WP1 Shared modelling framework and learnings

D1.2 – Description of scientific methods

Task 1.2 Framework for foreground life cycle inventory of bio-based sectors

Screening and comparison of data sources to calculate market mix

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PROJECTS DETAILS			
Project title		Aligning Life Cycle Assessment methods and bio-based sectors for improved environmental performance.	
Project acronym	ALIGNED	**Start / Duration**	01/10/2022 – 36 months
Type of Action	RIA	**Website**	www.alignedproject.eu

Summary

The document presents a screening of potentially useful literature and data sources as basis for modelling a market mix of unconstrained suppliers of biomass feedstocks, as well as a comparison of the data from three selected sources, that showed poor agreement. Based on the screening of the literature and on the analysis, the conclusion is that the use of FAOSTAT data is recommended for calculating a market mix of unconstrained suppliers for use in the Life Cycle Assessment(s)(LCA) of the ALIGNED project.

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1. Screening of data sources as basis for modelling a market mix of unconstrained suppliers of biomass feedstocks.

As background knowledge, three aspects are relevant to understand the constraints to biomass supply in the context of ALIGNED. For practical modelling purposes, the ALIGNED project focusses on data regarding production of different forestry and timber products over time or forecasts about the amounts produced.

1) Information about what is the current availability of biomass residues in the EU and what are future scenarios for that (time series, projections).

2) Same as above but for timber. Is the forest sector expanding or shrinking? Can we find country-specific information on plantation area and timber production over time, and projections? Can we find this data for different types of species?

3) The size of the market. Is the demand larger than the supply in the EU. Where is the additional demand provided from? If the need for timber increases, will it be produced outside the EU and then imported? And where? What are scenarios for that?

A literature review of various scientific articles and data repositories was conducted as part of task 1.2. The objective is to identify the most useful data for the ALIGNED project such that the LCA practitioner modelling bio-based products can easily make a marginal mix of the unconstrained suppliers for each type of biomass, at EU scale, and focusing on forest biomass.

A summary of the checked sources is provided on following together with critical reflections.

Scarlat et al. (2019) Proposes a GIS-based model that calculates absolute amounts of residues for different crop types in all countries in the EU, but no future scenarios.

Verkerk et al. (2019) provides insights into which European regions could increase the supply of woody biomass from forests and could be a focus of targeted policies. The issue of constraints is explicitly mentioned: *" Indeed, our study showed that **the consideration of constraints can have a large effect on the extent that biomass is available**, especially with regards to the availability of logging residues and stumps." and "Our results suggest that the largest total forest biomass potentials per unit of land can be found in northern Europe (southern Finland and Sweden, Estonia and Latvia), Central Europe (Austria, Czech Republic and southern Germany), Slovenia, southwest France and Portugal."* Dataset referred to as S2biome are present in kTon for different wood products from now to 2030 under different scenarios. Data are very disaggregated, shared in Excel format with separate tables. This data could be used to calculate e.g. yearly increments per type of product and per country, or the difference between current and future production, and thus to define a product-specific marginal mix based on those countries that are planning to expand production.

Watanabe et al. (2022) in a study on drop-in and hydrogen-based biofuels for maritime transport: mention the issue of constraints: *"Although a portion of the crop and forest residues are currently in use by other industries [38], [39] and other sectors (e.g., aviation) may*

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exacerbate competition for biomass residues, this study investigates the total potentials for the maritime transport sector and thus considers that all available residues will be converted into biofuels. " However, in this study there is no specific analysis of the constraints, and the burden-free assumption is used instead (residues bear no impact because it is allocated to the crop/wood product), this seems justified in this context as the study is only looking at the "potential" for biofuel production from residues. One could have perhaps considered to model this supply as avoided degradation on soil. *" We assume no life-cycle greenhouse gas emissions to produce agricultural and forest residues since the entire environmental burdens of biomass production were allocated to their main products, such as grains, seeds, and wood. " Watanabe* et al. have aggregated the data of Verkerk et al. (2019) by country – it is unclear whether these can be used to calculate time increments.

Grogan et al. (2022) provides data on global gridded crop harvested area, production, yield, and monthly physical area data. These are the FAO data and spatial data (GIS) at national scale for all countries. No projection nor scenario is available.

Hu et al. (2021) study recent global land cover dynamics and implications for soil erosion and carbon losses from deforestation which is impressive research with interesting findings but of little practical use for the purpose of modelling constraints to biomass availability as no scenarios are presented. Time series (historical) on forest cover could be extracted here but this has not much relation with supply though.

Chen et al. (2020) calculate Global land use for 2015–2100 at 0.05° resolution under diverse socioeconomic and climate scenarios. The focus is on land use and projections are provided up to 2100. The usefulness of this study for the model is not apparent.

Mishra et al. (2022) In their Nature study on Land use change and carbon emissions of a transformation to timber cities affirm that *"It remains unclear where and in which way the additional demand for wooden construction material shall be fulfilled "* and arrive at the conclusion that *"expansion of timber plantations for wooden buildings is possible without major repercussions on agricultural production."* This suggests that for calculating constraints to biomass availability one might not need to consider induced demand outside EU as *" Wood needed for future timber constructions can come from increasing forest harvest from managed forest plantations and natural forests, redirecting existing wood uses, or establishing new forest plantations (which can be harvested at maturity in the future but provide wood from intermediate thinning until then) ".* The authors estimate demand for industrial roundwood, and wood fuel based on current demand for these products, population, and income changes. And using a global partial equilibrium model that" *simulates agricultural and timber trade among world regions ensuring that the regional demand for food, feed, and timber can always be met by domestic production and imports from other regions". Datasets* are available Zenodo. In this study, Figure 1 shows a projection where the forest plantations will increase globally in the future if we increase the demand for construction wood. Also, it shows how much other land will be converted and that agricultural land will not be affected. So, this is the data that we need to determine the effect of increasing demand for wood. However, this is too aggregated as it is at Global scale. The SI show that the data are available also disaggregated to regions to show where the increment will be. These data could potentially be used to create a marginal mix of suppliers (only suppliers that are expected to grow and are thus not constrained) for direct use in LCA. This can be done by calculating the increments per region (Delta between two points in time)

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and then including only the suppliers with positive increment and normalizing their share to one.

Favero et al. (2020) uses a forestry model – Global Timber Model (GTM) to study dynamic forest markets and policies (4, 30). GTM combines the spatially detailed data on forests with an economic model that weighs optimal forest management alternatives. The model contains 200 forest types in 16 regions. However, not much useful data are available from this source.

Camia et al. (2018) provide a good overview of the supply chain of wood products, and the current trends in the EU. Both information can potentially be used to make a model (identify the co-products and the constraints) and to define a marginal mix. The same historical data are provided by the commission and could be accessed to perform a similar calculation. They calculate in the publication a net annual increment (NAI) defined as the wood produced in the forest annually minus losses due to natural mortality of trees, reported as the increment in the stem volume in forests and using a 10-year average.

2. Comparison of data and selection of most fitting source.

After screening the literature and available data, we selected three data sources in ALIGNED as they provided data on production of forest products at a sufficiently disaggregated level: for multiple countries in EU, for multiple forest products, and for multiple years.

The analysis consisted in retrieving the data, critically evaluating their suitability for the purposes of making a mix of unconstrainted suppliers for use in process based LCA within the context of the ALIGNED project, and also to check the level of agreement across these sources.

Forestry production data from the JRC. These data on forest biomass production are available from the *"Data-Modelling platform of resource economics"* platform of the Joint Research Centre, see *"Update of "EU Biomass flows" data and dashboard, following new publication"* (European Commission. Joint Research Centre. 2022) and also the publication by Camia et al. (2018). The specific dataset can be downloaded online. These data are potentially useful because they are at EU scale, refer to a range of specific wood products, and cover several years (2009-2017). For a sample and more details see file: *"Production-data-JRC.xlsx".*

Forestry production data from S2Biom, as used by and **documented in Verkerk et al. (2019).** This database provides insights into which European regions could increase the supply of forest products. Underneath is an excerpt from their own website: *"The S2Biom project supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing harmonised data sets, strategies, and roadmaps at local, regional, national and pan European level for EU28, Western Balkans, Ukraine, Moldova and Turkey that can be accessed via this S2BIOM tool set."* Data are available here. These data are potentially useful because they are at EU scale and particularly at regional scale, refer to a range of specific wood products, and cover several years (2012 and 2020) including future scenario for years 2030. However, the number of years included is very limited.

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Forestry production data from FAOSTAT. The statistical office of the Food and Agricultural Organisation provides time series data on the production and trade of agricultural and forest products. This is an established and reputable source. These data are potentially useful because they are at global scale, refer to a range of specific wood products, and cover an extensive period of several years (from 1960s).

The comparison was conducted by selecting five countries representing areas in the North, South and Central Europe (France, Germany, Italy, Denmark, Sweden) and different years, matching production values for different years, calculating historical trends, and comparing them across sources. A summary is provided on following while detailed results and calculations are provided in the file: *ALIGNED-T1.2-Comparison-data-sources.xlsx*

The comparison showed poor agreement across data sources. It appears that the JRC data follow closely the FAOSTAT data in terms of trends, while in absolute value there is a difference between them, but this might be due to the rough conversion from m^3 to kg. S2biom data deviate substantially but for some countries the data are closer to the other two sources. For example, the figures below show the variations in the estimated quantities in tons of roundwood production from Denmark and Italy in different years when comparing the three different sources. Similar results were obtained for the other countries analysed. It should be considered that FAOSTAT data do not include forecasts, so the data validation was only performed using data about past years.

Another factor that might explain the variation is that the forest products are categorized, measured, and aggregate differently by the different sources. However, in this analysis it was attempted to obtain the closest match so that e.g. "Production" of "Domestic roundwood" in "T of dry matter" from JRC is the closest correspondence to "Roundwood" in m^3 from FAOSTAT aggregated together and converted using a density of 0.353 ton/m^3. [1]

Considered the pros and cons of the different data sources, the suggestion is to use FAOSTAT for making market mix. The advantage is that data for several years and countries are available, and that the source is reputable and continuously updated so it might be a more sustainable choice on the long term. Additionally, FAOSTAT includes data about several types of wood products, and this can allow to tailor the analysis to the type of wood product of interest (e.g. sawn wood, wood pulp, or other industrial wood for fences[2]). The drawbacks are that the selection of forest products is not wide, and these are not all reported in units of mass. Volumetric amounts of wood can be converted to mass by multiplying them to density of the key wood species supplied from these countries. Also, there are no predicted scenarios to determine the forecast of the unconstrained suppliers. Currently, it can only be done based on the assumption that the past trends can be used to predict the future.

[1] The density of roundwood derived from softwoods such as Spruce or Pine which are the common species of wood derived from nordic EU forests

[2] Definitions of FAOSTAT wood products are available here: https://www.fao.org/forestry/37537-0192cab302795d2aed9baa79b4d0bb040.pdf

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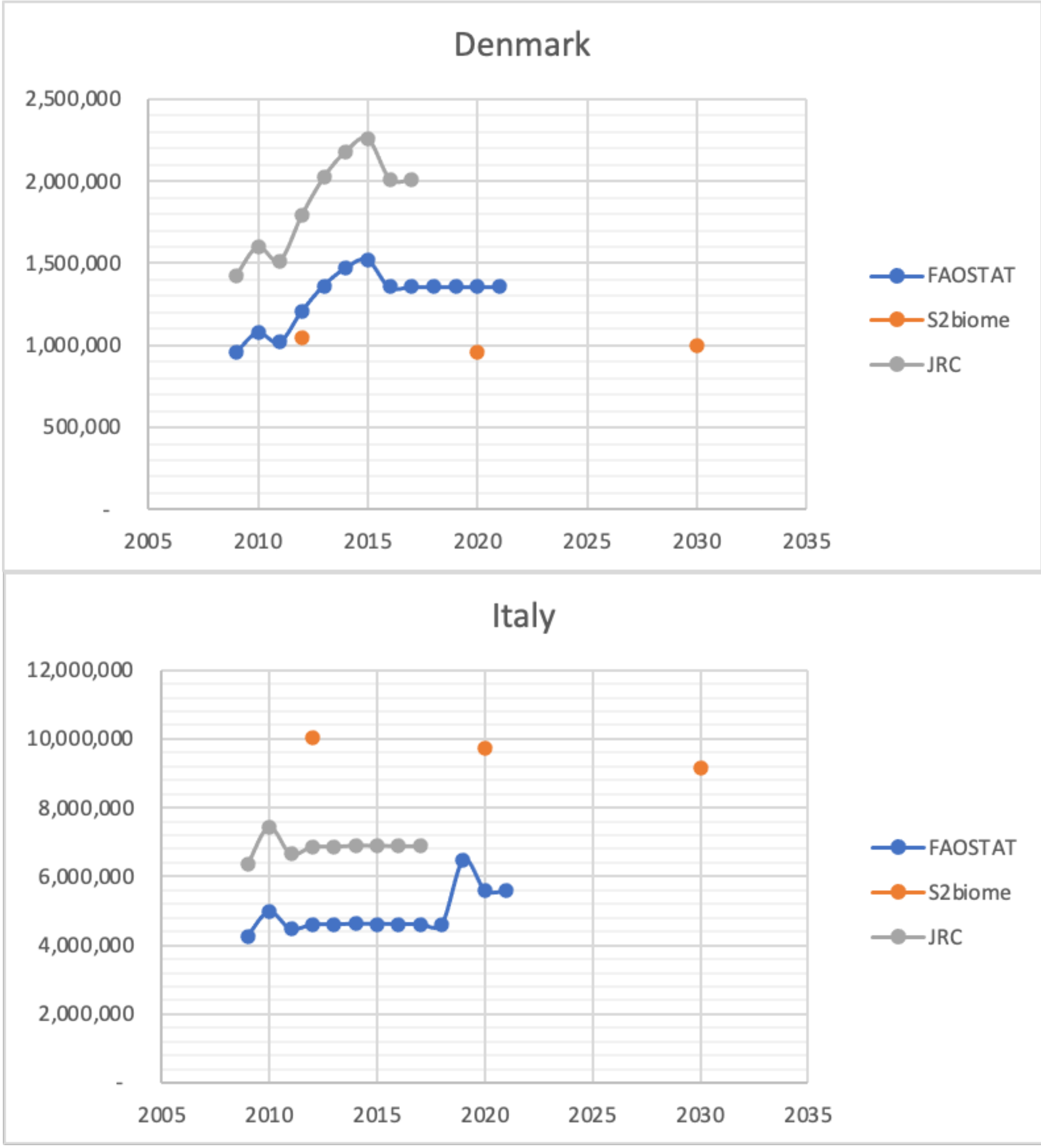

Figure 1 Comparison of the production data (ton roundwood) across the three main data sources considered: FAOSTAT, S2Biome, JRC (values in metric tonnes).

The recommendation to use of FAOSTAT data as primary source for the identification of constraints to supply is only indicative – the other sources can also be used being mindful of their limitations and of the uncertainties.

Based on the conclusions from this document the following analysis and calculations of market mixes are performed using the FAOSTAT data. See file *ALIGNED-T1.2-Market-mix-from-FAOSTAT-data*.

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References

Camia, A., N. Robert, K. Jonsson, R. Pilli, C.S. Garcia, L.R. Lopez, D.V.M. Van, et al. 2018. *Biomass production, supply, uses and flows in the European Union: First results from an integrated assessment*. February 21. https://publications.jrc.ec.europa.eu/repository/handle/JRC109869. Accessed April 27, 2023.

Chen, M., C.R. Vernon, N.T. Graham, M. Hejazi, M. Huang, Y. Cheng, and K. Calvin. 2020. Global land use for 2015–2100 at 0.05° resolution under diverse socioeconomic and climate scenarios. *Scientific Data* 7(1): 320.

European Commission. Joint Research Centre. 2022. *EU biomass flows: update 2022.* LU: Publications Office. https://data.europa.eu/doi/10.2760/082220. Accessed August 3, 2023.

Favero, A., A. Daigneault, and B. Sohngen. 2020. Forests: Carbon sequestration, biomass energy, or both? *Science Advances* 6(13): eaay6792.

Grogan, D., S. Frolking, D. Wisser, A. Prusevich, and S. Glidden. 2022. Global gridded crop harvested area, production, yield, and monthly physical area data circa 2015. *Scientific Data* 9(1): 15.

Hu, X., J.S. Næss, C.M. Iordan, B. Huang, W. Zhao, and F. Cherubini. 2021. Recent global land cover dynamics and implications for soil erosion and carbon losses from deforestation. *Anthropocene* 34: 100291.

Mishra, A., F. Humpenöder, G. Churkina, C.P.O. Reyer, F. Beier, B.L. Bodirsky, H.J. Schellnhuber, H. Lotze-Campen, and A. Popp. 2022. Land use change and carbon emissions of a transformation to timber cities. *Nature Communications* 13(1): 4889.

Scarlat, N., F. Fahl, E. Lugato, F. Monforti-Ferrario, and J.F. Dallemand. 2019. Integrated and spatially explicit assessment of sustainable crop residues potential in Europe. *Biomass and Bioenergy* 122: 257–269.

Verkerk, P.J., J.B. Fitzgerald, P. Datta, M. Dees, G.M. Hengeveld, M. Lindner, and S. Zudin. 2019. Spatial distribution of the potential forest biomass availability in Europe. *Forest Ecosystems* 6(1): 5.

Watanabe, M.D.B., F. Cherubini, A. Tisserant, and O. Cavalett. 2022. Drop-in and hydrogen-based biofuels for maritime transport: Country-based assessment of climate change impacts in Europe up to 2050. *Energy Conversion and Management* 273: 116403.

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