

S2Biom Project Grant Agreement n°608622

Deliverable 5.2:

**Benchmark and gap analysis of criteria and indicators (C&I)
for legislation, regulations and voluntary schemes at
international level and in selected EU Member States**

Main Report

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.

Project coordinator



Scientific coordinator



Project partners



About this document

This report corresponds to deliverable 5.2 – Benchmark and gap analysis of criteria and indicators (C&I) for legislation, regulations and voluntary schemes at international level and in selected EU Member States.

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Executive Summary

This report aims to contribute to a better understanding about sustainability requirements by analyzing a selected representative list of schemes and regulations relevant for the bioeconomy. This will help elaborate a sound approach to biomass sustainability in the S2Biom project. The specific objectives of this task are:

- Benchmark the selected schemes based on criteria and indicators (C&I) against the draft S2Biom sustainability indicators with the aim of characterizing sectoral patterns and of identifying gaps.
- Identify concepts present in other schemes that could help enhance the final S2Biom approach to sustainability.

To achieve these specific objectives, several activities have been carried out:

1. **Identification of representative schemes:** Sustainability schemes in the forestry, agriculture, bioenergy, and waste management sectors, among others, were considered in order to present a global review of sustainability considerations. The analysis took into account international and national schemes and/or regulations as well as voluntary approaches. These schemes concern various regions, different feedstocks and assorted end uses.
2. **Benchmark and Gap Analysis:** Selected schemes were structured as a set of C&I and they were benchmarked against the draft S2Biom structure. The results of the selected schemes were aggregated sectorally to understand the respective patterns more deeply.
3. **Identification of additional issues:** All schemes were examined further to identify elements that are not currently represented in the draft S2Biom approach to sustainability, and could enhance its performance. These additional concepts have been classified as framework indicators and complementary indicators. For each of these categories we have distinguished between “topics” and “indicators”.

In total, more than 50 schemes and regulations were selected, covering broad bioeconomy aspects. From this total, 31 schemes and regulations were benchmarked against the S2Biom draft proposal (objective 2 above) of which 6 corresponded to the agriculture sector, 14 to the forest sector and 11 to the bioenergy sector. Given the variability in the structure and function of the remaining schemes, these schemes were used only to identify potential additional useful concepts for the S2Biom approach (objective 3 above), without systematizing their requirements. The benchmark and gap analysis (Section 4) showed that schemes from different sectors managed environmental impacts to

varying degrees with the exception of resource efficiency which was not meaningfully considered in any of the schemes. Biodiversity, soil and land tenure are well reflected, while indicators related to climate change, water, participation and transparency as well as employment conditions and labor rights were partially covered in the schemes. Social and economic impacts were found to be typically less well reflected. The same general patterns are found when solely investigating the selected voluntary certification schemes.

The analysis of other concepts of interest for the S2Biom proposal in the benchmarked schemes resulted in detecting 4 framework topics and 18 respective indicators. The analysis of complementary concepts resulted in 20 topics and 39 indicators.

Non-benchmarked schemes provided complementary concepts such as cascading use, requirements to deal with biomass competition, and considerations regarding type of feedstocks that should be used for different purposes (e.g. for solid bioenergy).

All of the above considerations might contribute to enhancing the S2Biom approach to sustainability. In particular, these findings might serve to propose well-grounded policy recommendations to support further development of sustainable bioeconomy strategies develop an appropriate set of sustainability indicators particularly for specific feedstocks and/or value-chains and further refine the S2Biom sustainability criteria and indicators proposal.

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List of Acronyms and Abbreviations

BMELV	German Federal Ministry of Food, Agriculture and Consumer Protection (until 2013)
BMEL	German Federal Ministry of Food and Agriculture (from 2014 onwards)
BOD	Biological Oxygen Demand
Bonsucro EU	Bonsucro scheme aimed to show compliance with the EU Renewable Energy Directive's requirements
BP	Best Practices
C&I	Criteria and Indicators
CAP	Common Agricultural Policy
CEN	European Committee for Standardization
CENBIO	Centro Nacional de Referência em Biomassa (Brazil)
CL	Country Level
EC	European Commission
EFI	European Forest Institute
EMBRAPA	Brazilian Agricultural Research Corporation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
FUL	Forest Unit Level
FW	Framework Indicators
GBEP	Global Bioenergy Partnership
GEF	Global Environment Facility
GGL	Green Gold Label
GHG	greenhouse gas(es)
GMO	genetically modified organisms
GRI	Global Reporting Initiative
IAS	Invasive Alien Species
IINAS	International Institute for Sustainability Analysis and Strategy
II	Implementable Indicators
ILUC	indirect land use change(s)
ISCC	International Sustainability Carbon Certification

ISCC-EU	International Sustainability Carbon Certification scheme to show compliance with the EU Renewable Energy Directive's requirements
ISCC PLUS	International Sustainability Carbon Certification for food and feed products as well as for technical/chemical applications and applications in the bioenergy sector
ITTO	International Tropical Timber Organization
LUC	land use change(s)
MS	Member States
NEN	Netherlands Standardization Institute
PEFC	Program for the Endorsement of Forest Certification
RE	Resource Efficiency
RED	Renewable Energies Directive 2009/28/EC
RSB	Roundtable on Sustainable Biomaterials
RSPO	Roundtable on Sustainable Palm Oil Production
RTRS	Roundtable on Responsible Soy
RSPO RED	Roundtable on Sustainable Palm Oil Production. Scheme aimed to show compliance with the EU Renewable Energy Directive's requirements
RTRS EU RED	Roundtable on Responsible Soy. Scheme aimed to show compliance with the EU Renewable Energy Directive's requirements
SAN	Sustainable Agriculture Network
SBP	Sustainable Biomass Partnership
SFI	Sustainable Forestry Initiative
SFM	Sustainable Forest Management
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 an improved understanding among decision-makers in policy and industry regarding **sustainability requirements** in biomass value chains addressed in Theme 1.

This goes beyond previous discussions on sustainability of liquid biofuels¹ and the ongoing discussions on solid/gaseous bioenergy² and biomaterials³ in aiming to develop comprehensive sustainability requirements for **all non-food biomass** in the broader **bioeconomy**⁴.

To achieve this, specific objectives of WP5 are:

1. Adaptation of the life-cycle-based EC Environmental Footprint methods in order to develop a complementary methodology specific to non-food biomass value chains⁵,
2. 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 State level (i.e. this paper),
3. Compilation of consistent sustainability C&I for the short- and medium-term bioeconomy, and an outlook for long-term developments, and
4. Development of guidelines for applying the toolset developed in WP4 to evaluate the environmental performance of biomass for bioenergy and bio-based product (e.g. chemical, material, etc.) supply chains⁶.

To this end, five tasks have been identified in WP5, as shown in Figure 1.

¹ See EU (2009a) for the respective requirements in the EU, and Franke et al. (2013) for global requirements.

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

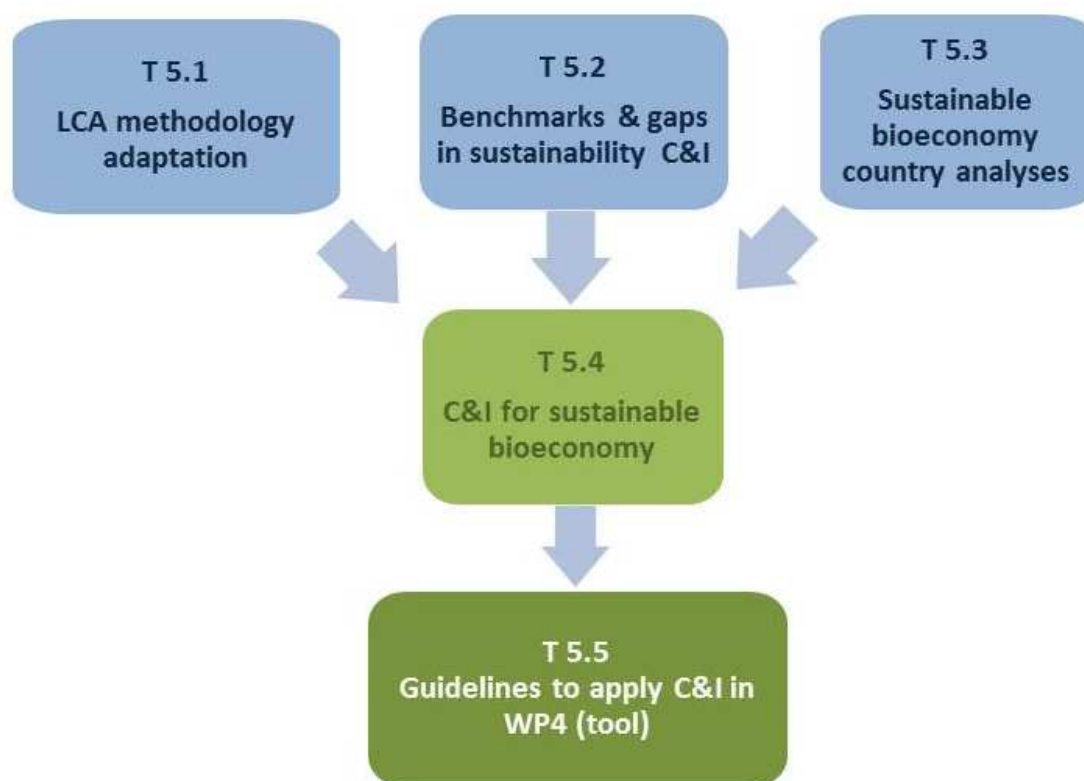
³ See e.g. activities within the BISO (<http://sa.jrc.ec.europa.eu/>), the FP7 project Bioeconomy observatory (<http://www.biobasedeconomy.eu/>) and INRO (<http://www.inro-biomasse.de/en.htm>)

⁴ Bioeconomy 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 (EC 2012a, EC 2012b). For a discussion of activities on bioeconomy sustainability requirements, see Fritsche, Iriarte (2014).

⁵ See WP5 Task 5.1 (carried out by the JRC) with its deliverable D5.1

⁶ See WP5 Task 5.5 (carried out by EFI).

Figure 1 Overall Configuration of Sustainability Activities in S2Biom



Source: own elaboration

This paper presents findings from Task 5.2, focusing on the benchmark and gap analysis of criteria and indicators (C&I) for legislation, regulations and voluntary schemes at the international level and for selected EU Member States.

The specific objectives of Task 5.2 are:

- Identify the **patterns** of C&I among the various biomass supply and use sectors by means of:
 - **Benchmark** identified sustainability requirements from the selected schemes against the draft S2Biom proposal.
 - Analyze **concept gaps** in existing schemes in comparison with the draft S2Biom proposal,
- Identify **other sustainability concepts** that might be helpful to strengthen the S2Biom sustainability proposal.

Ultimately, the findings from Task 5.2 will **help improve** the draft S2Biom C&I proposal in Task 5.4, according to relevant findings, and also Task 5.5 will benefit from the information collected here.

This paper is structured as follows:

- Section 2 presents the methodology used for the benchmarking and gap analysis.
- Section 3 introduces and briefly discusses the identified schemes.
- Section 4 shows the benchmarking and gap analysis for the various schemes in the forestry, agriculture and bioenergy sectors.
- Section 5 describes additional concepts identified in the non-benchmarked schemes that may be useful in evaluating a feedstock, value chain or end use.
- Section 6 offers conclusions on the important next steps for Tasks 5.4 and 5.5.

The (external) **Annex** provides the full description of the requirements in the schemes benchmarked against the S2Biom draft C&I. Furthermore, the Annex contains details of the additional concepts identified in Task 5.2 (see Section 5).

2 Methodology

To meet the objectives described above, four main steps were carried out, as shown in Figure 2, and described below.

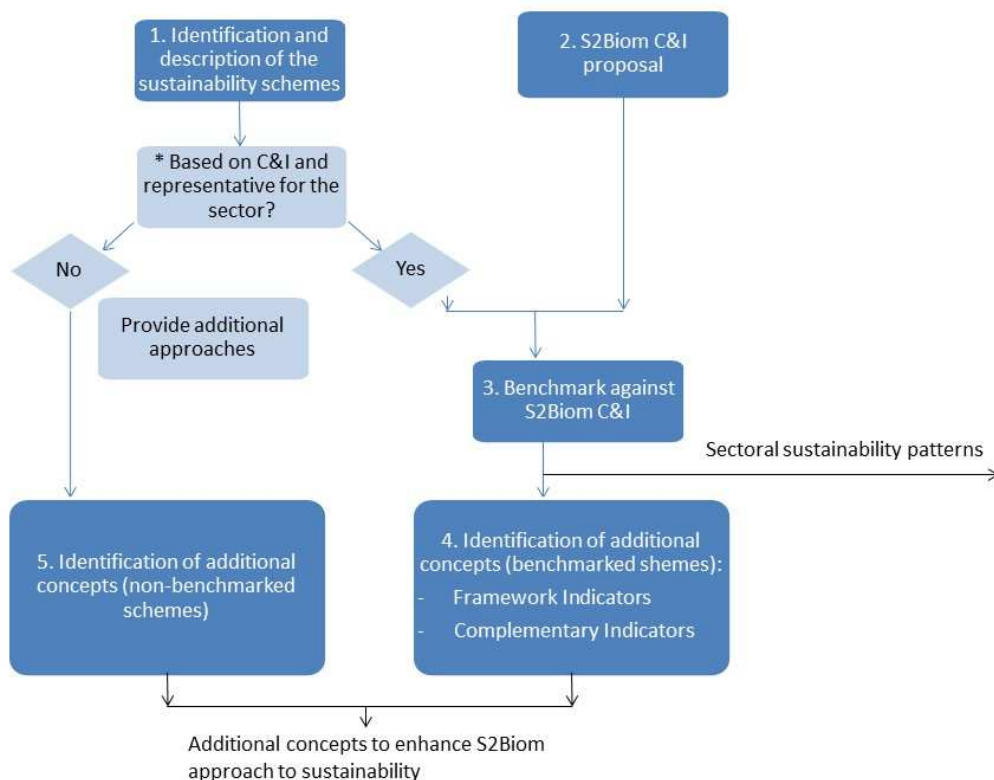
First (step 1), relevant schemes were identified and briefly described (Section 3).

When those schemes were based on sustainability C&I and were representative in the sectors included in this analysis (forestry, agriculture or bioenergy sectors), they were benchmarked (step 3) against the draft S2Biom C&I proposal.

When the schemes did not provide additional points of view to that reflected in benchmarked schemes (steps 3 and 4), but captured other perspectives that might be relevant for the S2Biom approach, the additional requirements were taken into account (step 5).

Schemes targeting specific feedstocks (e.g. forest residues) or schemes under development (e.g. NTA 8080) were included in step 5.

Figure 2 Steps of the Benchmark and Gap Analysis



Source: own elaboration

2.1 Identification of Schemes

The first step was to identify relevant sustainability schemes to be considered in the benchmarking and gap analysis. The schemes were selected with the goal of ensuring:

- Full coverage of a variety of **sectors** related to the bioeconomy: agriculture, forest, bioenergy, waste management, resource efficiency, etc. in order to encompass the range of issues and concerns present within the bioeconomy.
- **A Geographical** scope beyond the EU-28. Although S2Biom is mainly focused on the EU-28 and neighboring countries, imports of feedstocks or products from non-EU countries are also considered. Thus, international initiatives as well as initiatives in countries outside the EU were taken into account⁷.
- Initiatives promoted from various **bodies and organisms** are covered, including intergovernmental processes, national regulations, and private sector schemes.
- **High representativeness** of the schemes within each sector aiming at covering different relevant approaches.

Additional schemes were examined, but not formally benchmarked for one or several of the following reasons:

- They are sufficiently similar in **structure and content** to other benchmarked schemes. An example of this is some voluntary schemes certifying biofuels and bioliquids for compliance with the EU Renewable Energy Directive -RED- (EU 2009), such as SQC or the Abengoa scheme.
- They target **specific activities** such as forest residue harvesting, providing only specific requirements for these activities while broader supply chains are not considered.
- They are under **revision** so only provisional information is available, as is the case for the Dutch NTA8081 (NEN 2014).

The selected schemes included relevant:

- international schemes,

⁷ S2Biom is seen as an “umbrella” project given support to parallel IEE projects (www.BiomassPolicies.eu and www.BioTrade2020plus.eu).

- sustainability requirements in current legislation and regulations at EU level and in selected Member States (MS),
- voluntary approaches and management practices in selected MS, and
- voluntary certification schemes used in the private sector.

The final list of selected schemes is presented in Section 3.

There are other initiatives, such as those focusing on the reporting of companies on sustainability (e.g., Global Reporting Initiative⁸, UN Global Compact⁹) that are beyond the scope of this report.

Also beyond the present scope, are some of the efforts proposing indicators for the green economy at the country level such as the Green Growth Knowledge Platform (2013), iGrowGreen (EC 2012c) or the European environment — state and outlook (SOER) indicators by European Environment Agency indicators¹⁰ – for EU MS.

This report has considered a broad and comprehensive overview of issues related to sustainability without specific focus on any one the dimensions.

Thus, standards aimed exclusively at one issue, such as environmental management (e.g. ISO 14000 series¹¹) or social responsibility (e.g. ISO 26000¹²), have not been included in this analysis.

2.2 S2Biom Draft Sustainability C&I Proposal

The draft S2Biom sustainability C&I proposal is shown in Section 4.1¹³. This proposal focuses on “mid-point indicators” aimed at capturing the core environmental, social and economic values to be maintained or protected and is composed of 12 criteria and 26 indicators.

This generic proposal aims to provide a framework for use in developing sectoral approaches. Thus, this proposal is meant as an umbrella sustainability set for the

⁸ <https://www.globalreporting.org/Pages/default.aspx>

⁹ <https://www.unglobalcompact.org>

¹⁰ <http://www.eea.europa.eu/soer>

¹¹ <http://www.iso14000-iso14001-environmental-management.com/>

¹² <http://www.iso.org/iso/home/standards/iso26000.htm>

¹³ This is a draft proposal as agreed in the Document of Work and refers to the draft deliverable “S2Biom Task 5.4: Consistent Cross-Sectoral Sustainability Criteria & Indicators” as December 2014.

bioeconomy. In fact, the S2Biom “**mid-point indicators**”¹⁴ identify fundamental sustainability considerations cutting across all sectors for bioeconomy. Where there are considerations specific to one sector or value chain, these were incorporated as “**implementable indicators**”.

In fact, the draft S2Biom proposal targets biodiversity, soil and water (mid-point indicators) but does not specify the amount of residues needed (implementable indicators) to maintain those natural values¹⁵.

2.3 Benchmarking against the S2Biom Proposal

Selected schemes were evaluated in three categories to determine the extent to which they account for the concepts covered by the S2Biom sustainability C&I:

- Indicator **fully** considered (symbol ✓), this means that the main issues of S2Biom indicators are captured by the schemes (units have not been considered).
- Indicator **partially** considered (symbol ~). In this case, the main message is only partially covered by the concept considered in the scheme. Generally, just part of the S2Biom indicator’s message is taken into account or the requirement of the scheme is quite ambiguous.
- Indicator **not** considered (no entry). This category expresses that the concept is not present in the scheme.

Once each scheme was benchmarked, aggregated information by sector was compiled. To consider that an indicator is meaningfully included in a sector, the majority (at least 50 %) of the schemes in the sector should have fully met the given indicator. Given the limitations that this aggregation faces, a category for partially considered indicators has not been proposed. This means that the sectoral compilation only distinguishes between considered/not considered indicators.

Some schemes do not present their requirements in form of indicators¹⁶. Nonetheless, the most “operable” concept (e.g. criteria) were taken into account

¹⁴ See Deliverable 5.4: “Consistent Cross-Sectoral Sustainability Criteria & Indicators”

¹⁵ This will be part of other tasks of WP5.

¹⁶ There are different understandings of the meaning of indicators. According to D5.4 of the project, 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.

in the benchmarking. For instance, the international FSC scheme for sustainable forest management has not developed its requirements at the indicator level. The indicator level is considered in the adaptation of the scheme to regional or national levels which have not been considered here.

For the objectives of this task, we considered that the **requirements** of the FSC international scheme fully comply with the S2Biom C&I proposal, i.e. the requirement to deal with water quality reads “The Organization shall avoid negative impacts on water quality and quantity and mitigate and remedy those that occur” is considered as fully compliant with the S2Biom criterion “water quality”, because it is expected that the FSC indicators to be developed at a regional (or country) level comply with this criterion.

Specific **procedural** differences between schemes are not taken into account here. Schemes may differ in methods for quantifying an indicator, quantitative limits for indicator values, and proposed practices to improve performance against given criteria. For instance, the Sustainability Assessment of Food and Agriculture systems, SAFA (FAO 2013) considers within the concept “Air Pollution” three different indicators: Air Pollution Reduction Target, Air Pollution Prevention Practices and Ambient Concentration of Air Pollutants. The first two indicators are not taken into account in this analysis while the third might be in line with S2Biom indicator “SO₂ equivalents”.

Many schemes have specific requirements about **labor rights**, employment conditions, and overall wellbeing of local communities. These detailed requirements are beyond the scope of this study.

The (external) Annex to this deliverable fully describes the criteria, indicators or concepts considered in the benchmarking for the selected schemes. This does not only include the requirements of the schemes, but sometimes also some additional clarifications to frame the full meaning (such as the wording of the associated criteria or some guidance about the indicator).

For instance, in the Standard for Responsible Soy Production (RTRS 2013a), when searching for information on biodiversity conservation, one of the related indicators is “4.5.1. There is a map of the farm which shows the native vegetation.” We have added the respective criterion before the related indicator, which is “4.5. On farm biodiversity is maintained and safeguarded through the preservation of native vegetation” to contextualize the meaning of the indicator.

When the information provided for any scheme was not relevant or was too detailed, the symbol (...) was used to indicate that some information was omitted.

2.4 Identification and Benchmark of Other Concepts

In parallel to the benchmark and gap analysis against the S2Biom indicators, other concepts of interest for the S2Biom sustainability approach beyond those considered under the C&I proposal were identified. These concepts include indicators or issues that might be complementary to those already developed, taking into account issues associated with specific feedstocks or value chains. These concepts have been categorized as:

Framework indicators: this type of indicator refers to general cross-cutting requirements that might apply to several criteria and indicators included in the S2Biom proposal (e.g. compliance with laws or issues related to planning and monitoring) and that are beyond the scope of the S2Biom indicators.

Complementary indicators: here we include a great variety of requirements found in the schemes. It is indicated where these complementary indicators are related to one or various S2Biom themes or criteria. In this general category we include several “best practices” (i.e. “avoidance of burning” or “responsible management of waste water”) as well as other indicators with a view towards practical application (i.e. determine sustainable potentials or assess the sustainability of value chains). An example of the latter indicators could be “the amount of residues to be left on the ground when harvesting forest residues” that addresses issues related to biodiversity and soils¹⁷.

These concepts were identified by scheme and later were systemized in a single list in order to have a better understanding of the issues of interest in each scheme. These requirements have been systemized (benchmarked) when at least 3 schemes (of the 31 benchmarked schemes) have fully considered them. To consider that any indicator (whenever a “framework indicator” or “complementary indicator”) is meaningfully considered in the analyzed schemes, at least 50 % of the schemes should have fully considered it.

Each list of “framework indicators” and “complementary indicators” was further grouped into different topics (equivalent to the S2Biom criterion’s level of information). Section 5 presents the list of these concepts and the annex gives the full description of the performance of the schemes and related requirements.

¹⁷ See Deliverable 5.4 for a more detailed theoretical approach.

2.5 Additional Requirements in Non-Benchmarked Schemes

Description of additional concepts extracted from schemes that could not be benchmarked have been included in section 5. This description could not be systemized, though given the different purposes, approaches and requirements that these schemes have.

3 Identification of Schemes

The schemes considered in this report, as shown in Table 1 are related to:

- The sector to which they apply: This study has taken into account primary and secondary land-based resources from the agriculture, forestry, bioenergy and others (waste, biodiversity, etc.) sectors since those are the resources targeted in the S2Biom project.
- The geographical scope: Country or regional level or management unit level¹⁸.
- The type of initiative: Public or private international or regional initiatives, current legislation and regulation, voluntary certification schemes, voluntary approaches and management practices in selected MS.

Whether these schemes were benchmarked is shown in Table 2.

These initiatives were derived from previous work on this issue (Fritsche et al. 2014; Fritsche, Iriarte 2014; Eppler, Iriarte, Fritsche 2013). Some initiatives (e.g. RSPO, RTRS and Bonsucro) might apply to both the agriculture and bioenergy sector. Given their potential relevance in both sectors, these schemes are included in both sectoral benchmarks.

For the forestry sector, two main types of initiatives have been considered:

- Voluntary forest certification schemes: The international Forest Stewardship Council (FSC) and the Program for the Endorsement of Forest Certification (PEFC) standards have been benchmarked, and additional requirements from Sustainable Forestry Initiative (SFI) have been considered as well (it is under the PEFC umbrella).
- International processes on Sustainable Forest Management (SFM): These systems are often used to guide policy development, monitor and exchange information on national systems for SFM and the design of C&I at more local levels through government activities or private sector certification schemes (Stupak et al. 2011). All these processes address criteria and indicators for forests and forestry at the Country Level¹⁹ with only two of them (International Tropical Timber Organization, and Tarapoto) give requirements at the forest management unit level. These processes have been selected with the aim of

¹⁸ This mainly refers to forests. According to FAO (2000) a “forest management unit” is a well defined and demarcated land area, predominantly covered by forests, managed on a long-term basis and having a set of clear objectives specified in a forest management plan.

¹⁹ The Lepaterique process also provides indicators for the regional level (Latin America) that were deemed as not relevant for the purposes of this report.

reflecting the various challenges of forest land all around the world given that differences, e.g. in voluntary forest certification for woodfuel, might be more significant between countries than between selected schemes (Stupak et al. 2011). The ongoing discussions about the “Legally binding agreement on forests in Europe”²⁰ have not been considered since this agreement is still under negotiations.

Other requirements for specific feedstocks or practices related to forest biomass (e.g. forest residues) are considered under the bioenergy sector.

In the **agricultural sector** the initiatives considered are:

- International processes coordinated by FAO such as SAFA²¹ (FAO, 2013). SAFA is a holistic global framework for the assessment of sustainability along food and agriculture value chains.
- Selected voluntary certification schemes such as Sustainable Agriculture Network (SAN) or voluntary schemes for specific feedstocks such as palm oil (Roundtable on Sustainable Palm Oil - RSPO), soy bean (Roundtable on Responsible Soy - RTRS), or sugarcane (Bonsucro). As recognized by FAO²², there are at least 120 voluntary sustainability standards being implemented by the food and agriculture industry. Many of them are particularly focused on the *quality* of food and feed²³ so they are beyond the scope of this report.
- The requirements of the Common Agricultural Policy and related EU legislation.

Many countries have developed specific regulations for organic agriculture and there are several voluntary certification schemes²⁴. Here we focused on the requirements made at the EU level (EU 2007+2008a). These regulations have not been benchmarked against the S2Biom list of indicators.

With respect to **bioenergy**, different efforts were analyzed:

²⁰ <http://www.forestnegotiations.org/>

²¹ <http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en/>

²² Ibid

²³ The website of the International Trade Centre (<http://www.standardsmap.org/>) offers comprehensive information about many different type of standards, including those related to food and feed.

²⁴ http://en.wikipedia.org/wiki/Organic_certification

- International frameworks such as the Global Bioenergy Partnership (GBEP) indicators on sustainability.
- Legislation at the EU level: such as the sustainability requirements included in the RED (EU 2009b).
- EU MS schemes specifically targeting solid bioenergy (Belgium -BE-, Denmark -DK-, The Netherlands -NL-, United Kingdom -UK-).
- Other EU MS regulations covering solid bioenergy
- Regulations in third countries such as United States (US), Mozambique (MZ) and Brazil (BR).
- Voluntary certification schemes: such as the Roundtable on Sustainable Biomaterials -RSB-, the Sustainable Biomass Partnership -SBP- or other schemes targeting specific feedstocks (e.g. RSPO or Bonsucro). Some agriculture and/or bioenergy standards have adapted their schemes to certify compliance with the EU RED (e.g. RSPO, RTRS, or Bonsucro).
- Different types of voluntary guidelines:
 - For forest residue harvesting
 - Guidelines for ash recycling
 - Guidelines for woodwaste combustion

Some considerations have to be kept in mind:

- For biofuels and bioliquids, most EU MS have adopted the sustainability requirements laid out under the RED applying the same sustainability requirements (CNE 2012) and adopted the Fuel Directive Quality (EU 2009b). However, the draft revision of the NTA8081 (NEN 2014) proposes stricter sustainability criteria than the specific EU directives (i.e. RED and FQD). Given the potential impact of NTA8081 requirements, they are considered here, even though they are still under consideration.
- For solid biomass (including agricultural and forestry biomass) a formal, EU-wide, sustainability framework is lacking (EC 2014a). Nonetheless, it bears noting that:
 - Likely, many sustainability requirements and strategy documents are included in other European initiatives (i.e. EU Biodiversity Strategy (EP 2012), EU Forest Strategy (EC 2013), EU Timber Regulation (EU 2010), etc.). These might apply to EU sourced

biomass and that produced somewhere else. Also, there are different pieces of sectoral legislation at the MS level²⁵.

- The most relevant (mainly) pellet importing countries in the EU (i.e. UK, NL, BE and DK) are developing their own regulations to assure sustainability of bioenergy carriers. UK and BE have passed regulations, while those in NL and DK are still under development. In light of the efforts made in NL (NEN 2014) to extend the sustainability requirements from the bioenergy sector to the bioeconomy in general (including bio-products) remarkable requirements of the draft NTA8081 have been included, as indicated above.

As previously mentioned, there are three schemes (RSPO, RTRS and Bonsucro) feedstock specific (palm oil, soy and sugar cane respectively) that were originally developed to assure responsible/sustainable cultivation of the feedstock for food purposes. Later, these schemes were adapted in order to comply with the EU-RED sustainability requirements for biofuels and bioliquids. Required adaptations have been different for each scheme:

- RSPO RED (RSPO 2013a). The requirements for compliance with the EU RED have been designed as voluntary add-on to the RSPO standard. This separate document has to be used in conjunction with the RSPO Principles & Criteria (RSPO 2013b), the RSPO Certification System requirements, the RSPO Supply Chain Certification System requirements and the RSPO Supply Chain Certification Standard.
- RTRS EU RED requirements (2013a) is provided as an additional document which allows soy producers and processors to meet the requirements for supplying soy-based biofuels to EU MS. Producers (growers) seeking to comply with the RTRS EU RED scheme must as well demonstrate compliance with the RTRS Standard for Responsible Soy Production (2013b) besides other mandatory documents (RTRS 2011).
- Bonsucro EU is the Bonsucro certification option that complies with Bonsucro requirements plus additional requirements that are needed for EU RED compliance. Within the Bonsucro Certification System documents (i.e. Standards, Guidance, and Certification Protocol) the extra Bonsucro EU

²⁵ WP6 of the S2Biom project “Regulatory & financial framework to mobilize non-food biomass to biobased products & bioenergy market” is elaborating a comprehensive database of the different regulations at the EU level, in MS and neighboring countries.

requirements are clearly marked. In the case of the production standard (Bonsucro 2014) they are described as section 6 of the same document.

The main differences between the agriculture and bioenergy (RED-compliant) standards of these three schemes are found in the indicators related to GHG emissions along the value chain (S2Biom indicator 2.1) and protected areas and land with significant biodiversity values (S2Biom indicator 3.1). The details of these indicators, even if relevant in their various implications, are beyond the scope of this report.

RSB and NTA8081 have been benchmarked within the bioenergy sector even though they are intended to apply to both bioenergy and bio-products. This is similar for the International Sustainability and Carbon Certification (ISCC)²⁶, which is a voluntary certification scheme applicable for all types of biomass and biomass-based products. Complementary to ISCC-EU aimed to show biofuels sustainability with regard to the RED, ISCC PLUS has been developed for food, feed, technical/chemical applications (e.g. bioplastics) and other bioenergy applications (e.g. solid biomass). All the sustainability core requirements of the various ISCC standards (EU, DE, PLUS) are aligned.

The ISCC PLUS is composed of a list of relevant references whose contents have to be considered (obligatory requirements are indicated with an asterisk):

- ISCC PLUS 201 System Basics
- ISCC PLUS 202 Sustainability Requirements – ISCC PLUS Standard on Sustainability*
- ISCC PLUS 202a Sustainability Requirements – Equivalence Benchmark
- ISCC PLUS 203 Requirements for Traceability*
- ISCC PLUS 204-01 Mass balance requirements*
- ISCC PLUS 204-02 Physical Segregation requirements*

Additionally to the core requirements of ISCC PLUS, interested parties can chose from a set of voluntary add-ons:

- ISCC PLUS 202-01 Environmental Management and Biodiversity
- ISCC PLUS 202-02 Classified Chemicals

²⁶ <http://www.iscc-system.org/en/iscc-system/about-iscc/>

- ISCC PLUS 205-01 GHG Emission Requirements. While for biofuels (ISCC-EU) compliance with this requirement is mandatory (ISCC 2011), for other biomass feedstocks (ISCC PLUS) it is only mandatory for the biomass production and must be available at the first gathering point (ISCC 2012). All other elements in the value chain can choose this add-on (205-01) as a modular approach.
- ISCC PLUS 205-02 Consumables of a Production Process

Moreover, for some types of biomass or biomass-based products special ISCC PLUS requirements are defined as special requirements or audit procedures. These special requirements must be applied together with the overall ISCC PLUS standard. Several extensions have been developed for various purposes:

- ISCC PLUS 260-01 – Short Rotation Coppices
- ISCC PLUS 260-02 – Bioplastics
- ISCC PLUS 260-03 – Feed
- ISCC PLUS 260-04 – Food
- ISCC PLUS 260-05 - Waste fuels, renewable fuels, non biological origin

This benchmark has considered the ISCC-EU (2015) version 2.4, obligatory from 01 January 2015.

RSB has also developed two sets of standards that describe sustainability requirements: the global set of standards, and the RSB EU-RED consolidated standards. The global set of standards applies to any type of feedstock worldwide whereas the RSB EU-RED consolidated standards is an adaptation of the RSB standards developed for compliance with the RED, which defines the land-use and GHG criteria for biofuels entering the EU market. This study has focused on the global set of standards because documentation differences between both of them are not relevant for the purpose of this work.

There are regulations in third countries such as the Renewable Fuel Standard in the US, the Environmental zoning in Brazil (CENBIO 2013) and the national biofuels policy and strategy of Mozambique (Schut, Slingerland, Locke 2010) that add other angles to the analysis. Those initiatives are extensively discussed in section 5.3.

Also, ISO²⁷ is in the process of developing a sustainability standard for bioenergy, though it is not yet operational. This standard will cover the production, supply chain, and application of bioenergy.

There are also **other regulations** that directly or indirectly apply to bioeconomy such as:

- The **EU Biodiversity Strategy** (EU 2012), that calls on the Commission to develop reliable indicators of environmental sustainability in order to assess the degree of progress towards the overall goal of protecting biodiversity.
- The **EU Waste Directive** (EU 2008b), which regulates different considerations for wastes and by-products that might be relevant for some biomass-value chains.
- The **Resource Efficiency Scoreboard** (EC 2014b) presents indicators covering themes and subthemes of the Roadmap to a Resource Efficient Europe (EC 2011). This Roadmap indicated the necessity to develop adequate indicators and targets for guiding actions and monitoring progress. The Scoreboard had identified a total of 5 themes, 12 sub-themes and 17 indicators. Several of these indicators clearly overlap the S2Biom proposal (e.g. those related to soils and water), while others might provide additional points of view (see section 5.3).
- The Action Plan of the **Bioeconomy Strategy** for EU (EC 2012a), points out that the Action Plan should support the future development of standardized sustainability assessment methodologies for bio-based products and food production systems, including environmental footprints, e.g. using life cycle assessments”. Moreover, the Commission Staff Working Document (EC 2012b) analyzes different scenarios and considers various requirements that might be of interest (see section 5.3).
- The **German Biorefinery Roadmap** (BMELV 2012) specifically considers sustainability issues not only on the supply side but also with respect to biomass use.
- The **CEN TC411 Bio-Based Products**²⁸ is also working on the development of horizontal standards for bio-based products which are not yet available.

²⁷

http://www.iso.org/iso/home/standards_development/list_of_iso_technical_committees/iso_technical_committee.htm?commid=598379

²⁸ <http://www.biobasedeconomy.eu/standardisation/cen-tc411/wg4/>

It is worth noting that in this work the schemes' documents regarding administrative procedures to certify value chains have not been considered.

Table 1 Identified Schemes and Regulations in Biomass Supply and Use Sectors

Scheme or Regulation	Reference	Sector	Geographical scope	Type of scheme
SAFA- Sustainability Assessment of Food and Agriculture systems	FAO 2013	Agriculture	International	International voluntary sustainability assessment
SAN- Sustainable Agriculture Network	SAN 2010	Agriculture	International	Voluntary certification
RSPO- Roundtable on Sustainable Palm Oil (Agriculture + Bioenergy)	RSPO 2013a+b	Agriculture	International	Voluntary certification
RTRS- Round Table on Responsible Soy (Agriculture + Bioenergy)	RTRS 2013a+b	Agriculture	International	Voluntary certification
Bonsucro- Better Sugarcane Initiative (Agriculture + Bioenergy)	Bonsucro 2014	Agriculture/Bioenergy	International	Voluntary certification
CAP- Common Agricultural Policy	EU 2013a-c; EU 2014a+b	Agriculture	EU-28	EU legislation
EU organic production	EU 2007+ 2008a	Agriculture	EU-28	EU legislation
FSC- Forest Stewardship Council	FSC 2014	Forest	International	Voluntary certification
PEFC- Programme for the Endorsement of Forest Certification	PEFC 2012	Forest	International	Voluntary certification
SFI- Sustainable Forestry Initiative	SFI 2015	Forest	North America	Voluntary certification
Tarapoto (Forest Management Unit level and National Level)	FAO 2008	Forest	International	International process
ITTO- International Tropical Timber Organization (Forest Management Unit level and Country Level)	FAO 2008	Forest	International	International process
ASI- Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia (Country Level)	FAO 2008	Forest	International	International process

Scheme or Regulation	Reference	Sector	Geographical scope	Type of scheme
ATO- African Timber Organization (Country Level)	FAO 2008	Forest	International	International process
CILSS- Permanent Interstate Committee for Drought Control in the Sahel (Country Level)	FAO 2008	Forest	International	International process
SADC- Southern African Development Community (Country Level)	FAO 2008	Forest	International	International process
Lepaterique (Country Level)	FAO 2008	Forest	International	International process
Near East Process (Country Level)	FAO 2008	Forest	International	International process
MCFPE- Ministerial Conference on the Protection of Forests in Europe (Forest Europe) (Country Level)	FAO 2008	Forest	International	International process
Montreal Process (Country Level)	FAO 2008	Forest	International	International process
EU Forest Strategy	EU 2103	Forest	EU level	EU Strategy
EU Timber Regulation	EU 2010	Forest	EU level	EU Regulation
GBEP- Global Bioenergy Partnership	GBEP 2011	Bioenergy	International	International process
RED – EU Renewable Energy Directive	EU 2009a	Bioenergy	EU level	EU Regulation
National schemes for solid bioenergy (BE, DK, NL, UK)	Pelkmans et al. 2012; Iriarte, Fritsche, Pelkmans et al 2014a; NEN 2014	Bioenergy	EU country level	EU regulations
Other EU MS regulations related to solid bioenergy	Pelkmans et al. 2012	(Related to bioenergy)	EU country level	EU MS regulations or guidelines
Non-EU countries bioenergy regulations	e.g. Goovaerts et al. 2013; CENBIO 2013; Schut, Slingerland, Locke 2010	Bioenergy	National various	Non-EU regulations
Voluntary guidelines for forest residue harvesting	Fritsche et al. 2014	(Forest) Bioenergy	National (various)	Voluntary guidelines

Scheme or Regulation	Reference	Sector	Geographical scope	Type of scheme
Guidelines for ash recycling	Swedish Forest Agency 2008	(Forest) Bioenergy	Sweden	EU MS guidelines
Guidelines for woodwaste combustion	Alakangas 2014	(Forest) Bioenergy	Finland	EU MS guidelines
RSB- Roundtable on Sustainable Biomaterials	RSB 2010+2011	Bioenergy (include bioproduct)	International	Voluntary certification
SBP- Sustainable Biomass Partnership	SBP 2014	Bioenergy	International	Voluntary certification
Greenenergy	Greenenergy 2011	Bioenergy	International	Voluntary certification
ISCC EU- International Sustainability and Carbon Certification	ISCC 2015	Bioenergy (include bioproducts)	International	Voluntary certification
GGL-Agri- Green Gold Label Program. Agricultural source	GGL 2013a	Bioenergy	International	Voluntary certification
GGL-Forest- Green Gold Label Program. Forest Management	GGL 2013b	Bioenergy	International	Voluntary certification
EU Biodiversity Strategy	EU 2012	Other	EU level	EU Strategy
EU Waste Directive	EU 2008b	Other	EU level	EU Legislation
EU Resource Efficiency Strategy	EC 2011	Other	EU level	EU Strategy
EU Bioeconomy Strategy	EC 2012a	Other	EU level	EU Strategy
German Biorefinery Roadmap	BMELV 2012	Other	EU MS	MS Strategy

Source: own compilation; FMU = Forest Management Unit; CL = Country level; MS = Member State

Table 2 Overview of benchmarked and non-benchmarked schemes by sectors

	Agriculture	Forest	Bioenergy	Others
Benchmarked	SAFA- Sustainability Assessment of Food and Agriculture systems	FSC- Forest Stewardship Council (FMU)	GBEP- Global Bioenergy Partnership	
	SAN- Sustainable Agriculture Network	PEFC- Programme for the Endorsement of Forest Certification (FMU)	RED – EU Renewable Energy Directive	
	RSPO- Roundtable on Sustainable Palm Oil (Agri)	Tarapoto (FMU + CL)	RSB- Roundtable on Sustainable Biomaterials	

	Agriculture	Forest	Bioenergy	Others
	RTRS- Round Table on Responsible Soy (Agri)	ITTO - International Tropical Timber Organization (FMU + CL)	SBP- Sustainable Biomass Partnership	
	Bonsucro- Better Sugarcane Initiative (Agri + Bioenergy)	ASI - Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia	RSPO- Roundtable on Sustainable Palm Oil (Bioenergy)	
	CAP- Common Agricultural Policy	ATO - African Timber Organization (CL)	RTRS- Round Table on Responsible Soy (Bioenergy)	
		CILSS- Permanent Interstate Committee for Drought Control in the Sahel (CL)	Bonsucro (Agri+Bio)	
		SADC- Southern African Development Community (CL)	Greenenergy	
		Lepaterique CL	ISCC-EU International Sustainability and Carbon Certification	
		Near East Process (CL)	GGL-Agri- Green Gold Label Program. Agricultural source	
		MCFPE - Ministerial Conference on the Protection of Forests in Europe (Forest Europe) (CL)	GGL-Forest- Green Gold Label Program. Forest Management	
		Montreal Process (CL)		
Non-Benchmarked	EU organic production	SFI – Sustainable Forestry Initiative	National schemes for solid bioenergy (BE, DK, NL, UK)	EU Biodiversity Strategy
		EU Forest Strategy	Other EU MS regulations related to solid bioenergy	EU Waste Directive
		EU Timber Regulation	Non-EU countries bioenergy regulations	EU Resource Efficiency Strategy

	Agriculture	Forest	Bioenergy	Others
			Voluntary guidelines for forest residue harvesting	EU Bioeconomy Strategy
			Guidelines for ash recycling	German Biorefinery Roadmap
			Guidelines for woodwaste combustion	

Source: own compilation

4 Benchmark and Gap Analysis

The benchmark and gap analysis has been performed evaluating the relevant schemes structured as criteria and indicators against the draft S2Biom structure (see Table 3). Results of this analysis are presented first as a compilation by sector (see Table 4) and later the performance of each scheme in the respective sector (see Tables 5-7).

4.1 S2Biom C&I Proposal

The draft Sustainability C&I Proposal in the framework of the S2Biom project (version December 2015) is presented in Table 3. A final draft version of the Sustainability C&I is given in deliverable 5.4 of the project (Consistent Cross-Sectoral Sustainability Criteria & Indicators). This proposal encompasses the environmental (including resource efficiency issues), social, and economic themes and is composed of 12 criteria and 26 mid-point indicators.

Table 3 Draft Sustainability Criteria and Indicators for the Bioeconomy as Proposed in the framework of the S2Biom project

Theme	Criterion	Indicator		
		#	Indicator name	Description
Environment	1. Resource efficiency	1.1	Land use efficiency	Available bioenergy carriers (including by- and co-products along the bioenergy life cycles) per hectare of cultivated area
		1.2	Secondary resource efficiency	Heating value of the bioenergy output divided by the heating value of the secondary resource. This indicator applies to bioenergy carriers stemming from the conversion of secondary biomass resources such as residues and wastes.
		1.3	Energy efficiency	Cumulative energy demand (all inputs (based on LHV primary energy), incl. renewable energy and biomass input, compared to the outputs
		1.4	Functionality (output service quality)	Economic value of the outputs (€/GJ x GJ energy carriers + €/ton x ton materials), compared to the economic value of the heat which could be produced from burning the (dried) primary inputs (reference = heat from NG ~ 10€/GJ); economic values are excl. tax, for industrial customers
	2. Climate Change	2.1	Life cycle GHG emissions (CO ₂ eq), including direct LUC	GHG emissions during crop growth & harvesting, logistics, pretreatment and conversion, distribution, end use; in relation to the final output (combination of electricity, useful heat, biofuels & biomaterials)
		2.2	Other GHG emissions	GHG from iLUC and C stock changes
	3. Biodiversity	3.1	Protected areas and land with significant biodiversity values	Categories established by the RED
		3.2	Biodiversity conservation and management	"Agrobiodiverse cultivation" (crop rotation; diversity in the landscape; avoidance of alien species) and amount of chemicals (pesticides/herbicides); release of GMO

Theme	Criterion	Indicator		
		#	Indicator name	Description
	4. Soil	4.1	Erosion	Probability of erosion where mitigation measures are not feasible
		4.2	Soil Organic C	Probability of soil organic C 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 + processing
		5.3	Water quality	Water quality: water pollution (nitrate, phosphorous, pesticides, BOD)
	6. Air	6.1	SO ₂ equivalents	Life cycle emissions of SO ₂ , NO _x , NH ₃ and HCl/HF from bioenergy requirement, expressed in SO ₂ equivalents and calculated in accordance to the life cycle emission methodology for GHG
		6.2	PM ₁₀	Life cycle emissions of PM ₁₀ from bioenergy requirement, calculated in accordance to the life cycle emission methodology for GHG
	Social	7. Participation and transparency	7.1	Effective participatory processes
7.2			Information transparency	Documentation necessary to inform stakeholder positions shall be made freely available to stakeholders in a timely, open, transparent and accessible manner
8. Secure tenure of land		8.1	Compliance with the VGGT (CFS 2012) to secure land tenure and ownership	Share of area or share of biomass that could be under secure land tenure, based on literature revision and national (or international) statistics.

Theme	Criterion	Indicator		
		#	Indicator name	Description
	9. Employment and labor conditions	9.1	Full direct jobs equivalents along the full value chain	Number of jobs from bioenergy
		9.2	Full direct jobs equivalent in the biomass consuming region (or country)	Number of jobs from bioenergy
		9.3	Human and Labor Rights	Adherence to ILO (1998) principles and voluntary standards. Not all countries are signatories of ILO
		9.4	Occupational safety and health for workers	Measures taken to guarantee occupational safety and health for workers
	10. Health risks	10.1	Risks to public health	Measures taken to safeguard public health, i.e. regulation of noise level and accidents
	11. Food security	11.1	Risks for negative impacts on price and supply of national food basket and fuelwood	This indicator needs to be fully described and will consider the BEFS methodology (FAO 2014) and literature references
Economic	12. Production costs	12.1	Levelized life-cycle cost (excl. subsidies, incl. CAPEX, OPEX)	Levelized life-cycle cost, excluding subsidies

Source: own elaboration

4.2 Benchmark and Gap Analysis

Aggregated results²⁹ of the benchmarking process for all of the schemes considered against the draft S2Biom C&I (26 indicators) are presented in Table 4. The agriculture sector covered more S2Biom indicators (17) in a meaningful way than the bioenergy (12) and forestry sectors (9). All sectors presented a better performance against the indicators under the environmental theme than in the social theme whilst the economic side was not meaningfully considered in any sector.

As shown in this table, Table 4, biodiversity, soil and secure tenure of land are fully covered in the schemes and sectors analyzed. Thus, seven S2Biom indicators are considered in all sectors, as follows:

- Protected areas and land with significant biodiversity values
- Biodiversity conservation and management
- Erosion
- Soil Organic C
- Soil nutrient balance
- Water availability and regional water stress
- Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (CFS 2012).

Indicators related to climate change, water, participation and transparency as well as employment and labor conditions are partially covered. In particular, the following 6 S2Biom indicators are meaningfully included in two sectors:

- Life-cycle GHG (CO₂eq) emissions, including direct land use change (LUC)
- Water use efficiency
- Water quality
- Effective participatory processes
- Human and Labor Rights

²⁹ For an indicator to be considered in a sector, at least 50 % of the schemes should have covered the respective requirement in a meaningful way.

- Occupational safety and health for workers

The following 5 S2Biom indicators are only taken into account significantly in one sector:

- Energy efficiency
- Effective participatory processes
- Information transparency
- Full direct jobs equivalent in the biomass consuming region (or country), and
- Risks to public health

Moreover, there are 8 S2Biom indicators that are not significantly reflected in any sector:

- Land use efficiency
- Secondary resource efficiency
- Functionality (Output service quality)
- Other GHG emissions
- SO₂ equivalents
- PM₁₀
- Risks for negative impacts on price and supply of national food basket and fuelwood.
- Levelized life-cycle cost (excluding subsidies, including CAPEX, OPEX)

If focusing on voluntary certification schemes targeting the project level, the same pattern as for the overall sectoral analysis is found. Thus, the indicators meaningfully considered within those schemes are the indicators included in 2 or 3 sectors as described above.

When closely looking at the differences between the agriculture and bioenergy sector, it could be concluded that these differences are minimum. Thus, those indicators that are covered by the agriculture sector and not meaningfully taken into account in the bioenergy one (Energy efficiency, Effective participatory processes, Information transparency, and Full direct jobs equivalent in the biomass consuming region (or country)) are also considered in several of the bioenergy schemes even if not in a meaningful way.

Also, when looking at the forest certification schemes selected for the benchmarking (FSC and PEFC), there are additional indicators to those

mentioned above that are relevantly included such as: water quality, Information transparency, Full direct jobs equivalent in the biomass consuming region (or country), Human and Labor Rights, occupational safety and health for workers.

These results should be carefully analyzed given the limitations of this analysis (i.e. the selected schemes for each sector might not reflect the majority of the volumes/amount of biomass used in each sector). Nevertheless this compilation results helpful to better understand the patterns in forestry, agriculture and bioenergy. The non-inclusion of some indicators in these sectors might respond to several issues. For example, with respect to indicators related to the resource efficiency criterion, it is only recently that the discussion on this topic gained momentum so there has not been time to deeply discuss (and incorporate if appropriate) these requirements in the respective schemes (or regulations). Other requirements, as i.e. with respect to the Air criterion might be reflected in other legislation.

Table 5 shows the benchmark and gap analysis for the selected forestry sector schemes against the draft S2Biom indicators. Environmental criteria with the exception of resource efficiency and climate change are well covered within the schemes analyzed³⁰. Nonetheless, new developments in the framework of the forestry sector at the EU level such as the EU Forest Strategy (EU 2013) captures the need to consider resource efficiency in the forest sector. Particularly, the EU Forest Strategy points out that an option to improve the resource efficiency in this sector is the cascade use of wood³¹ (see Section 5.3).

The SFI (2015) just released the “Forest Management Standard” and the “Fiber Sourcing Standard”. There is a requirement with respect to the “Efficient Use of Fiber Resources (objective 7)” which aims to minimize waste and ensure the efficient use of fiber resources. For this, “Program Participants shall employ appropriate forest harvesting technologies and in-woods manufacturing processes and practices to minimize waste and ensure efficient utilization of harvested trees (...)”.

In fact, different requirements with respect to the forestry sector are appearing in the last developments.

³⁰ The role of forest with regard to climate change is discussed within the framework indicators See FW16 “Maintenance of forest contribution to global carbon cycles”.

³¹ According to the EC (2013), under the cascade principle, wood is used in the following order of priorities: wood-based products, extending their service life, re-use, recycling, bio-energy and disposal.

Social criteria are only partially considered, while economic criteria are not taken into account in the forestry sector. One of the reasons that might explain this lack of coverage for these themes is that many of the schemes analyzed correspond to international forest processes on C&I for SFM so they address issues of interest at the national level. However, they consider other concepts of relevance for the S2Biom approach (see Section 5).

The results of the benchmark and gap analysis for the agricultural schemes is shown in Table 6. The agriculture schemes selected cover most of the S2Biom indicators, particularly for the environmental and social themes. Many schemes address the energy efficiency indicator, contrary to what occurs for the forest schemes. No scheme covers food security issues while the cost of production is only considered in one scheme.

A similar pattern as for the agriculture is observed for the selected schemes related to bioenergy, as shown in Table 7. Nonetheless, there are more indicators covered in the agriculture sector than in the bioenergy one.

With regards to bioenergy, in the EU there are a number of legal measures addressing environmental issues such as air pollution (see e.g. EC 2014a) so even if this issue is not directly covered under the RED or the Common Agricultural Policy, this and other environmental issues might be covered under other pieces of legislation.

Table 4 Compilation of the Benchmark and Gap analysis of the selected Schemes and Regulations against the (draft) S2Biom Indicators

Theme	Criterion	Indicator		Sector		
		#	Indicator name	Forestry	Agriculture	Bioenergy
Environmental	1. Resource efficiency	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 GHG emissions (CO ₂ eq), including direct LUC		✓	✓
		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 C	✓	✓	✓
		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 ₂ equivalents			
		6.2	PM ₁₀			
Social	7. Participation and transparency	7.1	Effective participatory processes	✓	✓	
		7.2	Information transparency		✓	
	8. Secure Land Tenure	8.1	Compliance with the VGGT to secure land tenure and ownership	✓	✓	✓

Theme	Criterion	Indicator		Sector		
		#	Indicator name	Forestry	Agriculture	Bioenergy
	9. Employment and labor conditions	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 Labor Rights		✓	✓
		9.4	Occupational safety and health for workers		✓	✓
	10. Health Risks	10.1	Risks to public health		✓	
	11. Food security	11.1	Risks for negative impacts on price and supply of national food basket and fuelwood.			
Economic	12. Production costs	12.1	Levelized life-cycle cost (excluding subsidies, including CAPEX, OPEX)			

Source: own compilation.

Note: It has been considered that a sector takes into account any of the S2Biom indicators when at least 50 % of the schemes in the sector consider the given indicator fully.

Table 5 Benchmark and Gap analysis of the selected Forest Schemes against the (draft) S2Biom Indicators

Theme	Criterion	Indicator		FSC	PEFC	Tarapoto FMU	ITTO FMU	Tarapoto CL	ITTO CL	ASI	ATO	CILSS	SADC	Lepaterique	Near East Process	MCFPE	Montreal	
		#	Indicator name															
ENVIRONMENTAL	1. Resource efficiency	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 GHG emissions (CO ₂ eq), including direct LUC															
		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 C	✓	✓	✓		✓						✓	~	✓	✓	✓
		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 ₂ equivalents	~														
		6.2	PM ₁₀	~														



Theme	Criterion	Indicator		FSC	PEFC	Tarapoto FMU	ITTO FMU	Tarapoto CL	ITTO CL	ASI	ATO	CILSS	SADC	Lepaterique	Near East Process	MCFPE	Montreal	
		#	Indicator name															
SOCIAL	7. Participation and transparency	7.1	Effective participatory processes	✓	✓	✓	✓	✓	✓	~	✓	✓	✓	✓	✓	~	~	
		7.2	Information transparency	✓	✓			~				✓						
	8. Secure tenure of land	8.1	Compliance with the VGGT to secure land tenure and ownership	✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	
	9. Employment and labor conditions	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 Labor Rights	✓	✓							~			✓			
		9.4	Occupational safety and health for workers	✓	✓		✓		✓		✓						✓	
10. Health Risks	10.1	Risks to public health	~	~														
11. Food security	11.1	Risks for negative impacts on price and supply of national food basket and fuelwood								~		~	~		~			
ECONOMIC	12. Production costs	12.1	Levelized life-cycle cost (excluding subsidies, including CAPEX, OPEX)															

Source: own compilation

Note: FMU: Forest Management Unit; CL: Country level

Table 6 Benchmark and Gap analysis of the selected Agricultural Schemes against the (draft) S2Biom Indicators

Theme	Criterion	Indicator		SAFA	SAN	RSPO	RTRS	Bonsucro	CAP
		#	Indicator name						
ENVIRONMENTAL	1. Resource efficiency	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 GHG emissions (CO ₂ eq), including direct LUC	✓	~	✓	✓	✓	✓
		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 C	✓	✓	✓	✓	~	✓
		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 ₂ equivalents	~		✓		✓		
	6.2	PM ₁₀	~		✓		✓		
SOCIAL	7. Participation and transparency	7.1	Effective participatory processes	✓		✓	~	✓	
		7.2	Information transparency	✓	✓	✓	~	✓	
	8. Secure tenure of land	8.1	Compliance with the VGGT to secure land tenure and ownership	✓	✓	✓	✓	✓	
	9. Employment and labor conditions	9.1	Full direct jobs equivalents along the full value chain						

Theme	Criterion	Indicator		SAFA	SAN	RSPO	RTRS	Bonsucro	CAP
		#	Indicator name						
		9.2	Full direct jobs equivalent in the biomass consuming region (or country)*	✓	✓		✓		
		9.3	Human and Labor Rights	✓	✓	✓	✓	✓	
		9.4	Occupational safety and health for workers	✓	✓	✓	✓	✓	
	10. Health Risks	10.1	Risks to public health	✓	✓		✓		~
	11. Food security	11.1	Risks for negative impacts on price and supply of national food basket and fuelwood						
ECONOMIC	12. Production costs	12.1	Levelized life-cycle cost (excluding subsidies, including CAPEX, OPEX)	✓					

Source: own compilation

Note: FMU: Forest Management Unit; CL: Country level

Table 7 Benchmark and Gap Analysis of the selected Bioenergy Schemes against the (draft) S2Biom Indicators

Theme	Criterion	Indicator		GBEP	RED	RSB	SBP	RSPO	RTRS	Bonsucro	Greenery	ISCC-EU	GGL-Agri	GGL-Forest	
		#	Indicator name												
ENVIRONMENTAL	1. Resource efficiency	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 GHG emissions (CO ₂ eq), including direct LUC		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		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 C		✓	~	✓	✓	✓	✓	~	✓	✓	✓	~
		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 ₂ equivalents		✓		✓	~	✓		✓	~			
		6.2	PM ₁₀		✓		✓	~	✓		✓	~			
	SOCIAL	7. Participation and transparency	7.1	Effective participatory processes		~		✓	✓	~	✓	✓	~	✓	
			7.2	Information transparency		~		✓	✓	~	✓	~	~		

Theme	Criterion	Indicator		GBEP	RED	RSB	SBP	RSPO	RTRS	Bonsucro	Greenenergy	ISCC-EU	GGL-Agri	GGL-Forest	
		#	Indicator name												
	8. Secure tenure of land	8.1	Compliance with the VGGT to secure land tenure and ownership	✓		✓	✓	✓	✓	✓	✓	✓		✓	
	9. Employment and labor conditions	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 Labor Rights			✓	✓	✓	✓	✓	✓	✓	✓		
		9.4	Occupational safety and health for workers	✓		✓	✓	✓	✓	✓	✓	✓	✓		
	10. Health Risks	10.1	Risks to public health	✓	~	✓			✓			✓			
11. Food security	11.1	Risks for negative impacts on price and supply of national food basket and fuelwood.	✓		~	✓						✓	✓		
ECONOMIC	12. Production costs	12.1	Levelized life-cycle cost (excluding subsidies, including CAPEX, OPEX)	✓											

Source: own compilation

5 Other Relevant Concepts

5.1 Framework Indicators

Table 8 shows the framework topics and respective indicators identified in the selected benchmarked schemes. 4 framework issues and 18 related indicators were found among the schemes. The only indicator meaningfully considered³² in the schemes was the existence of a “Management Plan”.

Table 8 Framework indicators identified in the selected schemes

Framework topics	#	Framework indicators
Compliance with laws	1	Compliance with the applicable, laws, international conventions and obligatory codes of practice
	2	Avoidance of illegal activities
Governance	3	Continual improvement
	4	Product or Benefits Diversification
Planning and monitoring	5	Consider other functions of forests than productive ones
	6	Risk assessment/management
	7	Social and Environment Impact assessment
	8	Avoid and mitigate negative impacts and promote positive ones
	9	Management plan
	10	Apply precautionary approach
	11	Identify and Analyze potential emergencies
	12	Planning and management at the landscape level
	13	Connectivity, fragmentation, forest encroachment
Technology	14	To implement adaptive management
	15	Monitor production and process efficiency; to measure the impacts of production and processing
	16	Technological inputs
	17	Transfer of technology
	18	Environmentally friendly technologies

Source: own compilation

³² An indicator is meaningfully considered when at least half of the schemes benchmarked fully takes it into account.

5.2 Complementary Indicators

In Table 9, complementary topics and respective indicators to these included in the draft S2Biom set of indicators that are significantly considered in the benchmarked schemes are stated. In total 20 topics and 39 indicators have been identified. In this analysis those schemes considered relevant in the agriculture and bioenergy sectors (RTRS, RSPO and Bonsucro) are included only once. Seven indicators are meaningfully included in these schemes, as follows:

- Land Use Change
- Harvest products and services from the Management Unit at or below a level which can be permanently sustained
- Maintain or restore of areas of water influence
- Monitor periodically key biotic and abiotic factors that might affect health and vitality of ecosystems
- Measures for soil conservation
- Existence of conflict management mechanisms
- Training and requalification of the workforce

Table 9 *Other concepts identified in the benchmarked schemes*

S2Biom related Theme (T) or Criterion (C)	#	Topic	#	Indicators
T1: Environment	1	Waste	1	Waste Management and Reduction, recycle and re-use of waste
			2	Waste generation per ton of product
	2	Best environmental practices	3	“Responsible” management of wastewater
			4	No use of burning
			5	Responsible management infrastructural development, transport activities and silviculture
	3	Land Use and Land Use Change	6	Assure the permanence of vegetation (regenerate vegetation cover)
			7	Rehabilitate degraded ecosystems
			8	Land Use Change
	4	Sustainable harvesting of forest products and non-wood forest products	9	Harvest products and services from the Management Unit at or below a level which can be permanently sustained
C1: Resource Efficiency	5	Resource use	10	Efficiency of systems of production and transformation
			11	Intensity of fossil fuel use
C2: Climate Change	6	Best Practices for Resource Efficiency	12	Energy saving practices
			7	Best Environmental Practices for Climate Change mitigation
	14	Practices to increase carbon dioxide sequestration		
8	Climate Change	15	Maintenance of forest contribution to global carbon cycles	
C3: Biodiversity	9		16	Practices to diminish spread of invasive introduced species and new pests or diseases

S ₂ Biom related Theme (T) or Criterion (C)	#	Topic	#	Indicators
		Best Environmental Practices for Biodiversity conservation	17	"Responsible" application of agrochemicals (in the case of forestry minimize or eliminate) and biological control agents
			18	Avoid harvesting of threatened or endangered plant species
	10	Other indicators for biodiversity conservation	19	Maintain or restore of areas of water influence
			20	Monitor periodically key biotic and abiotic factors that might affect health and vitality of ecosystems
C4:Soils	11	Best Environmental Practices for soils	21	Avoid planting in certain areas to protect soils
	12	Other considerations for soils conservation	22	Soil surface mechanically tilled per year (% of cultivated area)
			23	Measures for soil conservation
			24	pH (Percentage fields with samples showing analyses within acceptable limits for pH)
C5: Water	13	Best environmental practices	25	Avoid natural water contamination
T2: Social	14	Social Wellbeing	26	Promote gender equality
T2: Social	15	Social Wellbeing	27	Availability of a mutually agreed and documented system for dealing with complaints and grievances, which is implemented and accepted by affected parties
			28	Use local processing, local services, and local value adding.
			29	Benefit sharing mechanism
			30	Support to Vulnerable People
T2: Social	16	Rights of indigenous peoples & local communities	31	Rights of indigenous peoples & local communities -defined in the United Nations Declaration on the Rights of Indigenous Peoples (2007) and ILO Convention 169 (1989).
			32	Existence of conflict management mechanisms

S ₂ Biom related Theme (T) or Criterion (C)	#	Topic	#	Indicators
T2: Social	17	Traditional knowledge	33	Traditional knowledge
C7: Participation and transparency	18	Documented system for participatory processes	34	Negotiations concerning compensation for loss of legal, customary or user rights are dealt with through a documented system that enables indigenous peoples, local communities and other stakeholders to express their views through their own representative institutions as free, prior and informed consent and negotiated agreements
C9: Employment and labor conditions	19	Employment and labor conditions	35	Fair Pricing and Transparent Contracts
		Training of workers	36	Training and requalification of the workforce
T3: Economic	20	Economic	37	Value of products (includes value and volume of production and/or value added per ton)
			38	Means for research
			39	Incentives for investments

Source: own compilation

5.3 Other requirements

The screening of the benchmarked schemes also resulted in a list of indicators that, even if not meaningfully reflected in the schemes analyzed, might be of interest for different purposes within the S2Biom sustainability approach:

- Commitment to a code of ethical conduct
- Due-diligence
- Food sovereignty
- Fair access to means of production
- Internal Investment (*assumed that internal investment is a must to comply with the commitment to long-term economic viability)
- Net cash flow
- Marketing of forest products
- Material consumption practices
- Renewable and recycled materials consumption
- (Reduction) of intensity of material use
- Conversion of abandoned agricultural and treeless land into forest
- Promote the use of fallow areas
- Minimum separation of production areas from natural terrestrial ecosystems
- Fallen dead wood, hollow trees, old groves and special rare tree species shall be left in quantities and distribution necessary
- Process of residue removal minimizes harm to ecosystems.
- Use of locally adapted varieties and breeds

Complementary to the systematized issues, some additional requirements were found within the non-benchmarked schemes, as follows:

There are some considerations in the EU MS regulations for solid bioenergy (Pelkmans et al. 2012) that could be of interest for the S2Biom sustainability approach such as:

- In Belgium, according to the PelletNorm, it is necessary that wood pellets are made from material produced under **Sustainable Forest Management** (for instance, FSC, PEFC or equivalent).
- In Belgium-Flanders, certain biomass types are excluded if they can be used by the **wood processing industry**. When biomass from waste can be valorized by recycling into materials, fodder, etc., it is not eligible as well (Iriarte, Fritsche, Pelkmans 2014).
- The Feed-in Tariff regulation in Hungary states that for **waste** a declaration is needed that it cannot be used from other purposes than fuel. For other biomass the seller has to prove that the biomass cannot be used for food consumption.
- In Poland, there is a draft Decree for large installations (>5MW_{el}) where **round wood** is excluded from green certificates; in terms of wood biomass only forestry residues are allowed, and a minimum (increasing) share of agricultural biomass is required.
- In many countries, there are measures in place to promote the use of **local** biomass for energy.

These requirements recall the approach towards the “cascading use of materials” already integrated in the EU Forest Strategy (EU 2013) for wood, in the waste sector by means of the EU Waste Directive (EU 2008b) or indicated in the German Biorefinery Roadmap (BMELV 2012) and under discussion in NTA8081 (see Section 3). The EU Waste Directive states that options that deliver the best overall environmental outcome should be encouraged so that adaptations for specific waste streams might be needed. This concept and its applicability are still under discussion in the scientific and policy arenas³³.

Ultimately, beyond general considerations with respect to forest bioenergy or solid bioenergy, several countries have developed guidelines for other specific issues such as:

- Harvesting of **forest residues**: Finland, France, Germany, several states in Canada and several states in the US have in place guidelines with the general requirement of maintaining 1/3 of the forest residues on the ground in order to protect biodiversity and soils (Fritsche et al. 2014).

³³ See i.e. <https://biomassekaskaden.de/>

- **Ash recycling:** Sweden has guidelines with recommendations on amount and quality of ashes to be recycled when forest residues are harvested (Swedish Forest Agency 2008).
- **Wastewood for combustion:** Finland makes efforts to determine the chemical composition of recycled wood that can be combusted (Alakangas 2014). Halogenated organic compounds or heavy metals should be at levels lower than those in typical virgin material or higher than typical values of the country of origin.

These considerations are of high interest with regard to particular biomass value chains in the bioenergy sector (see Section 6).

Complementing these considerations there are other requirements included in the SFI (2015) scheme that might be of interest:

- Community Involvement and Landowner Outreach (Objective 12). To broaden the practice of sustainable forestry through public outreach, education, and involvement, and to support the efforts of SFI Implementation Committees.
- Public Land Management Responsibilities (Objective 13). To participate and implement sustainable forest management on public lands by means of “Program Participants with forest management responsibilities on public lands shall participate in the development of public land planning and management processes”.

Other initiatives such as the draft NTA 8081 (NEN 2014) proposes additional issues to be considered:

- **Competition** with food and local applications of biomass (6.3)
- **Local prices** (6.3.1)
- **Raw materials-efficient use of biomass (cascading)** (6.3.2)
- **'ILUC low risk'** (6.3.3)
- **Use of residual flows** (6.5.4.2) including prevention of unnecessary losses and limitation of unnecessary withdrawal of residual flows from other local functions;

There are other approaches that in addition to determining boundaries (they differentiate what is sustainable and what it is not) apply a “**performance based approach**”. This view has been applied in the double counting for certain feedstocks within the RED and in other regulatory structures such as the US

Renewable Fuel Standard (RFS2)³⁴ and the California Low Carbon Fuel Standard. The RED stipulates that biofuels made from wastes, residues, non-food cellulosic material and lignocellulosic material can be double-counted towards the renewable energy target for transport³⁵. The RFS2 requires that each category of renewable fuel emit fewer GHG emissions than the petroleum fuel it replaces and sets specific GHG threshold for each renewable fuel type. Also, the RFS2 sets restrictions on the type of feedstock and the types of land that can be used to grow and harvest the feedstock (Goovaerts et al. 2013). The biofuels categories are defined based on the nature of feedstock/technology, the production process used, and minimum GHG reduction thresholds obtained. The definition (requirements) of renewable biomass limits the types of biomass as well as the type of land from which biomass may be harvested to produce compliant renewable fuels.

In the agriculture sector, it is worth noting that Organic production in the EU (see Annex for details) also makes specific requirements for soils and the products that can be used for pest, disease and weed management.

With respect to the EU **bioeconomy** action plan (EC 2012a) and respective working document (EC 2012b), some requirements are made with respect to sustainability such as:

- Maintain (or create) diverse land structures for farming
- Within the social impacts, the pre-requisite for job creation is that skilled entrepreneurs and project managers can develop and implement business models creating new value chains and value-added bio-based products that are successful in the global marketplace.

Among the targets³⁶ considered in the EU Biodiversity Strategy with relevance for the purpose of this work (and not extensively discussed in previous sections), we should highlight:

- **Restoration**, by 2020, of at least 15 % of degraded ecosystems.
- Increase the contribution of agriculture (by means of the CAP) and forestry to maintaining and enhancing biodiversity (by means of **Forest Management Plans**).

³⁴ <http://www.epa.gov/oms/fuels/renewablefuels/index.htm>

³⁵ See discussion on the impact of this mechanism in Pelkmans et al. 2014b.

³⁶ <http://biodiversity.europa.eu/policy/biodiversity-strategy-plan>

- By 2020, **Invasive Alien Species** (IAS) and their pathways are identified and prioritized, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS.

The Resource Efficiency Scoreboard (EC 2014b) proposed as an indicator related to “biodiversity” the **Index of common farmland bird species**.

Other ways to integrate the sustainability of feedstock production are provided by the Brazilian **Environmental zoning** that aims to control by environmental zoning the areas of expansion of biofuels, mainly sugarcane (CENBIO 2013). In this zoning, economic, social and environmental variables were taken into account to assess regional features, potential, and vulnerabilities. Through these GIS-based assessments, overlapping the different maps and information, several categories can be determined, ranging from “inappropriate” to “suitable” areas.

The state of São Paulo has conducted a similar zoning, considering various variables: soil and climate potentials, surface water availability, underground water vulnerability, restrictions to mechanized harvesting, biodiversity protection areas, biodiversity connectivity, biodiversity protection importance, and integral protection units (CENBIO 2013). The resulting map has been the basis for defining regulations that determine parameters and guidelines for sugarcane facilities.

At the federal level, the Brazilian Government launched two national agro-ecological zoning initiatives for sugarcane in 2009 (EMBRAPA 2009), and for palm oil in 2010 (EMBRAPA 2010). The principles guiding the sugarcane agro-ecological zoning were (CENBIO 2013):

- Exclusion of areas with native vegetation. Removal of native vegetation for the expansion of sugarcane cultivation is forbidden,
- Exclusion of some regions for cultivation (e.g. Amazon),
- Identification of areas with low needs for irrigation,
- Identification of low-slope areas (less than 12 %), to allow mechanical harvesting,
- Prioritization of degraded areas or pasture, identifying land currently underutilized or occupied by livestock or degraded pastures as suitable for sugarcane production, and
- Respect for food security guiding the expansion of sugarcane production in order to avoid any sort of risk to food production or to food security.

States such as Mato Grosso do Sul have launched their own zoning, including also the zoning for eucalyptus plantations for pulp and charcoal.

The national biofuels policy and strategy of Mozambique (Resolution 22/2009) considers as strategic pillars (Schut, Slingerland, Locke 2010):

- Limitations on land allocation to biofuel production on the basis of suitable agro-climatic regions through land zoning,
- Approval of selected feedstocks, namely sugarcane and sweet sorghum for ethanol, and coconut and Jatropha for biodiesel,
- The use of sustainability criteria to select investment projects and allocate land titles, and
- The creation of a domestic market for biofuels via blending mandates and increased exports.

6 Conclusions and Recommendations

The benchmark and gap analysis of the selected schemes in the agriculture, forest, and bioenergy sectors against the S2Biom draft sustainability C&I proposal (conceived as an umbrella set of mid-point indicators) has shown that the selected schemes (including voluntary certification schemes and regulations) meaningfully cover the following criteria: biodiversity, soil, water, secure land tenure, and to some extent employment and labor conditions. These schemes also address climate change, particularly with respect to GHG emissions savings along the value chains. Nevertheless, in the forest sector, considerations with respect to climate change are formulated as the Maintenance of forest contribution to global carbon cycles.

In the social theme, Participatory management and transparency are also considered in the schemes. Less frequently present were indicators covering resource efficiency or health risks. Requirements related to air, food security, and production costs were rarely found.

The same general patterns were present when closely looking at the selected voluntary certification schemes.

Identifying consistent sectoral patterns is challenging given that the schemes and regulations selected in each sector serve specific purposes and address specific, sectoral concerns, thus limiting the possibility for intercomparison. Nonetheless, the research carried out has determined that in addition to environmental considerations, social criteria are also relevant, whilst the production costs (which is the selected indicator in the economic theme in the draft S2Biom proposal) seem to be beyond the purposes of the schemes.

Additional requirements of the benchmarked schemes have been identified and classified as either framework indicators or complementary concepts that provide valuable information to consolidate the approach to sustainability to be developed in task 5.4.

The framework indicators have emphasized the importance of some “accompanying” and cross-cutting requirements beyond the draft S2Biom indicators. The framework indicators were grouped around four topics (“Compliance with laws”, “Governance”, “Planning and Monitoring” and “Technology”). Among the 18 indicators found, only the “Existence of Management Plan” was deemed relevant among the benchmarked schemes.

The complementary concepts were grouped around 20 topics and 39 indicators. There were seven indicators meaningfully reflected in the benchmarked

schemes: “Land Use Change”, “Harvest products and services from the Management Unit at or below a level which can be permanently sustained”, “Maintain or restore of areas of water influence”, “Monitor periodically key biotic and abiotic factors that might affect health and vitality of ecosystems”, “Measures for soil conservation”, “Existence of conflict management mechanisms”, and “Training and requalification of the workforce”.

In addition to these complementary indicators, other requirements sparsely found were also listed. The requirements encountered in non-benchmarked schemes were also discussed. These requirements refer to a broad range of provisions for specific feedstocks or value-chains such as “cascading use of wood”.

All of these insights will be considered and integrated in the elaboration of the sustainability approach for specific feedstocks, value-chains, or different scopes to be discussed in other tasks of the project, including the tool to be elaborated in WP4.

In view of this analysis, we have a solid basis to consider in further work on sustainability within the project:

- Consider the insights found here in the policy recommendations to progress on the development of **sustainable bioeconomy strategies** at country (or regional) levels to be elaborated in Task 5.3.
- Take into account the different angles, goals, and specific requirements when elaborating the **S2Biom sustainability approach**, especially when developing the so-called “implementable indicators”.
- **Specific** recommendations to refine the S2Biom sustainability set of C&I:
 - Further specify the indicator "**Agrobiodiverse cultivation**" (crop rotation; diversity in the landscape; avoidance of alien species) and amount of chemicals (pesticides/herbicides); release of GMO” to avoid any confusion as to its scope.
 - Given the complexity of some indicators, (e.g. in considering the extent to which **VGGT** are met), this exercise will help more appropriately demarcate the indicator set, especially when implementable indicators are drawn.
 - Regarding **risks to public health**, a definition for this indicator might be “Measures taken to safeguard public health, e.g. regulation of noise level and accidents”.

- In respect to **food security**, this indicator might be reworded as measures to avoid risks for negative impacts on price and supply of national food basket and fuelwood.

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