ALIGNED methodology

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ALIGNED

CONSTRUCTION - PULP AND PAPER - WOODWORKING - TEXTILE - BIO-CHEMICALS.

Aligning Life Cycle Assessment methods and bio-based sectors for improved environmental performance

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ALIGNED PROJECT

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About

14 Scientific + industrial partners

ALIGNED will advance the scientific field of Life Cycle Assessment (LCA) and collaborate with industries and representatives from five bio-based sectors:

https://alignedproject.eu

CONSTRUCTION | WOODWORKING | PULP AND PAPER | TEXTILE | BIO-CHEMICALS

The models and tools developed in ALIGNED will allow the performance of high-quality assessment studies across the bio-based sectors, with industrial relevance and interoperability. This is made possible by the iterative application and improvement of the new and harmonised models and tools in five specific cases of biobased industrial technologies (TRL 2-6), one for each sector.

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Project objectives

1 **Improve, harmonize, and align LCA methodology** for the assessment of bio-based industries covering environmental and socioeconomic aspects.

2 Demonstrate the power of the methodology on **five specific technology development cases in industries** within these sectors, to improve their environmental performance.

3 Inform, involve, and **empower all relevant stakeholders**, enabling an efficient methodological uptake and practice improvement to support a sustainable growth of the bio-based sector in Europe.

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ALIGNED FRAMEWORK

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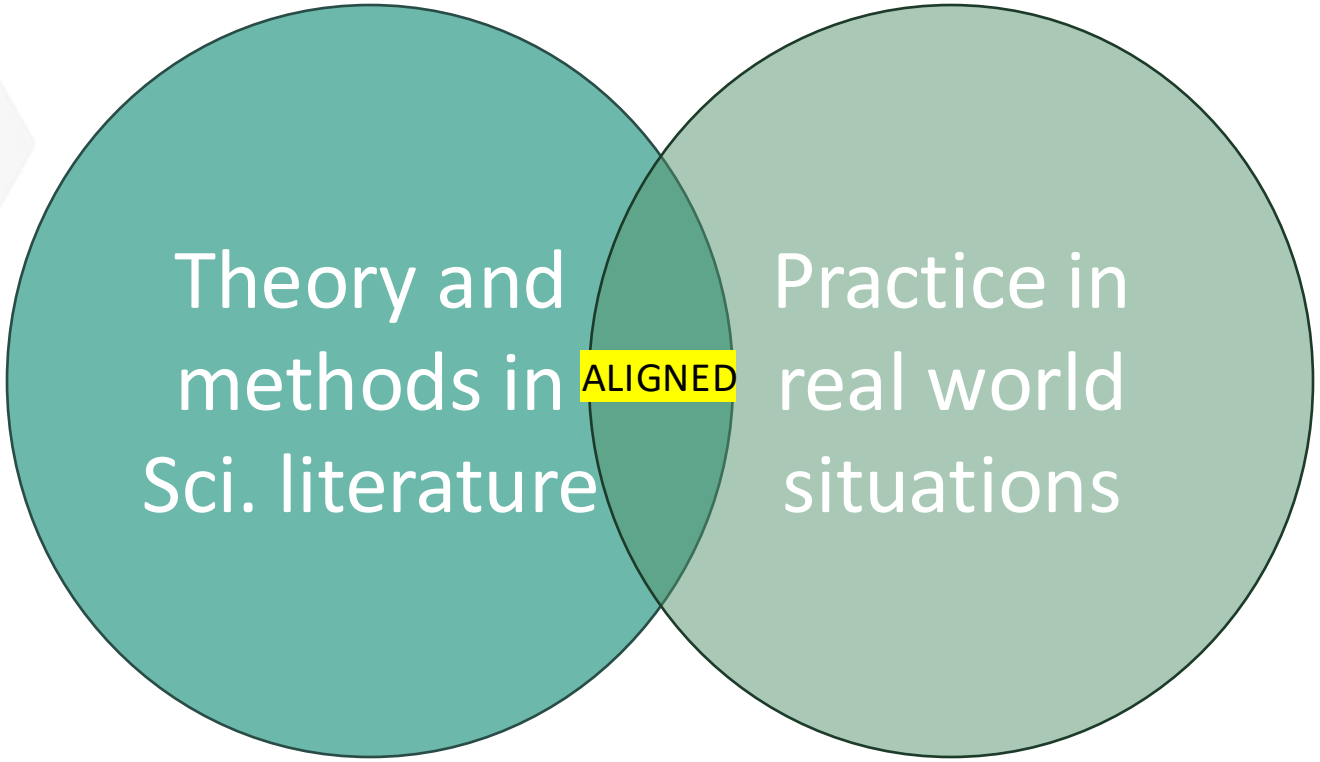
ALIGNED: a scientific framework

- Based on best available science selected and harmonised
- Including approaches, methods, and tools
- Openly available
- Applied and tested in the case studies of the project
- Applicable across five sectors



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Scope

Following ISO phases:

- LCI: A method for generating **dynamic background systems for prospective LCA**
- G&S, LCI: A method for **identification of market constraints.** A method for **time and space-dependent carbon accounting** (uptake and release) to return mass balanced carbon inventories.
- LCIA: Methods and **characterization factors for dynamic assessment of climate change** and assessment of **biodiversity** impacts.
- Interp: Methods for **uncertainty and sensitivity analysis** in bio-based sectors.
- Interp: A method for **socio-economic assessment** in bio-based sectors.

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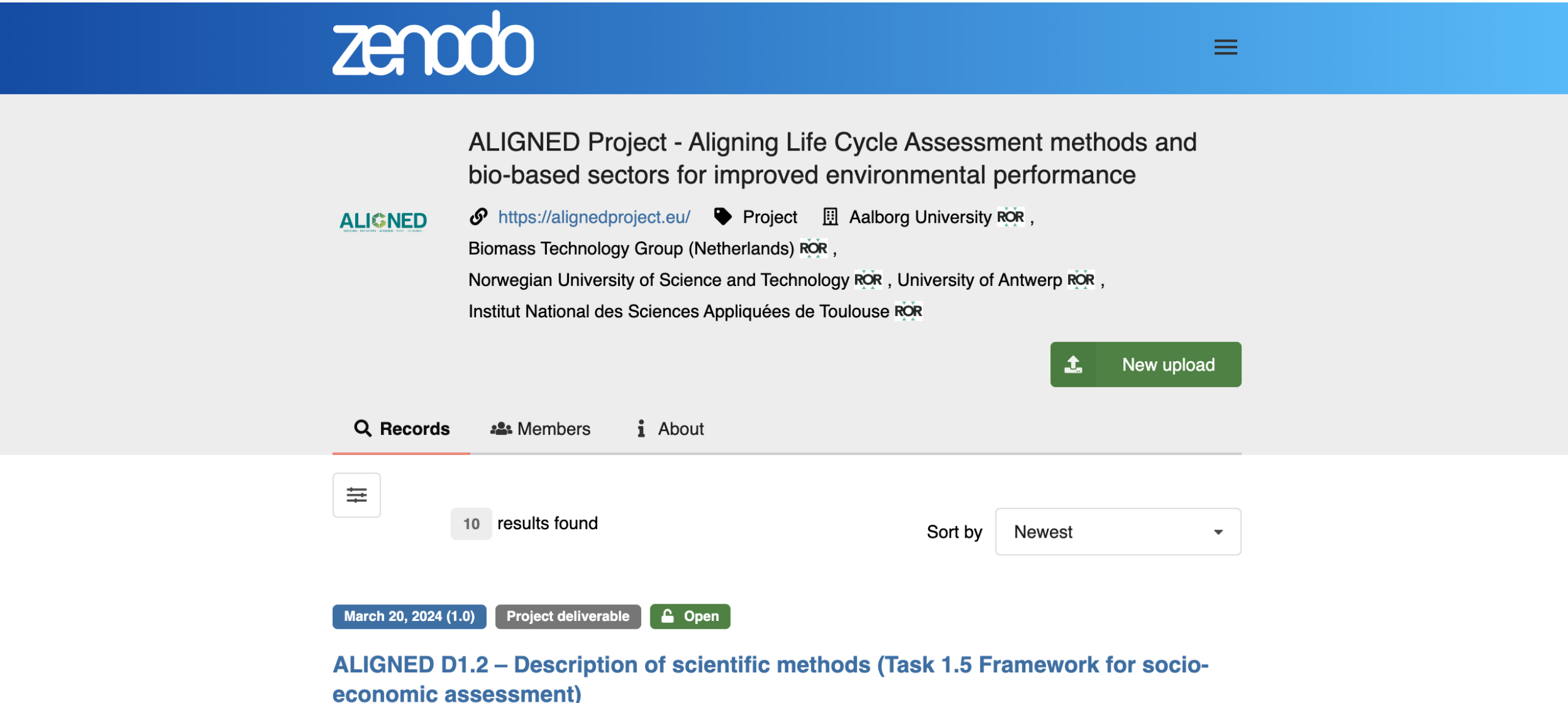
Where https://zenodo.org/communities/aligned-he/



USING THE FRAMEWORK: AN EXAMPLE

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(Example)
Problem: how to inventory carbon flows?

- Bio-based products have different lifetimes and end of lives
- Carbon uptake and release at different points in time
- The impact of carbon uptake and release depends on the timing
- *"A **dynamic** LCA approach allows for a consistent assessment of the impact, through time, of all GHG emissions (positive) and sequestration (negative)"* (Levasseur et al., 2013, 2010)
- Feedstock (e.g., wood) comes from different plantations with different rotation times
- Current plantation LC inventories not dynamic and not diverse

- What are the dynamics of carbon uptake and emissions in biobased products?
- How can we make a LCA inventory that considers these dynamics accurately?
- Will this LCA model improve the assessment of biobased products?

Levasseur, A., Lesage, P., Margni, M., Deschênes, L., Samson, R., 2010. Considering time in LCA: Dynamic LCA and its application to global warming impact assessments. Environ. Sci. Technol. 44, 3169–3174. https://doi.org/10.1021/es9030003
Levasseur, A., Lesage, P., Margni, M., Samson, R., 2013. Biogenic Carbon and Temporary Storage Addressed with Dynamic Life Cycle Assessment. J. Ind. Ecol. 17, 117–128. https://doi.org/10.1111/j.1530-9290.2012.00503.x

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(Example)
Time and space-dependent carbon accounting

- Starting point in carbon flux model (De Rosa et al. 2017, 2019)
  - Calculates time-dependent material and carbon flows for forest plantation
  - Above / below ground carbon pools included
  - Can be parameterized to good extent
  - Originally limited to two species
- Advancements during the project
  - Improved model interface (Excel-based) did initial testing, fixed bugs, extended data basis
  - Expanded EU species coverage
  - Optimized import in LCA software (SimaPro, Brightway)
  - Model any type of wood product from virgin (unconstrained) plantation.
- Intended application area:
  - LCA of wood-based products in woodworking, construction, pulp & paper, biochemicals

De Rosa, M., Pizzol, M., Schmidt, J., 2018. How methodological choices affect LCA climate impact results: the case of structural timber. Int. J. Life Cycle Assess. 23, 147–158. https://doi.org/10.1007/s11367-017-1312-0
De Rosa, M., Schmidt, J., Brandão, M., Pizzol, M., 2017. A flexible parametric model for a balanced account of forest carbon fluxes in LCA. Int. J. Life Cycle Assess. 22, 172–184. https://doi.org/10.1007/s11367-016-1148-z

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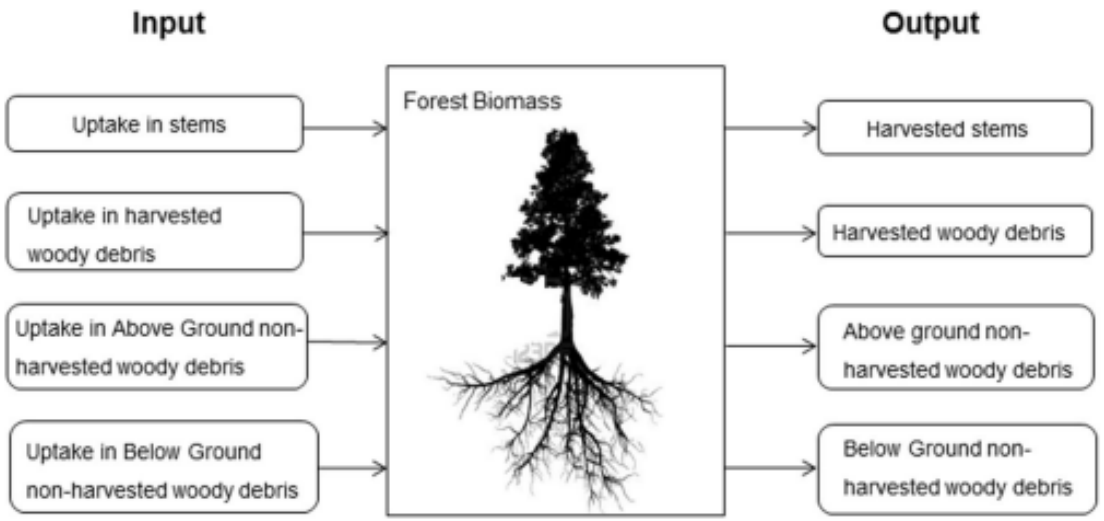
(Example)
Time and space-dependent carbon accounting

- Examples of model input, output, and new data



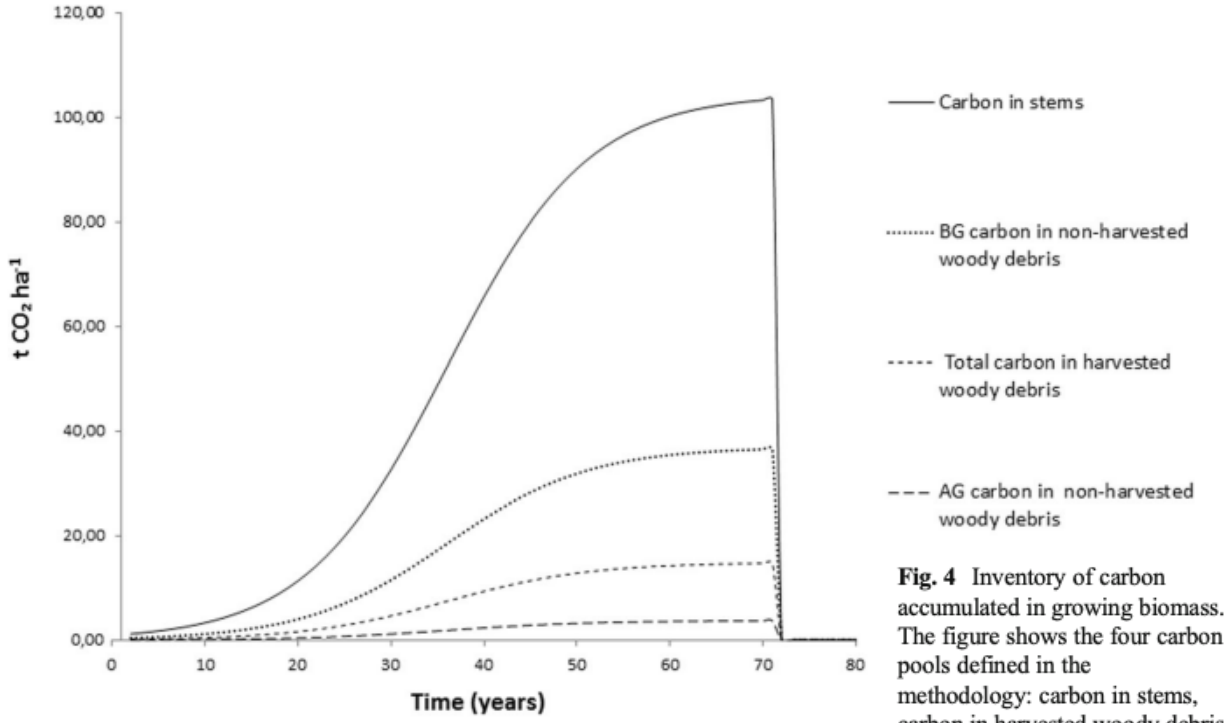


Fig. 4 Inventory of carbon accumulated in growing biomass. The figure shows the four carbon pools defined in the methodology: carbon in stems, carbon in harvested woody debris and carbon in non-harvested aboveground (AG) and belowground (BG) woody debris

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(Example)
Methods for foreground life cycle inventory
(dynamic carbon)

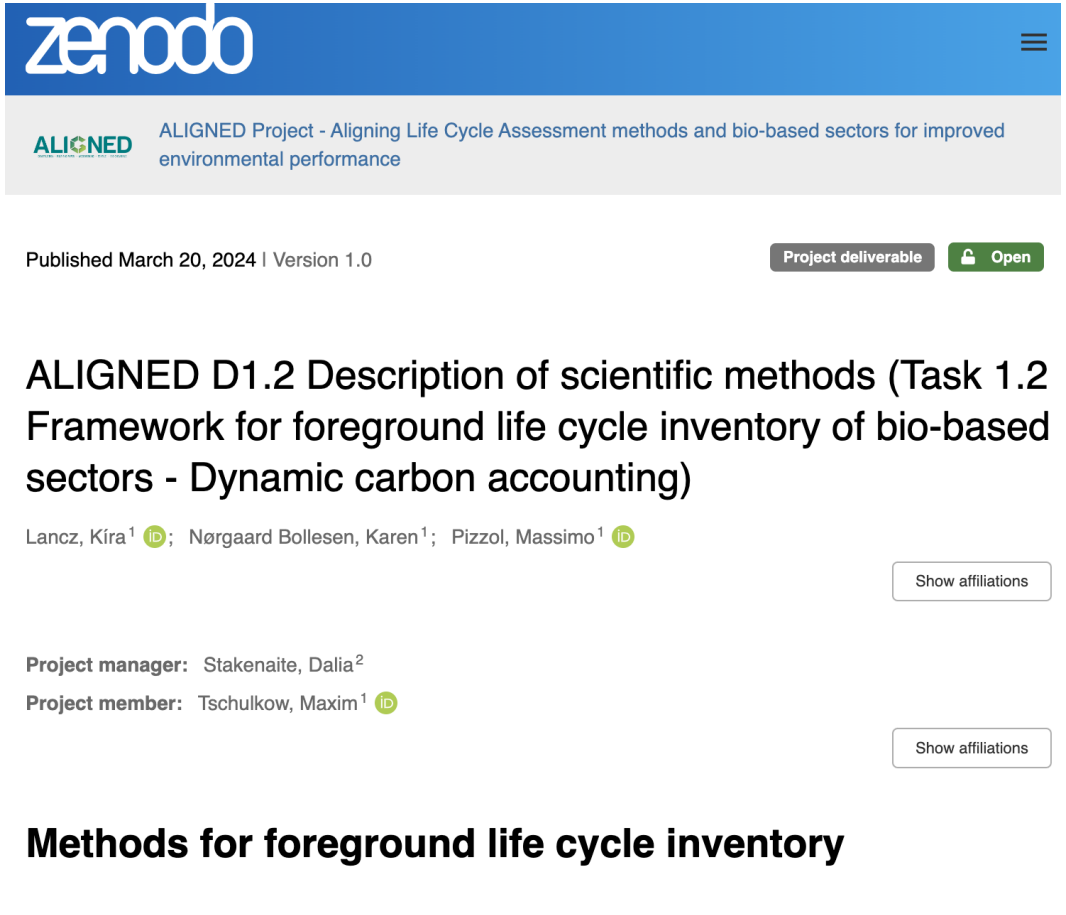
Dataset overview of biomass types

LCA Carbon Flux emissions model

Tutorial for dynamic carbon flux modelling of forest plantation

Carbon Flux model validation data

Carbon Flux model validation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Project deliverable | Open

ALIGNED D1.2 Description of scientific methods (Task 1.2 Framework for foreground life cycle inventory of bio-based sectors - Dynamic carbon accounting)

Lancz, Kíra[1]; Nørgaard Bollesen, Karen[1]; Pizzol, Massimo[1]

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Project manager: Stakenaite, Dalia[2]

Project member: Tschulkow, Maxim[1]

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Methods for foreground life cycle inventory

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ALL ALIGNED METHODS

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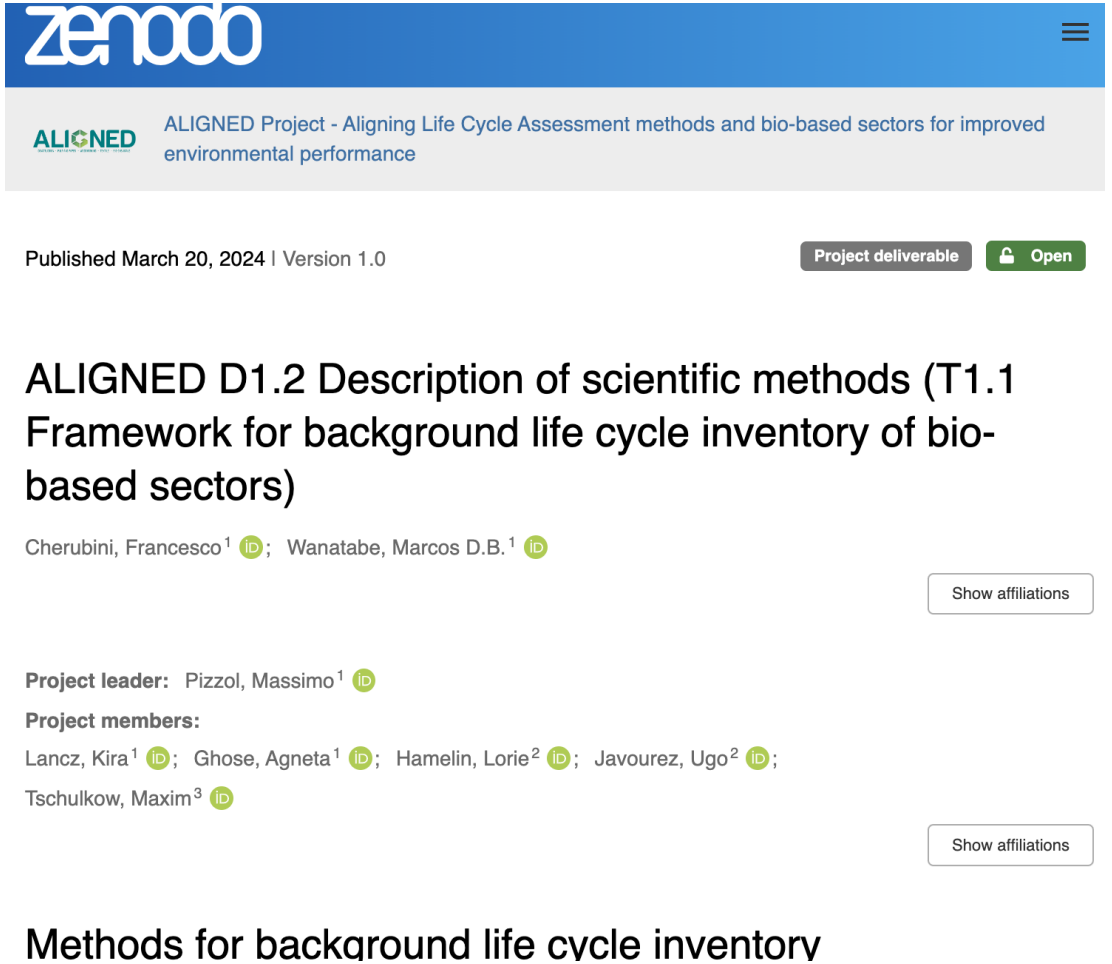
Methods for background life cycle inventory

Model description for background life cycle inventory of bio-based sectors

Tutorial for generating background life cycle inventories, Tier 1 (attributional and consequential)

Tutorial for generating background life cycle inventories, Tier 2 (attributional and consequential)

Example of the foreground inventory format to be modified by the user (an excel file)



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Methods for foreground life cycle inventory
(constraints to biomass)

Method for modelling constraints to biomass availability

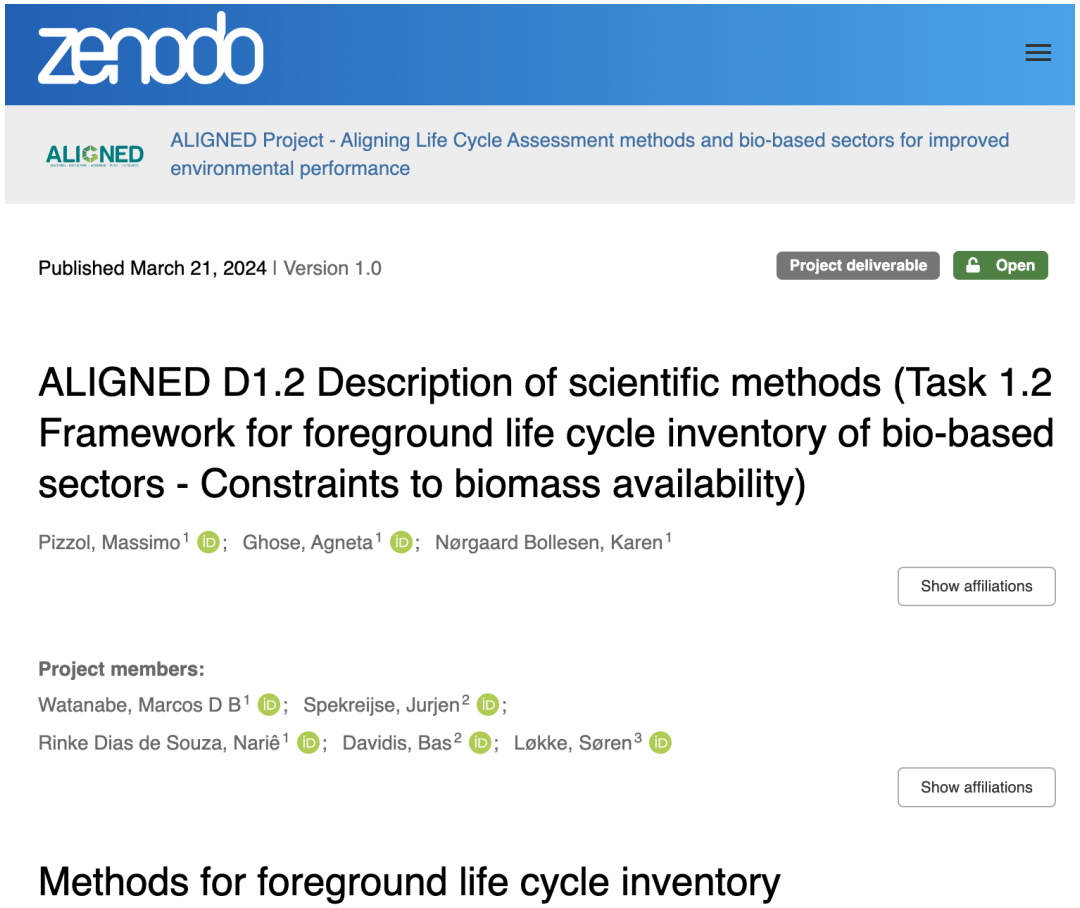
Screening and comparison of data sources to calculate market mix

Comparison data sources (.xlsx file)

Modelling a market mix from FAOSTAT data

Code for implementation of calculations for marginal mix (.xlsx, .py, .pynb .html and .R files)

Datasets used for market mix calculation analyses (.csv files)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ALIGNED D1.2 Description of scientific methods (Task 1.2 Framework for foreground life cycle inventory of bio-based sectors - Constraints to biomass availability)

Pizzol, Massimo[1]; Ghose, Agneta[1]; Nørgaard Bollesen, Karen[1]

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Project members:

Watanabe, Marcos D B[1]; Spekreijse, Jurjen[2];
Rinke Dias de Souza, Nariê[1]; Davidis, Bas[2]; Løkke, Søren[3]

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Methods for foreground life cycle inventory

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Methods for foreground life cycle inventory
(Data template)

Guide for structuring and sharing LCI data

Explainer to understanding the ALIGNED LCI data template

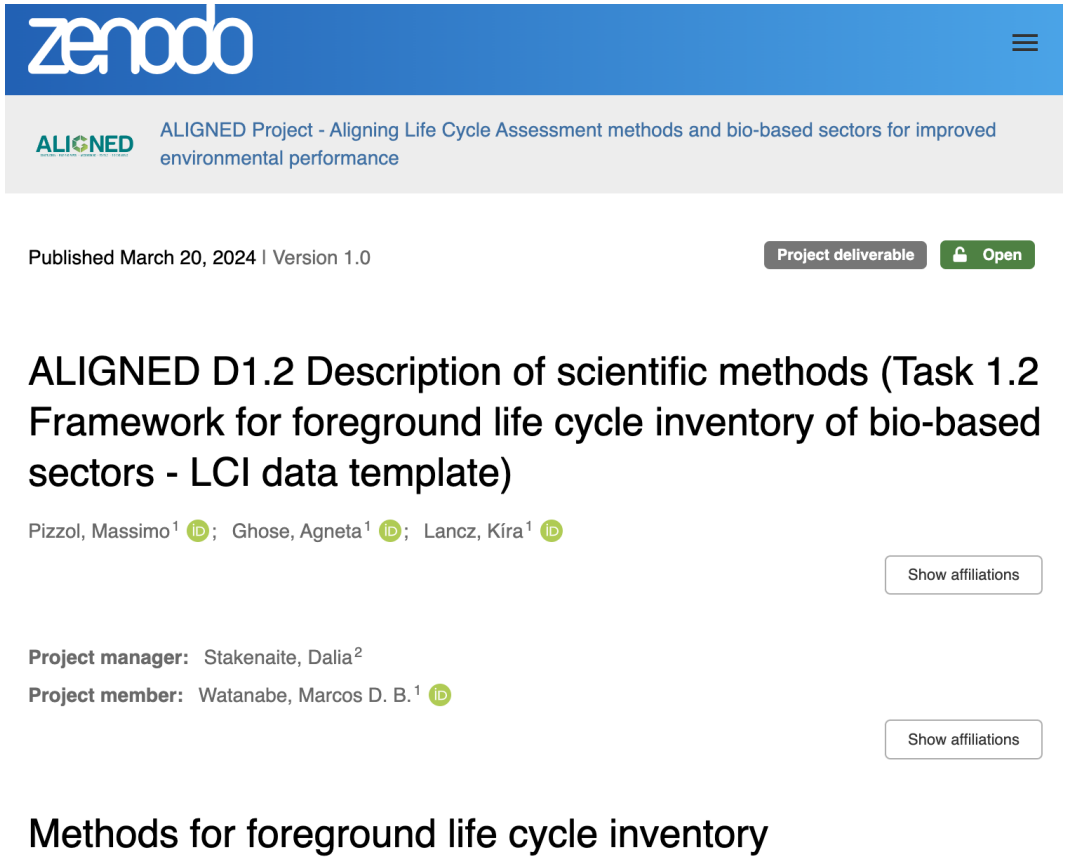
ALIGNED LCI template (.xlsx file)

ALIGNED LCI template example with data (.xlsx file and .csv files)

GLAD metadata template (.xlsx file)

Data import notebook (.ipynb and html files)

Importer for life cycle inventory data (.py file)



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Methods for foreground life cycle inventory
(dynamic carbon)

Dataset overview of biomass types

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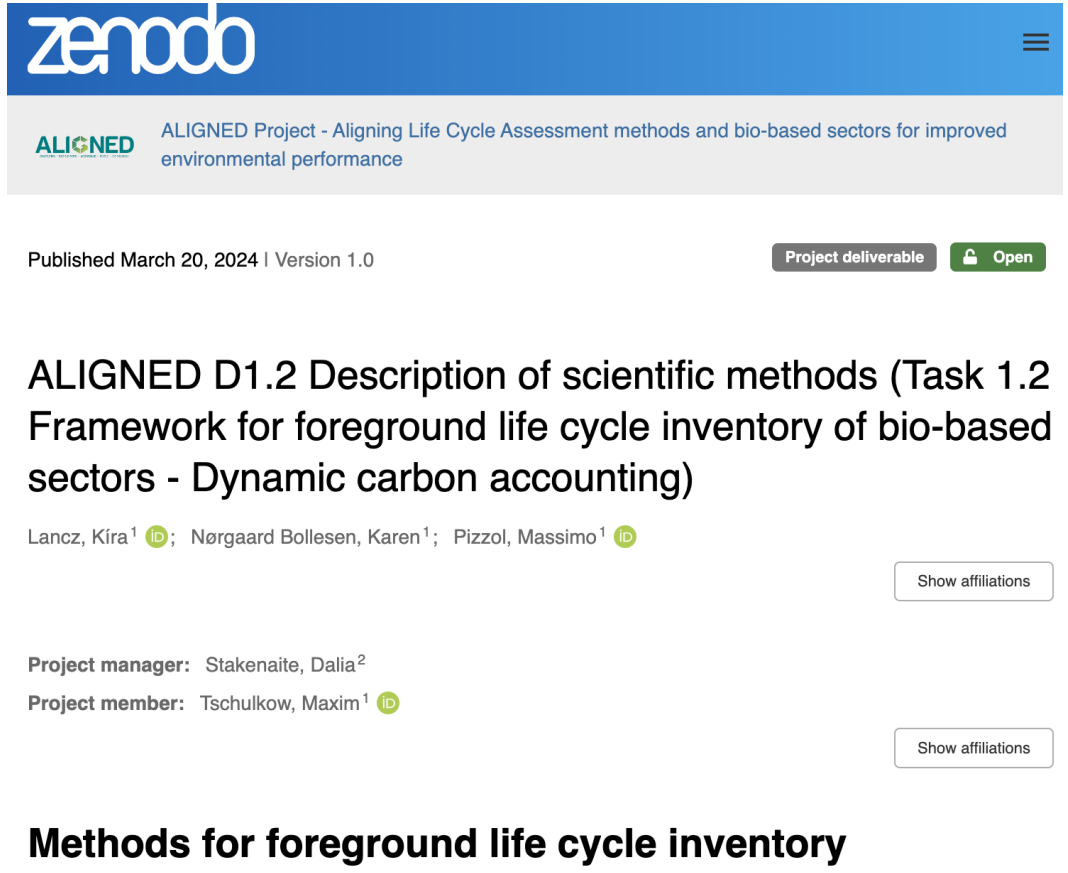
Carbon Flux model validation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ALIGNED D1.2 Description of scientific methods (Task 1.2 Framework for foreground life cycle inventory of bio-based sectors - Dynamic carbon accounting)

Lancz, Kíra[1]; Nørgaard Bollesen, Karen[1]; Pizzol, Massimo[1]

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Project manager: Stakenaite, Dalia[2]

Project member: Tschulkow, Maxim[1]

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Methods for foreground life cycle inventory

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Methods for Life Cycle Impact Assessment

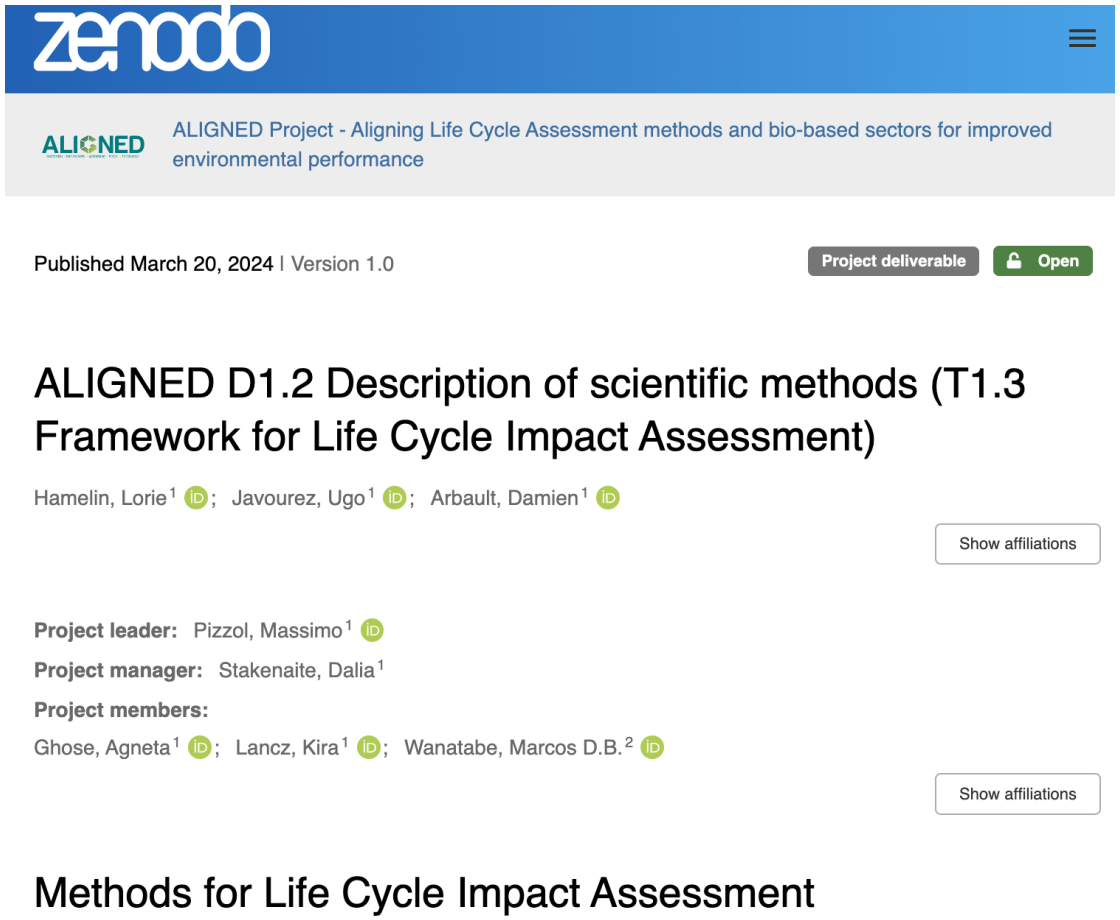
Guide on the Life Cycle Impact Assessment (LCIA) for bio-based products – Climate change and – Biodiversity

Tool for deriving dynamic characterization factors for climate change

Tutorial on including time-dependencies in the estimation of climate change midpoint scores of bio-based productions

Dataset with the Biodiversity characterization factors

Tutorial to import biodiversity characterization factors (.ipynb and html files)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ALIGNED D1.2 Description of scientific methods (T1.3 Framework for Life Cycle Impact Assessment)

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Project leader: Pizzol, Massimo[1]

Project manager: Stakenaite, Dalia[1]

Project members:

Ghose, Agneta[1]; Lancz, Kira[1]; Wanatabe, Marcos D.B.[2]

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Methods for Life Cycle Impact Assessment

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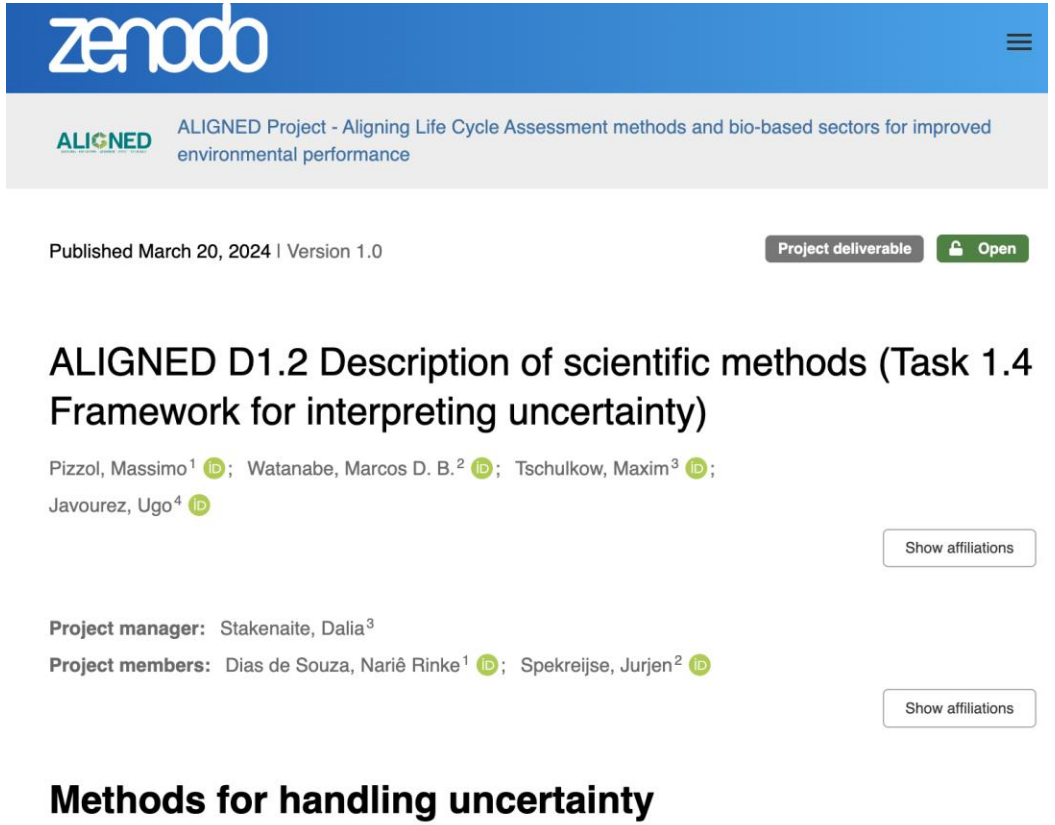
Methods for handling uncertainty

Guide on the appraisal of uncertainty in the LCA of bio-based products

Calculators (.xlsx file) for uncertainty using pedigree matrix, uncertainty estimates from measurement data, sensitivity ration, analytical error propagation

Tutorial (.ipynb and .html files) for assessment of model uncertainty, comparative Monte Carlo simulation, One at Time (OAT) sensitivity analysis, Global Sensitivity Analysis (GSA) using correlation and with FAST method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ALIGNED D1.2 Description of scientific methods (Task 1.4 Framework for interpreting uncertainty)

Pizzol, Massimo[1]; Watanabe, Marcos D. B.[2]; Tschulkow, Maxim[3]; Javourez, Ugo[4]

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Project manager: Stakenaite, Dalia[3]

Project members: Dias de Souza, Nariê Rinke[1]; Spekreijse, Jurjen[2]

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Methods for handling uncertainty

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Methods for socio-economic assessment

Model description for techno-economic assessment for technologies within the bio-based sectors

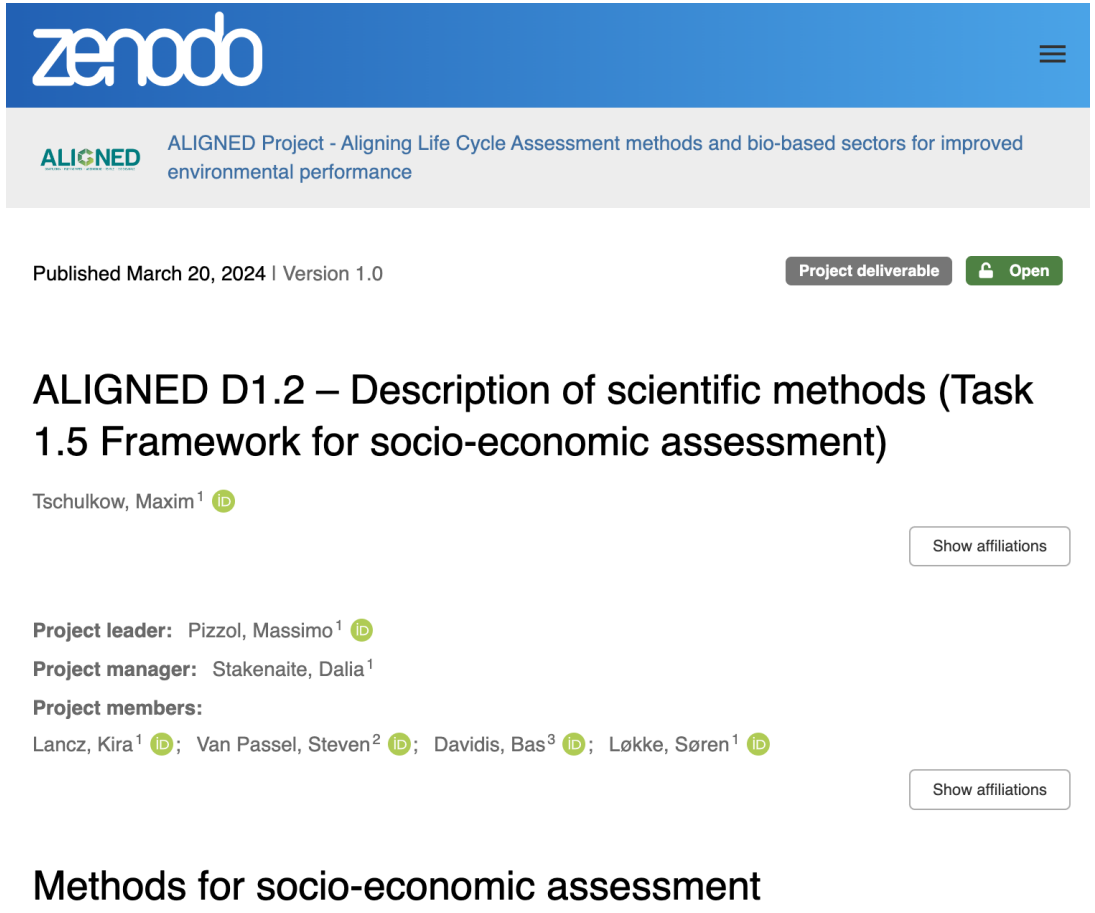
Tool for techno-economic assessment (.xlsx file)

Model description for the quantification of social indicators within the bio-based sectors

Tool for the quantification of social indicators (.xlsx file)

Model description for Stochastic multi-criteria decision analysis

Tool for stochastic multi-criteria decision analysis (.xlsx file)



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ALIGNED D1.2 – Description of scientific methods (Task 1.5 Framework for socio-economic assessment)

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Project manager: Stakenaite, Dalia[1]

Project members:

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Methods for socio-economic assessment

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ALIGNED CASE STUDIES

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WP2-6, 9 case studies in five bio-based sectors

- Currently applying the framework on 5 cases (until March 2025)
- Evaluate real world environmental improvements
- Evaluate effectiveness of the methods
- Further method refinement based on feedback

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Sector	Partners involved (WPL + industrial partners)	Subfield and location	Short summary of the case study
Construction	INSAT, KING (WP2)	Insulation, Netherlands	• Bio-based phenolic foams used as insulation materials. Phenol replaced by lignin and phenol fully replaced by bio-based oil • New mechanical recycling process
Woodworking	ANTW, FOR (WP3)	Chemical treatment, Netherlands	• Use alternative wood-working feedstocks such as untreated, treated, and painted timber for façade applications. • New types of fencing applications
Bio-based textiles	BTG, UTEX, CENT (WP4)	Work clothing, Belgium	• Recycling of work clothing containing both polyester and cotton fibres • Valorisation of waste cotton fibres from shredding
Pulp and paper	AAU, BLOOM (WP5)	Lignin products, Switzerland	• Biorefinery focusing on lignin valorization using aldehyde assisted fractionation to produce multiple products such as lignin polymers, oligomers, cellulose.
Bio-based chemicals	NTNU, OLEON (WP6) A4F (WP9)	Oleochemicals, France Microalgae, Portugal	• Impact of different vegetable oil use in the production of consumer products. • Impact of different improvements for energy and water savings in the production of microalgal-based biochemicals

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CONCLUSIONS

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Concluding remarks

- Our methods are open here – you are welcome to try them on your case study

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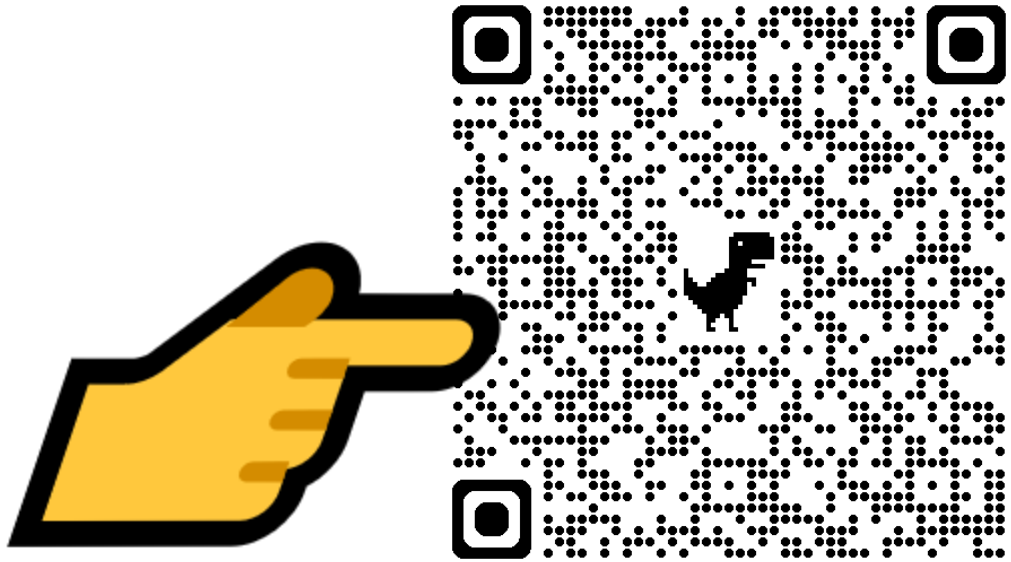
- …and we would like to hear from you afterwards
- ***Help us improving the ALIGNED tools:*** ***provide a feedback on your user experience***



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THANK YOU

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