



Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bioeconomy in Europe

**S2Biom Project Grant Agreement n°608622**

**D5.4**  
**Consistent Cross-Sectoral Sustainability**  
**Criteria & Indicators**

**Final Report**

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## About S2Biom project

The S2Biom project - Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bioeconomy in Europe - supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies, and roadmaps that will be informed by a “computerized and easy to use” toolset (and respective databases) with updated harmonized datasets at local, regional, national and pan European level for EU28, Western Balkans, Moldova, Turkey and Ukraine. Further information about the project and the partners involved are available under [www.s2biom.eu](http://www.s2biom.eu).

### Project coordinator



### Scientific coordinator



### Project partners



## About this document

This report corresponds to deliverable 5.4 – Consistent Cross-Sectoral Sustainability Criteria & Indicators - of S2Biom.

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## Executive Summary

The general objective of S2Biom Work Package 5 (WP5) is to provide a better understanding regarding sustainability requirements in biomass value chains. The compilation of consistent sustainability criteria & indicators (C&I) for the short- and medium-term bioeconomy is one of the specific objectives of this WP and the focus of this draft paper.

Based on the compilation of sustainability requirements and provisions made in task 5.1 of this project and literature review, this paper provides:

- a) an overview of different points of view to be acknowledged when delineating the approach to sustainability (i.e. scope, sustainability sets or type of indicators) , and
- b) a specific proposal of sustainability C&I for non-food biomass.

The approach to sustainability has taken into account the scope of the assessment (biomass value chains and calculation of biomass potentials), the sustainability ambition (a “basic” and a more “advanced” set of C&I), and the types of indicators to be considered (minimum requirements, comparative with non-renewable or biomass references, and descriptive indicators).

The sustainability C&I draft proposal has considered the three “pillars” (dimensions) of sustainability, i.e. environment, social and economic. In total, 12 criteria and 27 indicators are included. This set aims to serve as an **umbrella** to the bioeconomy (bioenergy and bioproducts) that can be the basis for more specific indicators in certain applications.

In the environment dimension, the following C&I are proposed:

- Resource use: Land use efficiency, secondary resource efficiency, energy efficiency, and functionality (Output service quality),
- Climate Change: Life cycle-based CO<sub>2</sub>eq including direct land use change, and other GHG emissions,
- Biodiversity: Protected areas and land with significant biodiversity values, and biodiversity conservation and management,
- Soil: Erosion, Soil Organic Carbon, and soil nutrient balance,
- Water: Water availability and regional water stress, water use efficiency, and water quality,
- Air: emissions of SO<sub>2</sub> equivalents, and PM<sub>10</sub>.

In the social dimension:

- Participation and transparency: Effective participatory processes, information transparency,
- Land Tenure: Land tenure assurance

- Employment and labour rights: Full direct jobs equivalents along the full value chain, full direct jobs equivalent in the biomass consuming region (or country), Human and Labour Rights, and occupational safety and health for workers,
- Health risks: Risks to public health,
- Food, fuelwood and other products: Food, fuelwood and other products supply security

The criterion related to the economic dimension is:

- Production costs: Current levelised life-cycle cost, and future levelised life-cycle costs

Most of these indicators are “mid-point” indicators that need further elaboration to be implementable for specific feedstocks, locations or value chains. Further work will refine these indicators and develop respective thresholds, if applicable.

Other tasks of the project will analyse how these indicators can be applied for the calculation of biomass potentials and value chains.

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## List of Acronyms and Abbreviations

BEE	Biomass Energy Europe
BOD	Biological Oxygen Demand
C	Completeness (in data quality evaluation)
CF	Characterisation Factor
C&I	Criteria and Indicators
CFCs	Chlorofluorocarbons
CPA	Statistical Classification of Products by Activity
CTU	Comparative Toxic Unit
DG ENV	Directorate General for Environment
DQR	Data Quality Rating
EC	European Commission
EF	Environmental Footprint
EMAS	Eco-Management and Audit Schemes
EoL	End-of-Life
GR	Geographical Representativeness
GHG	Greenhouse Gas
GIS	Geographic Information Systems
iLUC	Indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCT	Life Cycle Thinking
LHV	Low Heating Value



LU	Land Use
LUC	Land Use Change
M	Methodological appropriateness and consistency (in data quality evaluation)
MS	Member State
NMVOG	Non-Methane Volatile Organic Compounds
OEF	Organisation Environmental Footprint
P	Precision/Uncertainty (in data quality evaluation)
PM	Particulate Matter
PEF	Product Environmental Footprint
SOM	Soil Organic Matter
TeR	Technological Representativeness (in data quality evaluation)
TiR	Time-related representativeness (in data quality evaluation)
VGGT	Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

## 1. Introduction and Objectives

The general objective of S2Biom Work Package 5 (WP5) is to provide a better understanding among decision-makers in policy and industry as well as in the scientific community and civil society regarding **sustainability requirements** in biomass value chains addressed in Theme 1.

This goes beyond the previous discussions around sustainability of liquid biofuels<sup>1</sup>, and the ongoing discussions on solid/gaseous bioenergy<sup>2</sup> and biomaterials<sup>3</sup> in aiming to develop comprehensive sustainability requirements for **all non-food biomass** in the broader **bioeconomy**<sup>4</sup>.

To achieve this, the specific objectives of WP5 are:

1. Identification of sustainability criteria and indicators (C&I) for non-food biomass value chains, gap analysis of respective legislation, regulation and voluntary schemes at international, European and Member States level<sup>5</sup>.
2. Adaptation of the life cycle-based EC Environmental Footprint methods in order to develop a complementary methodology specific to non-food biomass value chains<sup>6</sup>.
3. Compilation of consistent sustainability C&I for the short- and medium-term bioeconomy, and an outlook for long-term developments (i.e. this paper).
4. Development of guidelines for evaluating the environmental performance with the toolset developed in WP4 of all lignocellulosic feedstocks for the various industrial routes, building on existing tools, and extending to bio-based products (chemicals; materials, etc.), and their interrelations<sup>7</sup>.

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<sup>1</sup> See EU (2009) for the respective requirements in the EU, and Franke et al. (2013) for global requirements.

<sup>2</sup> See EC (2014) for the view of the European Commission on that, and Fritsche et al. (2014) for other views.

<sup>3</sup> See e.g. BISO (<http://sa.jrc.ec.europa.eu/>), bioeconomy observatory (<http://www.biobasedeconomy.eu/>) and INRO (<http://www.inro-biomasse.de/en.htm>)

<sup>4</sup> "Bioeconomy" (EC 2012) encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. Its sectors and industries have strong innovation potential due to their use of a wide range of sciences, enabling and industrial technologies, along with local and tacit knowledge. For a discussion of the status of activities to derive sustainability requirements for the broader bioeconomy, see Fritsche, Iriarte (2014).

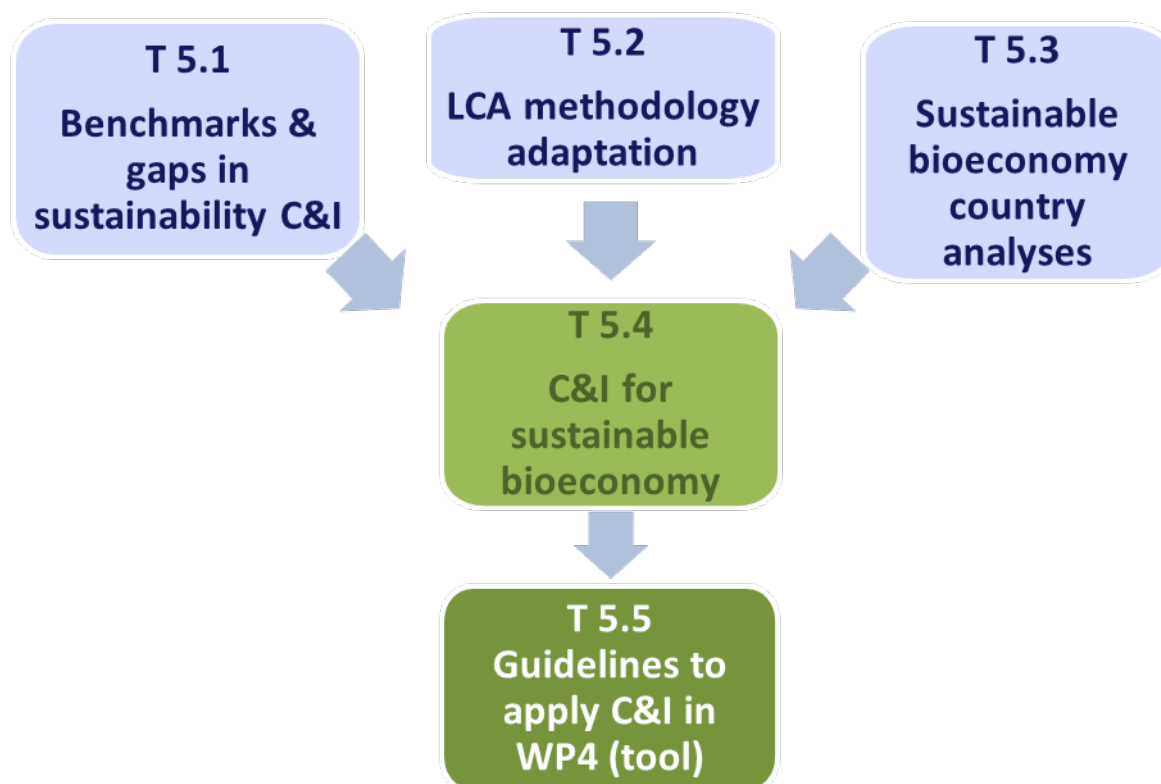
<sup>5</sup> See WP5 Task 5.1 (carried out by IINAS) with its deliverable D 5.1

<sup>6</sup> See WP5 Task 5.2 (carried out by the JRC) with its deliverable D 5.2

<sup>7</sup> See Task 5.5 (carried out by EFI and IINAS) with its deliverables D 5.5 and 5.6.

To this end, five tasks have been identified in WP5, as shown in Figure 1. The outcomes of the first three tasks serve in addition to their own value to the purposes of this work. Later, task 5.5 provides the link to the other project WPs of the project.

Figure 1 Structure of Sustainability Activities in S2Biom



Source: own elaboration

This draft paper presents preliminary findings from Task 5.4, focusing on consistent sustainability C&I for the short- and medium-term bioeconomy. The specific objectives of Task 5.4 are twofold:

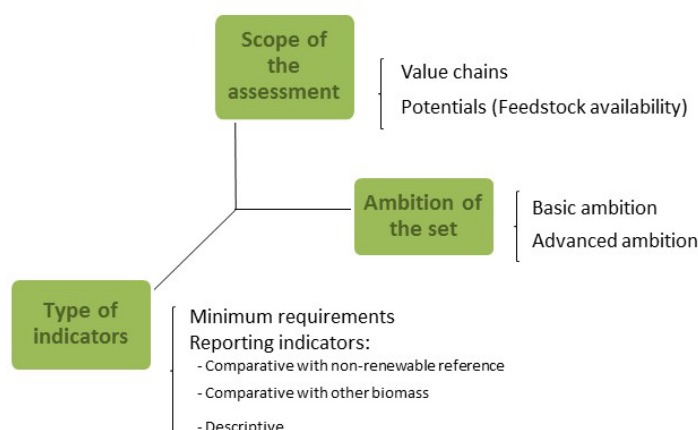
- Develop a sustainability **framework** according to which biomass chains can be evaluated in the S2BIOM project (and beyond), particularly in the tools developed as part of the project, as illustrated in Figure 2. This includes the distinction among:
  - **Scope** of the assessment: different considerations have to be in place when biomass value chains are assessed or when biomass potentials calculated.

- **Ambition** of the sustainability assessment: “sustainability” might refer to many different indicators, and respective thresholds. Taking this into account, once a comprehensive set of indicators were identified, a “basic” and a more “advanced” set of sustainability C&I were proposed.

In both cases, it is necessary to differentiate between **types** of indicators (different categories): minimum requirements, and reporting indicators (comparative with non-renewable reference, comparative with biomass reference, and descriptive indicators).

- Propose a draft (scientific) sustainability **C&I set** and from this set elaborate basic and advanced sustainability sets that capture different ambitions.

Figure 2 The various dimensions of sustainability in S2Biom – The umbrella approach



Source: own elaboration

The main added value of this report over previous efforts is that it addresses sustainability within the several aspects encompassed by the bioeconomy in a sound way, providing a comprehensive and coherent framework. Within the scope of the assessment “policy” considerations have not been included since this is indirectly addressed when analysing value chains and potentials. It is **not** the objective of Task 5.4 to develop a sustainability scheme for certification.

The paper is structured as follows:

- **Section 2** describes the various approaches considered in carrying out a sustainability assessment in bioeconomy value chains.
- In **Section 3**, the preliminary list of sustainability criteria and indicators and a proposal for a basic and advanced sustainability set are presented.

- **Section 4** drafts the next steps to elaborate the final report.

The **references** used are given in the last section.

In the **annex**, detailed requirements proposed in other projects relevant for the scope of this work are provided.

## 2. Sustainability Assessment

Assessing biomass sustainability is a complex exercise. The proposal presented here did not only focus on drafting a list of sustainability C&I (Section 3) but also on depicting different approaches to facilitate sound understanding. This refers, for example to describing various types of indicators (see Section 2.2), defining the scope of analysis and assessment (see Section 2.3) or defining the ambition of the assessment (see Section 2.4).

This report builds on previous relevant efforts to address a sound approach to biomass sustainability such as Biomass Policies (Pelkmans et al. 2014), Biomass Energy Europe - BEE- (Vis et al. 2010; Koch et al. 2011), Biomass Futures (Fritsche et al. 2012), Biocore (Piotrowski et al. 2013; Rettenmaier et al. 2014), and Global BioPact (Diaz-Chavez et al. 2012).

Definition of Principles, Criteria and Indicators, based on FAO (2002):

- **Principles (or themes)** are commonly formulated around a core concept based on societal ethics, values, and tradition as well as on scientific knowledge. Principles are used as the primary framework for the general scope and provide the justification for criteria, indicators and verifiers.
- **Criteria** are ‘second order’ principles that add meaning and operationability to standards/principles without being a direct measure of performance. Criteria are intermediate points to which information provided by indicators can be integrated, facilitating an interpretable assessment.
- **Indicators** are quantitative or qualitative factors or variables providing means to measure achievement, to reflect changes, or to help assess performance or compliance, and - when observed periodically - demonstrate trends. Indicators should convey a single meaningful message (information). Indicators have to be judged on the scale of acceptable standards of performance.

### 2.1 Overall approach

As explained in Section 1, the S2Biom project is focused on the delivery of **non-food** biomass for the bioeconomy. This has implications in terms of sustainability since it has to consider a broad variety of products with alternative end-uses (bioenergy or bio-based products). Given this complexity, this C&I sustainability proposal (see section 3.2) opted for an **umbrella approach** from which more specific indicators could be derived.

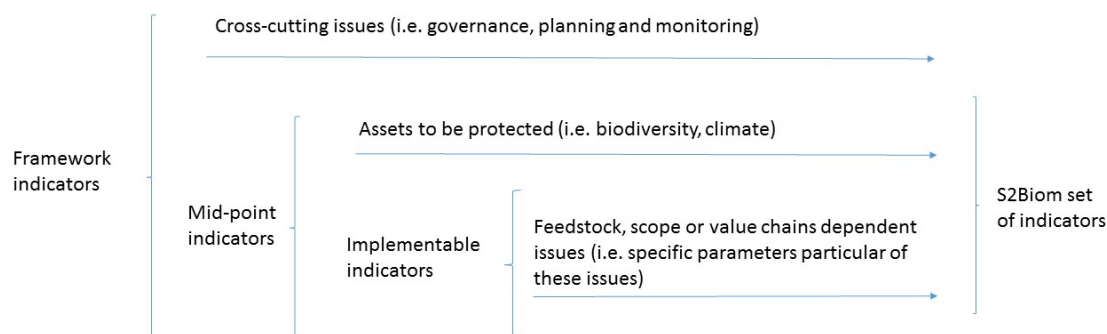
A working hypothesis of the S2Biom project is that all non-food biomass in the bioeconomy should be subject to the **same** sustainability requirements, regardless of feedstocks and end-uses (bioenergy or bio-based products).

This is the main reason why this proposal for sustainability C&I is mainly focused on midpoint indicators from which implementable indicators (with respective

thresholds – see Section 4) applicable for specific feedstocks and end-uses can be derived when needed. Nonetheless, the approach to sustainability indicators presented here has been conceptualized around 3 categories of information, as shown in Figure 3. Thus, this proposal has distinguished between:

- **Framework indicators:** This type of indicator refers to general cross-cutting requirements that might apply to several criteria and indicators included in this proposal (e.g. compliance with laws or planning and monitoring) and that are beyond the scope of the indicators elaborated here.
- **Mid-point indicators:** Are those requirements that aim to address assets or commons to be maintained or protected. This proposal focuses on this type of indicators since this is the conceptual level that can cover all types of feedstocks and value chains. From this “umbrella” set of indicators, specific implementable indicators can be elaborated.
- **Implementable indicators:** based on the mid-point indicators, this level aims to delineate concrete indicators adapted to various feedstocks, value chains or scopes. In this category, cross-cutting requirements that could affect to several mid-point indicators are also included.

Figure 3 Conceptualization of the types of indicators



Source: own elaboration

Some of the mid-point indicators can be directly applied to achieve the respective scope (e.g. assess biomass potentials or sustainability in a value-chain) while other indicators have to be further elaborated to capture (and assure) the sustainability risks posed by any activity (implementable indicators). For instance, when harvesting forest residues for bioenergy, it is necessary to leave a certain amount of residues to protect biodiversity and soils. On the other hand, the amount of residues to be left on the ground is a very particular sustainability consideration for primary residues, not being relevant for other types of feedstocks. The draft set of C&I considers biodiversity and soils but does not specify this particular requirement (the amount of residues to be left on the ground), as illustrated in Table 1. Then, for this specific feedstock more detailed indicators, aimed to meet sustainability requirements formulated as midpoint

indicators might be proposed. The question here would be whether these specific indicators are enough to show the compliance with the mid-point indicators or additional considerations are needed.

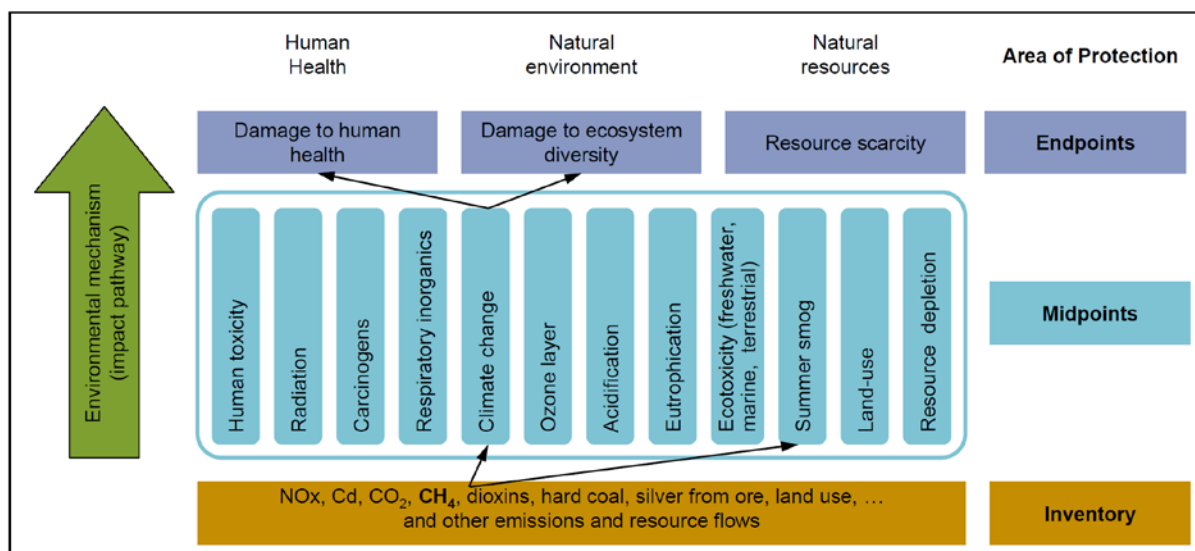
*Table 1 Overview of the relation between “mid-point” indicators and “implementable” indicators.*

S2Biom Criteria	S2Biom Mid-point Indicators		S2Biom Implementable Indicators
3. Biodiversity	3.1	Protected areas and land with significant biodiversity values	Amount of residues to be left on the ground in every location
	3.2	Biodiversity conservation and management	
4. Soil	4.1	Erosion	
	4.2	Soil Organic Carbon	
	4.3	Soil nutrient balance	

Source: own elaboration

This conceptualization is in line with the hierarchy used in life-cycle assessment, as represented in Figure 4, which distinguishes between “inventory”, “mid-points” and “endpoints”. In the approach presented here, the LCA point of view is acknowledged but also non-environmental indicators are proposed to address all sustainability dimensions (see Section 0).

*Figure 4 Life cycle impact assessment: Schematic steps from inventory to category endpoints*



Source: JRC (2010)

The main difference between the midpoint indicators proposed in life-cycle impact assessment and those proposed here (see Section 3) is structure and scope:



Here we have used themes (sustainability dimensions) instead of LCA “endpoints”, and criteria and indicators instead of LCA “impact categories”. Scope-wise, social and economic aspects are also addressed here. Yet, the environmental criteria proposed here are comparable to the midpoint indicators used in LCA.

Table 2 describes the impact categories considered in the “Methodology for life-cycle based environmental sustainability assessment of non-food biomass value chains” developed within the S2Biom project (JRC 2014). These impact categories were taken as a base for the environmental theme in the S2Biom proposal (see Section 3.2).

*Table 2 Default list of impact categories and indicators for inclusion in the environmental sustainability assessment*

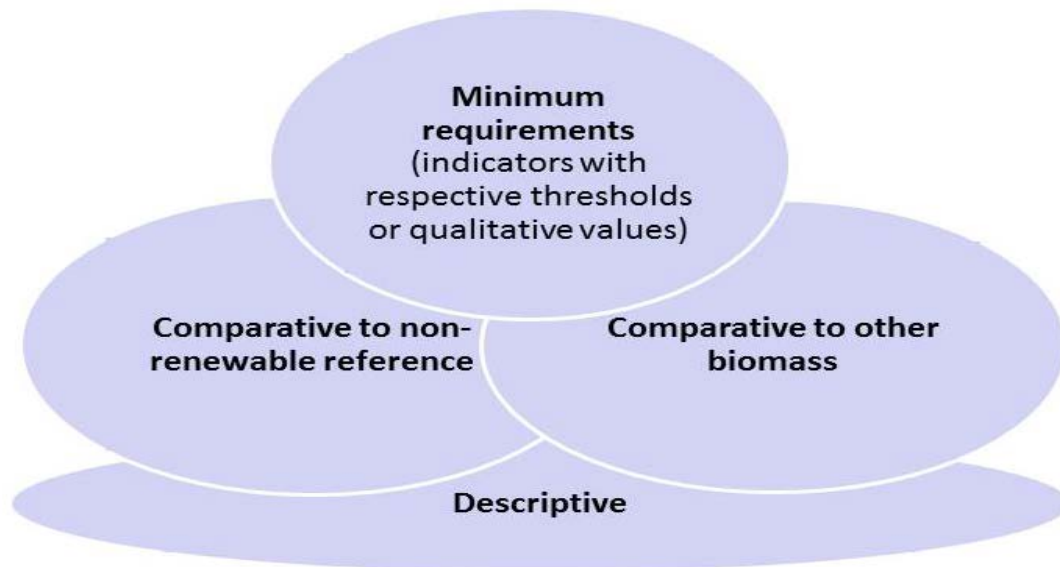
Impact Category	Impact Category indicators
Climate change	kg CO <sub>2</sub> equivalent
Ozone depletion	kg CFC-11 equivalent
Ecotoxicity for aquatic fresh water	CTUe (Comparative Toxic Unit for ecosystems)
Human toxicity - cancer and non-cancer effects	CTUh (Comparative Toxic Unit for humans)
Particulate matter/respiratory inorganics	kg PM <sub>2.5</sub> equivalent (particulate matter with a diameter of 2.5 µm or less)
Ionising radiation – human health effects	kg U <sup>235</sup> equivalent (to air)
Photochemical ozone formation	kg NMVOC equivalent
Acidification	mol H <sup>+</sup> eq
Eutrophication – terrestrial	mol N eq
Eutrophication – aquatic	fresh water: kg P equivalent; marine: kg N equivalent
Resource depletion – water	m <sup>3</sup> water use related to local scarcity of water
Resource depletion – mineral, fossil	kg antimony (Sb) equivalent
Land use	Soil Organic Matter kg (deficit)

Source: JRC (2014)

## 2.2 Type of Indicators

As shown in Figure 5, this work distinguishes between different types of indicators that play different roles in sustainability assessments. In general words, we distinguish between two main categories: “minimum requirements” and “reporting indicators” (those that provide complementary information to assess sustainability performance).

Figure 5 Type of Indicators



Source: own elaboration

Four categories are identified:

- **Minimum requirements:** present the minimum list of indicators, which sustainable biomass is subject to, and associated thresholds (or qualitative attributes) that should be met, resulting in an acceptable compliance only if indicator meets a certain value (e.g. minimum GHG emissions reduction level).
- **Comparative to non-renewable reference:** these indicators can be compared with e.g. fossil fuel or non-renewable material references (e.g. PM<sub>10</sub> and SO<sub>2</sub>eq).
- **Comparative to other biomass value chains:** indicators that are to be compared to other biomass systems only, as they are not relevant for non-renewable value chains (e.g. Soil Organic Carbon).
- **Descriptive:** these indicators provide information about key complementary characteristics relevant for assessment (e.g. participation and transparency).

These indicators are helpful to assess both biomass potentials (i.e. availability of feedstocks) and the sustainability performance of biomass value chains.

The differentiation into minimum requirements and “reporting indicators” (i.e. comparative and descriptive indicators) is also considered in other schemes such as the draft NTA8080-1 (NEN 2014), currently under development.

The concepts included within each of these indicators is quite flexible and might be overlapped. This means that depending on the ambition of the sustainability

assessment (see Section 2.4), the same indicator might be descriptive, comparative or a minimum requirement. For example, CO<sub>2</sub> emissions from indirect Land Use Change and carbon stock changes might be classified as descriptive, comparative to other biomass value chains, or a minimum requirement depending on the sustainability ambitions.

### 2.3 Scope of Analysis and Assessment

Applying sustainability considerations might serve different purposes such as the evaluation of the sustainability of value chains in the bioeconomy or the calculation of sustainable biomass potentials.

Assessing sustainability in a **value chain** should consider the full range of indicators to obtain the full and complete picture<sup>8</sup>. Comparative and descriptive indicators could provide additional information to be expressed by means of a spider chart (or a traffic light system in tools and applications for which this classification might be of interest).

When assessing sustainable biomass **potentials**, the minimum requirements should be used to derive the sustainable potential from the technical potential.

The indicators are also different with regard to their geographical scope, as they can be:

- **spatially explicit** (e.g. for biodiversity, soil, etc.) when they depend on the location.
- **partially** attributable to spatial distribution (e.g. GHG, land use efficiency) when a part of the indicator is associated to the location (i.e. production) and another part depends on the value chain.
- **non-spatial** but circumstantial (e.g. labour conditions, employment) when their performance depend on the context and not specifically on the location.

Then, the methodology both for the assessment of biomass potentials and value chains needs to combine:

- Definition of typical (default) data of value chains to perform LCA.
- Geographic Information Systems (GIS) application (especially for potentials).
- Setting approach (for circumstances).

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<sup>8</sup> When the **end use** of the value chain is unknown, the delivered biomass can be compared to a fossil or biomass reference system. Complete combustion for all end-energy carriers might be assumed to take into account the C in the fuels (and S etc. for the air emissions) so that the emissions per unit of energy is known without factoring in efficiencies, location etc.

## 2.4 Ambition of the Sustainability Sets

First a science-based set of sustainability C&I was elaborated (see Section 3.1). **Policy** issues and other practical aspects that might restrict the application of these indicators have not been considered.

Based on this set, a set with minimum ambition (**basic set**) towards sustainability, and a more “advanced” one (**advanced set**) with higher ambition can be elaborated which explicitly takes into account the “willingness” to apply a narrower or a broader concept of sustainability requirements to the bioeconomy. A proposal in this respect is provided in Section 3.2.

There are several ways to **move** from the basic set to the advanced one:

- (1) **Type of indicators**: an issue classified as comparative or descriptive indicator might become minimum requirements, e.g. the proposal in the basic and advanced set (see Table 3) with respect to “food, fuelwood and land tenure security”.
- (2) **Threshold level**: thresholds of the minimum requirements might become more “demanding”, e.g. regarding GHG savings.
- (3) **Issues to consider**: the list of indicators might be expanded, e.g. with respect to air emissions, soil or water criteria.

### 3. Proposal for Sustainable Biomass C&I

This proposal goes beyond sustainability requirements for biomass for bioenergy, including also provisions for bio-based products, thus targeting non-food biomass for the bioeconomy in general. Given the differences in various feedstocks and end-uses that the bioeconomy includes, this work focused on the “**mid-point indicators**” (see Section 2.2). This approach aims to go beyond current sectoral policies in the agriculture, forestry or waste sectors to provide an integrated point of view towards sustainability of the bioeconomy.

#### 3.1 Data Background for the C&I Proposal

To develop this set of sustainability C&I, particular attention has been paid to:

- The methodology for life-cycle based environmental sustainability assessment of non-food biomass value chains, elaborated by the JRC (2014)
- Current criteria and indicators developed for bioenergy at the international, EU and country level, including voluntary private sector schemes<sup>9</sup>.
- Other sectoral policies with sustainability requirements (i.e. EU Forest Strategy).
- Proposals from other research projects focused (mainly) on biomass for bioenergy such as Biomass Energy Europe (Vis et al. 2010), Biomass Futures (Fritsche et al. 2012), Biomass Policies (Pelkmans et al. 2014), Global Bio-Pact (Díaz Chavez et al. 2012) and BioTrade2020plus<sup>10</sup>.
- Efforts from other projects that focuses on biorefineries such as BIOCORE (Piotrowski et al. 2013; Rettenmaier et al. 2014), EuroBioRef<sup>11</sup>, and SUPRA-BIO<sup>12</sup>.

Also, the information compiled in the deliverable 5.2 of S2Biom (benchmark and gap analysis) has been taken into account. This benchmark and gap analysis covered more than 50 sustainability schemes in the agriculture, bioenergy, forest and other sectors (e.g. waste, biodiversity, etc.) and selected schemes were benchmarked against the draft set of indicators developed in this proposal. This report concluded that biodiversity, soil and land tenure criteria were extensively addressed in the schemes subject to the analysis. Indicators related to climate change, water, participation and transparency as well as employment and labour

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<sup>9</sup> See the schemes identified in S2Biom Deliverable 5.1

<sup>10</sup> The main aim of BioTrade2020plus project is to provide guidelines for the development of a European Bioenergy trade strategy for 2020 and beyond, see project website: <http://www.biotrade2020plus.eu/>

<sup>11</sup> <http://eurobioref.org/>

<sup>12</sup> <http://www.suprabio.eu/>

conditions were partially considered while indicators for resource efficiency and risks to public health were addressed only occasionally. Food security and production costs were not meaningfully covered in any sector.

The benchmark and gap analysis made a wide range of suggestions, including some with respect to the draft set indicators. These recommendations have been incorporated in this proposal.

### 3.2 Sustainability C&I

The proposal on sustainability C&I for bioeconomy is presented in Table 3. This proposal has considered the three common sustainability dimensions, i.e. environment, social and economic. Each indicator is formulated in a general way and accompanied by its respective definition. In total, 12 criteria and 27 indicators are included in this proposal.

*Table 3 Draft Sustainability Criteria and Indicators for the Bioeconomy*

Theme	Criterion	Indicator Description		
		#	Indicator	Definition
Environment	1. Resource use	1.1	Land use efficiency	Biomass (including by- and co-products along life cycles) per hectare of cultivated area
		1.2	Secondary resource efficiency	Heating value of biomass output divided by heating value of secondary resource; applies to conversion of residues and wastes
		1.3	Energy efficiency	Cumulative energy requirements (all inputs based on LHV primary energy) compared to outputs
		1.4	Functionality (Output service quality)	Economic value of outputs (€/GJ and €/ton), compared to economic value of heat which could be produced from burning (dried) primary inputs (reference = heat from NG ~ 10€/GJ); economic values excluding taxes, for industrial customers
	2. Climate change	2.1	Life cycle-based CO <sub>2</sub> eq including direct land use change	GHG emissions during the whole value chain (i.e. crop growth & harvesting, logistics, pre-treatment and conversion, distribution and end-use phase) in relation to the final output (combination of electricity, useful heat, biofuels & biomaterials)
		2.2	Other GHG emissions	GHG from indirect land use changes (ILUC) and carbon stock changes in forests
	3. Biodiversity	3.1	Protected areas and land with significant biodiversity values	Categories established by the RED: - Protection of land with high biodiversity value (Art. 17.3). Primary forests, areas designated by laws, and other highly biodiverse areas (recognized by international

Theme	Criterion	Indicator Description		
		#	Indicator	Definition
				<p>agreements or International Union for Conservation of Nature (IUCN)) and natural and non-natural highly biodiverse grasslands should be excluded.</p> <ul style="list-style-type: none"> <li>- Protection of land with high carbon stocks (Art. 17.4). Wetlands, continuously forested areas and lightly forested areas with this status in January 2008 but no longer have it should be avoided (not applicable if the status in January 2008 is maintained).</li> <li>- Protection of peatlands (Art. 17.5).</li> </ul>
		3.2	Biodiversity conservation and management	"Agrobiodiverse cultivation" (crop rotation; diversity in the landscape; avoidance of alien species), amount of chemicals (pesticides/herbicides), and release/monitoring of Genetically Modified Organisms
	4. Soil	4.1	Erosion	Probability of erosion where mitigation measures are not feasible
		4.2	Soil Organic Carbon	Probability of soil organic carbon loss where mitigation measures are not feasible (it depends on the type of crops - perennials and annual crops- and respective land management)
		4.3	Soil nutrient balance	Probability of nutrient balance loss where mitigation measures are not feasible
	5. Water	5.1	Water availability and regional water stress	Water use in relation to TARWR (total actual renewable water resources), or average replenishment from natural flow in a watershed
		5.2	Water use efficiency	Water use for biomass production (cropping), irrigation, and processing/kg biomass
		5.3	Water quality	Presence of water pollutants (e.g. nitrate, phosphorous, pesticides, biochemical oxygen demand)
	6. Air	6.1	SO <sub>2</sub> equivalents	Life cycle emissions of SO <sub>2</sub> , NO <sub>x</sub> , NH <sub>3</sub> and HCl/HF from bioenergy provision, expressed in SO <sub>2</sub> equivalents and calculated in accordance to GHG emissions
		6.2	PM <sub>10</sub>	Life cycle emissions of PM <sub>10</sub> , calculated in accordance to GHG emissions
Social	7. Participation and transparency	7.1	Effective participatory processes	Enable effective participation of all directly affected stakeholders by means of a due diligence consultation process, incl. Free Prior & Informed Consent when relevant
		7.2	Information transparency	Freely availability of documentation necessary to inform stakeholder positions in a timely, open, transparent and accessible manner

Theme	Criterion	Indicator Description		
		#	Indicator	Definition
	8. Land tenure	8.1	Land tenure assurance	Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land to secure land tenure and ownership (CFS 2012)
	9. Employment and labour rights	9.1	Full direct jobs equivalents along the full value chain	Number of jobs (gross figure) from biomass along the full value chain
		9.2	Full direct jobs equivalent in the biomass consuming region (or country)	Number of jobs (gross figure) from biomass in the biomass consuming region (or country)
		9.3	Human and Labour Rights	Adherence to ILO (1998) principles and voluntary standards
		9.4	Occupational safety and health for workers	Measures taken to guarantee occupational and health safety for workers
	10. Health risks	10.1	Risks to public health	Measures taken to safeguard public health, i.e. regulation of noise level and prevention of accidents
	11. Food, fuelwood and other products	11.1	Food, fuelwood and other products supply security	Measures to avoid risks for negative impacts on price and supply of national food basket, fuelwood and other products.
Economic	12. Production costs	12.1	Current levelised life-cycle cost	Current levelised life-cycle cost, excluding subsidies (excl. subsidies, incl. CAPEX and OPEX)
		12.2	Future levelised life-cycle costs	Future levelised life-cycle cost, excluding subsidies (excl. subsidies, incl. CAPEX and OPEX)

Source: own elaboration



To have a better understanding of the sustainability requirements in other research projects, and apply their outcomes in S2Biom, a benchmark of the indicators proposed in these works against this proposal has been carried out, as shown in Table 4. The projects considered in this benchmark are:

- Biomass Policies (Panoutsou et al. 2013): This ongoing project “Strategic Initiative for Resource Efficient Biomass Policies” aims to develop integrated policies for the mobilisation of “resource efficient” indigenous bioenergy ‘value chains’ in order to contribute towards the 2020 bioenergy targets set within NREAPs & 2030, and other EU27/ national policy measures. Within the project principles of resource efficiency for biomass uses have been developed (Pelkmans et al. 2014). These principles and guidelines have been aligned with the efforts within S2Biom.
- BEE: Biomass Energy Europe (Vis et al. 2010). This project proposed a list of sustainability requirements to assess different types of biomass potentials.
- Biomass Futures (Fritsche et al. 2012). This project developed a set of criteria and indicators for bioenergy.
- BIOCORE: BIOCCommodity Refinery (Piotrowski et al. 2013; Rettenmaier et al. 2014). This project focused on developing a sustainability approach for biorefineries. Sustainability requirements of this project were harmonized with those of other research projects investigating biorefineries (e.g. EuroBioRef and Suprabio). The Star Colibri project<sup>13</sup>, which also targeted biorefineries, provided an overview of fundamental considerations regarding environmental, economic and social aspects of biorefineries from a life cycle perspective. Given that the approach is based on LCA, the indicators have not been specifically included in this benchmark.
- Global BioPact (Diaz-Chavez et al. 2012). This project developed and harmonised a global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts.

Main differences between this proposal and the proposals of the projects stated above refer to:

At the **theme** level:

- The BIOCORE project took into account indicators related to technology that did not seem relevant in this umbrella proposal.

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<sup>13</sup> [http://www.star-colibri.net/wiki/index.php?title=Main\\_Page](http://www.star-colibri.net/wiki/index.php?title=Main_Page)

- At the **criterion level**:
  - In the environmental theme, BEE, Biocore and Global Bio-Pact have included “Land Use, Land Use Change and indirect Land Use Change” (LU, LUC and iLUC) as a criterion. This proposal based on mid-point indicators does not take this criterion into account since it is a cross-cutting issue. Thus, issues related to “LU, LUC and iLUC” might have impacts on climate change, biodiversity soil or water mid point criteria and indicators. Because of this, provisions with respect to “LU, LUC and iLUC” will be considered when developing “implementable indicators”.
  - Rural development and infrastructure: this criterion, proposed in Biocore and addressed by Global Bio-Pact, is indirectly considered in the indicators proposed here with respect to jobs creation (see indicators 9.1 and 9.2). On the other hand, potential indicators under this criterion should be “reporting indicators”, similar to “Production of feedstock”, “Identification of stakeholders along the supply chain” and “Policies and regulations”.
  - Gender equality: given the difficulty on proposing a sound definition of this criterion and the lack of sound data for its quantification, it has not been included in this proposal.
  - The Biomass Policies project also considers “Markets” and “System versatility” as criteria under the economic theme. These criteria and corresponding indicators are not focused on the sustainability assessments of biomass potentials or values chains so have not been included in this proposal.
  - “Other economic considerations” refer to issues as considered in Biocore and Global Bio-Pact, mostly related to production costs.
- At the **indicator level**:
  - The requirement stated in BEE, “Increase of resource efficiency” refers to recycle before waste is used for energy production, and ensure a sustainable use of renewable resources”. This is partially included in indicators 1.4 (Functionality) and 11.1 (Measures to avoid risks for negative impacts on price and supply of national food basket and fuelwood) of this proposal.
  - “Fauna” and “Landscape”, as proposed in Biocore, are covered by the criterion for biodiversity.
  - “Photochemical ozone formation (POPC)” and “(Stratospheric) Ozone depletion”. These indicators are partially covered though the “Life Cycle-based CO<sub>2</sub>eq including direct land use change” and the “SO<sub>2</sub>eq emissions”. POPC might be relevant due to CO release, when biomass is combusted incompletely. This might happen only in fireplaces and stoves. Then, given this limited potential impacts, these indicators have not taken into account in the S2Biom proposal.

It is worth noting that in the scientific discussion around “relevant” environmental impact categories, the UNEP-SETAC Life-Cycle Initiative tries to achieve a broad

consensus<sup>14</sup>. Following lines aim to explain why some of the impact categories included in the “LCA indicators” (see JRC 2014) are not directly covered here.

One outcome of the UNEP-SETAC Life-Cycle Initiative is a prioritization of impact categories which identified global warming (i.e. climate change), particulate matter (e.g. PM<sub>10</sub>), land and water use as well as acidification, among others, as key issues (Jolliet et al. 2014), and argues:

*"The success of the Montreal protocol makes stratospheric ozone depletion less relevant as the magnitude of impacts has been largely mitigated." (Jolliet et al. 2014:964)*

Furthermore, biomass systems typically contribute only very small emissions relevant for this impact category (similar for tropospheric ozone formation).

Acidification is most commonly expressed in SO<sub>2</sub>eq (instead of mol H<sup>+</sup> eq) and data for particulate matter emissions are available typically for PM<sub>10</sub> (instead of PM<sub>2.5</sub>).

As regards mineral and fossil resource depletion, the use of Antimon equivalents (Sbeq) is surely one option to quantify impacts, but it may be more informative to differentiate overall resource and to focus on e.g. non-renewable primary energy factors (PEF).

Last but not least, the environmental impacts are just on part of sustainability assessment (see e.g. Singh et al. 2012). Indeed, social and economic issues are also relevant.

**Table 4** *Benchmark of the indicators included in previous relevant research projects*

Theme	Criterion	Indicator	S2Biom	Biomass Policies	BEE	Biomass Futures	Biocore	Global Bio-Pact
Environmental	Resource use	Land Use Efficiency	✓	✓		✓		
		Secondary Resource Efficiency	✓	✓		✓		
		Energy Efficiency	✓	✓			~	
		Functionality (Output service quality)	✓	✓				
		Increase of resource efficiency		~	✓			
	Climate Change	Life cycle-based CO <sub>2</sub> eq including direct land use change	✓	✓		✓	✓	
		Other GHG emissions	✓	✓		✓		

<sup>14</sup> See <http://www.lifecycleinitiative.org/>

Theme	Criterion	Indicator	S2Biom	Biomass Policies	BEE	Biomass Futures	Biocore	Global Bio-Pact
	Biodiversity	Protected areas and land with significant biodiversity values	✓	✓	✓	✓		~
		Biodiversity conservation and management	✓	✓	✓	✓		✓
		Fauna					✓	✓
		Landscape					✓	
		Access to ecosystem services						✓
	Soil	Erosion	✓	✓	✓	✓	✓	✓
		Soil Organic Carbon	✓	✓	~	✓	✓	✓
		Soil nutrient balance	✓	✓	~	✓	~	✓
	Water	Water availability and regional water stress	✓	✓	✓	✓	✓	✓
		Water use efficiency	✓	✓				
		Water quality	✓	✓	✓	✓	✓	✓
	Air	SO <sub>2</sub> equivalents	✓	✓	✓	✓	✓	~
		PM <sub>10</sub>	✓	✓	✓	✓	✓	~
		Photochemical ozone formation					✓	~
		(Stratospheric) ozone depletion					✓	
	Land use, LUC and iLUC	Land use, Land Use Change and indirect Land Use Change			✓		✓	✓
Social	Participation and transparency	Effective participatory processes	✓				✓	~
		Information transparency	✓					
	Land tenure	Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land to secure land tenure and ownership (CFS 2012)	✓			✓	✓	✓
	Employment and labour rights	Full direct jobs equivalents along the full value chain	✓	✓			✓	~
		Full direct jobs equivalent in the biomass consuming region (or country)	✓	✓				
		Human and Labour Rights	✓		✓	✓	✓	✓
		Occupational safety and health for workers	✓				✓	✓
	Health risks	Risks to public health	✓					
	Food, fuelwood and other products	Measures to avoid risks for negative impacts on price and supply of national food basket, fuelwood and other products	✓		~	✓	~	✓
	Rural development and infrastructure	Rural development and infrastructure		✓			✓	✓
		Local embedding-proximity to markets		✓				
	Production of feedstock	Production of feedstock					✓	

Theme	Criterion	Indicator	S2Biom	Biomass Policies	BEE	Biomass Futures	Biocore	Global Bio-Pact	
	Identification/involvement of stakeholders along the supply chain	Identification of stakeholders along the supply chain					✓	~	
	Policies and regulations	Policies and regulations					✓		
	Gender equality	Gender equality					✓	✓	
Economic	Production costs	Current levelised life-cycle cost (excl. subsidies, incl. CAPEX and OPEX)	✓	✓			✓	✓	
		Future life cycle costs		✓					
	Markets	Business case for biomass mobilization			✓				
		Market size			✓				
		Technological maturity			✓				
		Other non-fossil alternatives			✓				
		Competing pathways/market distortion			✓				
		Access to markets						✓	
	System versatility	Flexibility and controllability (energy) security			✓				
					✓				
	Other economic considerations	Internal Rate of Return						✓	
		Price support						✓	
		CO <sub>2</sub> avoidance costs						✓	
		Energy resource savings costs						✓	
Value added								✓	
Taxes/royalties paid to the government								✓	
Contributions made by the operation to allied industries in the local economy								✓	
Technology	Maturity						✓		
	Availability of infrastructure for logistics and storage						✓		
	Use of GMOs						✓		
	Risk of explosions and fires						✓		
	Development of legislative framework and bureaucratic hurdles						✓		
	Feedstock flexibility of conversion technologies						✓		

Source: own elaboration

### 3.3 Basic and Advanced Set of Sustainability C&I

Based on the list of indicators proposed in Table 3, and considering the various ways to elaborate a basic and an advanced set of sustainability C&I as described in Section 2.3 (i.e. indicators to be considered and changes in the type of indicator), Table 5 presents a proposal of basic and advanced sustainability sets.

The basic set depicts a minimum sustainability ambition level (especially with respect to the indicators that might be “minimum requirements”). This proposal is in line with the Renewable Energy Directive requirements for biofuel and bioliquids (EU 2009). The advanced set is more ambitious in considering more indicators that are minimum requirements in contrast to be “reporting indicators”. These two sets aim to reflect „stronger“ or „looser“ sustainability concerns.

Table 5 S2Biom Proposal for Basic and Advanced Sustainability C&amp;I Sets

Theme	Criterion	Indicator		Level of ambition							
				Basic				Advanced			
		#	Indicator	Minimum requirement	Comparative (non-renewable reference)	Comparative (biomass reference)	Descriptive	Minimum requirement	Comparative (non-renewable reference)	Comparative (biomass reference)	Descriptive
Environmental	1. Resource use	1.1	Land use efficiency			✓		✓			
		1.2	Secondary resource efficiency			✓		✓			
		1.3	Energy efficiency		✓			✓			
		1.4	Functionality (Output service quality)						✓	✓	
	2. Climate change	2.1	Life cycle-based CO <sub>2</sub> eq including direct land use change	✓				✓			
		2.2	Other GHG emissions		✓	✓		✓			
	3. Biodiversity	3.1	Protected areas and land with significant biodiversity values	✓				✓			
		3.2	Biodiversity conservation and management			✓		✓			
	4. Soil	4.1	Erosion			✓		✓			
		4.2	Soil Organic Carbon			✓		✓			
		4.3	Soil nutrient balance			✓		✓			
	5. Water	5.1	Water availability and regional water stress		✓			✓			✓
		5.2	Water use efficiency						✓	✓	
		5.3	Water quality		✓				✓	✓	
	6. Air	6.1	SO <sub>2</sub> equivalents		✓	✓		✓			
		6.2	PM <sub>10</sub>		✓	✓		✓			

Theme	Criterion	Indicator		Level of ambition										
		#	Indicator	Basic				Advanced						
				Minimum requirement	Comparative (non-renewable reference)	Comparative (biomass reference)	Descriptive	Minimum requirement	Comparative (non-renewable reference)	Comparative (biomass reference)	Descriptive			
Social	7. Participation and transparency	7.1	Effective participatory processes										✓	
		7.2	Information transparency											✓
	8. Land tenure	8.1	Land tenure assurance			✓		✓						
	9. Employment and labour rights	9.1	Full direct jobs equivalents along the full value chain		✓	✓				✓	✓			
		9.2	Full direct jobs equivalent in the biomass consuming region (or country)		✓	✓				✓	✓			
		9.3	Human and Labour Rights	✓					✓					
		9.4	Occupational safety and health for workers	✓					✓					
	10. Health risks	10.1	Risks to public health											✓
	11. Food, fuelwood and other products	11.1	Food, fuelwood and other products supply security			✓			✓					
	Economic	12. Production costs	12.1	Current levelised life-cycle cost		✓	✓				✓	✓		
12.2			Future levelised life-cycle costs							✓	✓			

Source: own elaboration



## 4. Way Forward

This umbrella proposal is the basis to carry out further work:

- Integrate further the **findings** from the ongoing work on analyses of sustainable bioeconomy in selected countries (Task 5.3), and from other ongoing projects, especially BioTrade2020plus and on cascading use of wood<sup>15</sup>.
- **Further discussing** this approach to sustainability (i.e. list of indicators, type of indicators, scope, etc.) and proposed sets within S2Biom and with external stakeholders.
- Agree upon the **implementability** of the mid-point indicators and develop implementable indicators for specific feedstocks, value chains in different activities and for implementation in different tools in the project and for an overall sustainability evaluation framework to be used by end-users of the project.
- Agree on how to **test** the indicators as part of activities in the S2Biom project.

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<sup>15</sup> i.e. the on-going research project on “Resource efficiency by cascading use of biomass“ by Nova Institute (<http://www.biomassekaskaden.de/>) and the EC funded „Study on Optimised Cascading Use of Wood“ (<http://ted.europa.eu/udl?uri=TED:NOTICE:166917-2014:TEXT:en:HTML&src=0>)

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**S2Biom Project Grant Agreement n°608622**

**Deliverable 5.4:  
Consistent Cross-Sectoral Sustainability  
Criteria & Indicators**

**Final Report - Annex**

**March 2015**



## About S2Biom project

The S2Biom project - Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bioeconomy in Europe - supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies, and roadmaps that will be informed by a “computerized and easy to use” toolset (and respective databases) with updated harmonized datasets at local, regional, national and pan European level for EU28, Western Balkans, Moldova, Turkey and Ukraine. Further information about the project and the partners involved are available under [www.s2biom.eu](http://www.s2biom.eu).

### Project coordinator



### Scientific coordinator



### Project partners



## About this document

This report corresponds to the annex of the main report of deliverable 5.4 – Consistent Cross-Sectoral Sustainability Criteria & Indicators - of S2Biom.

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## Methodology overview

This annex provide the exact provisions for each indicator or issue of the research projects considered in deliverable 5.4. This refers to:

- Biomass Policies (Pelkmans et al. 2014)
- BEE: Biomass Energy Europe (Vis et al. 2010)
- Biomass Futures (Fritsche et al. 2012)
- Biocore: BIOCOmmodity refinery (Piotrowski et al. 2013; Rettenmaier et al. 2014)
- Global BioPact (Diaz-Chavez et al. 2012)

A benchmark against the S2Biom set of indicators was performed and it is presented in this annex. Two categories have been used to describe the extent to which each indicator performs against the S2Biom requirements:

- Indicator fully considered (symbol  $\surd$ ), this means that the main issues of any indicator in the research projects against which the S2Biom indicators are meaningfully captured.
- Indicator partially considered (symbol  $\sim$ ). In this case, the main message of the research project indicators against the S2Biom requirements, are partially covered.

Those indicators that are not included in the proposal under S2Biom but that are included in any of the schemes are also presented.

This serves to compile the exact requirements given in these projects and better understand these indicators in order to further elaborate the S2Biom proposal to sustainability.

In the Global Bio-Pact project (Díaz-Chavez et al. 2012), each indicator is linked to a measurement, monitoring process or unit depending of its nature and it is indicated from where the data could be accessed:

- Processing company or plantation (P)
- Government (G)
- Community (C)
- Non-Governmental Organisation (N)
- Worker (W)

## 1. Environmental theme

### 1.1 Resource Use

#### 1.1.1. Land use efficiency

**Biomass Policies** (✓): Land use productivity (bioenergy and bioproducts per hectare)

**Biomass Futures** (✓): Land use efficiency

#### 1.1.2. Secondary resource efficiency

**Biomass Policies** (✓): Secondary resource use

**Biomass Futures** (✓): Secondary resource efficiency

#### 1.1.3. Energy efficiency

**Biomass Policies** (✓): cumulative energy demand and non-renewable energy demand

**Biocore** (~): Depletion of non-renewable energy resources, i.e. fossil fuels such as mineral oil, natural gas, coal and uranium ore.

#### 1.1.4. Output service quality

**Biomass Policies** (✓): output service quality

#### 1.1.5. Increase resource efficiency

**BEE** (✓): Resource efficiency should be increased:

- Recycle before waste is used for energy production, and
- Ensure a sustainable use of renewable resources

## 1.2 Climate Change

### 1.2.1 Life cycle-based CO<sub>2</sub>eq including direct land use change

**Biomass Policies** (✓): Life cycle greenhouse gas emissions

**Biomass Futures** (✓): Life cycle GHG emissions incl. direct land use changes

**Biocore** (✓): Global warming as a consequence of the anthropogenic release of greenhouse gases. Besides carbon dioxide (CO<sub>2</sub>), a number of other gases like methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are included.

### 1.2.2 Other GHG emissions

**Biomass Policies** (✓): greenhouse gas emissions related to indirect land use change and sustainable harvest levels (the later indicator is also related with other indicators).

**Biomass Futures** (✓): Inclusion of GHG effects from indirect land use changes

## 1.3 Biodiversity

### 1.3.1 Protected areas and land with significant biodiversity value

**Biomass Policies** (✓): conservation areas

**BEE** (✓): The loss of habitats of high biodiversity value (HBV) shall be prevented:

- I.1 Adapt management in Natura2000 areas (based on Birds & Habitats Directive); in states not covered by the Natura2000 network, identify high biodiversity value areas from national legislation / data sources \*
- I.2 Exclude other legally protected areas - national (e.g. nature reserves, national parks) and international (e.g. Biosphere reserves (UNESCO MAB), Ramsar sites) \*
- I.3 "Adapt management on areas designated for the protection of rare, threatened or endangered ecosystems or species recognised by international agreements or included in lists drawn up by intergovernmental organisations or the IUCN \*\*"
- I.4 No drainage / use of land that was wetland (including peatlands) in January 2008 \*

I.5 Buffer zones between cultivated land and areas of high biodiversity value (protected areas and wetlands)

"Protection of High Nature Value (HNV) farmland"

I.14 Adapt management practices (i.e. crop choices and yields) on areas under agroenvironmental support

I.15 Adapt management practices (i.e. crop / tree choices) on agricultural areas under organic farming and in certified forestry areas

I.16 Adapt management practices (i.e. crop choices and yields) on extensively cultivated areas

**Biomass Futures** (✓): Conservation of land with significant biodiversity values

**Global Bio-Pact** (~):

Indicator: Conservation Measures

Measurement/Monitoring Process/Unit: % of surface set-aside for conservation purposes

Guidance: e.g. protected habitat, buffer zones, ecological corridors, riparian vegetation, etc.

Data access: P

### 1.3.2 Biodiversity conservation and management

**Biomass Policies** (✓): management practices and biodiversity

**BEE** (✓): Support forest and agrobiodiversity

I.10 Adapt management practices (i.e. crop/tree choices and yields) to local bio-physical conditions

I.11 Restrict use of genetically modified organisms (GMO)

I.12 Maximum extraction rates for primary agricultural and forestry residues

I.13 Minimum number of crop species and varieties as well as structural diversity within the cropping area

**Biomass Futures** (✓): Land management without negative effects on biodiversity

**Biocore** (~): Biodiversity among plants on and around cultivated areas is affected e.g. by weed control measures.

**Global Bio-Pact (✓):**

Indicator: Reduction of biodiversity

Measurement/Monitoring Process/Unit: Non-agricultural land or pasture that has been converted towards feedstock operation within a 5- year period (ha), type of previous vegetation of converted land

Guidance: This can be check with the operation and cross checked with local or national authorities or environmental NGOs

Data access: P (G, N)

### 1.3.3 Fauna

**Biocore (✓):** Local biodiversity among animals is affected e.g. by the presence of diverse habitats

**Global Bio-Pact (✓):**

Indicator: Impacts on local fauna/ flora perceived by community

Measurement/Monitoring Process/Unit: Impacts on local fauna/ flora perceived by community

Guidance: Questions addressed to local community, NGO or local authority

Data access: C, N, G

Indicator: Impacts on fisheries/ other aquatic fauna

Measurement/Monitoring Process/Unit: Local perceptions on impacts on fisheries/ other aquatic fauna

Guidance: Questions addressed to local community representatives, NGO or local authority

Data access: C, N, G

### 1.3.4 Landscape

**Biocore (✓):** Characteristics and diversity of the landscape.

### 1.3.5 Access to ecosystem services

Only Global BioPact (✓):

Measurement/Monitoring Process/Unit: Reduction in local communities' access to hunting, fishing

Guidance: Qualitative questions to local community representatives, and NGO(s)

Data access: C, N

Measurement/Monitoring Process/Unit: Reduction in local communities' access to non-timber forest products

Guidance: Qualitative questions to local community representatives, and NGO(s)

Data access: C, N

Measurement/Monitoring Process/Unit: Reduction in local communities' access to cultural ecosystem services such as sacred and recreational sites

Guidance: Qualitative questions to local community representatives, and NGO(s)

Data access: C, N

## 1.4 Soil

### 1.4.1 Erosion

**Biomass Policies** (✓): soil erosion

**BEE** (✓): Minimise soil erosion:

I.17 Maximum slope limits for cultivation

I.18 Only perennial crops on sites susceptible to soil erosion

**Biomass Futures** (✓): Erosion

**Biocore** (✓): Soil quality is affected e.g. by erosion, compaction or organic matter content.

**Global Bio-Pact** (✓):

Indicator: Implement Practices

Measurement/Monitoring Process/Unit: Percentage of surface under no or reduced tillage

Guidance: Check practices on the fields

Data access: P

Indicator: Soil Erosion

Measurement/Monitoring Process/Unit: Feedstock cultivation area in flood prone region (ha)

Guidance: Maps and data from company



Data access: P

Indicator: Soil Erosion

Measurement/Monitoring Process/Unit: Feedstock cultivation area in wind prone region (ha)

Guidance: Maps and data from company

Data access: P

Indicator: Soil Erosion

Measurement/Monitoring Process/Unit: Feedstock cultivation area in slopes above 25° surface gradient

Guidance: Maps and data from company

Data access: P

Indicator: Soil Erosion

Measurement/Monitoring Process/Unit: Implemented measures to control soil erosion

Guidance: List measures implemented

Data access: P

### 1.4.2 Soil Organic Carbon

**Biomass Policies** (✓): Soil Organic Carbon

**BEE** (~): Protect soil quality:

I.10 Adapt management practices (i.e. crop/tree choices and yields) to local biophysical conditions

I.11 Restrict use of genetically modified organisms (GMO)

**Biomass Futures** (✓): Soil Organic Carbon

**Biocore** (✓): Soil quality is affected e.g. by erosion, compaction or organic matter content.

**Global Bio-Pact** (~):

See indicators 1.4.1 and 1.4.3

### 1.4.3 Soil nutrient balance

**Biomass Policies** (✓): soil nutrient balance

**BEE** (~): Protect soil quality:

I. 10 Adapt management practices (i.e. crop/tree choices and yields) to local bio-physical conditions

I. 11 Restrict use of genetically modified organisms (GMO)

**Biomass Futures** (✓): Soil Nutrient Balance

**Biocore** (~): Soil quality is affected e.g. by erosion, compaction or organic matter content.

**Global Bio-Pact** (~):

Indicator: Soil analysis

Measurement/Monitoring Process/Unit: Frequency of carrying out soil analysis in the operation

Guidance: How often is soil analysis carried out in the operation?

Data access: P

Indicator: Implement Practices

Measurement/Monitoring Process/Unit: Fertiliser applied (type)(kg/ha/yr)

Guidance: List types of fertilizer and the annual amounts applied per hectare (5-year period)

Data access: P

Indicator: Implement Practices

Measurement/Monitoring Process/Unit: Herbicides and pesticides applied (type)(kg/ha/yr)

Guidance: List types of fertilizer and the annual amounts applied per hectare (5-year period)

Data access: P

## 1.5 Water

### 1.5.1 Water availability and regional water stress

**Biomass Policies** (✓): water availability and regional water stress

**BEE** (✓): Prevent overexploitation of water resources:

I.19 Adapt management practices (i.e. crop/tree choices and yields) to local bio-physical conditions (especially for rain fed agriculture)

I.20 For irrigation, adapt water consumption to regional resources; if no data are available, exclude irrigation as a precautionary principle

**Biomass Futures** (✓): Water availability and Use efficiency

**Biocore** (✓): Local water availability for ecosystems and its quality.

**Global Bio-Pact** (✓):

Indicator: Water consumption (irrigation)

Measurement/Monitoring Process/Unit: Net non-recycled water consumed through irrigation per unit mass of product (l/ton of feedstock)

Guidance: Check water balances at the company level

Data access: P

Indicator: Water Management Plan

Measurement/Monitoring Process/Unit: Implementing a water management plan

Guidance: Is there a water management plan, is it implemented?

Data access: P

Indicator: Availability of water

Measurement/Monitoring Process/Unit: Perceived change in availability of water by local communities (amount consumed)

Guidance: Questions addressed to local community representatives, NGO or local authority

Data access: C,N,G

### 1.5.2 Water use efficiency

**Biomass Policies** (✓): water use efficiency

**Biomass Futures** (✓): Water availability and Use efficiency

### 1.5.3 Water quality

**Biomass Policies** (✓): water quality

**BEE** (✓): Minimisation of harmful contamination of surface and ground water

**Biomass Futures** (✓): Water quality

**Biocore** (✓):

- Marine / freshwater eutrophication:

Input of nutrients into surface water (marine and freshwater) directly or via input into soils and gaseous emissions. E.g., nitrogen and phosphorous species contribute to this (keyword 'algal bloom').

- Water:

Local water availability for ecosystems and its quality.

### **Global Bio-Pact (✓):**

Indicator: Quality of water

Measurement/Monitoring Process/Unit: Perceived change in quality of water by local communities

Guidance: Questions addressed to local community representatives, NGO or local authority

Data access: C,N,G

## **1.6 Air**

### **1.6.1 SO<sub>2</sub> equivalents**

**Biomass Policies (✓):** acidification

**BEE (✓):** Minimization of emissions of air pollutants

**Biomass Futures (✓):** SO<sub>2</sub> equivalents

**Biocore (✓):** Terrestrial acidification: Shift of the acid / base equilibrium in soils by acidifying gases like sulphur dioxide, nitrogen oxides and ammonia (keyword 'acid rain').

### **Global Bio-Pact (~):**

Indicator: Open burning on company level

Measurement/Monitoring Process/Unit: Days open burning used in operations/year

Guidance: Annual days open burning used in operations, 5-year period

Data access: P

Indicator: Open burning area

Measurement/Monitoring Process/Unit: Percentage of surface under open burning regime

Guidance: % surface under open burning regime

Data access: P

Indicator: Use of Best Available Technologies for reducing emissions

Measurement/Monitoring Process/Unit: List of best available technologies in place

Guidance: Review technologies used at company

Data access: P

### 1.6.2 PM<sub>10</sub>

**Biomass Policies** (✓): particulate matter

**BEE** (✓): Minimization of emissions of air pollutants

**Biomass Futures** (✓): Particulate Emissions PM10

**Biocore** (✓):

- Respiratory inorganics (particulate matter emissions):
- Damage to human health due to air pollutants such as fine, primary particles and secondary particles (mainly from NOX, NH3 and SO2, keyword 'winter smog' or 'London smog').

**Global Bio-Pact** (~): See indicator 1.6.1

### 1.6.3 Photochemical ozone formation

**Biocore** (✓): Formation of specific reactive substances, e.g. ozone, in presence of nitrogen oxides, volatile hydrocarbons and solar radiation in the lower atmosphere (keyword 'ozone alert' or 'summer smog').

**Global Bio-Pact** (~): See indicator 1.6.1

### 1.6.4 (Stratospheric) Ozone depletion

**Biocore** (✓): Loss of the protective ozone layer in the stratosphere by certain gases such as CFCs or nitrous oxide (keyword 'ozone hole').

## 1.7 Land use, Land Use Change and indirect Land Use Change

### BEE (✓):

- Direct land cover change shall be prevented:

I.6 Avoid a massive conversion of permanent grassland to arable land; no conversion of highly biodiverse grassland \*

I.7 Allow afforestation of permanent grassland if it is compatible with the environment (exclusion of highly biodiverse grassland)

I.8 Exclude continuously forested areas and wooded land from conversion into arable land\*

- Indirect land cover change shall be prevented

I.9 Preference of using surplus land

### Biocore (✓):

- Direct additional land use:

Occupation of agricultural land by production of dedicated crops. Extraction of residues from already cultivated land is not included.

- Indirect land use

Agricultural land that may not be cultivated anymore elsewhere (e.g. in the EU or South America, SA) because co-products of the assessed process like feed replace competing products.

### Global Bio-Pact (✓):

Indicator: Expansion of land area

Measurement/Monitoring Process/Unit: Additional land area under production (ha/year)

Guidance: Additional land under feedstock production within the last 5 years. Previous land use of the land area.

Data access: P,G

## 2. Social theme

### 2.1 Participation and transparency

#### 2.1.1 Effective participatory processes

Biocore (✓): Community participation

Global Bio-Pact (~):

Indicator: Involvement of smallholders of small suppliers

Measurement/Monitoring Process/Unit: Percentage of feedstock that originates from associated smallholders and outgrowers

Guidance: Percentage of feedstock that originates from associated smallholders outgrowers within a 5-year period. Number of associated smallholders or outgrowers.

Data access: P,C,W

## 2.2 Land Tenure

### 2.2.1 Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land to secure land tenure and ownership

**Biomass Futures** (✓): Social Use of Land: changes in land tenure and access

**Biocore** (✓): Land use tenure: land ownership rights

**Global Bio-Pact** (✓):

Indicator: Legal title of land right

Measurement/Monitoring Process/Unit: Operation has a legal title/concession for the land that is not challenged.

Guidance: Document of legal title

Data access: P,G

Indicator: Communal/public land

Measurement/Monitoring Process/Unit: Area of land cultivated by the operation that is customary, public or community land (ha)

Guidance: Report on public or community land within the project which would affect people living from subsistence agricultures, nomads, etc. Cross-check this information with the land categories listed under 'basic information'

Data access: P, C (N)

Indicator: Land conflicts

Measurement/Monitoring Process/Unit: Area of land currently under dispute, land conflict. (ha) Has the operation had any land use conflicts, if so, what caused them, how were they resolved?

Guidance: Land area currently under dispute. Qualitative description of any current or previous land use conflicts. If they were resolved, how this happened.

Data access: P,C,G (N)

## 2.3 *Employment and labour rights*

### 2.3.1 Full direct jobs equivalents along the full value chain

**Biomass Policies** (✓): Full direct jobs equivalents along the full value chain

**Biocore** (~): Job creation and wages:

- Labour involved on feedstock gathering
- Labour involved in oil production
- Wages paid according to national/regional regulation (minimum wage)
- Poverty reduction

#### **Global Bio-Pact** (~):

Indicator: Employment

Measurement/Monitoring Process/Unit: Total number of employees and person days of employment per year

Guidance: Total number of people employed each year and total number of person days per year within a 5 year period. Breakdown should be given for categories of employment for operation (management/office/processor/field labour, male/female, contract/no contract)

Data access: P, W

Indicator: Ration between local and migrant workers

Measurement/Monitoring Process/Unit: Ratio of employment from local area / outside local area per category of employment (management/ office/ processor/ field labour)

Guidance: Local area is defined as state or province (however, assessor can further adapt this to local context). Absolute annual number of workers per employment category (including temporary/ permanent) within a 5-year period

Data access: P,G

Indicator: Percentage of permanent workers

Measurement/Monitoring Process/Unit: Percentage of workers that have a fixed contract employment per category of employment

Guidance: Annual percentage permanent vs. temporary workers within a 5-year period

Data access: P,G



Indicator: Provision of worker training

Measurement/Monitoring Process/Unit: Number of workers that have received training (for skills development, education etc.) each year, number of working days spent in training provided by the operation each year, type of training

Guidance: Annual numbers should be given for a 5-year period

Data access: P,W

### 2.3.2 Full direct jobs equivalent in the biomass consuming region (or country)

**Biomass Policies** (✓): Full direct jobs equivalent in the biomass consuming region (or country).

### 2.3.3 Human and Labour Rights

**BEE** (✓): Labour rights shall be complied with:

I23. Compliance with labour standards according to the conventions of the International Labour Organisation (No. 29, 87, 98, 100, 105, 111, 138, 182) \*

**Biomass Futures** (✓): Healthy livelihoods: Adherence to ILO Principles

**Biocore** (✓): Labour conditions. ILO conventions including:

- Child labour
- Right to organise
- Indigenous rights
- Forced labour

**Global Bio-Pact** (✓):

Indicator: Freedom of association

Measurement/Monitoring Process/Unit: Existence of labour unions

Guidance: Existence of labour unions and whether workers have the right to join them. This should be verified by interviewing the management and the workers: Do workers belong to a union or other type of working association?

Data access: P, W, C

### 2.3.4 Occupational safety and health for workers

**Biocore** (✓): Health and safety. Compliance with health and safety regulations at the different supply chains

**Global Bio-Pact (✓):**

Indicator: Work related accidents and diseases

Measurement/Monitoring Process/Unit: Number of work related accidents per person days of employment per year, number of work related diseases/person days of employment per year

Guidance: Records of any work-related accidents or diseases.

Data access: P, W

Indicator: Personal protective equipment

Measurement/Monitoring Process/Unit: Percentage of workers that use appropriate personal protective equipment

Guidance: To be calculated as a percentage of sample in a site visit

Data access: P

Indicator: OSH training

Measurement/Monitoring Process/Unit: Percentage of employees that have received OSH (Occupational Safety & Health) training

Guidance: Training records and worker interviews

Data access: P,W

## 2.4 Food & fuelwood

### 2.4.1 Measures to avoid risks for negative impacts on price and supply of national food basket and fuelwood.

**BEE (~):**

I.14 "Avoid competition with food production"

I.15 "Avoid competition with the production of biomaterials"

**Biomass Futures (✓):** Price and supply of national food basket

**Biocore (~):** Competition with other Sectors: Competition of residues use for biorefinery and impact on other industries and sectors that affects negatively

**Global Bio-Pact (✓):**

Indicator: Land that is converted from staple crops

Measurement/Monitoring Process/Unit: Land that has been converted from staple crops (ha)

Guidance: Hectares of land that has been converted from staple crops to the feedstock production (assessor should define staple crops for the country) within the last five years

Data access: P, (G,N)

Indicator: Edible feedstock diverted from food chain to bioenergy

Measurement/Monitoring Process/Unit: Amount of edible raw material diverted into bioenergy production (t)

Guidance: Annual amount of edible feedstock that was used in bioenergy production (5-year period)

Data access: P

Indicator: Availability of food

Measurement/Monitoring Process/Unit: Perceived change in availability of food after the beginning of bioenergy operations

Guidance: Check (survey) at community level about perceived change

Data access: C,W

Indicator: Time spent in subsistence agriculture

Measurement/Monitoring Process/Unit: Change in time spent in subsistence agriculture in the household

Guidance: Check (survey) at community level about perceived change

Data access: C,W

## 2.5 *Rural development and infrastructure*

### 2.5.1 *Rural development and infrastructure*

**Biomass Policies** (✓): contribution to rural economy

**Biocore** (✓):

- Road
- Water (availability and quality) for the local population
- Sanitation infrastructure
- Risk of not having bed at hospital

**Global Bio-Pact** (✓):

Indicator: Community investment

Measurement/Monitoring Process/Unit: Amount invested in community investment projects (e.g. CSR) (% of annual revenue) and qualitative description of investments including any projects specific for women

Guidance: Annual values should be given for a 5-year period. This should be calculated as percentage of annual revenue.

Data access: P,C

Indicator: Amount paid to smallholders and suppliers of feedstock

Measurement/Monitoring Process/Unit: Annual amount paid to smallholders and suppliers of feedstock (EUR)

Guidance: Annual value paid to associated smallholders and outgrowers per unit of product within a 5 year period

Data access: P,C,W

## 2.5.2 Local embedding-proximity to markets

### Biomass Policies (✓)

## 2.6 Production of feedstock

### Biocore (✓):

Incentives

Barriers

### 2.6.1 Identification of stakeholders along the supply chain

#### Biocore (✓):

Producers (farmers)

Regulators

Business

Traders

Research

#### Global Bio-Pact (~):

Indicator: Involvement of smallholders of small suppliers

Measurement/Monitoring Process/Unit: Percentage of feedstock that originates from associated smallholders and outgrowers

Guidance: Percentage of feedstock that originates from associated smallholders outgrowers within a 5-year period. Number of associated smallholders or outgrowers.

Data access: P,C,W

## 2.6.2 Policies and regulations

### **Biocore (✓):**

National  
Enforcement  
International conventions and agreements

## 2.7 Gender equality

**Biocore (✓):** Inclusion of women

### **Global Bio-Pact (✓):**

Indicator: Benefits created for women

Measurement/Monitoring Process/Unit: Employment benefits that are specific for women

Guidance: List any employment benefits that are specific for women (i.e. maternity leave, others)

Data access: P,W

## 3. Economic theme

### 3.1 Production costs

#### 3.1.1 Production cost (levelised life cycle cost)

**Biomass Policies (✓):** life cycle costs

### **Biocore (✓):**

Total capital investment

Sum of invested capital for the biorefinery facility including utilities.

NPV (5 %): The net present value is the sum of expenses and future returns discounted at a rate of 5 % per year (in this case)

Variants (no GP / incl. GP): Several economic indicators were calculated under the boundary conditions that Green Premium prices can be obtained or not.

### **Global Bio-Pact (✓):**

Indicator: Production cost

Measurement/Monitoring Process/Unit: Breakdown of yearly production costs of the facility (incl. labour, raw material, energy, services, etc.) (EUR/t of feedstock)

Guidance: Annual production costs within a 5-year period

Data access: P

### 3.1.2 Future prospects of life cycle production costs

**Only Biomass Policies** (✓): future life cycle costs

## 3.2 Markets

### 3.2.1 Business case for biomass mobilization

**Biomass Policies** (✓)

### 3.2.2 Size of the markets to valorise the outputs

**Biomass Policies** (✓)

### 3.2.3 Technology readiness level

**Biomass Policies** (✓)

### 3.2.4 Other non-fossil alternatives in the markets

**Biomass Policies** (✓)

### 3.2.5 Competing biomass pathways / potential market distortions

**Biomass Policies** (✓)

### 3.2.6 Access to markets

**Biocore** (✓):

Access to markets is determined by demand for the final product and by restrictions like the adaptation of manufacturers to new chemicals.

## 3.3 System versatility

**Only Biomass Policies** (✓)

### 3.3.1 Flexibility and controllability

### 3.3.2 (energy) security

## 3.4 Other economic considerations

### 3.4.1 IRR (Internal Rate of Return)

#### Biocore (✓):

The Internal Rate of Return is defined as the discount rate at which the NPV is just equal to zero. The higher the IRR, the more favourable the investment project appears.

### 3.4.2 Price support

#### Biocore (✓):

Support of product prices (in %) that is necessary to reach the indicated IRR. Product price support is one option to make projects economically feasible that are considered valuable for other effects.

### 3.4.3 CO<sub>2</sub> avoidance costs

#### Biocore (✓):

Monetary losses (or profits if indicator result is negative) per unit of avoided greenhouse gas emissions. This indicator is not defined if no greenhouse gas emissions are avoided.

### 3.4.4 Energy resource savings costs

#### Biocore (✓):

Monetary losses per unit of saved non-renewable energy resources (analogous to CO<sub>2</sub> avoidance costs).

### 3.4.5 Value added

#### Global Bio-Pact (✓):

Indicator: Value added

Measurement/Monitoring Process/Unit: Value added by the operation. Annual value of sales less the price of goods, raw materials (including energy) and services purchased. (EUR/t of feedstock)

Guidance: Annual value added within a 5-year period

Data access: P

### 3.4.6 Taxes/royalties paid to the government

#### Global Bio-Pact (✓):

Indicator: Taxes/royalties paid to the government

Measurement/Monitoring Process/Unit: Breakdown of payments made to the government/year (EUR)

Guidance: Payments made to the government per year within 5 years

Data access: P, G

### 3.4.7 Contributions made by the operation to allied industries in the local economy

#### Global Bio-Pact (✓):

Indicator: Contributions made by the operation to allied industries in the local economy

Measurement/Monitoring Process/Unit: Percentage of feedstock that originates from associated smallholders and outgrowers

Guidance: Percentage of feedstock that originates from associated smallholders outgrowers within a 5-year period. Number of associated smallholders or outgrowers.

Data access: P,C, W

## 4. Technology

Only Biocore (✓)

### 4.1.1 Maturity

Technical maturity of involved processes.

### 4.1.2 Availability of infrastructure for logistics and storage

This indicator refers to logistics as well as short-term and seasonal storage of biomass.



#### **4.1.3 Use of GMOs**

Use of genetically modified organisms (here: microbes) in closed fermentation facilities within the biorefinery. Release of GMOs like genetically modified plants to the environment is not intended.

#### **4.1.4 Risk of explosions and fires**

Risk of explosions and fires within industrial facilities like biorefineries.

#### **4.1.5 Development of legislative framework and bureaucratic hurdles**

Potential legislative and bureaucratic hurdles for the implementation of the scenario.

#### **4.1.6 Feedstock flexibility of conversion technologies**

The capability of the core process to use several different feedstocks interchangeably or in a mixture.

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