MAINSTREAM BIO

MAINSTREAMING SMALL-SCALE BIO-BASED SOLUTIONS ACROSS RURAL EUROPE

D2.4 - Initial version

MainstreamBIO methodology for matching available biomass and waste streams with market and technology information

WR, QPLAN, AUP, INNV & DRAXIS

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ABBREVIATIONS

BM	Business Model
CAT	Circular Assessment Tool
CMC	Carboxymethyl cellulose
CO2	Carbon dioxide
DME	Dimethyl ether
DoA	Description of Action
DSS	Decision Support System
EU	European Union
GHG	Greenhouse Gas
HTL	Hydrothermal liquefaction
ICT	Information and Communications Technology
IEA	International Energy Agency
MCDM	Multi-criteria decision making
MIPs	Multi-Actor Innovation Platforms
NRP	Nutrient recycling practice
PE	Polyethylene
PEF	Polyethylene 2,5-furandicarboxylate
PET	Polyethylene terephthalate
PHA	Polyhydroxyalkanoates
PLA	Polylactic acid
R&D	Research & Development
SI	Social Innovation

SME	Small and Medium-sized Enterprise
SNG	Synthetic Natural Gas
SSO	Source Separated Organics
TRL	Technology Readiness Level
VC	Value Chain
WP	Work package

Executive Summary

MainstreamBIO is a HORIZON Coordination and Support Actions project funded by the European Union under grant agreement 101059420. It started in September 2022 and will have a duration of 36 months (August 2025). The project aims to co-develop innovation support services and digital tools to build awareness, understanding and capacity to uptake small-scale bio-based solutions in line with market demand and regional specificities. As part of the project activities related to the development of the MainstreamBIO digital toolkit, the present report presents the work performed in Task 2.4 'Development of a methodology for matching available biomass and waste streams with market and technology information' of the MainstreamBIO project.

A simple, easy-to-use Decision Support System (DSS) has been developed in Task 2.4 to facilitate the identification of solutions that match available local biomass with suitable small-scale technologies to deliver biobased products that meet a certain market demand. The DSS should support farmers (either individuals or a cooperative group) and their advisors to take well-informed decisions.

The DSS methodology consists of two steps. The first step in the DSS guides the users through a matching process to find a specific small-scale biobased solution which is a combination of a certain feedstock with a certain technology to produce a certain product. In the second step of the DSS the users will make a personal multicriteria assessment of this specific small-scale biobased solution (the chosen match) compared to the current use. This assessment is based on a simple multi-criteria decision making (MCDM) model with different criteria in several categories (social, economic and environmental).

All choices of the users in the DSS are supported by local information that they have already available, combined with information from the MainstreamBIO Toolkit, e.g., the various catalogues and the bioeconomy repository. The small-scale biobased technologies catalogue is essential for the matching process. Furthermore, feedstock and biobased product information is needed in the matching tool. Additional information can be found in the business models catalogue, the social innovations catalogue and the best practices on nutrient recycling catalogue. All this information is stored in separate tables in the MainstreamBIO Toolkit.

Finally, it should be mentioned that the DSS methodology is designed to support the users to find matches and assess them ('what do I need to take into account before making a decision on a certain match'). However, the DSS methodology will not suggest an optimal match ('option 1 is a better match better than option 2'), but it will supply suitable solutions (not necessarily the best) to the users, and it will refer them to further information in the MainstreamBIO toolkit to assess these solutions.

1. Introduction

1.1 Description of work

This deliverable describes the work performed in Task 2.4 'Development of a methodology for matching available biomass and waste streams with market and technology information' of the MainstreamBIO project. The objective of this task was to compile knowledge that was developed in the first year under WP1 (especially Task 1.3 'Investigation of regional value chains along with available biomass, waste and residue streams') and WP2 (Tasks 2.1 'Cataloguing of technologies, business models and social innovations for small-scale bio-based solutions' and Task 2.2 'Collection of best practices for improved nutrient recycling in the circular bioeconomy'), and to integrate this knowledge in a **decision support system (DSS) including a multi-criteria decision making (MCDM) model**. This DSS is meant to serve as an easy-to-use tool for farmers, helping them make better informed decisions regarding the adoption of small-scale bio-based solutions, business models and social innovations. The multi-criteria decision-making model should include different social, economic and environmental criteria.

WR has led the development of the easy-to-use DSS with support of the partners that are supplying essential information (QPLAN, AUP & INNV) and with the partner that is building the Toolkit (DRAXIS). The work was also supported by members of the Multi-actor Innovation Platforms (MIPs) who have provided feedback in a dedicated survey about the criteria and their allocated weights. The **first version of the functional design** of the DSS methodology is reported in this deliverable D2.4. This functional design will serve as the basis for the actual operational DSS within the MainstreamBIO Toolkit that is being developed in Task 2.5. In the second year of the MainstreamBIO project the DSS will be tested, and the feedback will be incorporated in an update of the functional design of the DSS. The update will then be implemented in the second version of the DSS in MainstreamBIO Toolkit.

1.2 Content of deliverable

Chapter 1 gives an introduction to this deliverable. A general description of the DSS methodology is given in Chapter 2. The first step of the DSS methodology is the matching process that is described in detail in Chapter 3. And finally the details of step 2, the multicriteria assessment, are given in Chapter 4.

2. General description DSS methodology

2.1 Decision Support System (DSS)

Practical digital tools are needed which can easily be accessed and employed by the Multi-actor Innovation Platforms (MIPs) as well as other stakeholders all across Europe to better match information on available biomass with small-scale bio-based technologies, business models, social innovations and market intelligence, accounting for economic, social and environmental sustainability.

To this end, the MainstreamBIO project has developed a simple, easy-to-use **Decision Support System (DSS)** in Task 2.4 to facilitate the identification of solutions that match available local biomass with suitable small-scale technologies to deliver biobased products that meet a certain market demand. The DSS should support farmers (either individuals or a cooperative group) and their advisors to take well-informed decisions. Together these parties will be called 'the users' in the rest of the text. The MainstreamBIO Toolkit (to be developed in Task 2.5) will contain **catalogues** with information on feedstocks, technologies and products as information for the DSS. The MainstreamBIO Toolkit will also include a suite of links to other **existing tools** (that were already built in previous research projects such as S2BIOM[1] and POWER4BIO[2]). These tools can help rural actors to better understand the bioeconomy, and to learn how to generate socio-economic value from it. The DSS will guide rural actors through the catalogued information on small-scale bio-based solutions, enabling them to identify the ones that best fit their territorial dynamics, resource availability and socio-economic context.

The DSS methodology consists of **two steps** (Figure 1): first a matching process to find a feasible feedstock-technology-product combination and then the multicriteria assessment of this combination. The first step in the DSS guides the users through a **matching process** to find a specific small-scale biobased solution which is a combination of a certain feedstock with a certain technology to produce a certain product. In the second step of the DSS the users will make a personal **multicriteria assessment** of this specific small-scale biobased solution (the chosen match) compared the current use. This assessment is based on a simple multi-criteria decision making (MCDM) model with different criteria in several categories (social, economic and environmental).

The DSS tools for the matching and multicriteria assessment steps are not some sort of automated black-box system, but rather a **predefined matching table** (*Annex D*) and a simple Excel-file with a scoring and explanation form that has to be completed by the users and that shows a spider diagram of the scores. When using the DSS in the matching and assessment process the stakeholder should continuously take into account information on the following factors:

[1] https://www.s2biom.eu/

[2] https://power4bio.eu/

(i) stakeholder business framework and needs (infrastructure, funding, customers, key partners, key resources, labour conditions);
(ii) availability of biomass;
(iii) transportation/ logistics infrastructure;
(iv) business and technology dimensions (technology and market deployment levels, regulatory environment, scale-up readiness);
(v) small-scale technologies and business model alternatives;
(vi) opportunities for rural actors to move towards implementation of the selected solutions evaluated via defined external and internal success factors that account economic, environmental and social aspects.

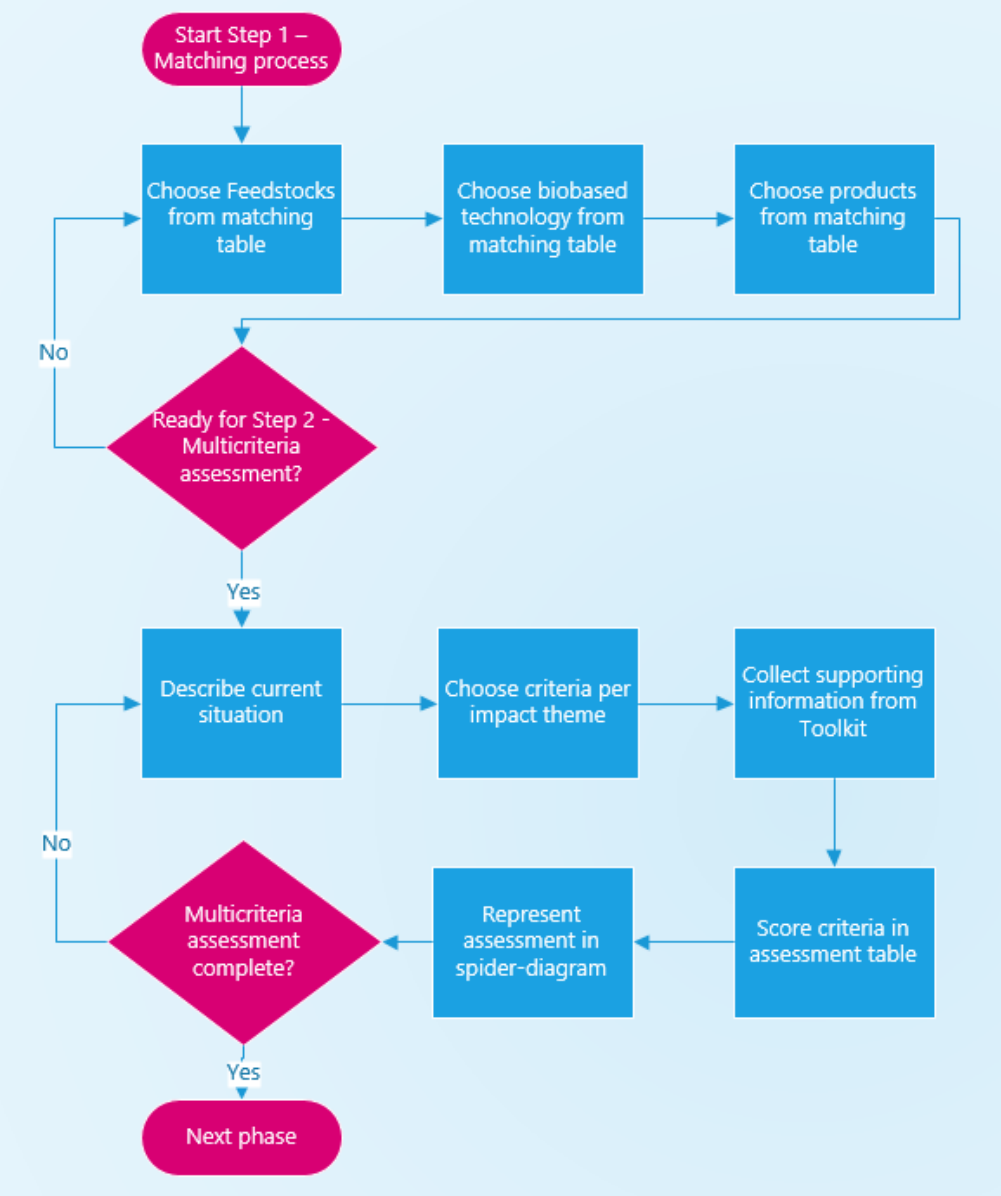

Figure 1: Schematic representation of the two steps of the DSS methodology. This version starts with the choice of a feedstock. The next phase is not included in the DSS.

All choices of the users in the DSS are supported by **local information** that they have already available, combined with **information from the MainstreamBIO Toolkit**, e.g., the various catalogues and the bioeconomy repository. The small-scale biobased technologies catalogue is essential for the matching process. Furthermore, feedstock and biobased product information is needed in the matching tool. Additional information can be found in the business models catalogue, the social innovations catalogue and the best practices on nutrient recycling catalogue. All this information is stored in separate tables in the MainstreamBIO Toolkit (see its functional design in D2.5). Each table should contain data that can be used to check if matches are feasible. Furthermore, all the other background information and tools in the MainstreamBIO Toolkit can be used in combination with the DSS.

In WP3 'Delivery of innovation support accelerating the scale up of small-scale bio-based solutions' the **technology scouting and business model design services** will utilise this easy-to-use DSS methodology in case studies, considering social, economic and environmental dimensions combined with requirements for implementation.

Finally, it should be mentioned that the DSS methodology is designed to support the users to find matches and assess them ('what do I need to take into account before taking a decision on a certain match'). However, the DSS methodology will not suggest an optimal match ('option 1 is a better match better than option 2'), but it will supply **suitable solutions** (not necessarily the best) to the users, and it will refer them to further information in the MainstreamBIO toolkit to assess these solutions.

2.2 Matching feedstocks, technologies and products

The **matching process** to design a specific small-scale biobased solution will contain several steps. The users will be supported during this process by the MainstreamBIO Toolkit, built in Task 2.5.

The users start by choosing certain **feedstocks** from the table Feedstocks in the MainstreamBIO Toolkit (see also *Annex A*). This could either be a feedstock that is at hand, or one that still needs to be contracted. To get an idea of the feedstocks that are nearby the results of WP1 can give an indication of the feedstock availability in specific regions of the MIPs.

Then the users match the chosen feedstock with possible **small-scale biobased technologies** from the table Technologies in the MainstreamBIO Toolkit (see *Annex B*). A check will be performed after the choice of the feedstock to see which technologies can handle the feedstock based on a predefined matching table.

The chosen feedstock - technology combination will determine which **biobased products** could be supplied in the small-scale biobased solution (see *Annex C*). The users have to choose the feedstock-technology-product combination that he or she wants to assess in the next step of the methodology.

The choices that are mentioned in the previous steps will be supported in the DSS by a pre-defined **matching table** that shows all the feasible combinations (Figure 2). This matching table can be found in *Annex D*.

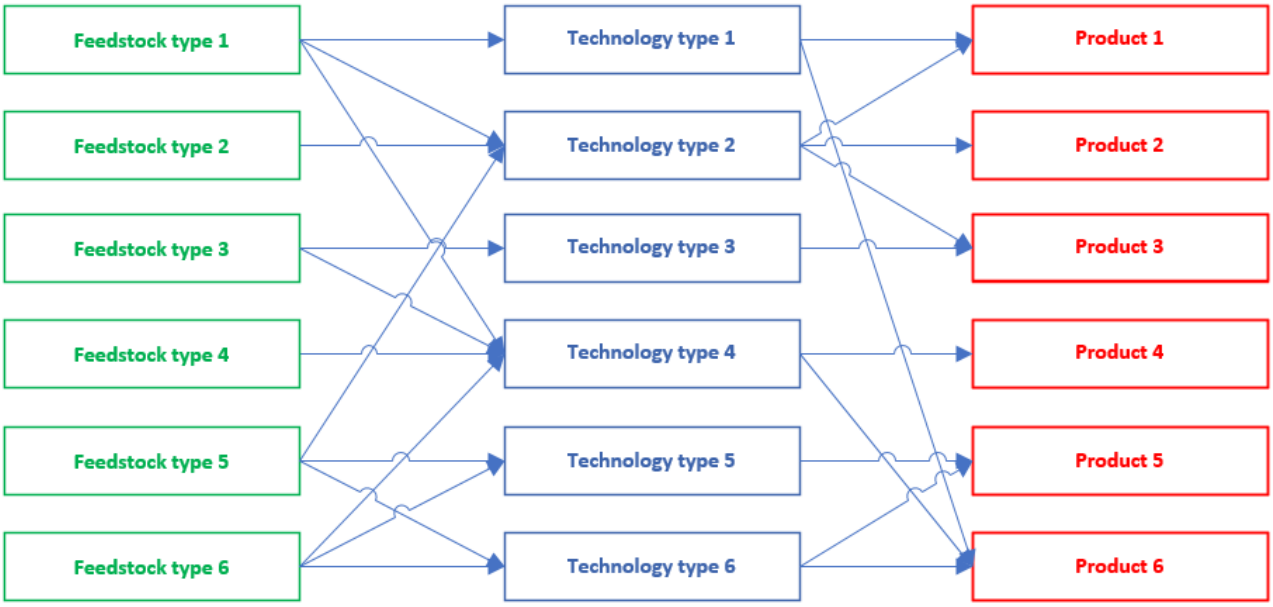

Figure 2: Schematic representation of the matching table.

2.3 Assessing the feedstock-technology-product match

The DSS will support the users to make a **Multi-Criteria Decision Making (MCDM) assessment** of the feedstock-technology-product match. This methodology is based on the approach suggested by Elbersen *et al.* (2022) and is applied as follows: based on all the available information the users will score the feedstock-technology-product match on several preferred criteria, that are grouped in four themes: social impact, economic impact, environmental impact and requirements for implementation. If needed also alternative criteria or themes could be defined by the users. Part of the information needed to decide on the scores will already be known by the users themselves, and for part of it the users will need supporting information that can be found in the MainstreamBIO Toolkit. The users can indicate if the new feedstock-technology-product match will score better or worse than the current situation. For that purpose, a **dedicated MCDM Excel file** can be used, that can be accessed in the MainstreamBIO Toolkit. That file will support the scoring process and it will visualize the suitability of the match in a multi-criteria spider diagram.

3. Details of step 1 - Matching process

3.1 Introduction

The matching process in Step 1 (Figure 1) involves finding a suitable combination (match) of the following three items: **feedstock, technology and product**. The Feedstock-Technology-Product match is the core of the business model. It could also relate to a social innovation, although that connection is not always obvious.

Step 1 should be performed with a practical **easy-to-use** matching tool that can be operated by stakeholders, e.g. the members of the MIPs. It is important to start from the perspective of the users of the matching tool: what do they already know when they start using the matching tool, and what output do they need? E.g., the starting point could be a certain feedstock, with a certain volume and quality. Then the matching tool should say: yes, you can consider this feedstock for these specific technologies, delivering these specific products.

The DSS is not an optimization tool because that would be too complex for the average users. The matching tool just supports the thinking process of the users. The tool does not take the decision. It just helps to screen out relevant options. So the matching tool helps to find one, two or even more **feasible feedstock-technology-product options** during an iterative design process.

The role of the **catalogues** in the matching methodology is very important. The catalogues that were built under Task 2.1 (and Task 2.2) deliver input tables, that contain general informative data and specific data that are needed for the actual matching process. Although the aim was to quantify the entries in the catalogues of D2.1 as much as possible, this was not always possible, so also additional information from other (regional) sources will be needed.

In the MainstreamBIO Toolkit a **matching screen** will be shown where the users can make choices from the three input tables in a drop-down list: feedstocks, technologies and products. It should be possible to switch between these three tables as a starting point of the matching process in the MainstreamBIO Toolkit.

Continuous **checking facilities** are needed in the matching tool during the design of the feedstock-technology-product to avoid infeasible solutions. This is to prevent infeasible choices during the matching process.

Based on the description of the functional design of the DSS methodology in this deliverable D2.4 DRAXIS will make a **running version** of the matching methodology in the MainstreamBIO Toolkit. In Task 2.5 DRAXIS will decide how everything can be implemented, and what is exactly feasible from point of Information and Communications Technology (ICT).

3.2 Matching table with fixed connections

The basic idea is to support the matching process by building a **matching table with fixed links** between the three parts of the feedstock-technology-product combination in advance based on the information in D2.1 (see *Annex D*). The aim is to support the decision maker.

You need a **terminology** for linking the feedstocks, technologies, and products. For this purpose, the Biorefinery Outlook classification system was used (Biorefinery Outlook, 2021). It should be noted that the category 'platform' was excluded to keep the matching process simpler. This terminology standardizes the input data concerning their names (e.g., feedstocks) to be able to match. These matching categories were already described in MainstreamBIO D2.1 (Annevelink et al., 2023) and are further detailed in *Annex A, B and C*.

3.3 Choose feedstocks from matching table

The most obvious way of matching is to start with the **availability** of feedstocks in the specific region. An overview of promising feedstocks in the regions of the MainstreamBIO project partners has been delivered in WP1. The availability of these feedstocks is shown in maps that can be found in D1.3 'Mapping of regional bio-based value chains'. Furthermore, see *Annex A* for the **classification** of the feedstocks. A precondition can be the wish of the users: e.g., they have this much feedstock of a certain type available and want to know if that amount would not be enough. Finding sufficient feedstock should be considered at the beginning of the matching process.

The **feedstock volume, quality and cost** determine a large part of the feasibility of a small-scale biobased solution. The feedstock volume relates to the availability in the specific local situation. However, the volume can be scaled up in most situations, e.g., by finding more feedstock volume in the next village. The quality of the feedstock should meet the requirements of the technology that will be chosen in order to obtain suitable biobased products. And finally, the costs of the feedstock will determine the final profitability of the solution.

When a type of feedstock and type of technology are chosen, a question that could remain is: Which other additional feedstocks would be suitable? However, the DSS will only handle one feedstock at the same time. This could be solved by including a combination of feedstocks in the next assessment.

3.4 Choose biobased technology from matching table

For the chosen type of feedstock several **small-scale biobased technologies** could be possible. The choice of a preferred technology has to be made by the users. An overview of feasible feedstock-technology combinations can be found in *Annex B*. The information in the small-scale biobased technology **catalogue** gives supporting information to assist the users in making a choice, when they do not know enough yet about a certain technology. It is up to the users to determine what feedstock-technology combinations can actually be achieved in their specific regional case study situation. Certain constraints, e.g., the available investment budget, could further limit the number of technologies that can be useful for the decision maker.

A challenge in practice could be that the solution requires a combination of technologies that are sequentially applied. However, in the current matching methodology only **single technologies** can be addressed.

3.5 Choose products from matching table

The list of possible **products** (see *Annex C*) follows automatically from the choice of the feedstock-technology combination (see *Annex D*). Sometimes the type and the number of products that are generated by the technology is fixed. In that case no choice is needed because the product mix is already known. However, sometimes a choice still has to be made from a list of possible (intermediate) products that could be delivered by the chosen technology. The choice could depend e.g., on further processing steps that the users have in mind.

Information on **market demand** (size, price, etc.), and market location where the product will be delivered (local, regional, national) will influence the choice of the users for a specific product. This market information will partially be included in the MainstreamBIO Toolkit. However, it should be supplemented by local knowledge of the users/decision makers. After this choice of products a preferred feedstock-technology-product combination will be clear.

3.6 Alternative starting points for making a match

Another approach is to not start with an available feedstock and find a suitable technology, but with a preferred technology and find suitable feedstocks. For one type of technology (e.g., anaerobic digestion) several feedstocks can be suitable. This alternative approach will be implemented in the second version of the MainstreamBIO Toolkit.

4. Details of step 2 - Multicriteria assessment

4.1 Introduction

Step 2 consists of a multicriteria assessment (Figure 1) of the preferred feedstock-technology-product match that was chosen by the users in step 1. The idea is to assess the chosen small-scale biobased solution on **multiple criteria** that are specified personally by the users. The assessment should be able to take into account both quantifiable and non-quantifiable factors. The users themselves should give a **relative score** (e.g., between -2 and +2, which could be interpreted as much worse, worse, neutral -i.e., nothing changes or impact is similar-, better, and much better) to the solution during the assessment, based on different sources of information. All these scores are relative to the current situation: is the solution an improvement or not compared to doing nothing. Weighting factors could possibly be applied to the scores. However, this has not been applied in the methodology.

An important point is how to obtain the **information** that is needed to make a judgement of each criterion. This could be specific local information, combined with information from the various sections of the Toolkit. Sometimes it might even be impossible to have specific information available so then an educated guess will be needed.

4.2 Describe current situation

The description of the current situation will form the starting point for the multicriteria assessment. This can be described by the users in very general terms, not too detailed. The purpose for the decision makers is just to have an idea in mind when they make the comparison with the new feedstock-technology-product combination. Items of the description relate to the themes and criteria that will be chosen in section 4.3. The decision makers could ask themself the following questions:

Feedstocks

- What local feedstocks are currently available?
- How much feedstock is currently available (fresh & dry matter) and how much of that is used already at the moment?
- What is the current quality of the feedstock (moisture content, size, …)?
- When does the current feedstock become available (year-round, limited period, …)?
- What happens to these feedstocks at the moment (are they unused, do the already have a current use with a lower value than the new solution, …)?
- Who is the owner of the feedstock (decision maker, external supplier, …)?
- Where and how are the feedstocks currently stored (open air, covered, …)?

Technology

- Do you already have a current technology in place?
- Can this current technology be adapted to the new solution?
- What is the size/scale of the current technology?
- How resource efficient is the current technology?

- Where is the current technology located?
- How many people operate the current technology?
- What is the education level of the current operators?
- What is public perception of the current technology?

Products

- What current products are made from the feedstock with the current technology (energy, materials, chemicals)?
- Do the current products have a large demand on your regional market?
- At what prices are the current products sold?
- How profitable is the current feedstock-technology-product combination?
- Where and how do you store the current products before distribution?

4.3 Choose criteria per impact theme

The users have to decide which criteria to consider during the multicriteria assessment. A **long list** of possible criteria is given in *Annex E* based on several sources (Elbersen *et al.*, 2022; Annevelink *et al.*, 2023; Power4Bio, 2019). Based on this long list a preliminary choice was made that resulted in a **short list** with eight criteria per theme (see *Annex E*, section E5).

Then a survey was held among the stakeholders of the MIPs to get their feedback. Stakeholders were asked to specify their opinion on the most relevant criteria in the list, and to possibly add extra criteria if they missed any. The results of this stakeholder survey (see *Annex F*) were then translated to a **default list** of four preferred criteria per theme:

Theme 1. Social impact

- Creation of new jobs
- Increased well-being of rural communities
- Increased public perception, participation and support
- Provision of education and training opportunities for the rural community

Theme 2. Economic impact

- Increased use of local biomass resources
- Increased rural business opportunities
- Increased resource use efficiency
- Increased profitability

Theme 3. Environmental impact

- Improvement of soil quality
- Improvement of water quality
- Reduction of greenhouse gas emissions
- Reduction of waste

Theme 4. Requirements for implementation

- Presence of sufficient biomass feedstocks
- Presence of workforce with knowledge and skills to operate technologies
- Presence of adequate infrastructure
- Presence of enabling government policies & regulations

These preferred four criteria per theme were then implemented in a **default version of the assessment table** that should be sufficient for a multicriteria assessment in most cases. However, the users are still free to change some of the default criteria to alternative criteria, if these are considered more relevant for their own regional situation. They might even change one of the overarching themes to another topic and add specific criteria for that new theme. So, the users have complete flexibility in the design of the final assessment table for a specific case study.

4.4 Collect supporting information from Toolkit

The availability of sufficient and reliable information is essential for the success of the multicriteria assessment. The necessary **supporting information** that needs to be collected by the users to make the comparison can mostly be found in the MainstreamBIO Toolkit. However, also several external sources could be taken into account. Suggestions for these sources of information are described in *Annex G*. for all criteria on the short list that is described in *Annex E*. Finally, some of the information will come from the records of the users themselves.

4.5 Score criteria in assessment table

Filling the **assessment table** (a filled example can be found in Table 1) means scoring the required criteria for a chosen small-scale biobased solution (feedstock-technology-product combination). The principle behind the assessment methodology is a normalization of the scores to **relative scores**. So, the users will not be giving an absolute value for the criterion, but a relative value compared to the current situation. This assessment methodology will work even when no absolute values are available, so when only a more descriptive reasoning is available (more than, less than). For example, in a certain case the only judgement that can be made by the users is ‘the price of the feedstocks might be too high for a profitable business model’, without having the exact data. In that case the users will score profitability as -1 or even -2. Giving the scores will probably be an iterative process of finding information, determining a score, finding more information and the adjusting the score for a certain criterion, until the users are satisfied. This process will be repeated for the consecutive criteria. The assessment table has the following columns:

- Theme name - In the standard format the four themes are: social impact, economic impact, environmental impact and requirements for implementation. Theme names can be changed by the users.
- Criterion name - Each theme has four preferred criteria, which have been prefilled in the standard format. Criteria names can be changed by the users.
- Rating - Based on the collected information the users have to fill in the relative score compared to the current situation. It is suggested to vary the score between -2 and +2.
- Comment - This is column is meant to enter a very short argumentation of the relative score. What is the reasoning behind it.

Table 1: A fictitious example of the assessment table where the users can enter the relative scores on the four most preferred criteria per theme.

Theme	Criterion	Rating	Comment
Social Impact	Creation of new jobs	1	Five new labourers are required to operate the small-scale biobased technology
	Increased well-being of rural communities	2	The group of farmers that supply the feedstock will vitalize their companies by this new business and thus stimulate the well-being of their rural community
	Increased public perception, participation and support	0	Not negative, but also not a huge effect
	Provision of education and training opportunities for the rural community	0	No extra education and training opportunities arise
Economic impact	Use of local biomass resources	2	A large biomass potential that was so far not used, is now brought to value
	Rural business opportunities	0	Not negative, but also not a huge effect
	Resource use efficiency	1	The resource efficiency will improve, but could still be further improved
	Profitability	1	The profitability will improve by the valorisation of the feedstock; however, the investment and operational costs are still relatively high
Environmental impact	Soil quality	-1	Without any further measures the soil quality could be reduced because of the removal of extra biomass and thus nutrients per ha
	Water quality	0	No influence on the water quality, because no extra water is needed and removal of crop residues
	Greenhouse gas emissions	1	The feedstock will lead to biobased products that replace fossil-based products; so less GHG emissions
	Reduction of waste	0	The feedstock is not considered to be waste, so no change compared to the current situation
Requirements for implementation	Sufficient biomass feedstocks	1	Biomass feedstocks are available in the group of users and can also be supplemented by supplies in the region
	Workforce with knowledge and skills to operate technologies	-1	Labourers still need to obtain the skills to operate the new technology
	Adequate infrastructure	-2	No infrastructure is available yet for installing the new technology
	Enabling government policies & regulations	1	Regulations do not prohibit the application of the feedstock and policies favour rural development

Although the DSS methodology uses relative scores, an additional table with the exact requirements of the users specified in absolute numbers (e.g., GHG reduction level, revenue level, …) could be useful to support the relative scoring process. However, it is up to the users to decide if such a table could be useful for their case study. The DSS methodology does not supply a specific format for this.

4.6 Represent assessment in spider diagram

Then the assessment table will be translated in a **spider diagram** to get an easy visualisation of the assessment (Figure 3).

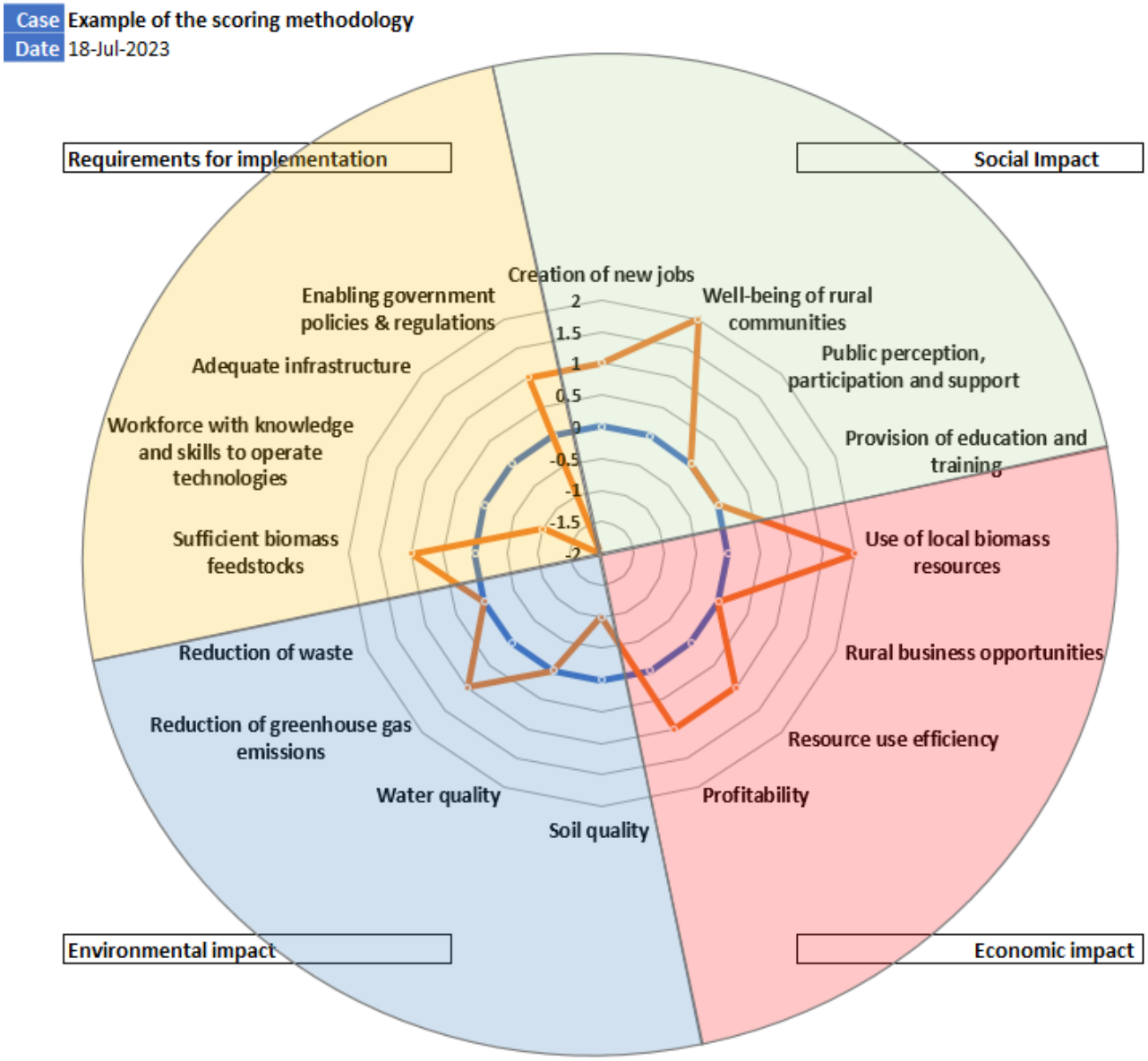

Figure 3: An example of the multi criteria spider diagram for the visual representation of the assessment of a feedstock-technology-product match.

To keep an overview of the assessment only a limited number of criteria is represented in the spider diagram. We have chosen a set-up with four criteria for each of the four themes, so a total of 16 items. Different colours have been used as a background of each of the four themes/categories.

4.7 Next phase: determine business model, nutrient recycling practices & social innovations

The final result of one iteration of the matching process is an **assessed feedstock-technology-product combination**. The matching and assessment process can be repeated several times to generate several suitable feedstock-technology-product combinations that can then be compared looking at the spider diagrams of each solution. That way the users can decide on their preferred feedstock-technology-product combination.

Generating a **business model** for this preferred feedstock-technology-product combination as a follow-up is not part of the DSS matching tool as such. This step should be taken in the next phase. The users can have a look at the business model catalogue in the MainstreamBIO Toolkit to find examples of suitable business models connected to the preferred feedstock-technology-product combination that can serve as inspiration for the creation of your own business model. The list of 'inspirational business models' in the catalogue will help the users to shape their own business model, but the MainstreamBIO toolkit will not create a business model as such. There are already some existing online tools that can help the users to create your CANVAS model after defining the elements.

Furthermore, they could see if the match can be linked to a certain **nutrient recycling practice (NRP)** chosen from the NRP catalogue in the MainstreamBIO Toolkit. And finally, the match could possibly be combined with a **social innovation (SI)** from the SI catalogue in the MainstreamBIO Toolkit. That way they will be completing their own design for a suitable small-scale biobased solution.

5. Literature

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Annex A: Feedstock categories

A1. Primary Biomass

Table 2: Overview of primary biomass sources. Categories are based on Biorefinery outlook (2021) & S2BIOM (2017). The feedstocks that are actually mentioned in the matching table (Annex D) are marked green and bold and the technology code is mentioned between brackets.

Main category	Subcategory	Sub-subcategory
Aquatic biomass	Aquatic biomass	• Aquatic plants • Microalgae • Aquaculture
Lignocellulosic from croplands and grasslands (B6)	Energy grasses, annual & perennial crops	• Sweet and biomass sorghum (Annual grasses) • Miscanthus (Perennial grass) • Switchgrass (Perennial grass) • Giant reed (Perennial grass) • Cardoon (Perennial crop) • Reed canary grass (Perennial grass)
	Grassland	• **Grass from unused grassland cuttings (abandoned grassland, managed grasslands not used for feed) (B2, B3, B8, B9)**
	Short rotation coppice	• SRC Willow • SRC Poplar • SRC Eucalyptus
Lignocellulosic wood/forestry	Stemwood from final fellings & thinnings	• Stemwood from final fellings originating from non-conifer tree species • Stemwood from final fellings originating from conifer tree species • Stemwood from thinnings originating from non-conifer tree species • Stemwood from thinnings originating from conifer tree species
Oil crops	Oil crops	• Soya beans • Olive tree • Castor beans • Sunflower seed • Rapeseed
Starch crops	**Grain crops**	• **Corn (B2, B3)** • **Wheat (B3)** • **Barley (B3)**
	Tuber crops	• Potatoes • Cassava

Sugar crops	-	• **Sugar cane (B3)** • **Sugar beet (B3)** • Sweet sorghum
Other primary biomass	-	-

A2. Secondary Biomass

Table 3. Secondary biomass overview. Categories are based on Biorefinery Outlook (2021) & S2BIOM (2017). Note that the category residues from livestock production is added extra compared to Biorefinery Outlook (2021) classification. The feedstocks that are actually mentioned in the matching table (Annex D) are marked green and bold and the technology code is mentioned between brackets.

Main category	Subcategory	Sub-subcategory
Microbial biomass	-	• Biomass generated by enzymes • Biomass generated by bacteria • Biomass generated by protist • Biomass generated by fungi
Residues from agriculture (B12, B14)	**Straw/stubbles/stalks**	• **Bell pepper stalks (B9)** • **Cereals straw (B1, B3, B5a, B6, B8, B10, B13)** • **Maize/corn stover (B3, B5a)** • Oil seed rape straw • Rice straw • Sugar beet leaves • Sunflower straw • **Tomato stalks (B8, B9)**
	Woody pruning & orchards residues	• Residues from vineyards • Residues from fruit tree plantations (apples, pears and soft fruit) • Residues from olives tree plantations • Residues from citrus tree plantations • Residues from nuts plantations
	By-products and residues from food and fruit processing industry (B1, B2)	• **Disposals from bakeries (e.g., cereal bran, bread & rolls losses) (B4)** • **Disposals from breweries (B11)** • Disposals from dairy industry (e.g., whey permeate) • **Disposals from fruit juice pressing industry (e.g., pits, seeds, pulp, grape lees, peel) (B4, B7, B11)** • **Disposals from seed-oil mills (e.g., sunflower, cotton, etc.) (B3, B11)** • **Disposals from olive oil industry (e.g., olive pomace, leaves and stones) (B3, B7, B13)** • **Disposals from rice industries (e.g., rice husk) (B11)** • Disposals from slaughterhouses

		• **Disposals from sugar industry (e.g., sugar beet pulp, molasses) (B3, B9)** • **Disposals from wineries (B2, B11)**
	Other industry by-products utilising agricultural products	• Cotton acorn • Hemp hurd • Other industry by-products utilising agricultural products
Residues from forestry and forest-based industry (B1, B5a, B8, B9, B11, B13, B14)	Logging residues from final fellings & thinnings	• Logging residues from final fellings from non-conifer tree species • Logging residues from final fellings from conifer tree species • Logging residues from thinnings from non-conifer tree species • Logging residues from thinnings from conifer tree species
	Stumps from final fellings & thinnings	• Stumps from final fellings originating from non-conifer tree species • Stumps from final fellings originating from conifer tree species
	Sawmill residues	• **Sawdust from sawmills from conifers (B12)** • **Sawdust from sawmills from non-conifers (B12)** • Sawmill residues: excluding sawdust, conifers • Sawmill residues: excluding sawdust, non-conifers
	Other wood processing industry residues	• Residues from industries producing semi -finished wood based panels • Residues from further wood processing
	Secondary residues from pulp and paper industry	• Bark residues from pulp and paper industry • **Black liquor (B12)** • **Paper slurry (B10)**
Residues from nature and landscape management (B6, B8, B9, B10, B12)	**Biomass from other areas under landscape maintenance**	• **Grassy biomass from landscape maintenance (recreational and nature protection areas, dykes) (B1)** • Woody biomass from landscape maintenance (landscape elements)
	Biomass from roadside verges	• **Grassy biomass from roadside verges (B2, B13)**
Residues from recycled bio-based products	Residues from recycled bio-based products	• Recycled bio-plastics and bio-polymers • Recycled bio-based textiles • Recycled paper
Residues from livestock production	**Animal manure (B13)**	• **Horse manure (B5a)** • **Cattle manure (B2, B5b)** • Pig manure • Sheep manure • Goat manure

		• **Chicken manure (B1, B10, B11)**
	Animal remains	• Horse remains • Cattle remains • Pig remains • Sheep remains • Goat remains • Chicken remains
Other organic residues (B4)	**Biodegradable municipal waste**	• **Biowaste as part of integrally collected municipal waste: Biodegradable waste of not separately collected municipal waste (excluding textile and paper) (B14)** • **Separately collected biowaste (SSO): Biodegradable waste of separately collected municipal waste (excluding textile and paper) (B1, B2)** • **Coffee residues (B5a)** • Corn cob from food consumption • **Expired food (B2, B14)** • **Industrial wastewater with high concentrations of organic substances (B2)** • **Sewage sludge (B1, B2, B3, B12, B13, B14)** • **Swill (mainly kitchen waste and food scraps) (B2)**
	Post-consumer wood	• Hazardous post-consumer wood • **Non-hazardous post-consumer wood (B11)**

Annex B: Small-scale biobased technologies

The overview of small bio-based technologies was already mentioned in MainstreamBIO D2.1, Table 3. However, for reasons of clarity it is repeated here, so that all three components of the matching table in *Annex D* are described.

Table 4. Overview of small-scale biobased technologies.

Code	Small-scale technology	Brief description
	Biochemical	
B1	**Aerobic conversion (composting)**	Aerobic conversion of instable fractions of bio-based feedstock into mainly carbon dioxide (CO_2) and water by microorganisms that thrive under aerobic conditions, i.e., where plenty of oxygen is available, resulting in residual stable fraction of biomass which can be used e.g., as soil improver
B2	**Anaerobic digestion**	Anaerobic digestion is a biological process in which micro-organisms break down organic material under oxygen-free conditions into useful compounds such as methane (biogas).
B2b	**Upgrading biogas**	During the upgrading process (almost) all contaminations (e.g., carbon dioxide) are filtered from the biogas and it is dried, so it can be used as green gas.
B3	**Fermentation**	Fermentation is a process in which micro-organisms (bacteria, yeasts, moulds) are used to convert organic material into alcohol, acids or hydrogen, for instance, which can be used in food and chemical industry. Often carbon dioxide is produced as a (not always useful) co-product.
B4	**Insect-based bioconversion**	Insect-based bioconversion also known as insect farming is based on growing a selection of insect species like e.g., Black Soldier Fly (BSF) larvae, house fly maggots, mealworms, and grasshoppers-crickets and different rearing substrates to produce e.g., protein rich feed.
B5a	**Cultivation Mushrooms**	The production system of mushrooms from residues.
B5b	**Cultivation Algae**	The production system of algae from residues.
	Mechanical and thermomechanical	
B6	**Blending or mixing**	Blending or mixing is used to modify the specification of biomass streams for different purposes, such as meeting the required emission, minimizing the ash production, obtaining the desired nutritional requirements for a specific animal or creating building materials.

B7	**Extraction & separation processes**	Extraction is a recovery and purification technology to extract impurities or valuable compounds. Separation is an important process for the conversion of biomass into components for use in chemicals, energy and materials.
B8	**Mechanical and thermomechanical disruption & fractionation**	Mechanical and thermomechanical disruption & fractionation are processes to modify the shape, particle size, bulk density and/or moisture of biomass.
B9	**Mechanical pulping**	Mechanical pulping is the process to open up the fibrous structure of plants or wood by grinding or refining. It frees fibre bundles, (partly) creating single fibres and fibril structures that can be used for the production of moulded fibre products, paper and fibre board materials.
	Thermochemical	
B10	**Combustion**	During combustion the biomass reacts with an oxygen surplus, and carbon dioxide, water and ash are primarily produced. Heat is released in this process, which can be used to produce steam that drives a steam turbine to produce electricity. Also, efficient co-production of power and heat can be applied by using so called CHP-plants (part of the heat is used to produce power, the other part for producing heat).
B11	**Gasification**	During gasification, biomass is converted into combustible product gas at high temperatures (more than 600°C) with a controlled amount of oxygen (or air). Depending on the use of the product gas, it is called fuel gas in case will be used for energy (power and/or heat) applications, and syngas in case it will be used for the often catalytically supported synthesis of bio-based products (transport fuels, chemicals). All the material that is not converted into gas ends up in a remaining fraction called biochar, which has properties similar to activated carbon, and can be used as a soil enricher or as a fuel for heating the gasifier.
B12	**Hydrothermal liquefaction (HTL)**	Hydrothermal liquefaction (HTL) is a process to increase the energy content of wet organic containing streams. Through this process biomass can be converted into a heavy oil (biocrude) product (similar to heavy fuel oil) without drying the biomass.
B13	**Pyrolysis**	In the pyrolysis process, the biomass is thermally cracked at temperatures between 400°C and 600°C in an oxygen-free environment, producing a combustible gas, pyrolysis oil and char. Pyrolysis oil can be used as fuel and as a source for a naphtha-cracking process in which chemicals can be extracted. The gas by-product is usually burned in order to generate process heat for the pyrolysis reactor, and the biochar is a solid carbonaceous residue and it is suitable as soil improver or as solid fuel.

B14	**Torrefaction & Carbonization**	Torrefaction & carbonization are thermal processes to convert biomass into a coallike material, with higher energy density and hydrophobic characteristics compared to the original biomass and can withstand biodegradation. This delivers improved retention (stability), and reduced storage and transportation costs. The material is suitable for gasification and co-firing in coal-fired power stations.

Annex C: Product categories

Table 5. Overview of product categories. Based on Biorefinery Outlook, 2021. Products that are actually mentioned in the matching table (Annex D) are marked green and bold and the technology code is mentioned between brackets.

Main category	Subcategory	Sub-subcategory
Chemicals	Additives	• Bio-based derived plasticizers • Stabilizers • Thickeners • Fillers • Inhibitors • Flame retardants
	Agrochemicals	• Plant hormones (e.g., jasmonic acid, abscisic acid) • Naturally occurring steroid plant • Bio-fungicides from plant extracts
	Building blocks	• Ethylene • Propylene • **Lactic acid (B3)** • BTX (benzene, toluene, xylene)
	Catalysts & Enzymes	• Catalyst produced from cellulosic agricultural waste and activated carbon • Enzymes produced from fungi or plants (e.g., amylase, papain, bromelin, ficin, malt diastase)
	Colorants (B7)	• Dyes • Pigments • Inks
	Cosmeceuticals	• Vitamins • **Antioxidants (B7)** • Botanical extracts • Flavonoids • Hyaluronic acid • Other bioactive substances
	Flavours & Fragrances	• Vanillin • Geraniol • Cinnamic acid • Geranyl acetate • Linalool
	Lubricants	• Triglyceride esters derived from vegetable oils obtained from plants
	Nutraceuticals	• Amino acids • Vitamins • **Proteins (B5b)**

		• **Antioxidants (B7)**
	Paints & Coatings	• Paint and coating containing a vegetable fraction coming from biobased materials such as vegetable oils, natural pigments or bio-based resins
	Pharmaceuticals	• Insuline • N-acetyl glucosamine • L-lysine • Artemisinic acid • Caffeic acid • Gallic acid • Oleuropein • Revastrol.
	Solvents	• **Methanol (B11)** • **Ethanol (B3)** • Toluene • Acetone • Turpentine • Ethyl acetate
	Surfactants	• Mostly produced from vegetable oils (e.g., glycolipids, sopherolipids, esterquats) • Some starch derivates (e.g., carboxy methyl starch) • Sugar derivates (e.g., alkyl polyglucoside)
	Other chemical products	• **Butanol (B3)** • **Isobutanol (B3)** • **Succinic acid (B3)** • **Itaconic acid (B3)** • **Other dicarboxylic acids (B3)**
Materials	**Composites**	• Natural composites (e.g., wood, mud bricks (mud+straw), bones) • Biobased derived composites: contain synthetic fibres or synthetic polymers (e.g., PLA/flax composites, paper, concrete) • **Fibre reinforced composites (B8)**
	Fibres	• Natural fibres (e.g. wool, jute, hemp, sisal, abaca, silk) • Bio-based derived fibres (e.g. polycaprolactam (polyamide 6, Nylon 6), Poly(hexamethylene adipamide) (polyamide 66, Nylon 66), polyamid-11 (Nylon 11)) • **Insulation materials (B8)** • **Fibres for the production of moulded fibre products paper and fibre board materials (B9)**
	Organic Fertilizers (B4)	• Humic acid • Guano • Sewage sludge • **Compost (B1)** • **Digestate (B2)** • **Spent mushroom substrate (B5a)**
	Polymers	• Natural polymers (e.g., starch, natural rubber, cellulose, CMC (carboxymethyl cellulose), lignin, chitin, pectin)

		• **Bio-based derived polymers** (e.g., polyethylene (PE), polyethylene terephthalate (PET), Polyethylene 2,5-furandicarboxylate (PEF), **Polyhydroxyalkanoates (PHA) (B3)**, polylactic acid (PLA))
	Resins	• Natural resins (e.g., rosin, shellac, copal, respin) • Bio-based derived resins (e.g., polyurethane resins, epoxy resins, alkyd resins)
	Other material product	• **Growth substrate inoculated with mushroom spawn (B5a)** • **Blended feedstock (B6)** • **Combustion ash (B10)**
Food	**Food**	• **Mushrooms (B5a)** • **Protein rich algae (B5b)** • **Food additives (B7)** • **Food supplements (B7)** • **Dietary fibre (B7)**
Animal Feed	**Animal Feed**	• **Proteins (insect based) (B4)** • **Fat (insect based) (B4)** • **Feed (B7)** • **Fibres for feed (B8)** • **Protein (B8)** • **Organic acids (B8)** • **Mineral containing juices, for pig feed and fertiliser (B8)**
Energy	Cooling agents	• Natural refrigerants like carbon dioxide and ammonia used in heat adsorption systems and refrigeration systems
	Fuels	• Biodiesel • **Bioethanol (B3; B11)** • Biomethane • **Ethers (DME - B11)** • **Hydrogen (B3)**
	Heat (B1; B10; B11)	• Warming and heating services
	Power	• **Electricity (B10, B11)**
	Other energy products	• **Bio-LNG (B2b)** • **Flue gas (B10, B13)** • **Fuel gas (B11)** • **Green gas (B2b)** • **Synthetic Natural Gas (SNG) (B11)**
Platforms	**Platforms**	• **Biochar (B11; B13)** • **Bio-Coal (B14)** • **Bio-Crude (B12)** • **Biogas (B2)** • **Bio-oils (B13)** • **Bio-hydrogen (B3)** • BioNaphta • C5/C6 sugars • Carbon dioxide • Lignin

		• Oils • Organic Fibres • Organic Juice • **Protein (B8)** • Pyrolytic Liquid • Starch • **Syngas (B11)**

Annex D: Matching table Feedstock-Technology-Product

Table 6. Matching table showing possible connections between feedstocks, small-scale biobased technologies and products.

Feedstock sub sub category	Feedstock main and sub category	Technology	Products main and sub category	Products sub sub category
		Biochemical		
• Vegetable, fruit and garden waste (SSO, Source Separated Organics) • Pruning and mowing material (grass, verge grass, grass from nature areas, foliage) • Straw • Dry manure types • Thick fraction of digestate from various types of digesters • Thickened sludge from biological wastewater treatment • Residues of the agro-industry	a) Residue from agriculture b) Residues from forestry and forest-based industry c) Residues from nature and landscape management d) Residues from livestock production e) Other organic residues	**B1 Aerobic conversion (composting)**	1. Materials_Organic Fertilizers 2. Energy_Heat	1. Compost 2. Heat
• Vegetable, fruit and garden waste (SSO, Source Separated Organics) • Fresh cattle manure	a) Residue from agriculture (specifically food processing industry) b) Residues from nature and landscape management	**B2 Anaerobic digestion**	1. Platforms 2. Materials_Organic Fertilizers	1. Biogas 2. Digestate

• Poultry manure • Sludge from sewage treatment plants • Verge grass • Other grass types • Grass juice • Agricultural residues • Residue streams from the food industry • Swill (mainly kitchen waste and food scraps) • Expired food • Marc and other by-products of distillery process • Industrial wastewater with high concentrations of organic substances • Corn	c) Residues from livestock production d) Other organic residues			
• Biogas	a) Platform[3]	**B2b Upgrading biogas**	1. Energy_Other 2. Energy_Other	1. Green gas 2. Bio-LNG
• Sugar cane • Sugar beet • Molasses • Corn • Wheat • Barley	a) Sugar crops b) Starch crops c) Residues from agriculture	**B3 Fermentation**	1. Chemicals_Solvents or Energy_Fuels 2. Chemicals_Others 3. Chemicals_Others 4. Energy_Fuels or Platforms	1. Ethanol 2. Butanol 3. Isobutanol 4. Hydrogen gas 5. Lactic acid

[3] A platform is an intermediate product, used in the Biorefinery Outlook (2021) classification.

• Corn stover • Straw • Grass • Leaves • Wood chips • Biologically acidified organic waste • Sewage sludge • Press cakes of oil seeds or food products			5. Chemicals_Building blocks 6. Materials_Polymers 7. Chemicals_Others 8. Chemicals_Others 9. Chemicals_Others	6. PolyHydroxyAlkanoate (PHA) 7. Succinic acid 8. Itaconic acid 9. Other dicarboxylic acids
• Organic agricultural residues (e.g. vegetable and fruit) • Food residues (e.g. bread & rolls losses).	a) Residues from agriculture b) Other organic residues	**B4 Insect-based bioconversion**	1. Animal feed 2. Animal feed 3. Materials_Organic Fertilizers	1. Proteins (insect based) 2. Fat (insect based) 3. Organic fertilizer
• Coffee grounds • Wheat straw • Horse manure • Other pasteurized/ sterilized cellulosic materials • Crop stalk • Alfalfa residues	a) Residues from agriculture b) Residues from forestry and forest-based industry c) Other organic residues	**B5a Cultivation Mushrooms**	1. Food 2. Materials_Organic Fertilizers 3. Materials_Other	1. Mushrooms 2. Spent mushroom substrate 3. Growth substrate inoculated with mushroom spawn
• Liquid fraction of cattle manure • Digestate	a) Residues from livestock production	**B5b Cultivation Algae**	1. Chemicals_Nutraceuticals or Food	1. Protein rich algae
		Mechanical and thermomechanical		
• Hemp hurds • Hemp fibres • Fibrous residues • Straw	a) Lignocellulosic from cropland b) Residues from agriculture	**B6 Blending or mixing**	1. Materials_Other	1. Blended feedstock

	c) Residues from nature and landscape management			
• Juice pressing residue (pits, seeds, pulp, grape lees, peel) • Vegetables • Olive pomace • Olive leaves • Olive stones	a) Residues from agriculture (specifically food processing industry)	**B7 Extraction & separation processes**	1. Chemicals_Cosmeceuticals or Chemicals_Nutraceuticals 2. Chemicals 3. Food 4. Food 5. Food 6. Animal feed	1. Anti-oxidants 2. Colorants 3. Food additives 4. Food supplements 5. Dietary fibre 6. Feed
• Meadow grass • Tomato stalks • Cereal straw	a) Residues from agriculture b) Residues from forestry and forest-based industry c) Residues from nature and landscape management	**B8 Mechanical and thermomechanical disruption & fractionation**	1. Animal feed 2. Animal feed 3. Animal feed 4. Animal feed 5. Materials_Fibers 6. Materials_Composites	1. Fibres for feed 2. Protein 3. Organic acids 4. Mineral containing juices, for pig feed and fertiliser 5. Insulation materials 6. Fibre reinforced composites
• Grass • Hay • Tomato stalks • Bell pepper stalks • Sugar beet pulp	a) Residues from agriculture b) Residues from forestry and forest-based industry c) Residues from nature and landscape management	**B9 Mechanical pulping**	1. Materials_Fibres	1. Fibres for the production of moulded fibre products paper and fibre board materials
		Thermochemical		
• Wood pellets • Pellets made from straw-like biomass • Straw	Secondary biomass: a) Residues from agriculture	**B10 Combustion**	1. Energy_Heat 2. Energy_Power 3. Materials_Other 4. Energy_Other	1. Heat 2. Electricity 3. Combustion ash 4. Flue gases

• Lignin • Paper slurry • Chicken manure	b) Residues from forestry and forest-based industry c) Residues from nature and landscape management			
• Woody biomass • Demolition wood • Solid biomass waste streams from wineries • Solid biomass waste streams from breweries • Solid biomass waste streams from cotton ginning industries • Solid biomass waste streams from rice industries • Seed-oil mills (olive, sunflower, cotton etc.) • Chicken manure • Solid biomass waste streams from fruit processing units (jam, juice production)	a) Residues from agriculture (also including food processing industry) b) Residues from forestry and forest-based industry c) Residues from livestock production d) Residues from food production	**B11 Gasification**	1. Energy_Power 2. Energy_Heat 3. Energy_Other 4. Chemicals_Solvents 5. Energy_Fuels 6. Energy_Fuels 7. Platforms	1. Electricity 2. Heat 3. Synthetic Natural Gas (SNG) 4. Methanol 5. Ethanol 6. Dimethyl ether (DME) 7. Biochar
• Garbage • Waste from agriculture • Black liquor • Lignin • Sawdust • Sludge • Wood	a) Residues from agriculture b) Residues from forestry and forest-based industry c) Residues from nature and landscape management d) Other organic residues	**B12 Hydrothermal liquefaction (HTL)**	1. Platforms	1. Biocrude

• Agricultural waste • Pruning wood • Verge grass • Dried wood • Dried manure • Straw • Olive residues • Dried sludge	a) Residues from agriculture b) Residues from forestry and forest-based industry	**B13 Pyrolysis**	1. Platforms 2. Energy_Other 3. Platforms	1. Pyrolysis oil 2. Gas by-product 3. Biochar
• Wood • Forestry residues • Sewage sludges • Agricultural residues • Food residues • Organic fraction (urban solid wastes)	a) Residues from agriculture b) Residues from forestry and forest-based industry	**B14 Torrefaction & Carbonization**	1. Platforms	1. Biocoal (black pellets)

Annex E: Long list assessment criteria

E1. Criteria Circular Assessment Tool (CAT)

The broader assessment methodology related to the detailed circular assessment tool of Elbersen *et al.* (2022) distinguishes the following criteria within four different main themes:

Circularity

- Functionality used: Has the functionality been used and at what level?
- Efficiency: What is the technical efficiency of the use?
- Re-use potential: Can the biomass (or components thereof) after initial use be reused? And at what functionality level?
- Land sparing / natural resource savings: When products are used for making products this can reduce the need to use more land, water and other finite natural resources.

Socio-economic impact

- Rural development: Does the proposed project contribute to economic activity beyond the project itself? Is the project expected to boost the well-being of surrounding communities?
- Job creation: Does the project create a situation with more employment opportunities than in the baseline situation without the project?
- Profitability: Does the project have a higher profitability than the agri-residue processing activities it replaces?
- Value added: Is there new economic value creation in terms of products from the project?

Environmental impact

- Does the proposed valorisation lead to less GHG emissions than would be the case in a situation without the proposed project?
- Does the proposed valorisation lead to better soil quality or reduced soil degradation compared to a situation without the proposed project?
- Does the proposed valorisation lead to improved air quality (or water quality) compared to a situation without the proposed project?
- Does the proposed valorisation lead to more biodiversity (or less biodiversity loss) compared to a situation without the proposed project?

Implementability

- Access to the required technologies, knowledge and skills to operate these.
- Presence of necessary physical infrastructure and business networks.
- Enabling government policies, regulations, subsidies, standards
- Availability of financing

Some of these criteria are a combination of several sub criteria like e.g., soil quality and water quality. It could also be argued that circularity is not an impact theme, but rather a means to achieve the other themes like environmental impacts.

E2. Impacts included in MainstreamBIO catalogues

The set-up of Annex C. 'Catalogue of business models that implement small-scale bio-based technologies' of MainstreamBIO deliverable D2.1 originates from the Power4BIO project (Annevelink *et al.*, 2023). The examples in the business models catalogue mention the following impacts:

Environmental Benefits

Indicating quantitative or qualitative benefits, compared to (fossil) benchmarks.

For example:

- Climate change mitigation/adaptation
- Soil protection
- Water protection
- Reduction of waste
- Reduction of virgin raw material consumption through the use of local renewable resources
- Reduction of Greenhouse Gas emissions
- Reduction of energy demand
- Reduction of land use
- Reduction of transportation movements and related Greenhouse Gas emissions by producing on a local scale
- Reduction of probability of fires by removing and using forestry residues
- Production of renewable bioenergy (electricity and heat) that replaces fossil fuels
- Production of biofertilizers that replace fossil chemical fertilizers
- Increased circularity of residues
- Recover and recycle water from residues
- Recover Phosphorous
- Carbon sequestration in biobased materials and soil
- Destruction and safe disposal of pollutants (e.g. toxins, heavy metals, organic compounds and pathogens)
- Responsible consumption

Challenges for Implementation

Indicating potential hurdles when setting up the solution.

For example:

- Restrictions by legislation in the European Union (waste, feed, food)
- Market readiness level / development
- Higher price of biobased products compared to conventional products
- Lack of appropriate support (e.g., financial)
- Weakness of value chain (e.g., transportability)
- Farmers not willing to guarantee multi annual supply
- Adequate infrastructure needed
- Failure in the technical infrastructure
- Optimization steps still needed

- Relatively high investment costs
- Need for high quality workforce
- Lack of knowledge about biobased products
- Transportability
- Difficult to align several actors from different economic sectors and backgrounds: farmers, industrial technology providers, R&D, innovators, entrepreneurs

Job Creation

Relevant topic in rural areas.

For example:

- Create new job positions
- Decent work conditions
- Industrial jobs created in structurally weak regions, that usually are agricultural heavy
- New workplaces can be created in other areas, e.g., technology providers, plant developers, and technical support
- Solution requires educated and specialized personnel, so it offers opportunities for young people to stay in or return to rural areas

Socio - Economic

Indicating local and societal impact, public perception, political attractiveness, etc.

For example social:

- Local companies perform maintenance of installations
- Cooperation between farmers can tighten social cohesion and spread cooperative values
- Public support
- Attention and interaction/cohesion of local community
- Area revitalisation
- Decrease poverty in poorer regions
- Well-being improvement
- Improvement on living conditions of the rural communities

For example economic:

- Locally produced fertilizers (nutrients) are sold to local farmers
- Local resources are used
- Funding schemes
- Optimization of profitability with minimal extra investments
- Avoiding expensive logistics
- Boosting the industrial network in the region
- Local production of renewable energy for local consumption

Furthermore, Annex D. 'Catalogue of social innovations related to small-scale bio-based solutions' of MainstreamBIO deliverable D2.1 mentions several types of impacts for bioeconomy development and also social impacts of the social innovations (SIs). Although these SIs do not directly influence the decision on the feedstock-technology-product combination, they are mentioned here for an inspirational purpose, while thinking of criteria:

Impact for bioeconomy development

- Enhancement of collaboration among key rural actors
- Increase the export of goods and services
- Preserve the environment and agricultural landscape
- Enable the economic development of rural areas
- Promote sustainable living
- Open dialogue on sustainable living development policies and measures
- Offering clients a better quality of life
- Viability of the farm holding
- Sharing/ transfer of knowledge
- Contribute to nature conservation by promoting sustainable farming practices
- Renewing existing resources
- Regenerating damaged ecosystems
- Collective action by farmers to engage in project
- Shared vision to create added value
- Increased income for farmers
- Employment opportunities for rural youth
- Maintenance or increase of the level of biodiversity
- Resource and energy efficiency
- Reduce the need for fossil-based transport
- Closed circulating systems reduce water consumption
- Work in a collaborative and co-creative manner
- Prioritize low carbon impact, zero waste, renewable energy, and organic food
- Create new opportunities for sustainable development in cities
- Generate value and wealth in rural areas and prevent depopulation
- Meet the Sustainable Development Goals (SDGs)
- Provide a local service, which promotes the development of the local economy
- Reduce food waste to save resources
- Reduce greenhouse gas emissions
- Create new opportunities for sustainable development
- Creation of new products and services
- Reduce the demand for land, water, and other resources
- Reduce waste that ends up in landfills, which pollutes the environment
- Reduce the reliance on fossil fuels and the atmospheric output associated with their use

Social impact

- Increased awareness and utilization of technologies
- Access to online resources
- Create new jobs
- Access to networks
- Provide financial support
- Provide education and training opportunities for the local community
- Support the growth of innovative businesses
- Provide job opportunities for poor villagers and jobless residents
- Involve public participation
- Empower stakeholders in the agriculture sectors and promote greater awareness of their importance to society
- Provide education and training
- Assist and advise elderly farmers
- Create intergenerational cooperation between the older generation and the younger generation
- Improve the well-being of farmers, unemployed individuals, and the broader community
- Provide a more sustainable production system
- Collaborative approach that involves local farmers, volunteers, and citizens
- Advance of sustainable living practices
- Promote public participation in sustainable development
- Provide education and training
- Offer assistance and advice on various sustainable practices
- Provides online resources to help people learn more about sustainable development and food waste management
- Promote public participation by raising awareness
- Provide assistance and advice
- Raise awareness about the importance of preserving traditional farming practices and cultural heritage
- Show the potential for crowdfunding initiatives to support local initiatives and rural development
- Non-profit organizations can contribute to sustainable development by providing innovative programs that educate and empower children and young people
- Reduce costs for households
- Offer training in the green economy for vulnerable social groups

E3. Preferred topics in Power4Bio catalogue

In the Power4BIO project the stakeholders indicated the preferred topics to be included in the Power4BIO catalogue (Power4Bio, 2019). Many topics relate to the kernel characteristics of the biobased solution (feedstock-technology-product combination), like price level of the feedstocks, investment costs for the technology and price level product ('ex-factory'). However, several of these topics could be important extra impact criteria for the assessment in the MainstreamBIO DSS. These topics include:

- Environmental benefits and drawbacks
- The regulations that apply in the value chain and should be considered to promote the initiative
- Barriers for implementation
- Weakness of the technology
- Expected return on investment
- Health benefits and drawbacks
- Socio-economics / Local and societal impact
- Competitive products (fossil-derived and biobased) and interchangeability

E4. Evaluation criteria MainstreamBIO open call

DEVELOPMENT OF SUSTAINABLE BIOECONOMY

- increased use of biomass
- reduced use of fossil raw materials
- climate or environmental benefits (reduced emissions, transport, energy use, etc.)

ECONOMIC POTENTIAL

- new business opportunities
- better profitability for the target group
- reducing the risks connected to new investments
- new knowledge important for strategic decisions and investments
- increased knowledge of market needs or potential for profitability

TECHNICAL POTENTIAL

- technical development that promotes the bioeconomy
- technical development of companies within the target group

SOCIAL POTENTIAL

- social benefits for the target group
- support safe and good lives in the society in general
- contribution to decreasing the social gaps concerning well-being, justice, power, rights and individual needs

E5. Description of criteria for the survey

Theme Social impact

- Creation of new jobs
- Increased well-being of rural communities
- Increased social cohesion within the rural community through cooperation
- Increased public perception, participation and support
- Increased political attractiveness
- Increased access to networks
- Provision of education and training opportunities for the rural community
- Provision of assistance and advice

Theme Economic impact

- Increased use of local biomass resources
- Increased local production for local demand
- Increased rural business opportunities
- Increased resource use efficiency
- Increased economic value added by the biobased product
- Increased profitability
- Increased knowledge of market demand
- Increased circularity

Theme Environmental impact

- Improvement of soil quality
- Improvement of air quality
- Improvement of water quality
- Improvement of biodiversity
- Reduction of greenhouse gas emissions
- Reduction of land use
- Reduction of waste
- Reduction of virgin raw material consumption

Theme Requirements for implementation

- Presence of sufficient biomass feedstocks
- Presence of required proven technologies
- Presence of workforce with knowledge and skills to operate technologies
- Presence of adequate infrastructure
- Presence of business networks
- Presence of enabling government policies & regulations
- Presence of enabling standards
- Presence of enabling subsidies & financial support to cover investment costs

Annex F: Results of the survey on criteria

F1. Survey

The MainstreamBIO project is developing a Decision Support System (DSS) to facilitate the identification of small-scale biobased solutions that match local biomass with technology information and market demand.

This DSS will be based on a multi-criteria decision making (MCDM) model that takes into account several types of criteria: social, economic, environmental and implementability criteria.

This survey is meant to get your opinion as member of one of our Multi-actor Innovation Platforms (MIPs).

You will be asked to score the importance of several criteria as you see it. You can also add missing criteria.

If you have any questions regarding this survey please contact: bert.annevelink@wur.nl

More information on the MainstreamBIO project can be found on our website: https://mainstreambio-project.eu/

Which of the following stakeholder groups do you associate with?

- ○ Biomass producer (farmers, forestry, aquaculture, unions, associations, etc.)
- ○ Business (agrifood & biobased industry, logistics, financing)
- ○ Government/Policy maker/Public Authority
- ○ Academic/Researcher
- ○ Civil society
- ○ Other, please specify

WAGENINGEN UNIVERSITY & RESEARCH

What is your age?

- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ Older

WAGENINGEN UNIVERSITY & RESEARCH

In what country do you live?

- ○ Bulgaria
- ○ Denmark
- ○ Greece
- ○ Ireland
- ○ Netherlands
- ○ Poland
- ○ Spain
- ○ Sweden
- ○ Other, please specify

WAGENINGEN UNIVERSITY & RESEARCH

Criteria on **social impact**

	Not important at all	Low importance	Neutral	Important	Very important
Creation of new jobs	○	○	○	○	○
Increased well-being of rural communities	○	○	○	○	○
Increased social cohesion within the rural community through cooperation	○	○	○	○	○
Increased public perception, participation and support	○	○	○	○	○
Increased political attractiveness	○	○	○	○	○
Increased access to networks	○	○	○	○	○
Provision of education and training opportunities for the rural community	○	○	○	○	○
Provision of assistance and advice	○	○	○	○	○

Please specify the social impact criteria that you miss and rank them (from 1=not important at all to 5=very important). Please use a new line for each new suggestion followed by the ranking number.

WAGENINGEN UNIVERSITY & RESEARCH

Criteria on **economic impact**

	Not important at all	Low importance	Neutral	Important	Very important
Increased use of local biomass resources	○	○	○	○	○
Increased local production for local demand	○	○	○	○	○
Increased rural business opportunities	○	○	○	○	○
Increased resource use efficiency	○	○	○	○	○
Increased economic value added by the biobased product	○	○	○	○	○
Increased profitability	○	○	○	○	○
Increased knowledge of market demand	○	○	○	○	○
Increased circularity	○	○	○	○	○

Please specify the economic impact criteria that you miss and rank them (from 1=not important at all to 5=very important). Please use a new line for each new suggestion followed by the ranking number.

WAGENINGEN UNIVERSITY & RESEARCH

Criteria on **environmental impact**

	Not important at all	Low importance	Neutral	Important	Very important
Improvement of soil quality	○	○	○	○	○
Improvement of air quality	○	○	○	○	○
Improvement of water quality	○	○	○	○	○
Improvement of biodiversity	○	○	○	○	○
Reduction of greenhouse gas emissions	○	○	○	○	○
Reduction of land use	○	○	○	○	○
Reduction of waste	○	○	○	○	○
Reduction of virgin raw material consumption	○	○	○	○	○

Please specify the environmental impact criteria that you miss and rank them (from 1=not important at all to 5=very important). Please use a new line for each new suggestion followed by the ranking number.

Criteria on requirements for implementation

	Not important at all	Low importance	Neutral	Important	Very important
Presence of sufficient biomass feedstocks	○	○	○	○	○
Presence of required proven technologies	○	○	○	○	○
Presence of workforce with knowledge and skills to operate technologies	○	○	○	○	○
Presence of adequate infrastructure	○	○	○	○	○
Presence of business networks	○	○	○	○	○
Presence of enabling government policies & regulations	○	○	○	○	○
Presence of enabling standards	○	○	○	○	○
Presence of enabling subsidies & financial support to cover investment costs	○	○	○	○	○

Please specify the criteria on requirements for implementation that you miss and rank them (from 1=not important at all to 5=very important). Please use a new line for each new suggestion followed by the ranking number.

Do you have any suggestions on the criteria to be used in the MainstreamBIO DSS?

We thank you for your time spent taking this survey.
Your response has been recorded.

F2. Results background data

Table 7. The stakeholder groups that the respondents associate with.

Type	Count
Biomass producer (farmers, forestry, aquaculture, unions, associations, etc.)	5
Business (agrifood & biobased industry, logistics, financing)	4
Government/Policy maker/Public Authority	3
Academic/Researcher	18
Civil society	2
Other, please specify	7[a)]
Total	39

a) Other types mentioned are: Research Institute; Engineering/design; Representative Body; consulting, NGO; Public Agricultural Advisory Centre; Contractor biogas plants; Citizen

There were 39 respondents who filled in the survey. Unfortunately, not all respondents completed all questions. Three respondents did not score the criteria of all the themes. The total number of respondents per specific theme and criterion are mentioned in Table 10 through Table 13.

Half of the respondents was of the type Academic/researcher (18). This could partially influence the preferences on the criteria. The other half was distributed among the types Biomass producer (5), Business (4), Government (3) and Civil society (2). Several of the items mentioned under the type Other (7) could possibly also be reallocated to one of the other categories. This was not done because no further detailed analysis per type was performed.

Table 8. The age of the respondents.

Age range	Count
18-24	0
25-34	9
35-44	13
45-54	8
55-64	7
Older	2
Total	39

All ages above 25 years were represented in the group of respondents, with a slight tendency towards the younger age ranges.

Table 9. The countries of the respondents.

Country	Count
Bulgaria	3
Denmark	4
Greece	2
Ireland	3
Netherlands	3
Poland	15
Spain	4
Sweden	5
Other	0
Total	39

All countries of the MainstreamBIO partners are represented with 2-5 respondents. However, Poland has contributed more than the other countries, with slightly more than one third of the respondents (15). This could influence the preferences on the criteria, but was not further analysed.

F3. Results criteria theme social impact

Table 10. Results criteria of the theme Social impact. One respondent did not score the second criterion of the theme Social impact. The four preferred criteria are marked bold.

Criteria	Not important at all	Low importance	Neutral	Important	Very important	Total
Creation of new jobs	0	0	7	**17**	**15**	39
Increased well-being of rural communities	0	1	6	**16**	**15**	38
Increased social cohesion within the rural community through cooperation	0	0	12	17	10	39
Increased public perception, participation and support	0	1	6	**21**	**10**	38
Increased political attractiveness	0	4	10	18	7	39
Increased access to networks	0	2	7	20	10	39
Provision of education and training opportunities for the rural community	0	0	**9**	**20**	**10**	39
Provision of assistance and advice	0	1	8	16	13	38

Social impact criteria that were missed (including rank):

- Increased public knowledge (very important)
- Increased income for agricultural activities (very important)
- Flexible education answering the current needs (very important)

Almost all criteria in the Social impact theme were scored by all 39 respondents. Two criteria that have the highest Neutral scores are ‘Increased social cohesion within the rural community through cooperation’ and ‘Increased political attractiveness’. Therefore, they were not marked as preferred criterion. Two criteria stick out as preferred because they have the highest Very Important score and also a high Important score: ‘Creation of new jobs’ (15-17) and ‘Increased well-being of rural communities’ (15-16). The criterion ‘Provision of assistance and advice’ (13-16) does have a high Very Important score but a relatively low Important score. Therefore, it was not chosen as one of the four preferred criteria for the default scoring table. The choice of the third and fourth preferred criterion was made on the basis of the combination of all the scores (including the Low importance score). This then results in the preferred criteria ‘Increased public perception, participation and support’ (10-21) and ‘Provision of education and training opportunities for the rural community’ (20-10). The four preferred criteria are marked bold in the table.

F4. Results criteria theme economic impact

Table 11. Results criteria of the theme Economic impact. Two respondents did not score the criteria of the theme Economic impact. The four preferred criteria are marked bold.

Criteria	Not important at all	Low importance	Neutral	Important	Very important	Total
Increased use of local biomass resources	0	1	1	16	**19**	37
Increased local production for local demand	0	1	8	10	18	37
Increased rural business opportunities	0	1	2	**16**	**18**	37
Increased resource use efficiency	0	1	3	12	**21**	37
Increased economic value added by the biobased product	0	1	4	17	15	37
Increased profitability	0	1	4	13	**19**	37
Increased knowledge of market demand	0	3	4	16	14	37
Increased circularity	0	1	6	14	16	37

Economic impact criteria that were missed (including rank):

- Increased communication regarding that a replacement of fossil energy/materials with biomass will result in higher prices for biomass (very important)

All criteria in the theme Economic impact were scored by 37 respondents. Three criteria immediately stick out as preferred because they have the highest Very Important score and also a high Important score: ‘Increased resource use efficiency’ (21-12), ‘Increased use of local biomass resources’ (19-16) and ‘Increased profitability’ (19-13). Although the criterion ‘Increased local production for local demand’ (18-10), has a high Very Important score, it has a lower Important score than the criterion ‘Increased rural business opportunities’ (18-16) and also the highest Neutral score (8), so it is not marked as preferred. Therefore, the choice of the fourth preferred criterion was ‘Increased rural business opportunities’ (18-16). The four preferred criteria are marked bold in the table.

F5. Results criteria theme environmental impact

Table 12. Results criteria of the theme Environmental impact. Three respondents did not score the criteria of the theme Environmental impact. The four preferred criteria are marked bold.

Criteria	Not important at all	Low importance	Neutral	Important	Very important	Total
Improvement of soil quality	1	0	4	**14**	**17**	36
Improvement of air quality	1	0	5	13	17	36
Improvement of water quality	1	0	2	15	**18**	36
Improvement of biodiversity	1	0	5	18	12	36
Reduction of greenhouse gas emissions	1	0	4	11	**20**	36
Reduction of land use	2	0	15	13	6	36
Reduction of waste	1	0	1	12	**22**	36
Reduction of virgin raw material consumption	2	0	11	11	12	36

No environmental impact criteria were missed.

All criteria in the theme Economic impact were scored by 36 respondents. Three criteria immediately stick out as preferred because they have the highest Very Important score and also a high Important score: ‘Reduction of waste’ (22-12), ‘Reduction of greenhouse gas emissions’ (20-11) and ‘Improvement of water quality’ (18-15). Although the criterion ‘Improvement of air quality’ (17-13), has a high Very Important score, it has a lower Important score than the criterion ‘Improvement of soil quality’ (17-14), so it is not marked as preferred. Therefore, the choice of the fourth preferred criterion was ‘Improvement of soil quality’ (17-14). The four preferred criteria are marked bold in the table.

F6. Results criteria theme requirements for implementation

Table 13. Results criteria of the theme Requirements for implementation. Three respondents did not score the criteria of the theme Requirements for implementation. The four preferred criteria are marked bold.

Criteria	Not important at all	Low importance	Neutral	Important	Very important	Total
Presence of sufficient biomass feedstocks	0	1	3	18	**14**	36
Presence of required proven technologies	0	2	5	16	13	36
Presence of workforce with knowledge and skills to operate technologies	0	1	1	18	**16**	36
Presence of adequate infrastructure	0	1	2	**20**	**13**	36
Presence of business networks	0	1	7	24	4	36
Presence of enabling government policies & regulations	0	2	2	15	**17**	36
Presence of enabling standards	0	2	10	20	4	36
Presence of enabling subsidies & financial support to cover investment costs	0	1	3	19	13	36

Requirements for implementation criteria that were missed (including rank):

- Presence of relevant policy framework (very important)
- Circular bioeconomy awareness (very important)

All criteria in the theme Requirements for implementation were scored by 36 respondents. Three criteria immediately stick out as preferred because they have the highest Very Important score and also a high Important score: ‘Presence of enabling government policies & regulations’ (17-15), ‘Presence of workforce with knowledge and skills to operate technologies’ (16-18) and ‘Presence of sufficient biomass feedstocks’ (14-18). Although the criterion ‘Presence of required proven technologies’ (13-16), has a high Very Important score, it has a lower Important score than the criterion ‘Presence of adequate infrastructure’ (13-20), so it is not marked as preferred. Therefore, the choice of the fourth preferred criterion was ‘Presence of adequate infrastructure’ (13-20). The four preferred criteria are marked bold in the table.

F7. Results further suggestions

In response to the question ‘Do you have any suggestions on the criteria to be used in the MainstreamBIO DSS?’ the only response was: ‘Economic and policy incentive will be foremost in mobilisation from technically feasible to economically viable’.

Annex G: External sources of supporting information

Criterion	External information source
Social impact	
Creation of new jobs	• https://knowledge4policy.ec.europa.eu/bioeconomy/topic/economy_en • Rubizmo Transformation Support Tool • EC JRC Data- Modelling platform of resource economics- Bioeconomy • COOPID Interactive platform • The best practices Atlas
Increased well-being of rural communities	• https://knowledge4policy.ec.europa.eu/bioeconomy/topic/economy_en • https://www.teagasc.ie/publications/ • BE-Rural resources • European Network for Rural Development https://ec.europa.eu/enrd/enrd-thematic-work/social-inclusion/information-sources_en.html • The best practices Atlas
Increased social cohesion within the rural community through cooperation	• https://knowledge4policy.ec.europa.eu/bioeconomy/topic/economy_en • COOPID Interactive platform • European Network for Rural Development https://ec.europa.eu/enrd/enrd-thematic-work/social-inclusion/information-sources_en.html
Increased public perception, participation and support	• Transition2bio- category: Stakeholders engagement and co-creation • BE-Rural resources • European bioeconomy library
Increased political attractiveness	• EC JRC Data Catalogue- Strategies and other policy initiatives dedicated to bioeconomy in the EU and some other countries

Increased access to networks	• https://www.biobridges-project.eu/challenges-/
Provision of education and training opportunities for the rural community	• COOPID Interactive platform • https://www.teagasc.ie/publications/ • European Network for Rural Development https://ec.europa.eu/enrd/home-page_en.html • European bioeconomy library
Provision of assistance and advice	• European Network for Rural Development https://ec.europa.eu/enrd/home-page_en.html
Economic impact	
Increased use of local biomass resources	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • Rubizmo Transformation Support Tool • S2Biom- Tools for biomass chains • The best practices Atlas
Increased local production for local demand	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • https://www.alpine-space.eu/project/alpbioeco/
Increased rural business opportunities	• Rubizmo Transformation Support Tool • https://bioswitch.eu/bioswitch-toolbox/ • BE-Rural resources
Increased resource use efficiency	• https://www.teagasc.ie/publications/ • The best practices Atlas
Increased economic value added by the biobased product	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • European bioeconomy library
Increased profitability	• EC JRC Data- Modelling platform of resource economics- Bioeconomy
Increased knowledge of market demand	• https://www.alpine-space.eu/project/alpbioeco/ • EC JRC Data- Modelling platform of resource economics- Bioeconomy • Transition2bio library- category: Foresight, market studies and market roadmaps • https://bioswitch.eu/bioswitch-toolbox/

Increased circularity	• https://www.alpine-space.eu/project/alpbioeco/
Environmental impact	
Improvement of soil quality	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Improvement of air quality	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Improvement of water quality	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Improvement of biodiversity	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Reduction of greenhouse gas emissions	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • Rubizmo Transformation Support Tool • https://bioswitch.eu/sustainability-assessment-tool/
Reduction of land use	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Reduction of waste	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Reduction of virgin raw material consumption	• EC JRC Data Catalogue- Database of LCA results for bio-based commodities • https://bioswitch.eu/sustainability-assessment-tool/
Implementation	
Presence of sufficient biomass feedstocks	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • https://www.s2biom.eu/en/publications-reports/s2biom.html • MAGIC project- Magic maps
Presence of required proven technologies	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • Rubizmo Transformation Support Tool

	• Transition2bio- Category: Uptake of RTD results • https://task42.ieabioenergy.com/databases/ • MAGIC project- Bio2Match Tool • European bioeconomy library • Pilots4U Open Access Database
Presence of workforce with knowledge and skills to operate technologies	• https://knowledge4policy.ec.europa.eu/bioeconomy/topic/economy_en • European Network for Rural Development https://ec.europa.eu/enrd/home-page_en.html
Presence of adequate infrastructure	• EC JRC Data- Modelling platform of resource economics- Bioeconomy • Pilots4U Open Access Database
Presence of business networks	• EC JRC Data Catalogue- Policy initiatives, measures and instruments supporting the bioeconomy in the EU and MSs • https://www.biobridges-project.eu/ • https://bioswitch.eu/bioswitch-toolbox/ • BIOEAST documents • European Network for Rural Development https://ec.europa.eu/enrd/home-page_en.html
Presence of enabling government policies & regulations	• EC JRC Data Catalogue- Strategies and other policy initiatives dedicated to bioeconomy in the EU and some other countries • EC JRC Data Catalogue- Regional bioeconomy strategies in the EU • https://www.s2biom.eu/en/publications-reports/s2biom.html • BIOEAST documents
Presence of enabling standards	• Transition2bio library- category: Standardization, LCA, labelling and regulatory hurdles • Agrimax project resources • European bioeconomy library
Presence of enabling subsidies & financial support to cover investment costs	• EC JRC Data Catalogue- Policy initiatives, measures and instruments supporting the bioeconomy in the EU and MSs • BE-Rural resources • BIOEAST documents

MAINSTREAM BIO
MAINSTREAMING SMALL-SCALE BIO-BASED SOLUTIONS ACROSS RURAL EUROPE

The project

MainstreamBIO is a Horizon Europe EU funded project, which sets out to get small-scale bio-based solutions into mainstream practice across rural Europe, providing a broader range of rural actors with the opportunity to engage in and speed up the development of the bioeconomy. Recognizing the paramount importance of bioeconomy for addressing key global environmental and societal challenges, MainstreamBIO develops regional Multi-actor Innovation Platforms in 7 EU countries (PL, DK, SE, BG, ES, IE & NL). The project aims to enhance cooperation among key rural players towards co-creating sustainable business model pathways in line with regional potentials and policy initiatives. MainstreamBIO supports 35 multi-actor partnerships to overcome barriers and get bio-based innovations to market with hands-on innovation support, accelerating the development of over 70 marketable bio-based products and services. Furthermore, the project develops and employs a digital toolkit to better match bio-based technologies, social innovations and good nutrient recycling practices with available biomass and market trends as well as to enhance understanding of the bioeconomy with a suite of educational resources building on existing research results and tools. To achieve these targets, MainstreamBIO involves 10 partners across Europe, coming from various fields. Thus, all partners combine their knowledge and experience to promote the growth of bioeconomy in a sustainable and inclusive manner.

Coordinator: Q-**PLAN INTERNATIONAL ADVISORS PC (Q-PLAN**)

Partner		Short Name
Q-PLAN INTERNATIONAL	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN
MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University	MUNSTER TECHNOLOGICAL UNIVERSITY	MTU
WAGENINGEN UNIVERSITY & RESEARCH	STICHTING WAGENINGEN RESEARCH	WR
IUNG Institute of Soil Science and Plant Cultivation State Research Institute	INSTYTUT UPRAWY NAWOZENIA I GLEBOZNAWSTWA, PANSTWOWY INSTYTUT BADAWCZY	IUNG
RI. SE	RISE PROCESSUM AB	PROC
AGRICULTURAL UNIVERSITY-PLOVDIV	AGRAREN UNIVERSITET - PLOVDIV	AUP
Food & Bio Cluster Denmark	FBCD AS	FBCD
innovarum	EURIZON SL	INNV
DRAXIS ENVIRONMENTAL TECHNOLOGIES	DRAXIS ENVIRONMENTAL SA	DRAXIS
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