon Islands	Oceania	Melanesia	0	0	0	0

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Somalia	Africa	Eastern Africa	1,704	327	0	0
South Africa	Africa	Southern Africa	5,475	2,526	0	0
South Georgia & the South Sandwich Islands	Antarctica		0	0	0	0
South Sudan	Africa	Middle Africa	0	0	0	0
Spain	Europe	Southern Europe	5,337	6,141	5,256	5,750
Spratly Islands	Asia	South-Eastern Asia	0	0	0	0
Sri Lanka	Asia	Southern Asia	1,534	1,633	0	0
Sudan	Africa	Northern Africa	1,069	120	0	0
Suriname	Americas	South America	0	0	0	0
Svalbard and Jan Mayen Islands	Europe	Northern Europe	0	0	0	0
Swaziland	Africa	Southern Africa	0	0	0	0
Sweden	Europe	Northern Europe	16,940	29,916	14,911	17,032
Switzerland	Europe	Western Europe	1,323	1,531	16	26
Syrian Arab Republic	Asia	Western Asia	12	7	0	0
Taiwan	Asia	Eastern Asia	0	0	0	0
Tajikistan	Asia	Central Asia	0	0	0	0
Thailand	Asia	South-Eastern Asia	8,939	5,464	0	0

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The former Yugoslav Republic of Macedonia	Europe	Southern Europe	203	241	0	1
Timor-Leste	Asia	South-Eastern Asia	0	0	0	0
Togo	Africa	Western Africa	1,394	498	0	0
Tokelau	Oceania	Polynesia	0	0	0	0
Tonga	Oceania	Polynesia	1	0	0	0
Trinidad and Tobago	Americas	Caribbean	43	107	0	0
Tunisia	Africa	Northern Africa	1,428	597	0	0
Turkey	Asia	Western Asia	8,932	11,077	5	9
Turkmenistan	Asia	Central Asia	0	0	0	0
Turks and Caicos Islands	Americas	Caribbean	0	0	0	0
Tuvalu	Oceania	Polynesia	0	0	0	0
U,K, of Great Britain and Northern Ireland	Europe	Northern Europe	3,357	6,936	4	5
Uganda	Africa	Eastern Africa	14,632	29,306	0	0
Ukraine	Europe	Eastern Europe	5,966	8,662	8	10
United Arab Emirates	Asia	Western Asia	16	0	0	0
United Republic of Tanzania	Africa	Eastern Africa	0	0	0	0

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United States of America	Americas	Northern America	104,195	136,694	0	0
United States Virgin Islands	Americas	Caribbean	0	0	0	0
Uruguay	Americas	South America	5,290	7,498	0	0
Uzbekistan	Asia	Central Asia	0	0	0	0
Vanuatu	Oceania	Melanesia	0	0	0	0
Venezuela	Americas	South America	0	0	0	0
Vietnam	Asia	South-Eastern Asia	22,615	37,758	0	0
West Bank	Asia	Western Asia	0	0	0	0
Western Sahara	Africa	Northern Africa	0	0	0	0
Yemen	Asia	Western Asia	0	0	0	0
Zambia	Africa	Eastern Africa	4,708	3,755	0	0
Zimbabwe	Africa	Eastern Africa	0	0	0	0
TOTAL			974,501	1,159,633	134,930	148,154

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Primary forestry residual biomass scenario A in 1000 (Ton)

Name	Continent	Region	FAO	ESA	JRC BAWS	JRC ABG
Abyei	Africa	Northern Africa	0	0	0	0
Afghanistan	Asia	Southern Asia	0	0	0	0
Aksai Chin	Asia	Eastern Asia	0	0	0	0
Albania	Europe	Southern Europe	0	0	0	0
Algeria	Africa	Northern Africa	787	1,200	0	0
American Samoa	Oceania	Polynesia	0	0	0	0
Andorra	Europe	Southern Europe	0	0	0	0
Angola	Africa	Middle Africa	0	0	0	0
Anguilla	Americas	Caribbean	0	0	0	0
Antigua & Barbuda	Americas	Caribbean	0	0	0	0
Argentina	Americas	South America	0	0	0	0
Armenia	Asia	Western Asia	0	0	0	0
Aruba	Americas	Caribbean	0	0	0	0
Arunachal Pradesh	Asia	Eastern Asia	0	0	0	0
Australia	Oceania	Australia and New Zealand	4,771	1,915	0	0
Austria	Europe	Western Europe	3,111	3,831	3,312	3,735
Azerbaijan	Asia	Western Asia	0	0	0	0

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Azores Islands	Europe	Southern Europe	0	0	0	0
Bahamas	Americas	Caribbean	5	6	0	0
Bahrain	Asia	Western Asia	0	0	0	0
Bangladesh	Asia	Southern Asia	3,345	4,722	0	0
Barbados	Americas	Caribbean	0	0	0	0
Belarus	Europe	Eastern Europe	6,162	8,896	10	11
Belgium	Europe	Western Europe	0	0	0	0
Belize	Americas	Central America	0	0	0	0
Benin	Africa	Western Africa	0	0	0	0
Bermuda	Americas	Northern America	0	0	0	0
Bhutan	Asia	Southern Asia	818	237	0	0
Bolivia	Americas	South America	0	0	0	0
Bosnia & Herzegovina	Europe	Southern Europe	0	0	0	0
Botswana	Africa	Southern Africa	0	0	0	0
Bouvet Island	Antarctica		0	0	0	0
Brazil	Americas	South America	2,198	2,190	0	0
British Indian Ocean Territory	Africa	Eastern Africa	0	0	0	0
British Virgin Islands	Americas	Caribbean	0	0	0	0

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Brunei Darussalam	Asia	South-Eastern Asia	0	0	0	0
Bulgaria	Europe	Eastern Europe	3,597	2,783	1,898	2,177
Burkina Faso	Africa	Western Africa	78	3	0	0
Burundi	Africa	Eastern Africa	1,180	1,492	0	0
CÃ´te d'Ivoire	Africa	Western Africa	0	0	0	0
Cambodia	Asia	South-Eastern Asia	0	0	0	0
Cameroon	Africa	Middle Africa	0	0	0	0
Canada	Americas	Northern America	14,010	25,799	0	0
Cape Verde	Africa	Western Africa	34	10	0	0
Cayman Islands	Americas	Caribbean	0	0	0	0
Central African Republic	Africa	Middle Africa	0	0	0	0
Chad	Africa	Middle Africa	0	0	0	0
Chile	Americas	South America	15,231	12,837	0	0
China	Asia	Eastern Asia	115,366	134,346	0	0
Christmas Island	Asia	South-Eastern Asia	0	0	0	0
Cocos (Keeling) Islands	Asia	South-Eastern Asia	0	0	0	0
Colombia	Americas	South America	0	0	0	0
Comoros	Africa	Eastern Africa	62	257	0	0

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Congo	Africa	Middle Africa	28	40	0	0
Cook Islands	Oceania	Polynesia	0	0	0	0
Costa Rica	Americas	Central America	1,795	1,137	0	0
Croatia	Europe	Southern Europe	1,202	1,431	1,069	1,159
Cuba	Americas	Caribbean	723	694	0	0
Cyprus	Asia	Western Asia	22	30	7	18
Czech Republic	Europe	Eastern Europe	3,513	5,326	5,042	5,336
Democratic People's Republic of Korea	Asia	Eastern Asia	859	1,213	0	0
Democratic Republic of the Congo	Africa	Middle Africa	0	0	0	0
Denmark	Europe	Northern Europe	633	899	609	614
Djibouti	Africa	Eastern Africa	80	3	0	0
Dominica	Americas	Caribbean	0	0	0	0
Dominican Republic	Americas	Caribbean	386	477	0	0
Ecuador	Americas	South America	0	0	0	0
Egypt	Africa	Northern Africa	2,914	11,883	0	0
El Salvador	Americas	Central America	847	888	0	0
Equatorial Guinea	Africa	Middle Africa	0	0	0	0

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Eritrea	Africa	Eastern Africa	154	53	0	0
Estonia	Europe	Northern Europe	1,761	3,538	1,603	1,749
Ethiopia	Africa	Eastern Africa	19,489	14,167	0	0
Falkland Islands (Malvinas)	Americas	South America	0	0	0	0
Faroe Islands	Europe	Northern Europe	0	0	0	0
Fiji	Oceania	Melanesia	424	279	0	0
Finland	Europe	Northern Europe	12,945	30,562	12,779	15,081
France	Europe	Western Europe	14,709	16,427	15,441	16,520
French Guiana	Americas	South America	0	0	0	0
French Polynesia	Oceania	Polynesia	4	0	0	0
French Southern and Antarctic Territories	Antarctica		0	0	0	0
Gabon	Africa	Middle Africa	0	0	0	0
Gambia	Africa	Western Africa	130	70	0	0
Gaza Strip	Asia	Western Asia	0	0	0	0
Georgia	Asia	Western Asia	256	324	0	0
Germany	Europe	Western Europe	15,163	19,348	13,252	13,740
Ghana	Africa	Western Africa	13,227	11,580	0	0

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Gibraltar	Europe	Southern Europe	0	0	0	0
Glorioso Islands	Africa	Eastern Africa	0	0	0	0
Greece	Europe	Southern Europe	363	1,157	516	570
Greenland	Americas	Northern America	0	0	0	0
Grenada	Americas	Caribbean	0	0	0	0
Guadeloupe	Americas	Caribbean	0	0	0	0
Guam	Oceania	Micronesia	0	0	0	0
Guantanamo	Americas	Caribbean	0	0	0	0
Guatemala	Americas	Central America	3,022	4,192	0	0
Guernsey	Europe	Northern Europe	0	0	0	0
Guinea	Africa	Western Africa	1,209	941	0	0
Guinea-Bissau	Africa	Western Africa	418	228	0	0
Guyana	Americas	South America	0	0	0	0
Haiti	Americas	Caribbean	380	975	0	0
Hala'ib Triangle	Africa	Northern Africa	0	0	0	0
Heard Island and McDonald Islands	Antarctica		0	0	0	0
Holy See	Europe	Southern Europe	0	0	0	0
Honduras	Americas	Central America	1,041	1,109	0	0

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Hong Kong	Asia	Eastern Asia	0	0	0	0
Hungary	Europe	Eastern Europe	1,041	1,364	1,419	1,527
Iceland	Europe	Northern Europe	12	1,296	0	0
Ilemi Triangle	Africa	Northern Africa	0	0	0	0
India	Asia	Southern Asia	68,762	29,041	0	0
Indonesia	Asia	South-Eastern Asia	0	0	0	0
Iran (Islamic Republic of)	Asia	Southern Asia	87	13	0	0
Iraq	Asia	Western Asia	0	0	0	0
Ireland	Europe	Northern Europe	926	2,127	816	823
Isle of Man	Europe	Northern Europe	0	0	0	0
Israel	Asia	Western Asia	0	0	0	0
Italy	Europe	Southern Europe	3,339	3,914	2,887	3,448
Jamaica	Americas	Caribbean	148	117	0	0
Jammu-Kashmir	Asia	Eastern Asia	0	0	0	0
Japan	Asia	Eastern Asia	0	0	0	0
Jarvis Island	Americas	Northern America	0	0	0	0
Jersey	Europe	Northern Europe	0	0	0	0
Jordan	Asia	Western Asia	48	5	0	0
Kazakhstan	Asia	Central Asia	289	616	0	0

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Kenya	Africa	Eastern Africa	6,205	3,610	0	0
Kiribati	Oceania	Micronesia	0	0	0	0
Kuril Islands	Asia	Eastern Asia	0	0	0	0
Kuwait	Asia	Western Asia	0	0	0	0
Kyrgyzstan	Asia	Central Asia	259	610	0	0
Lao People's Democratic Republic	Asia	South-Eastern Asia	408	326	0	0
Latvia	Europe	Northern Europe	2,598	4,704	2,404	2,614
Lebanon	Asia	Western Asia	10	10	0	0
Lesotho	Africa	Southern Africa	327	1,143	0	0
Liberia	Africa	Western Africa	244	253	0	0
Libyan Arab Jamahiriya	Africa	Northern Africa	0	0	0	0
Liechtenstein	Europe	Western Europe	0	0	0	0
Lithuania	Europe	Northern Europe	1,558	2,665	1,443	1,572
Luxembourg	Europe	Western Europe	88	119	84	88
Macao	Asia	Eastern Asia	0	0	0	0
Madagascar	Africa	Eastern Africa	2,394	1,809	0	0
Madeira Islands	Europe	Southern Europe	0	0	0	0
Malawi	Africa	Eastern Africa	603	451	0	0

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Malaysia	Asia	South-Eastern Asia	0	0	0	0
Maldives	Asia	Southern Asia	3	0	0	0
Mali	Africa	Western Africa	1,343	91	0	0
Malta	Europe	Southern Europe	0	0	0	0
Marshall Islands	Oceania	Micronesia	0	0	0	0
Martinique	Americas	Caribbean	19	6	0	0
Ma'tan al-Sarra	Africa	Northern Africa	0	0	0	0
Mauritania	Africa	Western Africa	564	435	0	0
Mauritius	Africa	Eastern Africa	4	3	0	0
Mayotte	Africa	Eastern Africa	0	0	0	0
Mexico	Americas	Central America	6,353	6,520	0	0
Micronesia (Federated States of)	Oceania	Micronesia	0	0	0	0
Midway Is,	Americas	Northern America	0	0	0	0
Moldova, Republic of	Europe	Eastern Europe	170	212	1	1
Monaco	Europe	Western Europe	0	0	0	0
Mongolia	Asia	Eastern Asia	100	75	0	0
Montenegro	Europe	Southern Europe	1,240	1,263	0	0
Montserrat	Americas	Caribbean	0	0	0	0

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Morocco	Africa	Northern Africa	1,234	399	0	0
Mozambique	Africa	Eastern Africa	0	0	0	0
Myanmar	Asia	South-Eastern Asia	0	0	0	0
Namibia	Africa	Southern Africa	0	0	0	0
Nauru	Oceania	Micronesia	0	0	0	0
Nepal	Asia	Southern Asia	2,932	1,106	0	0
Netherlands	Europe	Western Europe	517	3,000	1,753	1,972
Netherlands Antilles	Americas	Caribbean	0	0	0	0
New Caledonia	Oceania	Melanesia	1	1	0	0
New Zealand	Oceania	Australia and New Zealand	5,668	3,223	0	0
Nicaragua	Americas	Central America	0	0	0	0
Niger	Africa	Western Africa	2,338	36	0	0
Nigeria	Africa	Western Africa	9,601	3,655	0	0
Niue	Oceania	Polynesia	0	0	0	0
Norfolk Island	Oceania	Australia and New Zealand	0	0	0	0
Northern Mariana Islands	Oceania	Micronesia	0	0	0	0
Norway	Europe	Northern Europe	3,803	7,727	3	7
Oman	Asia	Western Asia	5	1	0	0

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Pakistan	Asia	Southern Asia	5,304	1,810	0	0
Palau	Oceania	Micronesia	0	0	0	0
Panama	Americas	Central America	0	0	0	0
Papua New Guinea	Oceania	Melanesia	393	451	0	0
Paracel Islands	Asia	South-Eastern Asia	0	0	0	0
Paraguay	Americas	South America	0	0	0	0
Peru	Americas	South America	0	0	0	0
Philippines	Asia	South-Eastern Asia	2,864	2,959	0	0
Pitcairn Island	Oceania	Polynesia	0	0	0	0
Poland	Europe	Eastern Europe	9,599	12,977	9,808	10,119
Portugal	Europe	Southern Europe	0	0	0	0
Puerto Rico	Americas	Caribbean	0	0	0	0
Qatar	Asia	Western Asia	0	0	0	0
Republic of Korea	Asia	Eastern Asia	4,862	4,112	0	0
Reunion	Africa	Eastern Africa	35	36	0	0
Romania	Europe	Eastern Europe	4,113	3,769	2,992	3,492
Russian Federation	Europe	Eastern Europe	73,741	146,227	3	3
Rwanda	Africa	Eastern Africa	1,318	1,553	0	0
Saint Kitts and Nevis	Americas	Caribbean	0	0	0	0

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Saint Lucia	Americas	Caribbean	21	13	0	0
Saint Vincent and the Grenadines	Americas	Caribbean	1	1	0	0
Samoa	Oceania	Polynesia	1	0	0	0
San Marino	Europe	Southern Europe	0	0	0	0
Sao Tome and Principe	Africa	Middle Africa	2	2	0	0
Saudi Arabia	Asia	Western Asia	39	5	0	0
Senegal	Africa	Western Africa	790	113	0	0
Serbia	Europe	Southern Europe	1,242	1,002	4	5
Seychelles	Africa	Eastern Africa	3	0	0	0
Sierra Leone	Africa	Western Africa	808	1,666	0	0
Singapore	Asia	South-Eastern Asia	2	1	0	0
Slovakia	Europe	Eastern Europe	1,250	1,782	1,631	1,796
Slovenia	Europe	Southern Europe	667	553	523	601
Solomon Islands	Oceania	Melanesia	0	0	0	0
Somalia	Africa	Eastern Africa	1,023	196	0	0
South Africa	Africa	Southern Africa	3,489	1,610	0	0
South Georgia & the South Sandwich Islands	Antarctica		0	0	0	0

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South Sudan	Africa	Middle Africa	0	0	0	0
Spain	Europe	Southern Europe	3,614	4,158	3,559	3,893
Spratly Islands	Asia	South-Eastern Asia	0	0	0	0
Sri Lanka	Asia	Southern Asia	921	980	0	0
Sudan	Africa	Northern Africa	641	72	0	0
Suriname	Americas	South America	0	0	0	0
Svalbard and Jan Mayen Islands	Europe	Northern Europe	0	0	0	0
Swaziland	Africa	Southern Africa	0	0	0	0
Sweden	Europe	Northern Europe	13,048	23,042	11,485	13,118
Switzerland	Europe	Western Europe	955	1,104	12	19
Syrian Arab Republic	Asia	Western Asia	8	5	0	0
Taiwan	Asia	Eastern Asia	0	0	0	0
Tajikistan	Asia	Central Asia	0	0	0	0
Thailand	Asia	South-Eastern Asia	5,363	3,278	0	0
The former Yugoslav Republic of Macedonia	Europe	Southern Europe	125	148	0	0
Timor-Leste	Asia	South-Eastern Asia	0	0	0	0
Togo	Africa	Western Africa	837	299	0	0

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Tokelau	Oceania	Polynesia	0	0	0	0
Tonga	Oceania	Polynesia	1	0	0	0
Trinidad and Tobago	Americas	Caribbean	26	65	0	0
Tunisia	Africa	Northern Africa	899	376	0	0
Turkey	Asia	Western Asia	6,317	7,835	3	6
Turkmenistan	Asia	Central Asia	0	0	0	0
Turks and Caicos Islands	Americas	Caribbean	0	0	0	0
Tuvalu	Oceania	Polynesia	0	0	0	0
U,K, of Great Britain and Northern Ireland	Europe	Northern Europe	2,636	5,446	3	4
Uganda	Africa	Eastern Africa	8,815	17,655	0	0
Ukraine	Europe	Eastern Europe	4,237	6,151	6	7
United Arab Emirates	Asia	Western Asia	10	0	0	0
United Republic of Tanzania	Africa	Eastern Africa	0	0	0	0
United States of America	Americas	Northern America	72,916	95,659	0	0
United States Virgin Islands	Americas	Caribbean	0	0	0	0
Uruguay	Americas	South America	3,249	4,605	0	0

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Uzbekistan	Asia	Central Asia	0	0	0	0
Vanuatu	Oceania	Melanesia	0	0	0	0
Venezuela	Americas	South America	0	0	0	0
Vietnam	Asia	South-Eastern Asia	13,617	22,735	0	0
West Bank	Asia	Western Asia	0	0	0	0
Western Sahara	Africa	Northern Africa	0	0	0	0
Yemen	Asia	Western Asia	0	0	0	0
Zambia	Africa	Eastern Africa	2,825	2,253	0	0
Zimbabwe	Africa	Eastern Africa	0	0	0	0
Total			646,315	788,151	96,378	105,823

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Primary forestry residual biomass scenario B in 1000 (Ton)

Name	Continent	Region	FAO	ESA	JRC BAWS	JRC ABG
Abyei	Africa	Northern Africa	0	0	0	0
Afghanistan	Asia	Southern Asia	0	0	0	0
Aksai Chin	Asia	Eastern Asia	0	0	0	0
Albania	Europe	Southern Europe	0	0	0	0
Algeria	Africa	Northern Africa	564	861	0	0
American Samoa	Oceania	Polynesia	0	0	0	0
Andorra	Europe	Southern Europe	0	0	0	0
Angola	Africa	Middle Africa	0	0	0	0
Anguilla	Americas	Caribbean	0	0	0	0
Antigua & Barbuda	Americas	Caribbean	0	0	0	0
Argentina	Americas	South America	0	0	0	0
Armenia	Asia	Western Asia	0	0	0	0
Aruba	Americas	Caribbean	0	0	0	0
Arunachal Pradesh	Asia	Eastern Asia	0	0	0	0
Australia	Oceania	Australia and New Zealand	3,353	1,346	0	0
Austria	Europe	Western Europe	2,290	2,820	2,438	2,749
Azerbaijan	Asia	Western Asia	0	0	0	0

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Azores Islands	Europe	Southern Europe	0	0	0	0
Bahamas	Americas	Caribbean	3	4	0	0
Bahrain	Asia	Western Asia	0	0	0	0
Bangladesh	Asia	Southern Asia	2,230	3,148	0	0
Barbados	Americas	Caribbean	0	0	0	0
Belarus	Europe	Eastern Europe	4,487	6,478	8	8
Belgium	Europe	Western Europe	0	0	0	0
Belize	Americas	Central America	0	0	0	0
Benin	Africa	Western Africa	0	0	0	0
Bermuda	Americas	Northern America	0	0	0	0
Bhutan	Asia	Southern Asia	546	158	0	0
Bolivia	Americas	South America	0	0	0	0
Bosnia & Herzegovina	Europe	Southern Europe	0	0	0	0
Botswana	Africa	Southern Africa	0	0	0	0
Bouvet Island	Antarctica		0	0	0	0
Brazil	Americas	South America	1,488	1,483	0	0
British Indian Ocean Territory	Africa	Eastern Africa	0	0	0	0
British Virgin Islands	Americas	Caribbean	0	0	0	0

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Brunei Darussalam	Asia	South-Eastern Asia	0	0	0	0
Bulgaria	Europe	Eastern Europe	2,549	1,972	1,345	1,543
Burkina Faso	Africa	Western Africa	52	2	0	0
Burundi	Africa	Eastern Africa	788	997	0	0
CÃ´te d'Ivoire	Africa	Western Africa	0	0	0	0
Cambodia	Asia	South-Eastern Asia	0	0	0	0
Cameroon	Africa	Middle Africa	0	0	0	0
Canada	Americas	Northern America	10,153	18,697	0	0
Cape Verde	Africa	Western Africa	23	7	0	0
Cayman Islands	Americas	Caribbean	0	0	0	0
Central African Republic	Africa	Middle Africa	0	0	0	0
Chad	Africa	Middle Africa	0	0	0	0
Chile	Americas	South America	10,715	9,031	0	0
China	Asia	Eastern Asia	79,188	92,216	0	0
Christmas Island	Asia	South-Eastern Asia	0	0	0	0
Cocos (Keeling) Islands	Asia	South-Eastern Asia	0	0	0	0
Colombia	Americas	South America	0	0	0	0
Comoros	Africa	Eastern Africa	41	172	0	0

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Congo	Africa	Middle Africa	18	27	0	0
Cook Islands	Oceania	Polynesia	0	0	0	0
Costa Rica	Americas	Central America	1,199	760	0	0
Croatia	Europe	Southern Europe	817	973	727	788
Cuba	Americas	Caribbean	487	468	0	0
Cyprus	Asia	Western Asia	16	22	5	14
Czech Republic	Europe	Eastern Europe	2,616	3,965	3,754	3,972
Democratic People's Republic of Korea	Asia	Eastern Asia	618	872	0	0
Democratic Republic of the Congo	Africa	Middle Africa	0	0	0	0
Denmark	Europe	Northern Europe	461	655	444	448
Djibouti	Africa	Eastern Africa	54	2	0	0
Dominica	Americas	Caribbean	0	0	0	0
Dominican Republic	Americas	Caribbean	258	319	0	0
Ecuador	Americas	South America	0	0	0	0
Egypt	Africa	Northern Africa	1,943	7,923	0	0
El Salvador	Americas	Central America	565	592	0	0
Equatorial Guinea	Africa	Middle Africa	0	0	0	0

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Eritrea	Africa	Eastern Africa	102	36	0	0
Estonia	Europe	Northern Europe	1,254	2,520	1,142	1,245
Ethiopia	Africa	Eastern Africa	13,062	9,495	0	0
Falkland Islands (Malvinas)	Americas	South America	0	0	0	0
Faroe Islands	Europe	Northern Europe	0	0	0	0
Fiji	Oceania	Melanesia	302	199	0	0
Finland	Europe	Northern Europe	9,466	22,347	9,344	11,027
France	Europe	Western Europe	10,286	11,487	10,797	11,552
French Guiana	Americas	South America	0	0	0	0
French Polynesia	Oceania	Polynesia	2	0	0	0
French Southern and Antarctic Territories	Antarctica		0	0	0	0
Gabon	Africa	Middle Africa	0	0	0	0
Gambia	Africa	Western Africa	87	47	0	0
Gaza Strip	Asia	Western Asia	0	0	0	0
Georgia	Asia	Western Asia	177	224	0	0
Germany	Europe	Western Europe	11,038	14,085	9,647	10,002
Ghana	Africa	Western Africa	8,819	7,721	0	0

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Gibraltar	Europe	Southern Europe	0	0	0	0
Glorioso Islands	Africa	Eastern Africa	0	0	0	0
Greece	Europe	Southern Europe	248	790	352	389
Greenland	Americas	Northern America	0	0	0	0
Grenada	Americas	Caribbean	0	0	0	0
Guadeloupe	Americas	Caribbean	0	0	0	0
Guam	Oceania	Micronesia	0	0	0	0
Guantanamo	Americas	Caribbean	0	0	0	0
Guatemala	Americas	Central America	2,137	2,965	0	0
Guernsey	Europe	Northern Europe	0	0	0	0
Guinea	Africa	Western Africa	806	627	0	0
Guinea-Bissau	Africa	Western Africa	279	152	0	0
Guyana	Americas	South America	0	0	0	0
Haiti	Americas	Caribbean	256	656	0	0
Hala'ib Triangle	Africa	Northern Africa	0	0	0	0
Heard Island and McDonald Islands	Antarctica		0	0	0	0
Holy See	Europe	Southern Europe	0	0	0	0
Honduras	Americas	Central America	721	768	0	0

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Hong Kong	Asia	Eastern Asia	0	0	0	0
Hungary	Europe	Eastern Europe	709	929	966	1,039
Iceland	Europe	Northern Europe	9	957	0	0
Ilemi Triangle	Africa	Northern Africa	0	0	0	0
India	Asia	Southern Asia	46,050	19,449	0	0
Indonesia	Asia	South-Eastern Asia	0	0	0	0
Iran (Islamic Republic of)	Asia	Southern Asia	58	9	0	0
Iraq	Asia	Western Asia	0	0	0	0
Ireland	Europe	Northern Europe	694	1,594	611	616
Isle of Man	Europe	Northern Europe	0	0	0	0
Israel	Asia	Western Asia	0	0	0	0
Italy	Europe	Southern Europe	2,303	2,699	1,990	2,377
Jamaica	Americas	Caribbean	99	78	0	0
Jammu-Kashmir	Asia	Eastern Asia	0	0	0	0
Japan	Asia	Eastern Asia	0	0	0	0
Jarvis Island	Americas	Northern America	0	0	0	0
Jersey	Europe	Northern Europe	0	0	0	0
Jordan	Asia	Western Asia	32	3	0	0
Kazakhstan	Asia	Central Asia	199	424	0	0

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Kenya	Africa	Eastern Africa	4,178	2,431	0	0
Kiribati	Oceania	Micronesia	0	0	0	0
Kuril Islands	Asia	Eastern Asia	0	0	0	0
Kuwait	Asia	Western Asia	0	0	0	0
Kyrgyzstan	Asia	Central Asia	179	421	0	0
Lao People's Democratic Republic	Asia	South-Eastern Asia	272	217	0	0
Latvia	Europe	Northern Europe	1,861	3,369	1,722	1,872
Lebanon	Asia	Western Asia	7	7	0	0
Lesotho	Africa	Southern Africa	218	763	0	0
Liberia	Africa	Western Africa	163	169	0	0
Libyan Arab Jamahiriya	Africa	Northern Africa	0	0	0	0
Liechtenstein	Europe	Western Europe	0	0	0	0
Lithuania	Europe	Northern Europe	1,107	1,894	1,025	1,117
Luxembourg	Europe	Western Europe	63	85	60	63
Macao	Asia	Eastern Asia	0	0	0	0
Madagascar	Africa	Eastern Africa	1,597	1,207	0	0
Madeira Islands	Europe	Southern Europe	0	0	0	0
Malawi	Africa	Eastern Africa	402	301	0	0

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Malaysia	Asia	South-Eastern Asia	0	0	0	0
Maldives	Asia	Southern Asia	2	0	0	0
Mali	Africa	Western Africa	895	61	0	0
Malta	Europe	Southern Europe	0	0	0	0
Marshall Islands	Oceania	Micronesia	0	0	0	0
Martinique	Americas	Caribbean	12	4	0	0
Ma'tan al-Sarra	Africa	Northern Africa	0	0	0	0
Mauritania	Africa	Western Africa	376	290	0	0
Mauritius	Africa	Eastern Africa	3	2	0	0
Mayotte	Africa	Eastern Africa	0	0	0	0
Mexico	Americas	Central America	4,393	4,508	0	0
Micronesia (Federated States of)	Oceania	Micronesia	0	0	0	0
Midway Is,	Americas	Northern America	0	0	0	0
Moldova, Republic of	Europe	Eastern Europe	113	142	1	1
Monaco	Europe	Western Europe	0	0	0	0
Mongolia	Asia	Eastern Asia	74	56	0	0
Montenegro	Europe	Southern Europe	875	891	0	0
Montserrat	Americas	Caribbean	0	0	0	0

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Morocco	Africa	Northern Africa	835	270	0	0
Mozambique	Africa	Eastern Africa	0	0	0	0
Myanmar	Asia	South-Eastern Asia	0	0	0	0
Namibia	Africa	Southern Africa	0	0	0	0
Nauru	Oceania	Micronesia	0	0	0	0
Nepal	Asia	Southern Asia	1,955	737	0	0
Netherlands	Europe	Western Europe	358	2,075	1,212	1,364
Netherlands Antilles	Americas	Caribbean	0	0	0	0
New Caledonia	Oceania	Melanesia	1	1	0	0
New Zealand	Oceania	Australia and New Zealand	4,246	2,415	0	0
Nicaragua	Americas	Central America	0	0	0	0
Niger	Africa	Western Africa	1,559	24	0	0
Nigeria	Africa	Western Africa	6,400	2,436	0	0
Niue	Oceania	Polynesia	0	0	0	0
Norfolk Island	Oceania	Australia and New Zealand	0	0	0	0
Northern Mariana Islands	Oceania	Micronesia	0	0	0	0
Norway	Europe	Northern Europe	2,821	5,732	2	5
Oman	Asia	Western Asia	3	0	0	0

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Pakistan	Asia	Southern Asia	3,568	1,217	0	0
Palau	Oceania	Micronesia	0	0	0	0
Panama	Americas	Central America	0	0	0	0
Papua New Guinea	Oceania	Melanesia	262	301	0	0
Paracel Islands	Asia	South-Eastern Asia	0	0	0	0
Paraguay	Americas	South America	0	0	0	0
Peru	Americas	South America	0	0	0	0
Philippines	Asia	South-Eastern Asia	1,910	1,973	0	0
Pitcairn Island	Oceania	Polynesia	0	0	0	0
Poland	Europe	Eastern Europe	6,993	9,455	7,145	7,372
Portugal	Europe	Southern Europe	0	0	0	0
Puerto Rico	Americas	Caribbean	0	0	0	0
Qatar	Asia	Western Asia	0	0	0	0
Republic of Korea	Asia	Eastern Asia	3,476	2,940	0	0
Reunion	Africa	Eastern Africa	23	24	0	0
Romania	Europe	Eastern Europe	2,866	2,626	2,085	2,433
Russian Federation	Europe	Eastern Europe	53,891	106,864	2	2
Rwanda	Africa	Eastern Africa	880	1,037	0	0
Saint Kitts and Nevis	Americas	Caribbean	0	0	0	0

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Saint Lucia	Americas	Caribbean	14	8	0	0
Saint Vincent and the Grenadines	Americas	Caribbean	1	0	0	0
Samoa	Oceania	Polynesia	1	0	0	0
San Marino	Europe	Southern Europe	0	0	0	0
Sao Tome and Principe	Africa	Middle Africa	1	1	0	0
Saudi Arabia	Asia	Western Asia	26	3	0	0
Senegal	Africa	Western Africa	527	76	0	0
Serbia	Europe	Southern Europe	833	672	3	3
Seychelles	Africa	Eastern Africa	2	0	0	0
Sierra Leone	Africa	Western Africa	539	1,111	0	0
Singapore	Asia	South-Eastern Asia	1	1	0	0
Slovakia	Europe	Eastern Europe	889	1,268	1,161	1,278
Slovenia	Europe	Southern Europe	479	397	376	431
Solomon Islands	Oceania	Melanesia	0	0	0	0
Somalia	Africa	Eastern Africa	682	131	0	0
South Africa	Africa	Southern Africa	2,395	1,105	0	0
South Georgia & the South Sandwich Islands	Antarctica		0	0	0	0

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South Sudan	Africa	Middle Africa	0	0	0	0
Spain	Europe	Southern Europe	2,547	2,930	2,508	2,743
Spratly Islands	Asia	South-Eastern Asia	0	0	0	0
Sri Lanka	Asia	Southern Asia	614	653	0	0
Sudan	Africa	Northern Africa	428	48	0	0
Suriname	Americas	South America	0	0	0	0
Svalbard and Jan Mayen Islands	Europe	Northern Europe	0	0	0	0
Swaziland	Africa	Southern Africa	0	0	0	0
Sweden	Europe	Northern Europe	9,660	17,059	8,503	9,712
Switzerland	Europe	Western Europe	690	798	8	13
Syrian Arab Republic	Asia	Western Asia	6	4	0	0
Taiwan	Asia	Eastern Asia	0	0	0	0
Tajikistan	Asia	Central Asia	0	0	0	0
Thailand	Asia	South-Eastern Asia	3,576	2,186	0	0
The former Yugoslav Republic of Macedonia	Europe	Southern Europe	84	100	0	0
Timor-Leste	Asia	South-Eastern Asia	0	0	0	0
Togo	Africa	Western Africa	558	199	0	0

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Tokelau	Oceania	Polynesia	0	0	0	0
Tonga	Oceania	Polynesia	1	0	0	0
Trinidad and Tobago	Americas	Caribbean	17	43	0	0
Tunisia	Africa	Northern Africa	613	256	0	0
Turkey	Asia	Western Asia	4,531	5,619	2	5
Turkmenistan	Asia	Central Asia	0	0	0	0
Turks and Caicos Islands	Americas	Caribbean	0	0	0	0
Tuvalu	Oceania	Polynesia	0	0	0	0
U,K, of Great Britain and Northern Ireland	Europe	Northern Europe	1,965	4,059	2	3
Uganda	Africa	Eastern Africa	5,888	11,794	0	0
Ukraine	Europe	Eastern Europe	3,044	4,419	4	5
United Arab Emirates	Asia	Western Asia	6	0	0	0
United Republic of Tanzania	Africa	Eastern Africa	0	0	0	0
United States of America	Americas	Northern America	52,077	68,320	0	0
United States Virgin Islands	Americas	Caribbean	0	0	0	0
Uruguay	Americas	South America	2,191	3,105	0	0
Uzbekistan	Asia	Central Asia	0	0	0	0

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Vanuatu	Oceania	Melanesia	0	0	0	0
Venezuela	Americas	South America	0	0	0	0
Vietnam	Asia	South-Eastern Asia	9,094	15,184	0	0
West Bank	Asia	Western Asia	0	0	0	0
Western Sahara	Africa	Northern Africa	0	0	0	0
Yemen	Asia	Western Asia	0	0	0	0
Zambia	Africa	Eastern Africa	1,883	1,502	0	0
Zimbabwe	Africa	Eastern Africa	0	0	0	0
Total			451,415	556,225	69,392	76,192

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Primary forestry residual biomass scenario C in 1000 (Ton)

Name	Continent	Region	FAO	ESA	JRC BAWS	JRC ABG
Abyei	Africa	Northern Africa	0	0	0	0
Afghanistan	Asia	Southern Asia	0	0	0	0
Aksai Chin	Asia	Eastern Asia	0	0	0	0
Albania	Europe	Southern Europe	0	0	0	0
Algeria	Africa	Northern Africa	342	521	0	0
American Samoa	Oceania	Polynesia	0	0	0	0
Andorra	Europe	Southern Europe	0	0	0	0
Angola	Africa	Middle Africa	0	0	0	0
Anguilla	Americas	Caribbean	0	0	0	0
Antigua & Barbuda	Americas	Caribbean	0	0	0	0
Argentina	Americas	South America	0	0	0	0
Armenia	Asia	Western Asia	0	0	0	0
Aruba	Americas	Caribbean	0	0	0	0
Arunachal Pradesh	Asia	Eastern Asia	0	0	0	0
Australia	Oceania	Australia and New Zealand	1,935	777	0	0
Austria	Europe	Western Europe	1,469	1,809	1,563	1,763
Azerbaijan	Asia	Western Asia	0	0	0	0

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Azores Islands	Europe	Southern Europe	0	0	0	0
Bahamas	Americas	Caribbean	2	2	0	0
Bahrain	Asia	Western Asia	0	0	0	0
Bangladesh	Asia	Southern Asia	1,115	1,574	0	0
Barbados	Americas	Caribbean	0	0	0	0
Belarus	Europe	Eastern Europe	2,811	4,059	5	5
Belgium	Europe	Western Europe	0	0	0	0
Belize	Americas	Central America	0	0	0	0
Benin	Africa	Western Africa	0	0	0	0
Bermuda	Americas	Northern America	0	0	0	0
Bhutan	Asia	Southern Asia	273	79	0	0
Bolivia	Americas	South America	0	0	0	0
Bosnia & Herzegovina	Europe	Southern Europe	0	0	0	0
Botswana	Africa	Southern Africa	0	0	0	0
Bouvet Island	Antarctica		0	0	0	0
Brazil	Americas	South America	778	776	0	0
British Indian Ocean Territory	Africa	Eastern Africa	0	0	0	0
British Virgin Islands	Americas	Caribbean	0	0	0	0

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Brunei Darussalam	Asia	South-Eastern Asia	0	0	0	0
Bulgaria	Europe	Eastern Europe	1,500	1,161	792	908
Burkina Faso	Africa	Western Africa	26	1	0	0
Burundi	Africa	Eastern Africa	397	502	0	0
CÃ´te d'Ivoire	Africa	Western Africa	0	0	0	0
Cambodia	Asia	South-Eastern Asia	0	0	0	0
Cameroon	Africa	Middle Africa	0	0	0	0
Canada	Americas	Northern America	6,297	11,595	0	0
Cape Verde	Africa	Western Africa	11	3	0	0
Cayman Islands	Americas	Caribbean	0	0	0	0
Central African Republic	Africa	Middle Africa	0	0	0	0
Chad	Africa	Middle Africa	0	0	0	0
Chile	Americas	South America	6,200	5,225	0	0
China	Asia	Eastern Asia	43,011	50,087	0	0
Christmas Island	Asia	South-Eastern Asia	0	0	0	0
Cocos (Keeling) Islands	Asia	South-Eastern Asia	0	0	0	0
Colombia	Americas	South America	0	0	0	0
Comoros	Africa	Eastern Africa	21	86	0	0

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Congo	Africa	Middle Africa	9	13	0	0
Cook Islands	Oceania	Polynesia	0	0	0	0
Costa Rica	Americas	Central America	603	382	0	0
Croatia	Europe	Southern Europe	432	515	385	417
Cuba	Americas	Caribbean	252	242	0	0
Cyprus	Asia	Western Asia	10	14	3	9
Czech Republic	Europe	Eastern Europe	1,718	2,604	2,465	2,609
Democratic People's Republic of Korea	Asia	Eastern Asia	376	530	0	0
Democratic Republic of the Congo	Africa	Middle Africa	0	0	0	0
Denmark	Europe	Northern Europe	290	412	279	281
Djibouti	Africa	Eastern Africa	27	1	0	0
Dominica	Americas	Caribbean	0	0	0	0
Dominican Republic	Americas	Caribbean	130	161	0	0
Ecuador	Americas	South America	0	0	0	0
Egypt	Africa	Northern Africa	972	3,962	0	0
El Salvador	Americas	Central America	283	296	0	0
Equatorial Guinea	Africa	Middle Africa	0	0	0	0

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Eritrea	Africa	Eastern Africa	51	18	0	0
Estonia	Europe	Northern Europe	747	1,502	680	742
Ethiopia	Africa	Eastern Africa	6,636	4,824	0	0
Falkland Islands (Malvinas)	Americas	South America	0	0	0	0
Faroe Islands	Europe	Northern Europe	0	0	0	0
Fiji	Oceania	Melanesia	179	118	0	0
Finland	Europe	Northern Europe	5,986	14,132	5,909	6,974
France	Europe	Western Europe	5,862	6,546	6,154	6,584
French Guiana	Americas	South America	0	0	0	0
French Polynesia	Oceania	Polynesia	1	0	0	0
French Southern and Antarctic Territories	Antarctica		0	0	0	0
Gabon	Africa	Middle Africa	0	0	0	0
Gambia	Africa	Western Africa	43	23	0	0
Gaza Strip	Asia	Western Asia	0	0	0	0
Georgia	Asia	Western Asia	97	123	0	0
Germany	Europe	Western Europe	6,913	8,822	6,042	6,264
Ghana	Africa	Western Africa	4,411	3,862	0	0

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Gibraltar	Europe	Southern Europe	0	0	0	0
Glorioso Islands	Africa	Eastern Africa	0	0	0	0
Greece	Europe	Southern Europe	133	423	188	208
Greenland	Americas	Northern America	0	0	0	0
Grenada	Americas	Caribbean	0	0	0	0
Guadeloupe	Americas	Caribbean	0	0	0	0
Guam	Oceania	Micronesia	0	0	0	0
Guantanamo	Americas	Caribbean	0	0	0	0
Guatemala	Americas	Central America	1,253	1,738	0	0
Guernsey	Europe	Northern Europe	0	0	0	0
Guinea	Africa	Western Africa	403	314	0	0
Guinea-Bissau	Africa	Western Africa	139	76	0	0
Guyana	Americas	South America	0	0	0	0
Haiti	Americas	Caribbean	132	338	0	0
Hala'ib Triangle	Africa	Northern Africa	0	0	0	0
Heard Island and McDonald Islands	Antarctica		0	0	0	0
Holy See	Europe	Southern Europe	0	0	0	0
Honduras	Americas	Central America	400	426	0	0

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Hong Kong	Asia	Eastern Asia	0	0	0	0
Hungary	Europe	Eastern Europe	376	493	512	551
Iceland	Europe	Northern Europe	6	617	0	0
Ilemi Triangle	Africa	Northern Africa	0	0	0	0
India	Asia	Southern Asia	23,338	9,857	0	0
Indonesia	Asia	South-Eastern Asia	0	0	0	0
Iran (Islamic Republic of)	Asia	Southern Asia	29	4	0	0
Iraq	Asia	Western Asia	0	0	0	0
Ireland	Europe	Northern Europe	462	1,060	407	410
Isle of Man	Europe	Northern Europe	0	0	0	0
Israel	Asia	Western Asia	0	0	0	0
Italy	Europe	Southern Europe	1,266	1,483	1,094	1,307
Jamaica	Americas	Caribbean	49	39	0	0
Jammu-Kashmir	Asia	Eastern Asia	0	0	0	0
Japan	Asia	Eastern Asia	0	0	0	0
Jarvis Island	Americas	Northern America	0	0	0	0
Jersey	Europe	Northern Europe	0	0	0	0
Jordan	Asia	Western Asia	16	2	0	0
Kazakhstan	Asia	Central Asia	109	231	0	0

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Kenya	Africa	Eastern Africa	2,151	1,252	0	0
Kiribati	Oceania	Micronesia	0	0	0	0
Kuril Islands	Asia	Eastern Asia	0	0	0	0
Kuwait	Asia	Western Asia	0	0	0	0
Kyrgyzstan	Asia	Central Asia	98	231	0	0
Lao People's Democratic Republic	Asia	South-Eastern Asia	136	109	0	0
Latvia	Europe	Northern Europe	1,123	2,034	1,040	1,130
Lebanon	Asia	Western Asia	4	4	0	0
Lesotho	Africa	Southern Africa	109	383	0	0
Liberia	Africa	Western Africa	81	84	0	0
Libyan Arab Jamahiriya	Africa	Northern Africa	0	0	0	0
Liechtenstein	Europe	Western Europe	0	0	0	0
Lithuania	Europe	Northern Europe	656	1,122	608	662
Luxembourg	Europe	Western Europe	38	51	36	38
Macao	Asia	Eastern Asia	0	0	0	0
Madagascar	Africa	Eastern Africa	800	605	0	0
Madeira Islands	Europe	Southern Europe	0	0	0	0
Malawi	Africa	Eastern Africa	202	151	0	0

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Malaysia	Asia	South-Eastern Asia	0	0	0	0
Maldives	Asia	Southern Asia	1	0	0	0
Mali	Africa	Western Africa	448	30	0	0
Malta	Europe	Southern Europe	0	0	0	0
Marshall Islands	Oceania	Micronesia	0	0	0	0
Martinique	Americas	Caribbean	6	2	0	0
Ma'tan al-Sarra	Africa	Northern Africa	0	0	0	0
Mauritania	Africa	Western Africa	188	145	0	0
Mauritius	Africa	Eastern Africa	1	1	0	0
Mayotte	Africa	Eastern Africa	0	0	0	0
Mexico	Americas	Central America	2,433	2,497	0	0
Micronesia (Federated States of)	Oceania	Micronesia	0	0	0	0
Midway Is,	Americas	Northern America	0	0	0	0
Moldova, Republic of	Europe	Eastern Europe	57	71	0	0
Monaco	Europe	Western Europe	0	0	0	0
Mongolia	Asia	Eastern Asia	48	36	0	0
Montenegro	Europe	Southern Europe	510	520	0	0
Montserrat	Americas	Caribbean	0	0	0	0

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Morocco	Africa	Northern Africa	436	141	0	0
Mozambique	Africa	Eastern Africa	0	0	0	0
Myanmar	Asia	South-Eastern Asia	0	0	0	0
Namibia	Africa	Southern Africa	0	0	0	0
Nauru	Oceania	Micronesia	0	0	0	0
Nepal	Asia	Southern Asia	979	369	0	0
Netherlands	Europe	Western Europe	198	1,150	672	756
Netherlands Antilles	Americas	Caribbean	0	0	0	0
New Caledonia	Oceania	Melanesia	1	0	0	0
New Zealand	Oceania	Australia and New Zealand	2,825	1,606	0	0
Nicaragua	Americas	Central America	0	0	0	0
Niger	Africa	Western Africa	779	12	0	0
Nigeria	Africa	Western Africa	3,200	1,218	0	0
Niue	Oceania	Polynesia	0	0	0	0
Norfolk Island	Oceania	Australia and New Zealand	0	0	0	0
Northern Mariana Islands	Oceania	Micronesia	0	0	0	0
Norway	Europe	Northern Europe	1,839	3,737	1	3
Oman	Asia	Western Asia	2	0	0	0

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Pakistan	Asia	Southern Asia	1,833	625	0	0
Palau	Oceania	Micronesia	0	0	0	0
Panama	Americas	Central America	0	0	0	0
Papua New Guinea	Oceania	Melanesia	131	151	0	0
Paracel Islands	Asia	South-Eastern Asia	0	0	0	0
Paraguay	Americas	South America	0	0	0	0
Peru	Americas	South America	0	0	0	0
Philippines	Asia	South-Eastern Asia	956	987	0	0
Pitcairn Island	Oceania	Polynesia	0	0	0	0
Poland	Europe	Eastern Europe	4,387	5,932	4,483	4,625
Portugal	Europe	Southern Europe	0	0	0	0
Puerto Rico	Americas	Caribbean	0	0	0	0
Qatar	Asia	Western Asia	0	0	0	0
Republic of Korea	Asia	Eastern Asia	2,090	1,768	0	0
Reunion	Africa	Eastern Africa	12	12	0	0
Romania	Europe	Eastern Europe	1,619	1,483	1,178	1,374
Russian Federation	Europe	Eastern Europe	34,040	67,502	1	1
Rwanda	Africa	Eastern Africa	442	521	0	0
Saint Kitts and Nevis	Americas	Caribbean	0	0	0	0

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Saint Lucia	Americas	Caribbean	7	4	0	0
Saint Vincent and the Grenadines	Americas	Caribbean	0	0	0	0
Samoa	Oceania	Polynesia	0	0	0	0
San Marino	Europe	Southern Europe	0	0	0	0
Sao Tome and Principe	Africa	Middle Africa	1	1	0	0
Saudi Arabia	Asia	Western Asia	13	2	0	0
Senegal	Africa	Western Africa	263	38	0	0
Serbia	Europe	Southern Europe	425	343	1	2
Seychelles	Africa	Eastern Africa	1	0	0	0
Sierra Leone	Africa	Western Africa	269	555	0	0
Singapore	Asia	South-Eastern Asia	1	0	0	0
Slovakia	Europe	Eastern Europe	529	754	690	760
Slovenia	Europe	Southern Europe	291	241	228	262
Solomon Islands	Oceania	Melanesia	0	0	0	0
Somalia	Africa	Eastern Africa	341	65	0	0
South Africa	Africa	Southern Africa	1,300	600	0	0
South Georgia & the South Sandwich Islands	Antarctica		0	0	0	0

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South Sudan	Africa	Middle Africa	0	0	0	0
Spain	Europe	Southern Europe	1,479	1,702	1,457	1,593
Spratly Islands	Asia	South-Eastern Asia	0	0	0	0
Sri Lanka	Asia	Southern Asia	307	327	0	0
Sudan	Africa	Northern Africa	214	24	0	0
Suriname	Americas	South America	0	0	0	0
Svalbard and Jan Mayen Islands	Europe	Northern Europe	0	0	0	0
Swaziland	Africa	Southern Africa	0	0	0	0
Sweden	Europe	Northern Europe	6,272	11,076	5,521	6,306
Switzerland	Europe	Western Europe	425	492	5	8
Syrian Arab Republic	Asia	Western Asia	3	2	0	0
Taiwan	Asia	Eastern Asia	0	0	0	0
Tajikistan	Asia	Central Asia	0	0	0	0
Thailand	Asia	South-Eastern Asia	1,788	1,093	0	0
The former Yugoslav Republic of Macedonia	Europe	Southern Europe	44	52	0	0
Timor-Leste	Asia	South-Eastern Asia	0	0	0	0
Togo	Africa	Western Africa	279	100	0	0

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Tokelau	Oceania	Polynesia	0	0	0	0
Tonga	Oceania	Polynesia	0	0	0	0
Trinidad and Tobago	Americas	Caribbean	9	22	0	0
Tunisia	Africa	Northern Africa	327	137	0	0
Turkey	Asia	Western Asia	2,745	3,404	1	3
Turkmenistan	Asia	Central Asia	0	0	0	0
Turks and Caicos Islands	Americas	Caribbean	0	0	0	0
Tuvalu	Oceania	Polynesia	0	0	0	0
U,K, of Great Britain and Northern Ireland	Europe	Northern Europe	1,293	2,672	1	2
Uganda	Africa	Eastern Africa	2,962	5,932	0	0
Ukraine	Europe	Eastern Europe	1,851	2,687	2	3
United Arab Emirates	Asia	Western Asia	3	0	0	0
United Republic of Tanzania	Africa	Eastern Africa	0	0	0	0
United States of America	Americas	Northern America	31,238	40,982	0	0
United States Virgin Islands	Americas	Caribbean	0	0	0	0
Uruguay	Americas	South America	1,133	1,606	0	0
Uzbekistan	Asia	Central Asia	0	0	0	0

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Vanuatu	Oceania	Melanesia	0	0	0	0
Venezuela	Americas	South America	0	0	0	0
Vietnam	Asia	South-Eastern Asia	4,571	7,632	0	0
West Bank	Asia	Western Asia	0	0	0	0
Western Sahara	Africa	Northern Africa	0	0	0	0
Yemen	Asia	Western Asia	0	0	0	0
Zambia	Africa	Eastern Africa	942	751	0	0
Zimbabwe	Africa	Eastern Africa	0	0	0	0
Total			256,515	324,298	42,406	46,561

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