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Sustainability Transition Assessment and Research of Bio-based Products

Project completed: final newsletter with main results and outputs

Newsletter Issue 6



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Dear <<First Name>> <<Last Name>>, with a bit of sadness and a lot of pride, we report that our project on the sustainability assessment of bio-based products, [STAR-ProBio](#), has finished. This last newsletter presents our completed Smart Tools, summarizes our main findings as presented at our [final workshop](#). You can find all our public [deliverables here](#), and summarize their results and conclusions per topic in [posters and presentations](#). Keep this email as an easy reference to all our work and [forward](#) it to anyone you think can use our results! We say goodbye, but don't worry, you can continue to reach us at projectmanager@STAR-ProBio.eu

Foreword by the project coordinator



Prof. Piergiuseppe Morone
 (Unitelma Sapienza - University of Rome)

The research and coordination activities conducted over the last three years in the STAR-ProBio framework have marked one of the most exciting periods of my professional life. Its conclusion, which occurs under very difficult circumstances due to the outspread of the COVID-19 and the social distancing mitigation measures taken by most European governments, marks probably the beginning of something new both in my professional and personal life and the word "sustainability" now echoes in my mind with the word "vulnerability".

Although we are now overwhelmed by the ongoing crises, I'm deeply convinced that we will have to re-think sustainability once this pandemic will be over, and put more efforts in promoting sustainable habits, sustainable thinking and sustainable lives. Otherwise, the only lesson learned would be how to cough and sneeze in our elbow!

On a more prosaic note, let's take stock of what we have achieved in this three-year research journey. STAR-ProBio moved along three lines of enquiry:

In this Newsletter:

Our project is over... Too many results to fit in a newsletter, but

1. The development of tools for assessing sustainability
2. The development of a policy assessment tool for scenario analysis

[workshop](#) summarized the project, and this newsletter in turn summarizes that, **so if you read only one thing about this project, read this!**

- Looking for a bit more detail on our **final findings and conclusions**, without going through our reports? We have prepared [posters and presentations](#) for each of our topics!
- Our project already produced **26 peer-reviews publications**, and more to come, check out the latest ones
- The final update on our 9 technical work packages can be found [here](#), and the latest public deliverables are described [here](#)

With this newsletter we say goodbye, and thank you for your interest. Our website www.STAR-ProBio.eu and our email address projectmanager@STAR-ProBio.eu will remain active.



Key results have been achieved in each of these areas of investigation. As this is the final newsletter of our project, I will try to briefly touch upon each of them to tease readers' interest in our project and stimulate curiosity in our findings.

Sustainability assessment tools (SATs-ProBio):

SAT-ProBio framework demonstrates the applicability of STAR-ProBio results to the existing landscape of bio-based product certification schemes and sustainability assessment. SAT-ProBio is composed of four self-contained **smart tools** to be used as an integrated framework or separately. The first tool proposes criteria and indicator factsheets to serve as building blocks (BB) of our sustainability assessment. The second tool provides users with a benchmarking platform (BP), valuable to stakeholders and market actors working with existing product certification schemes. The third tool, the integrated assessment tool (IAT), delivers methodological guidance for conducting an integrated assessment of bio-based products, addressing, from a life cycle perspective, their most relevant sustainability aspects. IAT is accompanied by a scoring system that allows to quantify how well a bio-based product performs compared to an "ideal performance". Finally, the fourth tool, describes framework conditions and management rules (FR) in the practice of certification process.

If you are interested in any of these, do contact us and we will send you the smart tools!

System dynamic model for policy analysis (SyD-ProBio):

Given the complex and cross-cutting nature of the policy arena for bio-based products, SyD-ProBio builds on a multi-stakeholder perspective and is addressed to EU and Member States policy makers working for the improvement of the policy framework guiding the promotion of sustainable bio-based products (with biopolymers used as a case study).

SyD-ProBio puts forward a user-friendly interface, which allows users to create their own scenarios and compare simulation results, by just browsing the "Simulation lab". For those really into modelling, SyD-ProBio has an "About the model" section, where experts can learn about the model design (e.g. system boundaries, hypotheses, internal feedback loops and time delays, policy instruments tested).

If you are interested in this project outcome, do contact us and we will send you the SyD-ProBio smart tool and a link to the on-line modelling platform!

Bio-based markets assessment:

Along covering gaps in the existing framework for sustainability assessment, STAR-ProBio aimed at identifying measures for the market uptake of bio-based products. One of the main elements of the empirical analysis conducted to address this objective was a field experiment designed to elicit consumers' willingness to pay for bio-based products. Our findings show, among others, that sustainability certifications (social and environmental, such as eco-label) lead to an extra green premium and that the demand for conventional products is in general more elastic than the demand for bio-based and certified bio-based products. This latter result leads to some interesting (we believe) policy implications.

If you are interested in these results, do contact us and we will send you a policy brief stemming from this work!

None of these outputs would have been possible without the commitment of all members of the consortium. We created an amazing team, which has worked in close collaboration for three years, exchanging ideas, learning from each other, and growing together. Thank you to all of you!

Rome, 01/04/2020
Piergiuseppe Morone

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STAR-ProBio project final Workshop:

Assessing Sustainability of Bio-based Products:

Where do we stand?

The final STAR-ProBio international workshop, originally planned as an in-person event in Brussels, was converted into a highly successful online event, held on the 28th April 2020. [The 2.5 hour workshop](#), attended by 140 participants, was entitled "Assessing Sustainability of Bio-based Products: Where do we stand?". Its welcome address was given by the Italian Minister of Environment, followed by presentations from 8 project partners divided over 3 sessions: Identifying the way forward, Blueprint for a sustainability scheme and assessment tools, and Policy challenges in the European Green Deal era. The workshop finalized with a Q&A session including the most voted questions, that attendees could submit and vote on during the event. [Links to the presentations are available in the text below.](#)

The workshop was hosted by Sergio Ugarte from SQ Consult and chaired by Professor Piergiuseppe Morone, from UNITELMA, co-ordinator of the STAR-ProBio project.

Prof. Morone summarised the background and context for the project, explaining the importance of a transition towards a sustainable circular bioeconomy. But how to measure the sustainability? Here, the work from STAR-ProBio can help in three different ways: (1) Metrics and indicators for assessing the sustainability (economic, social and environmental), (2) Market assessment – the chances of these new products to penetrate the market, and (3) Policy analysis.

In his welcome address, Mr Sergio Costa, Italian Minister of the Environment, explained that he and other Environment Ministers throughout Europe continue to work on promoting a transition towards the circular economy, despite the challenges faced at the moment. He added that the results from the project can be exploited at the European level.

In the session "Identifying the way forward", [Mathilde Crêpy from ECOS discussed](#) the bioeconomy strategy and the role for schemes and labels, and where STAR-ProBio can help.

Subsequently, [Luana Ladu from TUB shared](#) the findings on the acceptance bio-based products, regarding the differences between consumers and businesses and the preferences regarding social, economic and environmental aspects. She also shared the results of a field experiment with consumers to address the questions: Are consumers willing to pay more for bio-based products than for fossil-based products? and Do certifications/ labels on bio-based products affect the consumers' willingness to pay? Further results and conclusions can be found in Deliverables [D5.1](#) and [D5.2](#).



The second session of the workshop focussed on the blueprint for a sustainability scheme and smart assessment tools. [Francesco Razza from Novamont introduced](#) the Integrated Assessment Tool (IAT) developed in the project: which problems it can address, how it relates to the UN SDGs, how it works and the lessons learnt. The IAT is one of the project's smart tools, [take a look the IAT brochure](#) to quickly see how this tool may be useful for you.

The next STAR-ProBio Smart Tool, the Sustainability Certification Tools (SCT) was [presented by Eva Merloni](#)

[from UNIBO](#), explaining how to operationalise all sustainability criteria and indicators, and the setting up of a benchmarking platform for sustainability certification schemes that identify their common denominators, propose a mechanism for self-improvement and include recommendations to improve their Framework Management Rules. [Anyone with an interest in sustainability certification](#) should definitely look at the SCT brochure, to discover the potential of the smart tools it contains.

The final session of the workshop "Policy challenges in the European Green Deal era" started with another



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products against fossil-based products. The model's background, methodology, a live demonstration and conclusions and further work were shown, and concisely summarised in [this SyD-ProBio brochure](#), a must-read for anyone with an interest in bio-economy policy options.

[Sergio Ugarte of SQ Consult](#) shared the project's recommendations for co-regulation as a valuable policy option for regulating a high level of sustainability of bio-based products at the EU level, while leaving the difficult task of proving sustainability in a cost-effective way largely to the market players. [Read the report with recommendations, D9.3, here.](#)

Stefan Majer from DBFZ discussed the importance and the options for effective monitoring of sustainability impacts in the EU bioeconomy and how the STAR-ProBio results can help, [summarising the full report, D9.4.](#)



During the presentations, attendees were invited to submit questions using [Slido](#). This offered both the possibility to ask a new question and the chance to "upvote" an existing question. The questions with the most votes were answered by live by the project's experts in the Q&A session led by Sjors van Iersel from SQ Consult. All 40+ questions were transformed into an FAQ document that can be found [here](#).

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STAR-ProBio Book

New STAR-ProBio book "Transition Towards a Sustainable Biobased Economy"

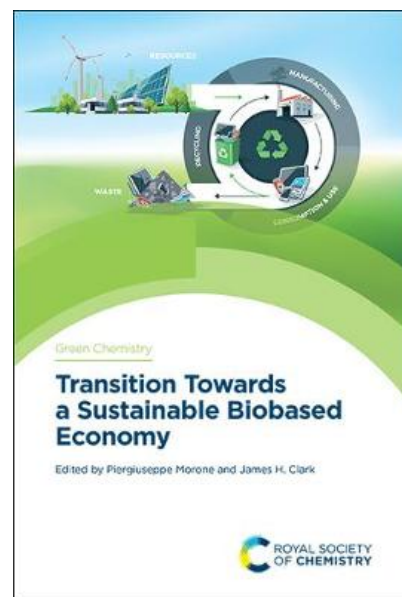
A new book by Piergiuseppe Morone and James Clark in the RSC Green Chemistry Series, *Transition Towards a Sustainable Biobased Economy*, is out now.

Globally we are being confronted by the depletion of many natural resources as a result of unsustainable use and increasing global population. Although the debate on the bioeconomy has gained momentum in recent decades, the interest in certifications and standards for biobased products is still weak. This book aims to fill this gap by promoting a holistic approach, which covers environmental, social and economic sustainability aspects and pushes forward the development of a circular, biobased economy.

This book promotes the development of sustainability schemes (including standards, labels and certifications) for the assessment of biobased products, which are fundamental to the establishment of a cutting-edge sustainable bioeconomy. Chemical-related, globally relevant case studies are used throughout the book. The content covers a range of issues from upstream and downstream environmental, techno-economic and social assessment, to crosscutting issues such as indirect land use change (iLUC) and end-of-life options. The chapters included in this book will provide a comprehensive review of recent works on life cycle assessment (LCA), life cycle costing (LCC) and social life cycle assessment (s-LCA) methodologies.

An important resource for researchers, industrial professionals and policy makers involved in the bioeconomy.

Read more on the [RSC website](#).



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Read More about STAR-ProBio Research

Recenty Completed Deliverables

With the culmination of the project, also many research lines published the final results in interesting reports :

- [Deliverable D2.4](#): Environmental impact assessment of feedstock production and upstream processing. This report investigates the environmental impacts of feedstock production and upstream processing, as regards the STAR-ProBio case studies, by means of LCA.

stakeholders.

- [Deliverable D7.2](#): Land Use Changes applied to the case studies: Land use change effects induced by policies for the promotion of bio-based products have become one of the most important aspects for the development of a sustainable bioeconomy policy framework. This report summarises the solutions for low iLUC risk certification developed by STAR-ProBio WP7.
- [Deliverable D7.3](#): Set of recommendations for land use policies: The increased production and consumption of biomass renewable based materials and fuels could lead to substantial changes in the way land is used. This report focuses on land use governance mechanisms enabling to mitigate the risk of the unwanted effects of land use change, whenever the use of renewable raw materials is promoted in policies and legislation.
- [Deliverable D8.2](#): Blueprint of sustainability certification schemes for bio-based products: Blueprint of sustainability certification schemes for bio-based products is structured in SAT-ProBio framework. It contains two key tools: (1) a sustainability assessment tool (IAT) – for the assessment of specific bio-based products enabling also the comparison of the bio-based products against fossil-based products, and (2) the sustainability certification tools (SCT) – as an overarching umbrella, describing the methodological framework and underpinnings.
- [Deliverable D8.3](#): Fast-track documentation for the procedure of certification of biobased products: This document is developed as part of the work under the STAR-ProBio project and is intended as a basis for a standard (national or industry).
- [Deliverable D9.3](#): Proposal for a co-regulation framework for the use of sustainability certification schemes in the production of bio-based products: This report puts forward a proposal for a co-regulation framework to introduce the use of sustainability assessment tools (and in particular, certification schemes) in a co-regulative framework for the market uptake of the broader bio-based materials and products.
- [Deliverable D9.4](#): Potential links to BE monitoring activities and their support by STAR-ProBio results: Analysis of the current activities for a monitoring of the Bioeconomy and its sectors and discussed the potential contribution with data from sustainability certification, which can be considered a growing activity in the EU Bioeconomy. This analysis has revealed a huge potential of useful data from certification activities, which could potentially support Bioeconomy monitoring in the future, when the overall share of certified biomass has increased and more, centralistic database structures would be established.
- [Deliverable D9.5](#): Report on policy effectiveness and alternative scenarios comparison: tested recommendations for framework conditions and coherent policy portfolios for a level playing field towards increasingly sustainable production and consumption patterns. For this, the SyD-ProBio model is co-developed with various stakeholder groups in a “systems science based and stakeholder participatory group modelling” process.

Publications

B. Santiago, A. Arias Calvo, B. Gullón, G. Feijoo, M.T. Moreira & S. González-García, **Production of flavonol quercetin and fructooligosaccharides from onion (*Allium cepa* L.) waste: An environmental life cycle approach**, *Chemical Engineering Journal*, 2019, 123772, <https://doi.org/10.1016/j.cej.2019.123772>; written by Universidade de Santiago de Compostela relevant to the work of WP2 and WP3.

E. Olba-Zięty, M.J. Stolarski, M. Krzyżaniak & J. Gołaszewski, **Environmental external cost of poplar wood chips sustainable production**, *J. Clean. Prod.*, 2020, 119854; <https://doi.org/10.1016/j.jclepro.2019.119854>; Open Access; written by UWM relevant to the work of WP8.

I. Câmara Salim, F. Almeida-García, S. González-García, A. Romero-Rodríguez, B. Ruíz-Nogueiras, S. Pereira-Lorenzo, G. Feijoo & M.T. Moreira, **Life cycle assessment of autochthonous varieties of wheat and artisanal bread production in Galicia, Spain**, *Sci. Total Environ.*, 2020, 713, 136720; <https://doi.org/10.1016/j.scitotenv.2020.136720>; written by Universidade de Santiago de Compostela relevant to the work of WP2

S. Wurster & L. Ladu, **Bio-based products in the automotive industry: the need for ecolabels, standards, and regulations**, *Sustainability*, 2020, 12(4), 1623; DOI: <https://doi.org/10.3390/su12041623>; Open Access; written by TU Berlin relevant to the work of WP9.

I. Wojnowska-Baryła, D. Kulikowska & K. Bernat, **Effect of bio-based products on waste management production**, *Sustainability*, 2020, 12, 2088; <https://doi.org/10.3390/su12052088>; Open Access; written by UWM relevant to the work of WP3.

D. Moosmann, S. Majer, S. Ugarte, L. Ladu, S. Wurster & D. Thrän, **Strengths and gaps of the EU frameworks for the sustainability assessment of bio-based products and bioenergy**, accepted for publication in *Energy, Sustainability and Society*, 2020, written by DBFZ, SQ Consult & TUB relevant to the work of WP9.

P. Morone & J.H. Clark (2020), **Transition Towards a Sustainable Biobased Economy**. *RSC Green Chemistry Series*, <https://doi.org/10.1039/9781839160271>

P. Morone, **Special Issue on: Standards for a Bio-Based Economy**, *International Journal of Standardization Research (IJSR)*, 2019, 17(1), 1-84; <https://www.igi-global.com/journal/international-journal-standardization-research-ijrsr/145878>; written by Unitelma and TUB relevant to the work of WP5 and WP6.

104753; <https://doi.org/10.1016/j.resconrec.2020.104753>; written by Novamont & UNIBO relevant to the work of WP8.

S.M. Ioannidou, C. Pateraki, D. Ladakis, H. Papapostolou, M. Tsakona, A. Vlysidis, I.K. Kookos & A. Koutinas, **Sustainable production of bio-based chemicals and polymers via integrated biomass refining and bioprocessing in a circular bioeconomy context**, *Bioresource Technology*, 2020, 307, 123093; <https://doi.org/10.1016/j.biortech.2020.123093>; written by AUA relevant to the work of WP4.

M. Witkowska-Dąbrowska, A. Napiórkowska-Baryła & N. Świdwińska, N. **Harmonization of criteria and operationalization of sustainable development indicators in the assessment of bioproducts**, *Economics and Environment*, 2020, 1(72), 58-73; <https://doi.org/10.34659/2019/1/4>; Open Access; written by UWM relevant to the work of WP8.

M. Witkowska-Dąbrowska, N. Świdwińska & A. Napiórkowska-Baryła, **Meeting the Europe 2020 Strategy sustainable development guidelines by Poland**, *Research Papers of Wrocław University of Economics*, 2019, 63(9), 103-116; <https://doi.org/10.15611/pn.2019.9.09>; Open Access; written by UWM relevant to the work of WP8.

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STAR-ProBio Dissemination & Communication

STAR-ProBio Workshops

STAR-ProBio/ICT-BIOCHAIN joint webinar

The STAR-ProBio project participated in the train-the-trainer webinar held on 2 April 2020. During the webinar, the ICT-BIOCHAIN (organiser) and STAR-ProBio presented the tools they developed to enhance efficiency in the biomass supply chain and sustainability in the bio-based industry respectively.

Watch the recording of the webinar at: www.youtube.com/watch?v=NkteNrsU0Ss



Conferences and Events

STAR-ProBio researchers have been out and about in recent months promoting our work at a range of different conferences and events including the following:

Luana Ladu of the Technical University of Berlin attended the **14th European Bioplastic Conference**, in order to distribute material and make contact with experts for getting feedback on the IAT. The conference was held on 2-3 December 2019 in Berlin, and was attended by ca. 500 scientists and industry NGOs from around the world.

Piergiuseppe Morone of Unitelma Sapienza gave an invited talk in a panel within the session "Standardisation, LCA, labelling and regulatory hurdles" at the **BBI JU Stakeholder Forum 2019**. The event took place on 3-4 December 2019 in Brussels, Belgium and was attended by ca. 300 scientists, researchers and policy makers from across Europe. The STAR-ProBio brochure was also distributed among all participants.

On 24 January 2020, **Piergiuseppe Morone** also presented STAR-ProBio at a BIOVOICES workshop in Udine, Italy, entitled "Bioeconomia in Friuli Venezia Giulia - Focus Sulla Formazione e l'Orientamento a Supporto di uno Sviluppo Sostenibile e Circolare". Around 150 industry representatives, scientists, researchers and policy makers were in attendance.

Janusz Gołaszewski of University of Warmia and Mazury in Olsztyn represented the STAR-ProBio project at the **8th International Conference on Sustainability, Technology and Education 2020 (STE 2020)** in Sao Paulo, Brazil on 5-7 February. Janusz gave an oral presentation to around 70



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STAR-ProBio Work Package Updates

The STAR-ProBio Work Package leaders provide updates on what has been achieved since the last newsletter.

WP2: Upstream environmental assessment

One of the routes to boost the bioeconomy and reduce the use of fossil fuels is based on the production of bio-products, made from renewable raw materials. However, bio-products must be produced responsibly, taking into account, from the first stage of development, their environmental, techno-economic and social viability. The production of bio-products may also involve competition with food and feed markets, as well as land use issues.

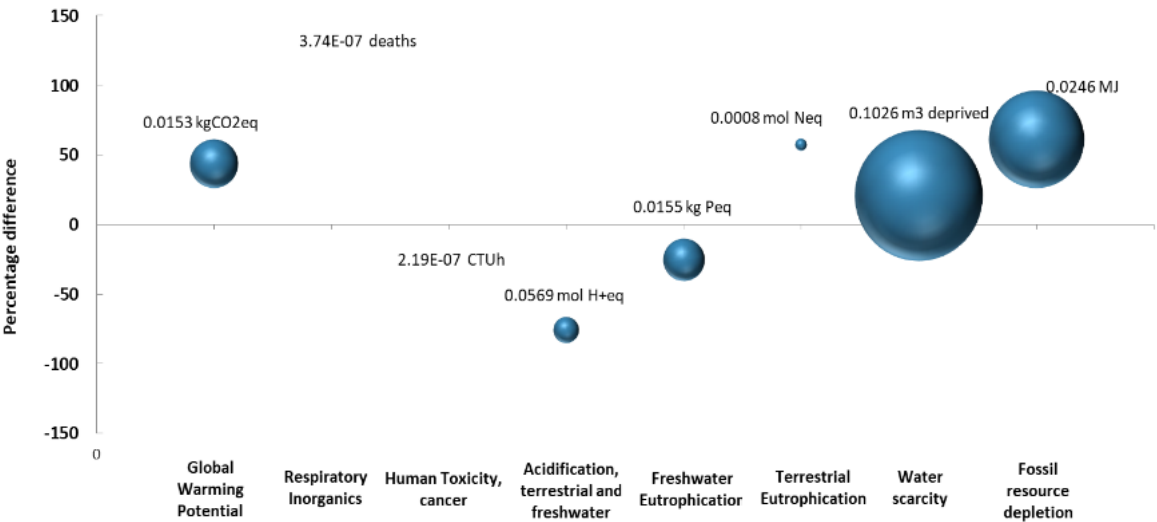
WP2 investigates the environmental impacts of feedstock production and upstream processing, with reference to the STAR-ProBio case studies. The feedstocks considered for the production of the case studies are fermentable sugars from sugar beet pulp, maize grain and maize stover. Fermentable sugars (e.g. glucose) are interesting renewable materials for producing a variety of bio-products, for instance, polylactic acid (PLA) and polybutylene succinate (PBS).

In this last stage of the STAR-ProBio project, Task 2.5 is being developed, which comprises the results of the life cycle assessment of the upstream processing of bio-based products. This assessment is the result and complement of a robust work carried out in the previous Tasks and Deliverables of WP2, where a review of environmental indicators related to bio-based products, system boundaries for WP2, a selection of environmental indicators and impact methods for bio-based products and life cycle inventory for WP2 were carried out.

WP3: Downstream environmental assessment aims to develop an environmental assessment framework covering the stages between manufacturing and end-of-life management of bio-based products. This framework will feed into the overall sustainability assessment blueprint, the ultimate deliverable of STAR-ProBio.

Life Cycle Assessment (LCA) was chosen as the method of choice, acknowledging its robust nature and capability at encompassing product and process-level environmental impact. A review of national and international standards, certification protocols and 85+ peer-reviewed publications, helped identify gaps in the existing methods of environmental sustainability evaluation. Resource efficiency and circularity characteristics of bio-based products and their production processes were seldom addressed in these schemes and studies. Moreover, such environmental evaluations provided limited coverage on the end-of-life characteristics and management of post-consumer products. A set of environmental indicators, drawn from LCA and from the principles of green chemistry and circularity (hybridised indicators) were selected or developed (where lacking) to draw an environmental framework that will address resource consumption-level impacts, in addition to addressing resource efficiency and circularity characteristics of the production process.

The selected environmental indicators were tested for effectiveness through application to a combination of bio-based and fossil-derived products as dedicated case studies. A comparative environmental impact assessment employing LCA, incorporating resource efficiency analysis was undertaken. An example of their application to one of the case studies and a reflection of the impacts as expected to be reported in the sustainability assessment tool has been presented in Figure 1.



The proposed set of indicators were valuable in bridging some of the key gaps in existing environmental sustainability assessments, capturing the resource efficiency and circularity, in addition to expanding their boundaries for a wide range of products and product groups. Further refinements through engagement with industrial stakeholders and reaching a scientific consensus on developing science based targets for environmentally efficient product development, use and disposal marks the next necessary steps.

WP4: Techno-economic assessment

The AUA team, of the "Natural Resources & Agricultural Engineering" (NRAE) Department, has been working during the last year of the project on Deliverable D.4.2., "Definition of techno- economic sustainability criteria and LCC indicators for bio-based products". The methodology to define the TESA principles and to develop criteria and indicators for the alternative EoL options of post-consumer/industrial bio-based products has been completed and it is presented in the D4.2 document. Furthermore, the illustrative implementation of the proposed TESA criteria and indicators of alternative EoL options in the selected case studies has been completed. The inventory and the relevant data have been used to perform Life Cycle Cost Analysis (LCCA) and the relevant analysis of the packaging case study using polylactic acid (PLA) and the reference polypropylene (PP) material. The LCCA of the mulching film case study is in progress. For the dissemination phase, a paper on the recirculation potential of post-consumer /industrial bio-based plastics through mechanical recycling has been prepared and will be submitted for publication. The chapter entitled "Technoeconomic Sustainability Assessment: Methodological Approaches for Biobased Products" by D. Briassoulis, A. Koutinas, J. Gołaszewski, A. Pikasi, D. Ladakis, M. Hiskakis, M. Tsakona, was published in the RSC book "Transition Towards a Sustainable Biobased Economy", edited by P. Morone and J.H. Clark.

The Department of Food Science and Nutrition (DFSN) AUA team is also working on Deliverable D.4.2. The design of the selected case studies of the project (PBS biopolymer, PLA biopolymer and mulch film) is described in D4.2 document and the inventories of the mass and energy balances of the manufacturing stage as well as the methodology described in D4.1 are used in order to implement the proposed TESA criteria and indicators. Moreover, the externalities of each case study for the manufacturing stage are estimated and presented according to the Life Cycle Cost Analysis (LCCA) methodology. Furthermore, a comparison with the fossil counterparts is performed. The combination of externalities from manufacturing stage with those during EoL stage is in progress, so as to present the results from an overall perspective. As for the dissemination phase, a paper entitled "Sustainable production of bio-based chemicals and polymers via integrated biomass refining and bioprocessing in a circular bioeconomy context", by S.M. Ioannidou, C. Pateraki, D. Ladakis, H. Papapostolou, M. Tsakona, A. Vlysidis, I.K. Kookos and A. Koutinas, members of the DFSN of AUA, was accepted in an international journal for publication. Furthermore, an ongoing paper related to PBS and PLA manufacturing stage by considering different types of feedstock and implementing the LCCA methodology is prepared for publication. One more publication is under study considering the mulch film life cycle up to the factory gate.

WP5: Market Assessment

Considering consumer preferences regarding sustainability is a key factor towards the market-uptake of bio-based products. Within a European perspective, WP5 aimed at identifying sustainability preferences of different consumer groups (private consumers, businesses and public procurement) regarding environmental, social and economic aspects. It also studied the propensity to buy bio-based products and the importance of product characteristics, such as performance and quality in influencing buying decisions.

The methods for data collection adopted include a Delphi Survey, a Focus Group Exercise and a Field Experiment. Professionals participated in a three round Delphi study, providing respectively, 344, 100 and 41 responses. Consumers participated in a two-round Delphi study, with respectively 744 and 80 responses. The majority of all target groups regard information related to all three sustainability pillars as relevant for their buying decisions. However, environmental aspects essential for the highest share of respondents. According to the experts, policy makers could promote acceptance of bio-based products by adopting the following measures: 1. Properly communicating the benefits of bio-based products; 2. Public procurement; 3. Taxation and subsidies; 4. Labels, certificates and standards; 5. Legislation including bans.

The experiment was conducted in an IKEA store in Bari (Italy) in April 2019. In total, 360 customers participated in the experiment providing 1080 observations. The results show the presence of a "green premium" for both bio-based and certified bio-based products. In particular, the presence of a sustainability certification (label) favours a greater consumers' willingness to pay (WTP). The experiment also revealed that the estimated aggregated demand curves for conventional products showed convexity, while the estimated aggregated demand curves for certified goods showed concavity. This means that it is confirmed that the price of bio-based products significantly influences its market share.

The activities related to WP5 were finalized in August 2019 and the results are included in the following two publicly available deliverables:

- [Deliverable D5.1](#): *Acceptance factors among consumers and businesses for bio-based sustainability schemes*
- [Deliverable D5.2](#): *Results of the experiment / Case study*

WP6: Social assessment aims to assess the social and socio-economic impacts of bio-based products, utilizing the Social Life Cycle Assessment (SLCA) methodology in order to make the assessment comparable with the analysis carried out by the WPs involved in environmental and techno-economic evaluations.

Focusing on the social items identified by the literature on social sustainability, grey literature and S-LCA applied to bio-based products, we propose a preliminary value item list that has been validated and integrated as a further step (see D6.1).

6.2 Stakeholders mapping and analysis and 'value items' validation

Task 6.2 focuses on: i) a stakeholder analysis for identifying and categorizing stakeholders according to their power and interest with regards to bio-based products development (Figure 1); and ii) the validation, through 4 workshops a participatory approach engaging the identified stakeholders, of the list of social impact categories, subcategories and indicators (Figure 2). This allows defining a social impact framework tailored to bio-based products - (see D6.2).

6.3 Impact categories and indicators for S-LCA

The objective of Task 6.3 regards the selection of the most important impact subcategories for the social analysis of bio-based products and the development of a specific methodology to measure them. Considering the final list of subcategories, a simple, flexible and practical methodology was developed and adapted to analyse the social performance of bio-products. The methodology considers the five categories of stakeholders: workers, consumers, local community, general society and value chain actors using several indicators. Finally, this Task provides a final score that embodies the overall social performance of the production of a specific bio-product (Figure 3) - (see D6.3).

6.4 Development of social and socio-economic criteria and indicators for end-of life analysis

Task 6.4 is focused on existing End of Life (EoL) options, with the aim of identifying key community priorities for sustainable EoL management of bio-based products. This is achieved by developing a win-win asset-based model (Figure 4) that has been tested on a selected case study, i.e. Poly Lactic Acid (PLA)-based packaging film. The results show that recycling (both mechanical and chemical) is the best EoL option for the considered product (Figure 5) - (see D6.4).

6.5 Actions to promote social acceptance

Task 6.5 shows the actions to increase social acceptance of bio-based products. It is stimulated through the development of promotional materials for different audiences. A good communicative strategy is crucial to ensuring that the message is properly received by different stakeholders - (see D6.5).

References

- D6.1 Preliminary draft of "value items" (confidential)
- D6.2 Stakeholders' map and validated list of "value items" (confidential)
- D6.3 Criteria and indicators developed for conducting S-LCA social impact assessment (public)
- D6.4 Report on end-of-life social and socio-economic assessment (public)
- D6.5 Actions to promote social acceptance (public)

WP7: ILUC risk assessment for bio-based products has been set up to contribute to and potentially complement existing tools and approaches to assess the iLUC risks of bio-based products, support the certification of potential low iLUC risk biomass and elaborate related policy recommendations.

To do so, in contrast to several existing studies, aimed at assessing iLUC risks on a broader, system level, our activities address mainly the producers of biomass and bio-based products, certification bodies and policy makers. In fact, the System Dynamics indirect Land Use Change (SydILUC) model has been translated to a user-friendly tool (iLUC Risk tool) which could be used: by policy makers to assess low iLUC risk strategies; by producers to reduce their relative iLUC risk; and by auditors to rank different biomasses/bio-based material by iLUC risk. Furthermore, taking into consideration a set of variables (iLUC risk Factors, e.g. different agricultural yields, different use of co-products, different types of bio-based material produced), the iLUC Risk Tool estimates the change in iLUC risk level as a result of the implementation of certain low iLUC risk practices, like the efficiency-related practices (improved chain efficiency, additional agricultural yield increase, use of co-products in substitution of the feed).

The main findings provided by the WP7 activities are turned in *ad hoc* policy recommendations for mitigating the iLUC risk related to the production of bio-based products in Europe. These *ad hoc* policy recommendations mainly deal with the combination of various land use governance and market-based mechanisms and the identification and promotion of the low iLUC risk practices in agriculture. The implementation of an iLUC risk framework, in close connection with the general sustainability requirements of the RED 2 (including the new criteria for agricultural residues and additionality practices) provides interesting opportunities to foster a general development towards improved land use and gains in productivity in agriculture more generally. This would especially be the case if the logic of this framework was expanded to the whole EU bioeconomy in the future.

WP8: Sustainability scheme blueprint for bio-based products is addressing sustainability standards for bio-based products by channeling outputs from technical work packages of STAR-ProBio. The seven research tasks of WP8 were organized in a sequence of activities that resulted in recommendations to current standards including amplification of principles, criteria and indicators; development of blueprint for a sustainability certification scheme; and development of documentation eventually leading to European standards. In the course of SWOT/PESTEL analysis some overall criteria that require development were concluded: 1) supplementary criteria addressing efficiency of land and tertiary resource use, land change and SO₂ related emissions, PM10 pollution, and end-of-life management; 2) integrability of multiple environmental claims and socio-economic indicators; 3) improving the interoperability between all stages of supply chain and actors; 4) conceptualizing a composable system; 5) development of methodology that enables checking of cross-sectoral compatibility of different certification schemes applied along the life-cycle supply chain; 6) development of methodology on "low iLUC risk biomass"; 7) merging cross-sectoral approaches, which can reveal conflicts of interests between conventional biomass-based sectors and in the

measurable traceability indicators.

Recommendation of environmental, social and economic principles, criteria and indicators and their operationalization were discussed assuming normative issues related to benchmarking and reference product characteristics on the basis of analysis of mulch film and packaging markets, feasibility of defined sustainability thresholds definition and communication of sustainability aspects. In this context there were highlighted and recommended a set of environmental, economic and social principles, criteria and indicators; virtual reference product as a „benchmark“; threshold concepts, e.g. "sustainable threshold" per capita for GHG emissions as a „sustainable budget“; communication of environmental sustainability - a proposal of graphical communication covering information on absolute LCIA in relation to F.U., the percentage positioning in comparison with the reference product, the relevance of LCIA results with the magnitude of impact, and a single score of sustainability.

The main challenge within the STAR-ProBio project was to combine the existing elements and project results into smart and meaningful frameworks supporting the sustainability assessment of bio-based products. Within WP8 it was conceptualized the SAT-ProBio framework. SAT-ProBio framework contains two key tools: (1) a sustainability assessment tool (IAT) – for the assessment of specific bio-based products enabling also the comparison of the bio-based products against fossil-based products, and (2) the sustainability certification tools (SCT) – as an overarching umbrella, describing the methodological framework and underpinnings. The blueprint provides with information on the most relevant sustainability assessment aspects concerning bio-based products and related value chains, that can be further used by policy makers, regulatory bodies, industries, associations, and the civil society. The IAT and the three tools of SCT: Benchmarking Platform (BP), Framework Rules (FR) and Building Blocks (BB) can be applied separately or complementary. IAT can be applied by companies for sustainability self-assessment, benchmarking, eco-design and pre-check sustainability certification process; BP benchmarks participating certification schemes, identify their common denominator and gaps, and propose a mechanism for self-improvement; FR describes rules for management of certification scheme; BB translates STAR-ProBio's criteria and indicators into factsheets designed to facilitate their usage by certification schemes. All tools complement each other in the thorough sustainability assessment in the light of current regulations and construct the fundament for standard documentation.

The development of SAT-ProBio standard documentation for sustainability assessment of bio-based products was based on the approaches similar to Publicly Available Specification (PAS) or CEN Workshop Agreement (CWA). The groundwork for development of SAT-ProBio standardization document was the Integrated Assessment Tool (IAT). The elaboration of the document in standard language was coordinated by the Netherlands Standards Institute. It was assumed that SAT-ProBio standard can be a basis to develop regulations on sustainability at national or industry level.

WP9: Analysis of regulations, (eco)labelling and policy initiatives

In the final phase of our project, WP9 continued to explore links between the STAR-ProBio results and the political framework of the Bioeconomy. In that sense, [Deliverable 9.4](#) discusses the recent activities in the EU to monitor the impacts of a growing bioeconomy. In our analysis of existing monitoring projects and schemes, we found several interesting links to product and sustainability certification. One of the main conclusions of our work is that both activities, Bioeconomy monitoring and sustainability certification as well as assessment for biobased products have become established instruments that are of great interest to various stakeholder groups of the bioeconomy. The results of our analysis show a great potential for synergies between both activities. Ideally, data from increasing sustainability certification and assessment activities can support monitoring activities of the Bioeconomy in the future.

Since STAR-ProBio aims to develop, amongst others, a smart sustainability assessment framework, our Task 9.3 develops potential co-regulation mechanisms and frameworks, that could be taken up and applied by policy makers in order to effectively use the results of research projects like STAR-ProBio and others in future policy regulations.

And, finally, STAR-ProBio dedicates the last deliverable of WP9 to highlight the European policy arena and respective scenes which are potentially relevant for the market development of progressively sustainable biobased materials. To this point the SyD-ProBio tool has been developed, allowing for the illustration of the biobased materials uptake and selected relevant dynamics, such as their overall global warming potential and water or land use. Based on this tool and in the Deliverable 9.5, the impact of policy measures in-place is put in contrast to the impact of potentially upcoming policy options. In a synthesis, recommendations are drawn to describe how a level playing field with the material use of fossil fuels can be created and how the project's labelling and standardisation efforts could contribute to this.

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STAR-ProBio project end: overview of all results and conclusions

WP1 – Screening and analysis of existing sustainability schemes for the bio-economy

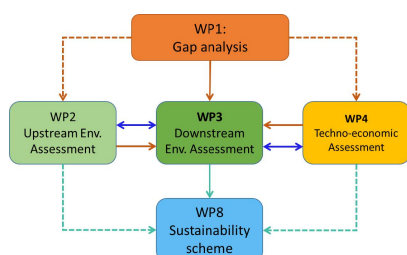
- Poster: [Gaps in Existing EU Sustainability Certification and Standardisation](#)

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A set of bags



A hand soap bar



- Poster: [Upstream Environmental Impact Assessment](#)
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WP3 – Downstream environmental assessment

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WP4 – Techno-economic assessment

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WP5 – Market assessment

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WP6 – Social assessment

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WP7 – ILUC risk assessment for bio-based products

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WP8 – Sustainability scheme blueprint for bio-based products

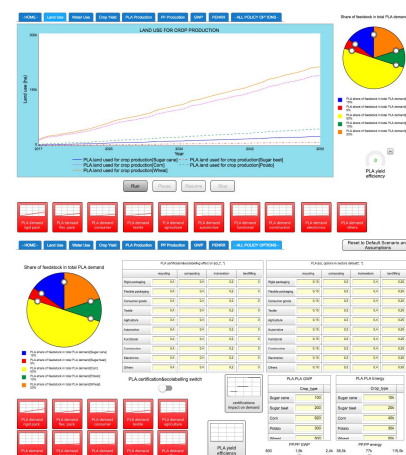
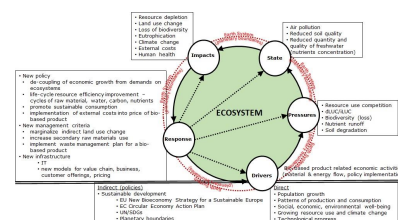
- Poster: [Sustainability scheme blueprint for bio-based products](#)
- Poster: [Integrated Assessment Tool \(IAT\)](#)
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- Presentation: [Integrated Assessment Tool](#)
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WP9 – Analysis of regulations, (eco)labelling and policy initiatives

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WP10 – Knowledge transfer, training and dissemination

- Poster: [Knowledge transfer, training and dissemination](#)

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STAR-ProBio Project Management
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**Sustainability Transition Assessment
and Research of Bio-based Products**



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Work Programme BB-01-2016: Sustainability schemes for the bio-based economy

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