WP1- Shared modelling framework and learnings

Deliverable D1.5 Sector briefings and all-sector summary

Lead: BTG

Author(s): Rachel van der Sluis, Jurjen Spekreijse

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DELIVERABLE CONTRIBUTORS			
	Name	**Organisation**	**Job title**
Deliverable leader	Rachel van der Sluis	BTG	Consultant
Contributing Author(s)	Jurjen Spekreijse	BTG	Consultant
Reviewer(s)	Massimo Pizzol	AAU	Professor
	Dalia Stakenaite	AAU	Project manager

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1 Introduction and purpose of this document

The ALIGNED project has provided a selection of scientifically sound methods for assessing biobased products, which is defined within the project as the ALIGNED "framework". The framework was subsequently applied to a series of case studies across five sectors. Based on the results and insights derived from the application to the case studies, as well as based on the feedback received during the stakeholder involvement surveys and workshops, several recommendations were derived. These recommendations target the analysis of the environmental performance of biobased products via Life Cycle Assessment (LCA).

This sector briefings document summarizes insights and learnings on developing and testing the ALIGNED harmonized modelling framework to assess and optimise the environmental and socio-economic performance of five bio-based sectors: construction, woodworking, textile, pulp and paper, and biochemicals. The objective of this document is to inform and provide recommendations to the stakeholders in each sector about the learnings gained during the project and case study work. These are extracts from deliverables reporting full recommendations, one report for each sector, produced in the ALIGNED project. The extracts can be distributed as separate documents. The documents with the full recommendations for each sector provide background information and can be found on the ALIGNED project website (https://alignedproject.eu). Additionally, a final sector wide summary provides overall insights and learnings from the project modelling harmonisation and application experience.

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2 Insights and learnings from the project modelling harmonisation and application experience

2.1 Introduction

In the ALIGNED project, a collection of methodologies has been further developed to improve the assessment of the environmental sustainability using Life Cycle Assessment (LCA) in five industrial bio-based sectors, namely construction, wood working, biochemical, pulp and paper and textiles. In a later phase, Microalgae production was added as sixth sector.

These ALIGNED methods have been made public, via the Zenodo repository[1], and tutorials have been written to facilitate their use. In six case studies – one for each sector – the ALIGNED methods were implemented by the ALIGNED project members, which provided an opportunity to test the use of these methods.

To determine whether these newly developed methods are practically applicable, scientifically sound and impactful, a series of interviews has been held to collect first experiences of ALIGNED consortium members in the period from the end of 2024 until May 2025.

2.2 ALIGNED methodologies, use and interview set-up

ALIGNED methodologies and their use

In Table 1 the methods are listed, as well as the case study and partner that utilized the method in their case study.

Table 1: Overview of ALIGNED methods applied in the project

		WP2: Construction	WP3 - Woodworking	WP4 - Textile	WP5 - Pulp and paper	WP6 - Biochemicals		WP9- Algae
Method	**By**	**INSAT**	**ANTW**	**BTG**	**AAU**	**BTG**	**NTNU**	**AAU**
a. Background LCA		N	N	Y	Y	N	Y	Y
b. Forground LCA								
I. LCI data template		Y	Y	Y	Y	Y	N	N
II. Carbon model (dynamic accounting)		Y	Y	N	Y	N	N	N
II. Constraints to biomass		Y	Y	Y	Y	Y	N	N
c LCIA								
I. Impacts on (land use) on biodiversity		N	N	N	N	N	N	N
II. Carbon accounting (GWP/GTP)		Y	Y	Y	Y	Y	Y	Y
d. Uncertainty		Y	Y	Y	Y	Y	Y	Y
e. Socio-economic assessment		Y	Y	N	N	N	N	N

Table 1 shows that most methods were used by one or more partners, with the exception of the Biodiversity method. Because of that, no information was gathered on this method nor its useability.

[1] https://zenodo.org/communities/aligned-he/

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Interview set-up

Semi-structured interviews were performed. The choice for this interview type was made because it was not known in advance how the new methods and tutorials would be perceived by the partners. The interview questions covered four aspects: practical implementation, scientific/technical outcomes, Impact of the ALIGNED methodology, and alignment of the methodologies. The complete list of questions was sent beforehand to every interviewee to facilitate preparation.

2.3 Conclusions

The overall conclusion from the interviews is that no major problems were encountered. All practitioners were able to apply the ALIGNED methodologies with reasonable effort. Sometimes there were case-specific reasons why this was not possible. Often the results of the LCA changed significantly due to the application of the new methods, and many considered the methods scientifically sound and practically applicable and were satisfied with the tutorials.

The details on the minor issues were shared among the consortium to improve the methodology and have since been incorporated into the latest version of the ALIGNED framework. The framework hereby poses a suitable tool to incorporate many of the recommendations listed in this document.

2.4 Recommendations

Based on the insights and learnings from the project, as well as the recommendations for each sector, the following recommendations can be seen as relevant for all sectors.

Improve data availability and quality

Lack of data availability and quality hinders consistent modeling. For example, data on regional forestry practices such as forest growth and management remain scattered across different sources. Another example are the sector specific needs. An LCA in the biobased textile sector requires data on the dimensions of the textile filaments and to distinguish between yarns of different constructions.

Improve data exchange

Systematic data exchange is required to collect reliable LCI data. Establishing long-term data-sharing agreements and using pre-defined templates can help overcome confidentiality concerns and inconsistencies. Standardised LCI data should include uncertainty information.

Improve carbon accounting

The impact of carbon emissions is addressed in insufficient detail in current LCAs of biobased products. Within the ALIGNED project, tiered guidance has been developed to support biogenic and dynamic carbon accounting as well as climate change characterization. To address this issue, regulatory frameworks and verification schemes need to explicitly address biogenic carbon accounting.

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Construction sector[2]

Due to its great size and important need for material resources, the construction sector faces some major environmental impacts. According to the European Commission, the construction sector is one of the largest consumers of resources in the European Union, as it consumes about 50% of the materials extracted in the EU. There are two key functions where biobased materials enter the construction sector, namely structure and insulation. The former is dominated by wood. Wood in fact accounts for 1.6%wt of materials used in the overall EU construction sector, averaging at 24.8 million tonnes per year between 2006 and 2010.

Current status and challenges in the sector

Many national certification schemes for the environmental performance of buildings and materials help industries in sharing and improving best practices. As compared to other sectors, practitioners, industries and policy makers are quite well equipped with tools for environmental accounting such as Environmental Product Declaration (EPDs), existing background database, certification and standards. It was made very clear at the second ALIGNED sectorial stakeholders' consultations held between May and June 2025 that the construction sector relies heavily on EPDs. Stakeholders from research institutions voiced that several environmental assessment challenges are not properly addressed in mainstream operational standards.

Consulted stakeholders clearly stated that a seasoned, well-accepted standard such as EPDs help newcomers performing an LCA, and bring a common, harmonized ground for LCA data sharing. However, relying solely on EPDs may induce biases grounded in the underlying normative choices inherent to any standard. It was made clear from the workshop that EPDs and consequential LCA frameworks are conflicting with one another.

In fact, EPDs deliver information on how the product *has been* manufactured. However, EPD results are frequently used by manufacturers as standalone information for decision-making on *future* eco-designed production processes. Environmental accounting and environmental strategy clearly have diverging goals and scopes, and thus should follow different LCA frameworks.

As a result, consulted stakeholders confessed lacking expertise on consequential LCA. In addition, consulted stakeholders expressed a keen interest in a framework for time-explicit climate impact assessment, especially to make explicit the effects of temporary carbon storage in biogenic resources and products.

[2] This document is an abstract of the full recommendation deliverable, available on the ALIGNED project website

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Recommendations

There are two key take aways from the construction case study in the ALIGNED project:

1. For wooden biomass production: invest in long-term partnerships with forestry activities, to secure environmentally-performant feedstock production at supply level (i.e. in m^3 wood, not ha land) and anticipate adaptation of forestry to climate change.
2. Promote a long-term, material use for biorefineries' coproducts, which directly contributes to phasing out reliance on fossil resources. Generally speaking, co-products should be targeted to obtaining higher-value compounds able to substitute fossil- and mineral-based products (e.g., polymer or mineral insulating products), able to store biogenic carbon for the longest periods.

Combined with the other ALIGNED inputs, this leads to the **following recommendations** for the sector:

1. **Ensure high-quality and standardized data** collection across the value chain
2. **Promote harmonization between standards**, scientific soundness and methodological alignment
3. Avoid allocation methods among bio-based co-products and **prefer system expansion**
4. Promote the **use of biomass for long-lived products**, preferably substituting fossil or mineral products,
5. Keep **clear carbon flow tracking** and advanced climate change impact assessment metrics, in order to shed light on the environmental advantage of long-term carbon storage,
6. Consider contrasted **scenarios for the end-of-life** phase for used products.

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Woodworking sector[3]

Wood is inherently bio-based and typically has a smaller carbon footprint than many substitutes because processing is less energy-intensive and wood stores biogenic carbon. When paired with sustainable forest management, growing demand for wood products can expand forest area and CO_2 capture, supporting climate-change mitigation. The sector can replace higher-carbon materials in buildings, but actual benefits depend on what is substituted and market response. Biodiversity losses, deforestation, forest degradation and the toxicity of wood modification chemicals were identified as most important environmental impacts by stakeholders.

Current status and challenges in the sector

Inconsistent scope and functional units undermine comparability of LCAs. Current LCAs vary widely in system boundaries and functional units, with cradle-to-gate still dominant and only a small share adopting cradle-to-cradle perspectives. This heterogeneity prevents robust benchmarking and technology evaluation, weakening both policy design and procurement decisions.

Fragmented standards and LCIA methods lead to conflicting results. EPDs, PCRs, and PEFs aim at transparency, yet incompatibilities among PEF, EN 16485 & EN 15804, and wood-specific EPD rules persist, and studies mix methods (e.g., ReCiPe, CML, TRACI) without clear justification. As endpoints (e.g., ecosystem quality, resource depletion) are highly relevant to forestry products, the frequent omission or inconsistent treatment of endpoint indicators distorts trade-offs and hampers reproducibility. This erodes trust and enables selective reporting.

Attributional LCA misses market-mediated effects and substitution realities. Most assessments are attributional, which cannot capture how increased timber demand alters harvest regimes, global trade, or the degree to which mass timber displaces steel or concrete and wood co-products. Consequential LCA is more prevalent in this sector than elsewhere but remains underused and inconsistently applied.

Biogenic carbon is handled statically. ISO acknowledges biogenic carbon but does not prescribe how to treat storage duration, release timing, or regrowth. Without dynamic, sector-specific protocols, LCAs can misinform forest planning, product design, and claims about "carbon-neutral" wood.

Inventory gaps hide promising low impact materials. Innovative bio-based adhesives (e.g., soy- or tannin-based) often have better environmental profiles than fossil alternatives but are poorly represented in mainstream LCI datasets. Similarly, forest growth and management data remain scattered across emerging resources.

Limited integration of broader sustainability metrics. Environmental LCAs are seldom combined with economic and social dimensions, and decision tools such as multi-criteria decision making are not yet mainstreamed for wood products.

[3] This document is an abstract of the full recommendation deliverable, available on the ALIGNED project website

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Recommendations

The recommendations for the woodworking sector can be summarised in five main recommendations:

Pair LCA with multi-criteria decision-making

Environmental LCAs should be integrated with economic/social metrics and constraints.

- Use multi-criteria decision making and the ALIGNED framework for socio-economic assessment[4].
- Identify risks when scaling specific wood products by using the method for modelling constraints to biomass availability[5].

Harmonize scope, boundaries, and functional units

Non-comparable LCAs arise from mixed scope, lifetimes, and functional units.

- Adopt cradle-to-grave as the default scope for product LCAs and apply cradle-to-cradle where relevant for reuse, recycling, or energy recovery.
- Use a sector functional unit (FU) pack for common applications.
- Publish a one-page method sheet with every study.
- For portfolios with many variants, maintain parametric models, handle multi-output processes as interlinked and apply system modelling to allocate or substitute burdens as late as possible.

Make biogenic carbon accounting dynamic and explicit

Static treatment of biogenic carbon obscures timing of uptake, storage, and release, while EoL pathways drive real outcomes.

- Apply dynamic biogenic carbon accounting using ALIGNED guidelines.
- Disaggregate climate results into fossil, biogenic, and land-use components.
- Use a minimum EoL scenario set with realistic yields and timing and include storage duration where relevant.
- Credit storage only when verifiably achieved and accompany any interim negative values with a disclaimer about EoL dependence.

Close inventory gaps on provenance, growth, and bio-based chemistry

Missing or generic LCIs hide low-impact options and weaken biodiversity/carbon credibility.

- Use a structured sector LCI template as the ALIGNED LCI data template[6].
- Improve reproducibility by adding relevant metadata.
- Integrate species- and region-specific growth models
- Record uncertainty and sensitivity.

Prioritize responsible material choices and decarbonize operations

- Tropical hardwood reliance, transport intensity, and fossil-heavy processing remain hotspots for the woodworking sector. Default to modified softwood, followed by hybrid designs nd Switch to renewable electricity and electrify kilns, presses and transport.

[4] https://zenodo.org/records/10843651
[5] https://zenodo.org/records/10843454
[6] https://zenodo.org/records/10843472

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Textile sector[7]

The textile industry faces significant sustainability challenges, including high water and energy consumption, chemical pollution, and social issues such as poor working conditions and lack of supply chain transparency. The fast fashion model exacerbates these problems through overproduction and waste, while recycling systems remain fragmented. To address these issues, Life Cycle Assessment (LCA) methodologies offer a structured approach to evaluate environmental impacts and support sustainable transitions.

Current status and challenges in the sector

Biobased fibres are derived from renewable biological sources and are gaining traction as alternatives to conventional petroleum-based synthetics. The main categories include:

- **Natural fibres**: Cotton (the most widely used), wool, silk, flax (linen), hemp, jute, and ramie. Cotton alone accounts for nearly a quarter of global textile fibre production.
- **Regenerated fibres**: These are made by chemically processing natural polymers. Examples include viscose, modal, and lyocell (all derived from cellulose), as well as chitosan fibres from crustacean shells and soybean protein fibres.
- **Biobased synthetics**: Polylactic acid (PLA) fibres, made from corn starch or sugarcane, and bio-based polyamides and polyesters, which are synthesized from plant-based feedstocks rather than petroleum. These fibres can offer biodegradability and a lower carbon footprint, though not all are biodegradable.

There are several barriers to sustainability assessment in the textile sector:

- **Complex global supply chains:** textiles often pass through multiple countries and suppliers, making it difficult to trace materials and collect reliable, consistent data across all stages of production.
- **Data gaps and quality issues:** several actors on the textile value chain lack robust environmental reporting systems. This leads to incomplete or inconsistent data, which undermines the accuracy of sustainability assessments.
- **Diversity of materials and processes:** the sector uses a wide range of fibres (natural, synthetic, biobased, blends) and processes (dyeing, finishing, coating), each with unique environmental profiles. Comparing impacts across such diversity is challenging.
- **Difficulties comparing LCA results:** LCA results can vary significantly depending on choices like system boundaries, allocation methods, and data sources. This makes it hard to compare results between studies or products.
- **Rapid technological change:** new materials, recycling methods, and production technologies are emerging faster than standardized assessment frameworks can adapt, making it hard to keep evaluations current and relevant.
- **Blended and composite materials:** the increasing use of fibre blends and composites complicates recycling and makes it harder to assess the end-of-life impacts and circularity potential of textile products.

[7] This document is an abstract of the full recommendation deliverable, available on the ALIGNED project website

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Recommendations

Based on the case study and stakeholder interactions in the ALIGNED project, the following recommendations can be made:

Making a standard document available for Life Cycle Inventory (LCI) data
To facilitate knowledge sharing between LCA practitioners and/or companies – without sharing any data about the (confidential) processes of companies.

Finding the stage that bears the most impact in (recycled) fabric life cycle
The ALIGNED case study on recycled textiles showed that the step with the largest impact on the environment (climate change impact) is the use phase. Therefore, a conclusion was that this impact could be minimized by using non-fossil-based electricity mix. Therefore, suggestions for performing LCA on recycled textiles include: comparing the fraction of energy used during the use phase compared to other steps; determining the energy needed for producing a virgin fabric vs a recycled fabric.

Contributing to LCA data availability and reproducibility
We recommend that stakeholders systematically contribute to LCA data availability and reproducibility by making anonymized input/output datasets and model documentation openly accessible—e.g., via open-access journals and repositories such as Zenodo—without breaching confidentiality. The ALIGNED templates can be used[8].

Organise training sessions in the textile sector
Textile sector federations may organize training for their members from the textile industry which may not have the necessary LCA expertise inhouse. More importantly, the training needs to be tailored depending on the function of the professional involved in the whole textile life cycle. This training will facilitate the gathering of quality information from the textile producer to be ready to use as input for LCA.

Several specific recommendations can be made for the sector in collaboration with LCA software developers and providers.

- **Ensuring interoperability of LCA software** When applying more advanced LCA methods it may be necessary to combine LCA data from different software.
- **Making more granular datasets on textiles supply chains available in LCA databases** The data found in commonly used-databases such as ecoinvent is often generic. To realistically represent textile value chains, specific data need to be collected at different stages, such as the dimension of yarns and their origin.
- **Supporting projects for creating background LCA data for non-conventional biobased materials** Unavailability of data, for example for organic cotton, in LCA databases leads to using an estimates or a proxies to assess the sustainability in value chains requiring these data sets.

[8] https://zenodo.org/records/10843472

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Pulp and Paper sector[9]

Europe is the world's second-largest producer of pulp and paper, manufacturing 37 million tonnes of pulp and 100 million tonnes of paper (Cepi, 2021). However, the consumption of graphic paper products (i.e. printer paper, newspapers and books) is decreasing in Europe due to digitalization. While there is an increase in demand for paper-based packaging material the current level of profits for the pulp and paper sector is relatively low (Toppinen, Patari, Tuppura, & Jantunen, 2017). Thus, traditional pulp and paper manufacturing units are transforming towards multi-output biorefineries. These biorefineries produce bio-based products such as cellulose, biodiesel, bio-naphtha, lignosulphonate and tall oil products. The production of these bio-based products led to an additional turnover of almost 2.7 billion euros, which is almost 3% of the EU pulp and paper sector's turnover.

Current status and challenges in the sector

The key environmental challenges identified within the sector are typically related to energy and water consumption. The EU pulp and paper sector directly emitted 29 Mt of CO_2 in 2020, which is about 15% of global pulp and paper emissions. In addition, the sector indirectly caused 8.77 Mt of CO_2 emissions through its bought electricity.

In the ALIGNED project, stakeholders indicated that impact of climate change, followed by increasing demands from customers and government policies were driving the push for environmental sustainability in the pulp and paper sector. Stakeholders supported the use of LCA as a tool for sustainability assessment as it is **holistic and data-driven with a scope beyond GHG emissions**. LCAs are also considered as **time-consuming**, **complex, expensive, subjected to data limitations and not harmonized**. However, stakeholders indicated that the verification of LCA results is largely hindered by data reliability, data availability as well as unclear definitions. They mentioned difficulties in performing internal LCAs, where data would have to be gathered from the suppliers, who often use different scopes and criteria.

The lack of data was particularly highlighted in relation to the use of consequential LCA. Additional challenges related to LCA are related to the calculation of biogenic carbon, and the application of allocation to different co-products. Stakeholders indicate a strong interest in applying the prospective LCA but lack the framework or guidelines to do so.

- **Carbon neutrality principle for biomass** – This assumption potentially oversimplifies the actual carbon dynamics
- **System Boundaries** – Conducting cradle to grave assessments are challenging as most products produced are platform chemicals that can be used in several products which makes the identification of end of life difficult.
- **Handling multifunctionality of co-products** – The biorefining produces multiple products. It is still unclear which markets the novel biomaterials will target and which functionally equivalent products will be substituted.
  Handling multifunctionality using allocation requires subjective decisions. Economic allocation depends on market prices which are currently not determined for novel products and are likely to fluctuate with time and market demand. This leads to inconsistencies and uncertainty in the results.

[9] This document is an abstract of the full recommendation deliverable, available on the ALIGNED project website

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- **Upscaling and prospective assessment** – In general, there is uncertainty regarding the functioning of the technology at a potential industrial scale.

Recommendations

Improve sector specific data collection and sharing

Given that a key challenge in the implementation of LCA is lack of data, efforts need to be made to collect and share data. The ALIGNED project provides specific frameworks and templates to build sector specific foreground systems.[10]

Anticipate future performance

Given the transition in technologies and increasing competition for bio-based feedstock, the environmental assessment needs to anticipate its future development. This can be done by:

- Application of consequential LCA – which considers market constraints and demand. ALIGNED provides a clear framework[11].
- Application of prospective LCA – the ALIGNED project provides a framework to perform the LCA using prospective background databases[12].

Adopt scenario and sensitivity analysis

The uncertainties in the market for novel biomaterials creates several challenges related choice of functional unit, addressing multi-functionality and the choice of system boundaries.

- In case of multi-functionality and unclear markets, analyse the system using multiple functional units.
- If the multifunctionality is handled using economic allocation, then the results should test the sensitivity of the results in relation to fluctuations in market prices.
- Use end-of-life scenarios to support the challenges with assessing biogenic carbon. ALIGNED recommends using the -1/+1 method in a cradle to grave analysis particularly to provide meaningful carbon balance. Using short-term and long-term end-of-life scenarios can be used to provide meaningful carbon balances.

Identify uncertainties by performing uncertainty analysis

Performing an uncertainty analysis, for example by using the ALIGNED framework[13], can support the reliability of the LCA model.

- Early-stage technologies may perform differently under varying conditions (e.g., scale-up, geographic location, operational parameters). Uncertainty analysis captures this variability and helps assess the robustness of LCA results.
- Modelling assumptions can contribute to uncertainty. Uncertainty analysis helps identify which choices most influence outcomes.
- Policy makers, investors, and stakeholders need to make decisions on novel technologies even when data is incomplete. Uncertainty analysis provides confidence intervals or probabilistic outcomes, supporting more informed decisions.

[10] https://zenodo.org/records/10843343
[11] https://zenodo.org/records/10843454
[12] https://zenodo.org/records/10842988
[13] https://zenodo.org/communities/aligned-he/

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Biobased chemical sector[14]

The European bio-based chemical sector is a strategic pillar in the EU's transition toward a circular and climate-neutral economy. By harnessing renewable biological resources, the sector offers sustainable alternatives to fossil-based chemicals across a wide range of applications. However, its full environmental potential remains under recognized due to persistent gaps in sustainability assessment frameworks.

Current status and challenges in the sector

The bio-based chemical sector is one of Europe's most promising industries for building a more sustainable and circular economy. By using renewable resources, this sector offers greener alternatives to fossil-based chemicals in everything from cosmetics to lubricants. While the potential is clear, the path forward is not without challenges. Companies in this space are navigating complex sustainability questions: how to measure their climate impact fairly, how to collect reliable data from suppliers, and how to account for the full life cycle of their products, including what happens at the end of life of the products.

Nevertheless, the sector is actively addressing concerns around feedstock competition and sustainability by exploring alternative and circular sourcing strategies. Companies are increasingly turning to non-edible crops, agricultural residues, and industrial by-products to reduce pressure on land and food systems. Algae-based feedstocks and waste-derived inputs are gaining traction as scalable, low-impact alternatives.
These efforts are complemented by circular supply chain initiatives. Together, these strategies reflect the sector's commitment to balancing environmental stewardship with industrial growth and resilience. The sustainability of feedstocks used in bio-based chemical production is a potential area of concern. Many processes still depend on crops which can lead to land use conflicts and contribute to deforestation and biodiversity loss.

A substantial share of the sector's environmental footprint is related to land use, land use change, and forestry. These emissions, categorized as FLAG by the Science-Based Targets initiative (SBTi), include CO_2 from deforestation, CH_4 and N_2O from fertilizer use, and biogenic carbon fluxes[15]. However, many companies lack the tools, data granularity, or methodological clarity to accurately quantify and report these emissions.

Despite its potential, the bio-based chemical sector currently occupies only a small share of the overall chemical market. This limited market penetration is due to a combination of increased production costs, infrastructure limitations, and policy gaps, which hinder the sector's ability to scale effectively.

End-of-life management and recycling remain challenging. Many bio-based products are not easily recyclable, and the infrastructure to support their proper disposal or reuse is often lacking. Composite materials and certain insulation products, for example, are difficult to separate and process, complicating efforts to close the loop in a circular economy.

[14] This document is an abstract of the full recommendation deliverable, available on the ALIGNED project website
[15] SBTi FLAG Guidance

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Recommendations

The recommendations for the biobased chemical sector can be divided into 3 main stakeholder groups: policy makers, sector, and industry associations.

Specific recommendations for policy makers are:

- **Promote the harmonization of supplier data reporting practices** by encouraging the uptake of voluntary frameworks or, where appropriate, regulatory incentives.
- **Promote regulatory alignment of LCA methodologies**: Encourage the adoption of harmonized LCA practices across EU frameworks (e.g. Sustainable Products Initiative, CSRD, DPP) to reduce fragmentation and enhance trust in environmental claims.
- **Clarify expectations for biogenic carbon treatment**: Ensure that regulatory frameworks and verification schemes explicitly address biogenic carbon.

Specific recommendations to chemical producers and LCA practitioners are:

- **Engage suppliers early and systematically in the data collection process**. Establishing long-term data-sharing agreements and using pre-defined templates can help overcome confidentiality concerns and improve data consistency.
- **Use harmonized data collection formats** and align with the sustainability data guidelines developed in ALIGNED (Pizzol et al., 2024) to ensure compatibility across different actors and tools.
- **Avoid over-reliance on proxy data by investing in primary data collection** where feasible. When proxies are used, clearly document assumptions and uncertainty ranges to improve transparency and comparability.
- **Apply harmonized and transparent LCA modelling practices**: Clearly document methodological choices, including allocation rules, impact assessment methods, and biogenic carbon accounting approaches (e.g. 0/0 or –1/+1). The project advises the –1/+1 approach for biogenic carbon accounting. Further methodological details are available in the project's open repository[16].
- **Enhance downstream data collaboration**: Producers should proactively engage with downstream users to exchange LCI data and improve transparency on EOL scenarios.

Specific recommendations for industry associations and data providers are:

- **Facilitate the creation of sector-specific guidance** for upstream data collection, including minimum data requirements and best practices for supplier engagement.
- **Support the development of shared datasets** for common intermediate and processing steps, especially where confidentiality is less of a concern.
- **Support the development of harmonized and accessible LCI datasets**: Facilitate the creation of open-access or anonymized datasets for bio-based feedstocks and intermediates, which specify carbon uptake and release in standardized formats.
- **Promote interoperability of LCA tools and databases**: Encourage software providers to improve compatibility and offer geographically differentiated, process-specific data.
- **Develop sector-specific EOL datasets**: Associations should coordinate the development of representative EOL datasets for common bio-based intermediates and applications.

[16] https://zenodo.org/communities/aligned-he/

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