BioTrade2020plus

Supporting a Sustainable European Bioenergy Trade Strategy

Intelligent Energy Europe
IEE/13/577/SI2.675534

Deliverable 2.4

BIOTRADE2020PLUS APPROACH TO SUSTAINABILITY

REPORT ON THE UPDATED SUSTAINABILITY CRITERIA TO BE CONSIDERED FOR BIOENERGY FOR 2020 AND 2030

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The BioTrade2020plus Project

Objectives

The main aim of BioTrade2020plus is to provide guidelines for the development of a **European Bioenergy Trade Strategy for 2020 and beyond** ensuring that imported biomass feedstock is sustainably sourced and used in an efficient way, while avoiding distortion of other (non-energy) markets.

This will be accomplished by analyzing the potentials (technical, economical and sustainable) and assessing key sustainability risks of current and future lignocellulosic biomass and bioenergy carriers. Focus is placed on wood chips, pellets, torrefied biomass and pyrolysis oil from current and potential future major sourcing regions of the world (Canada, US, Russia, Ukraine, Latin America, Asia and Sub-Saharan Africa).

BioTrade2020plus will thus provide support to the use of stable, sustainable, competitively priced and resource-efficient flows of imported biomass feedstock to the EU – a necessary pre-requisite for the development of the bio-based economy in Europe.

In order to achieve this objective close cooperation will be ensured with current international initiatives such as IEA Bioenergy Task 40 on “Sustainable International Bioenergy Trade - Securing Supply and Demand” and EU projects such as BiomassPolicies, S2BIOM, Biomass Trade Centers, DIA-CORE, and PELLCERT.

Activities

The following main activities are implemented in the framework of the BioTrade2020plus project:

- Assessment of **sustainable potentials of lignocellulosic biomass** in the main sourcing regions outside the EU
- Definition and application of sustainability criteria and indicators
- Analysis of the main economic and market issues of biomass/bioenergy imports to the EU from the target regions
- Development of a dedicated and **user friendly web-based GIS-tool** on lignocellulosic biomass resources from target regions
- **Information to European industries** to identify, quantify and mobilize sustainable lignocellulosic biomass resources from export regions
- **Policy advice on long-term strategies** to include sustainable biomass imports in European bioenergy markets
- **Involvement of stakeholders** through consultations and dedicated workshops

More information is available at the BioTrade2020plus website: www.biotrade2020plus.eu

About this document

This report corresponds to D2.4 “Approach to Sustainability. Report on the updated sustainability criteria to be considered for bioenergy (including social, political and institutional as well as environmental and economic aspects) for 2020 and 2030, drafting potential criteria for bioeconomy applications”. It has been prepared by IINAS in collaboration with Imperial College, and inputs form Alterra/DLO, and Utrecht University.

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RE	Restricted to a group specified by the consortium (including the Commission Services):	
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List of Acronyms and Abbreviations

BEE	Biomass Energy Europe
BR	Brazil
C&I	Criteria and Indicators
CFS	Committee on World Food Security
CO	Colombia
EC	European Commission
EEA	European Environment Agency
EFI	European Forest Institute
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GHG	Greenhouse gas(es)
GIS	Geographic Information Systems
ID	Indonesia
IINAS	International Institute for Sustainability Analysis and Strategy
iLUC	indirect land use change
IPCC	Intergovernmental Panel on Climate Change
JR	Joanneum Research
JRC	EC Joint Research Centre
KE	Kenya
LCA	Life cycle assessment
LHV	Low heating value
LU	Land use
LUC	Land use change
PM	Particulate matter
PRR	Product-to-residue ratio
SOM	Soil organic matter
UA	Ukraine
VGGT	Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security
WP	Work Package

1 Introduction and Objectives

One of the main goals of the BioTrade2020plus project is to assess **sustainable potentials of lignocellulosic biomass** in main sourcing regions outside the EU. The targeted feedstocks include:

- Primary and secondary forest residues
- Primary and secondary agricultural residues
- Feedstocks from existing forest plantations
- Feedstocks from surplus land: dedicated biomass crops and new forest plantations

The project considers the following targeted regions: Brazil (Atlantic Corridor), Colombia, Kenya (and Mozambique), Indonesia (and Malaysia), Ukraine (Central-Western), and United States (South East). For each country the most relevant feedstocks have been selected, as shown in Table 1.

Table 1 Selected Countries/Regions as the Most Relevant Players of Lignocellulosic Biomass to the EU

	Primary & secondary forest residues	Primary & secondary agricultural residues	Surplus land		
			Existing forest plantations	Dedicated biomass crops	New forest plantations
US (South East)	✓		✓		✓
BR (Atlantic Corridor)		✓		✓	✓
CO		✓		✓	
UA (Central-Western)	✓	✓		✓	
KE		✓	✓	✓	
ID		✓			

Source: own elaboration

The selected regions represent a great variety of socioeconomic conditions and biophysical circumstances which makes it necessary to have a broad understanding with respect to sustainability in the different contexts. Work Package (WP) 2 of the BioTrade2020plus project is focused on examining the “availability and sustainability of biomass in target regions”.

Under task 2.2 “Sustainability criteria and indicators (definition and application)”, the following deliverables are produced:

- D2.3 Report on the assessment of criteria and indicators (C&I) in existing sustainability schemes for lignocellulosic feedstocks.

- D2.4 Report on the updated sustainability criteria to be considered for bioenergy (including social, political and institutional as well as environmental and economic aspects) for 2020 and 2030 (this report).
- D2.5 Report on the issues conditioning the operability of the sustainability schemes including the impact on costs.

The objective of this Deliverable (D2.4) is to provide updated sustainability criteria and indicators (C&I) to be considered for bioenergy for 2020 and 2030, keeping in mind the main bioeconomy applications. To meet this goal, two main activities have been carried out:

- **Contextualize** the sustainability C&I, in an overall framework that allows a sound understanding of the approach.
- Deepen on the **applicability** of these sustainability requirements to be applied in other tasks of the project (including the case studies to be elaborated in WP3, the tool to be developed in WP4 and the policy considerations discussed in WP5).

To achieve these goals, the outcomes of D2.3 of this project (visions on sustainability by different organizations, "ambition" on sustainability and sustainability C&I endorsed in different schemes), have been considered. In addition, several discussions within the consortium and other stakeholders (see WP 6) have been carried out. In particular, three teleconferences were organized with representative stakeholders all over the world to discuss the sustainability approach proposed:

- 5 December 2014: participants from Canada, Mexico, and USA
- 11 December 2014: participants from Brazil, and USA
- 27 January 2015: participants from Argentina, Canada, and USA

The minutes of these teleconferences have been published in the D6.7: Report on the progress of stakeholder consultations (del Campo & Sánchez 2015) which also includes the input paper distributed before each conference.

The BioTrade2020plus project is being carried out in parallel to an EU FP7 research project: Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe – S2Biom (www.s2Biom.eu) which is addressing the broader bioeconomy on the EU level and neighboring countries, although it also considers imports from third countries. S2Biom has a specific WP addressing the "value chain sustainability across the biobased sectors" which aims to provide an improved understanding among decision-makers in policy and industry regarding sustainability requirements. Efforts in both projects have been aligned with the purpose of offering a coherent approach to non-food biomass sustainability.

Given that, this report has benefited from previous efforts in S2Biom (Iriarte & Fritsche 2015a), which focused on developing a sound approach to the so-called "sustainability umbrella" approach to non-food biomass in the bioeconomy.

This report is structured as follows:

- **Section 2** introduces the overall sustainability umbrella, including a proposal of C&I
- **Section 3** draws the application of the sustainability indicators to the BioTrade2020plus project

The last section provides the references.

2 Sustainability Umbrella Approach

The BioTrade2020plus concept to sustainability is based on the **umbrella** approach developed in parallel to the work in the S2Biom project. This umbrella approach aims to give a common vision to sustainability for **any lignocellulosic** feedstock, final use or origin but with differentiated specificities for the feedstocks.

Thus, it reflects the "common but differentiated approach to sustainability" since the challenges posed by some feedstocks differ to those presented by others.

Therefore, to conduct sustainability assessments for non-food biomass provision within the scope of the BioTrade2020plus project, we need to differentiate among:

- The types of indicators to be considered (minimum requirements, comparative with non-renewable or biomass references, and descriptive indicators).
- The set of indicators to consider. Which environmental, social and economic issues are important to be protected or maintained?
- The sustainability "ambition" (a "basic" and a more "advanced" set of C&I) that define whether a certain feedstock in a given location is sustainable or not.
- The implementability of the indicators with respect to feedstocks: this refers to how to apply any mid-point indicator for different types of feedstocks (e.g. the concerns about biodiversity protection are different if primary or secondary products are considered).
- The applicability of the indicators with respect to the geographical scale. Several case studies have been developed within the project (see WP3). In these case studies technical potentials have been constrained to sustainable potentials by means of the application of sustainability indicators used at the country or regional levels. Therefore, this report has considered those indicators applicable at national level in addition to the sustainability indicators that might be needed (and applicable) at the project level.

As mentioned earlier, the working hypothesis of this project is that sustainability requirements should be the **same** for all non-food biomass.

This implies that any type of non-food biomass for any application should meet the same (or equivalent) sustainability principles, criteria and indicators. Stakeholders gave positive feedback to this statement in the teleconferences with (del Campo & Sánchez 2015).

Conceptually speaking, the sustainability umbrella set is based on "**mid-point C&I"** (those parameters that aim to address goods or commons to be maintained or protected).

Nonetheless, in Section 3 we consider "**implementable indicators"** (those based on the mid-point indicators which aim to delineate concrete indicators adapted to various feedstocks) that might be specially applied at country level.

2.1 Type of Sustainability Indicators

This proposal recognizes different **types of indicators** that differentiate between "minimum requirements" and "reporting indicators":

- **Minimum requirements**: present the minimum list of indicators, which sustainable biomass should be subject to, and associated thresholds (or qualitative attributes) that should be met, resulting in an acceptable compliance only if an indicator meets a certain value (e.g. minimum GHG emissions reduction level).
- **Reporting indicators**: this type of indicators aims to give complementary information to the basic parameters that allows to compare any point of reference (value chain or potentials) with its comparator:
    - **Comparative to non-renewable reference**: these indicators can be compared with e.g. fossil fuel or non-renewable material references (e.g. PM_{10} and SO_2eq).
    - **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. SOC).
    - **Descriptive**: the indicator provides information about key complementary characteristics relevant for assessment (e.g. participation and transparency).

2.2 Set of Sustainability C&I

The compilation of sustainability C&I proposed by BioTrade2020plus has benefited from previous revisions of sustainability C&I (see D2.3) and discussions with stakeholders. During the teleconferences, a set of sustainability C&I was presented and discussed (see D6.7). In general, the participants agreed on having the "umbrella" approach suggested under the project framework that could apply to any feedstock for any end use and any location – the so-called mid-point indicators. From these mid-point indicators a more detailed set of indicators might be elaborated. Nonetheless, some participants voiced that this is the ideal situation but it is highly unrealistic.

Stakeholders have stressed that within the project we need to have a balanced set of indicators including environmental, economic and social issues. It is a challenge to include social issues that are related to national legislation.

The set of sustainability C&I for the BioTrade2020plus is presented in Table 2. This proposal has considered the three common sustainability dimensions, i.e. environment, social and economic with the aim to reflect key issues that need to be considered from a holistic point of view. This comprehensive list has derived from previous work targeted to sustainable provision of non-food biomass in the EU28 and neighboring countries (in S2Biom). Particular attention was paid to efforts from:

- Current criteria and indicators developed for bioenergy at the international, EU and country level, including voluntary private sector schemes (Iriarte & Fritsche 2015a).
- Various initiatives and approaches in sourcing countries selected for BioTrade2020plus.
- 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 & Berg 2010), Biomass Futures (Fritsche et al. 2012), Biomass Policies (Pelkmans et al. 2014), and Global Bio-Pact (Díaz Chavez et al. 2012).

- Efforts from other projects that focus on biorefineries such as BIOCORE (Piotrowski et al. 2013; Rettenmaier et al. 2014), EuroBioRef (http://eurobioref.org), and SUPRABIO (http://www.suprabio.eu)

This set is composed of a mixture of minimum requirements and comparative indicators (as it will be discussed in Section 2.2 when developing basic or advanced sustainability sets).

Each indicator (mid-point 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 2 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 or subsidies, for industrial customers
	2. Climate Change	2.1	Life cycle-based CO_2eq including direct land use change	GHG emissions during the whole value chain (i.e. crop growth & harvesting, logistics, pretreatment 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	Categories established by the RED (EU 2009): - Protection of land with high biodiversity value (Art. 17.3). Primary forests, areas designated by laws, and other highly biodiverse areas

Theme	Criterion	#	Indicator	Definition
			biodiversity values	(recognized by international agreements or International Union for Conservation of Nature (IUCN)) and natural and non-natural highly biodiverse grasslands should be excluded. - 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). - Protection of peatlands (Art. 17.5).
		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)

Theme	Criterion	#	Indicator	Definition
		Indicator Description		
	6. Air	6.1	SO_2 equivalents	Life cycle emissions of SO_2, NO_x, NH_3 and HCl/HF from bioenergy provision, expressed in SO_2 equivalents and calculated in accordance to GHG emissions
		6.2	PM_{10}	Life cycle emissions of PM_{10}, 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
	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 labor 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 Labor Rights	Adherence to International Labor Organization (1998) principles and voluntary standards
		9.4	Occupational safety and health for workers	Measures taken to guarantee occupational and health safety for workers

Theme	Criterion	Indicator Description		
		#	Indicator	Definition
	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 levelized life-cycle cost	Current levelized life-cycle cost, excluding subsidies or taxes (incl. CAPEX and OPEX)
		12.2	Future levelized life-cycle costs	Future levelized life-cycle cost, excluding subsidies or taxes (incl. CAPEX and OPEX)

Source: Iriarte & Fritsche (2015a)

2.3 Sustainability Ambitions

As discussed in D2.3 there are many different views on what sustainable non-food biomass is and how to translate that into sustainability C&I and respective thresholds. In order to reflect ”stronger“ or “looser“ sustainability ambition concerns, Table 3 shows the BioTrade2020plus proposal for a ”basic“ and an “advanced“ set of sustainability C&I.

The starting point for the elaboration of this proposal has been the list of indicators presented in Table 2. From this list, it has been proposed whether an indicator should be a minimum requirement or reporting indicator to appropriately reflect the respective “stronger“ or “looser“ ambition.

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 biofuels and bioliquids (EU 2009). The advanced set is more ambitious in considering more indicators as minimum requirements.

Reporting indicators provide additional information that can provide a better understanding of the impacts generated in any value chain. Obtaining reliable (and comparable) information about these reporting indicators is generally resource intensive so the proposal here is to prioritize a sound methodology to assess “minimum requirement indicators”.

According to the teleconferences conducted, the basic set might be achieved at the present time while the advanced set might be more problematic to be met under current conditions.

Table 3 BioTrade2020plus Proposal for Basic and Advanced Sustainability C&I Set

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_2eq 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			✓		✓			

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
		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_2 equivalents		✓	✓		✓			
		6.2	PM_{10}		✓	✓		✓			
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 labor rights	9.1	Full direct jobs equivalents along the full value chain		✓	✓			✓	✓	
		9.2	Full direct jobs equivalent in the biomass consuming		✓	✓			✓	✓	

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
			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, fuelwood and other products	11.1	Food, fuelwood and other products supply security			✓		✓			
Economic	**12. Production costs**	12.1	Current levelized life-cycle cost		✓	✓			✓	✓	
		12.2	Future levelized life-cycle costs						✓	✓	

Source: Iriarte & Fritsche (2015a)

A key difference between the basic set and the advanced set lies on the list of indicators considered as minimum indicators, as summarized in Table 4. While in the basic set the list of minimum requirements is closely aligned with the sustainability requirements of the RED (EU 2009), the advanced set reflects indicators with respect to resource use, more indicators about biodiversity and climate, soil quality, air, land tenure and food and fuel security.

Table 4 Minimum Requirements in the „Basic" and „Advanced" Sustainability C&I Sets

Criterion	Indicator	Basic Set	Advanced Set
Resource Use	Land use efficiency		✓
	Secondary resource efficiency		✓
	Energy efficiency		✓
Biodiversity	Conservation areas and land with significant biodiversity values	✓	✓
	Land management w/o negative effects on biodiversity		✓
Climate	Life cycle GHG emissions incl. direct LUC	✓	✓
	Other GHG emissions: C stock changes and iLUC		✓
Soil quality	Erosion		✓
	Soil Organic Carbon		✓
	Soil nutrient balance		✓
Water	Water availability and regional water stress		✓
Air	SO_2 equivalents		✓
	Particulates PM_{10}		✓
Land Tenure	Compliance with the VGGT to secure land tenure and ownership		✓
Employment and labor conditions	Human and Labor Rights	✓	✓
	Occupational safety and health for workers	✓	✓
Food and fuel security	Risks for negative impacts on price and supply of national food basket and fuelwood.		✓

Source: own elaboration

3 Sustainability Framework Application

A key aim of BioTrade2020plus is to develop a sound approach to evaluate sustainable biomass potentials considering the respective value chains from the selected regions. This section provides the conceptual approach and some practical guidelines to calculate the biomass sustainable potentials.

As mentioned in the report "General methodologies for the analysis and projection of sustainable biomass potentials of biomass in international sourcing regions and the potential surplus to import to the European Union" (Mai-Moulin et al. 2016), sustainable potentials in the various cases studies has been calculated applying sustainability indicators to the technical potentials. Given that it is very complicated to quantify some sustainability indicators in an aggregate way, a SWOT analysis was conducted for each case study.

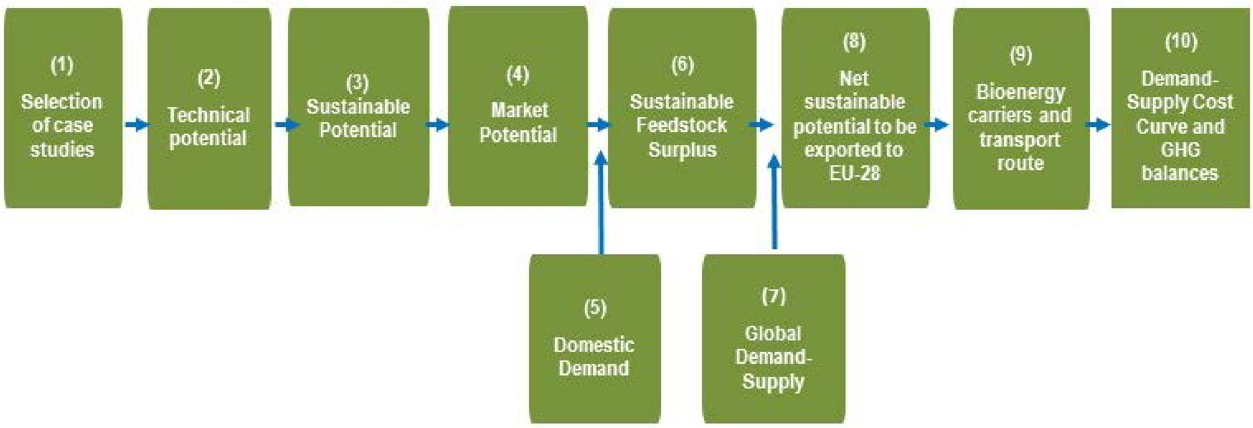
The difficulty in determining some indicators relates to the spatial distribution, e.g. without defined specific areas feedstock supply , no data on e.g. land tenure or soil characteristics are available.

3.1 Conceptual Approach

As part of the project, Utrecht University, Imperial College and IINAS have jointly developed the General methodologies mentioned above (Mai-Moulin et al. 2016) as basis to calculate biomass potentials in WP2 and develop the case studies on market analysis in selected regions in WP3.

This methodology considers several steps to assess sustainable bioenergy import chains, as shown in Figure 1. This deliverable is focused on step number 3: assessment of sustainable potential.

Figure 1 General Methodology to Assess Cost-Supply Curves of Sustainable Biomass in Selected Countries



Source: UU, IINAS, IC (2014)

To calculate the biomass potentials at any geographical level (in this case country or region) it is necessary to differentiate between:

- Those considerations that are related to **biomass production**. This would result in the sustainable potential regardless of the end-use (bioenergy or other uses) and the consumption place (producing country or exported to EU). Sustainable biomass production takes into account considerations regarding biodiversity or soils since the major impacts on these categories might be observed when primary biomass is produced (e.g. harvesting of forest or agricultural residues or any other "primary" feedstock). Hence, these indicators can be directly applied to constrain the technical potential to the sustainable one.

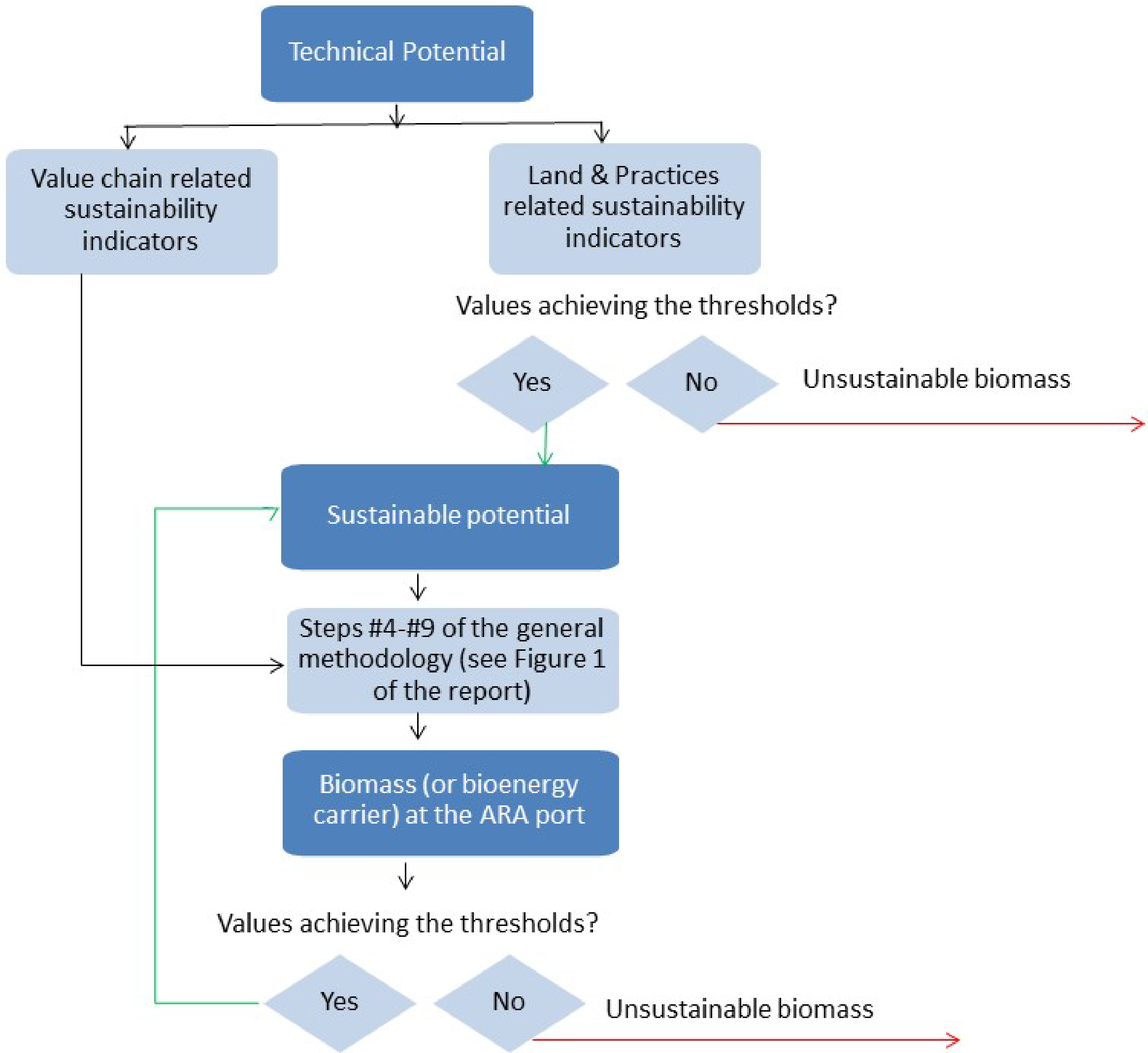
- Requirements that should apply to **value-chains**. In this case there are issues such as life-cycle GHG emissions or air emissions that need to consider value-chains. In the case of "Life Cycle-based CO_2eq including direct land use change", there are emissions all along the value chain: in the production, processing, transporting and final use of the value chain. Then, it is necessary:
  - First, define default (or typical) value chains to be considered (e.g. wood pellets from the US, raw biomass from other sourcing regions, etc.). Also, it is necessary to determine the geographic place for comparison given that BioTrade2020plus does not examine the end uses of the biomass. Since the project aims to assess sustainable biomass potentials to be exported to the EU, the place/area for comparison for those feedstocks transported by ship will be the ARA (Antwerp/Rotterdam/Amsterdam) ports. In the case of Ukraine, the feedstocks are expected to be transported to the EU by land via rail and truck.
  - Calculate for the selected indicators and value chains the corresponding values to determine whether the biomass might be sustainable or not. When a given value chain (or a fraction of it) results in not being sustainable (not meeting the thresholds or values established as sustainable – see Section 3.3), then this amount of biomass should not be considered as sustainable biomass.

The conceptual approach to calculate sustainable biomass potentials is illustrated in Figure 2. The key question is whether the thresholds established for any bioenergy carrier to be sustainable should apply as well to the sourcing regions and other end-uses.

According to stakeholders' opinion and consortium expert point of view, the same **sustainability requirements** should be met in the sourcing regions and within the EU.

For example, if biodiverse areas are to be avoided for feedstock cultivation, GHG, this requirement should be met both in sourcing regions and when exported to the EU.

Figure 2 Conceptual Approach to Assess Sustainable Potentials



Source: own elaboration

3.2 Applicability

As discussed above, the sustainability set of indicators is based on "mid-point indicators" that in some cases need further elaboration into "**implementable indicators**" to be applicable in the assessment of biomass potentials. Different feedstocks pose different sustainability risks so the implementable indicators should be **feedstock-tailored**. The focus has been put in the **feedstock** selected in the project:

- Primary & Secondary Forest Residues
- Primary & Secondary Agricultural Residues
- Surplus land, including:
  - Existing Forest Plantations
  - Dedicated lignocellulosic Biomass Crops
  - New Forest Plantations

The implementable feedstock-tailored indicators are also different with regard to their **geographical scope**, as discussed by Iriarte, Fritsche (2015a). With respect to the geographical scope, the following categories of indicators can be distinguished:

- spatially explicit indicators (e.g. for biodiversity, soil, etc.) when they depend on the location.
- indicators 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. Indeed, we can distinguish between the indicators based on LCA approach (i.e. GHG emissions) vs. those that are not based on this approach (i.e. indicators related to soil).
- non-spatial but circumstantial indicators (e.g. labor conditions, employment) when their performance depend on the context and not specifically on the location.

Given the focus of the project, the priority of the analysis has been to propose a methodology to evaluate the indicators that might be minimum requirements in the advanced set and that might be spatially explicit or partially attributable to spatial distribution.

Circumstantial indicators show several limitations to be introduced in any biomass potential assessment so this will be discussed in the SWOT analysis to be elaborated in D2.2 of the project (Guidelines for the sustainability assessment of biomass resources to conduct the SWOT analysis and to develop the interactive tool of WP 4). Market potential and local demand are considered later in next steps of the general methodology so issues related to biomass competition are not dealt within this report.

Following this systemic approach, Table 5 shows the applicability of the indicators that are minimum requirements depending on the Geographical Scope of the Indicators and the Type of Feedstocks, and Table 6 provides an overview of the indicators to be considered for the different feedstocks according to the geographical scope of the indicators.

When applying these indicators to the assessment of the biomass potentials, particular attention should be paid to the assessment of "Surplus land". Surplus agricultural or marginal land is a result of balancing available land and land required for food/feed production at a given time. When food/feed consumption decreases and/or when more efficient food/feed production methods offset increases in food demand, this balance will indicate a higher amount of "surplus" land (Smeets et al. 2007).

The assessment of land availability will consider potential displacement effects. In this assessment, land that becomes economically marginal to use for food/feed production will be included.

Table 5 Applicability of the Minimum Requirements Indicators depending on the Geographical Scope of the Indicators and the Type of Feedstocks

Criterion	Indicator	Geographical scope of the indicators				Type of feedstock		
		Spatially Explicit	Partially attributable to spatial distribution		Circum-stantial	Primary (forest or agriculture) residues	Secondary (forest or agriculture) residues	Surplus land
			Based on LCA	Non-based on LCA				
Resource Use	Land use efficiency		✓					✓
	Secondary resource efficiency		✓				✓	
	Energy efficiency		✓			✓	✓	✓
Climate	Life cycle GHG emissions incl. direct LUC		✓			✓	✓	✓
	Other GHG emissions		✓	✓		✓		✓
Biodiversity	Conservation areas and land with significant biodiversity values	✓				(✓)*		✓
	Land management w/o negative effects on biodiversity			✓		✓		✓
Soil quality	Erosion			✓		✓		✓
	Soil Organic Carbon			✓		✓		✓
	Soil nutrient balance			✓		✓		✓

Criterion	Indicator	Geographical scope of the indicators				Type of feedstock		
		Spatially Explicit	Partially attributable to spatial distribution		Circum-stantial	Primary (forest or agriculture) residues	Secondary (forest or agriculture) residues	Surplus land
			Based on LCA	Non-based on LCA				
Water	Water availability and regional water stress	✓						✓
Air	SO_2 equivalents		✓			✓	✓	✓
	Particulates PM_{10}		✓			✓	✓	✓
Land Tenure	Compliance with the VGGT to secure land tenure and ownership				✓	✓	✓	✓
Employment and labor conditions	Human and Labor Rights				✓	✓	✓	✓
	Occupational safety and health for workers				✓	✓	✓	✓
Food and fuel security	Risks for negative impacts on price and supply of national food basket and fuelwood.				✓	✓	✓	✓

Source: own elaboration

* *= only considered partially because the conservation of areas and lands with significant biodiversity values should be assured by the main product.*

Table 6 Summary of the indicators to be applied to different type of feedstocks depending on the geographical scope

Type of feedstock	Spatially Explicit indicators	Indicators Partially attributable to spatial distribution Based on LCA	Indicators Partially attributable to spatial distribution Non-based on LCA	Circumstantial Indicators
Primary (forest or agriculture) residues	- Conservation areas and land with significant biodiversity values	- Energy efficiency - Life cycle GHG emissions incl. direct LUC - Other GHG emissions - SO_2 equivalents - Particulates PM_{10}	- Other GHG emissions - Land management w/o negative effects on biodiversity - Erosion - Soil Organic Carbon - Soil nutrient balance	- Compliance with the VGGT to secure land tenure and ownership - Human and Labor Rights - Occupational safety and health for workers - Risks for negative impacts on price and supply of national food basket and fuelwood.
Secondary (forest or agriculture) residues		- Secondary resource efficiency - Energy efficiency - Life cycle GHG emissions incl. direct LUC - SO_2 equivalents - Particulates PM_{10}		- Compliance with the VGGT to secure land tenure and ownership - Human and Labor Rights - Occupational safety and health for workers - Risks for negative impacts on price and supply of national food basket and fuelwood
Surplus land	- Conservation areas and land with significant biodiversity values - Water availability and regional water stress	- Land use efficiency - Energy efficiency - Life cycle GHG emissions incl. direct LUC - Other GHG emissions - SO_2 equivalents - Particulates PM_{10}	- Other GHG emissions - Land management w/o negative effects on biodiversity - Erosion - Soil Organic Carbon - Soil nutrient balance	- Compliance with the VGGT to secure land tenure and ownership - Human and Labor Rights - Occupational safety and health for workers - Risks for negative impacts on price and supply of national food basket and fuelwood.

Source: own elaboration

3.3 Feedstock-specific Indicators

Some feedstocks such as primary agriculture or forestry residues pose specific risks on soils or biodiversity that can be addressed (at least partially) by leaving a certain amount of residues on the ground.

For **primary forest residues**, the amount of logging residues available varies among species, ecosystems and silviculture method, e.g., RENEW (2008) gave systemic data on logging residues for several EU countries. Certain amount of these logging residues needs to be left on the ground to protect soils and biodiversity. Fritsche et al. (2014) proposed that *"An adequate amount of residues is left on the ground to protect biodiversity. If no more adequate thresholds are available at biome or landscape level, a general recommendation is that residue harvesting not exceed 2/3 of total available harvest residues. More intensive harvesting could be performed if evidence is provided that the principles of Sustainable Forest Management are maintained or enhanced".*

EEA (2006) has proposed a classification thresholds for site suitability for forest residue removal as shown in Table 7.

Table 7 Classification Thresholds of Site Suitability for Forest Residue Removal

	Highly suitable	Moderately suitable	Marginally suitable	Unsuitable
Level of residue extraction	75%	50%	15%	0%
Soil erosion				
Slope	<5º	5º-10º	10º-25º	>25º
	(<9%)	(9-18%)	(18-47%)	(>47%)
Elevation	<1500 m	<1500 m	<1500 m	>1500 m
Soil compaction				
Peat land	No	No	Peat	
Soil water regime	Wet to a depth of 80cm, <6 months	Wet to a depth of 80cm, <6 months	Wet to a depth of 80cm, >6 months	Wet to a depth of 40cm, >11 months
Soil fertilily				
Base saturation in topsoil In subsoil	>50% >50%	<50% <50%		
Soil type (FAO85 Lv1)	Cambisol;Chernozem; Podzoluvisol; Kastanozem Rendzina; Gleysol Phaeozem; Fluvisol Luvisol; Greyzem Andosol; Vertisol; Town	Podzol Water	Histosol Ferraisol Pianosol	Ranker; Arenosol Lithosol; Xerosol Solanchak; Regosol Acrisol; Solenetz Marsh

Source: EEA (2006)

Note: Grey-shaded cells: criterion must be fulfilled (AND) no shading: criterion is optional (OR)

For **primary agriculture residues**, first consideration is the residue to product ratio (PRR).

This coefficient is specific for species, variety, and agro-climatic conditions, and enables the calculation of the amount of residues in multi-cropping systems.

As general guidelines, Table 8 provides the PRR for main cultivated species.

Table 8 Residue-to-Product-Ratios for Main Cultivated Species

	RPR_{low}	RPR_{high}
Rice straw	0.42	3.96
Rice husk	0.20	0.35
Maize stalk	1.00	4.33
Maize cob	0.20	1.80
Maize husks	0.20	1.00
Millet straw	1.10	2.00
Sorghum straw	0.90	7.40
Cassava straw	0.16	1.00
Groundnut shells	0.48	1.20
Groundnut straw	2.26	2.90
Soybean straw	1.00	3.94
Cane bagasse	0.10	0.33
Cane tops	0.10	0.30
Cotton stalk	1.77	5.00
Coconut husk	0.42	1.60
Coconut shell	0.1	1.10
Oil palm shell	0.06	0.09
Oil palm fibre	0.11	0.15
Oil palm bunch	0.23	0.27
Coffee husks	21	21
Cocoa	20	20

Source: FAO (undated)

Vis & Berg (2010) propose two methods to calculate the sustainable amount of agricultural residues to be extracted:

- In the basic statistical method, they indicate a maximum sustainable extraction rate between 25% and 33 %
- In the advanced statistical method, basically more attention is paid to the sustainable extraction rates and for that a humus balance method is proposed. This is calculated

by the amount of primary residues that can be extracted while maintaining sustainable carbon and nitrogen levels in the soil.

Humus is part of the soil organic matter. Despite the consideration of particular circumstances to assess the adequate level of soil organic carbon in soils, a minimum level of more than 3.4% of soil organic matter (soil organic carbon content of 2%) has been recommended (Batidzirai 2014).

3.4 Defining Thresholds: Examples

For the various indicators it is necessary to define respective thresholds to determine when the biomass or value chain fulfils a certain requirement or not. To define thresholds three main categories should be differentiated:

- Indicators based on LCA for which specific thresholds can be proposed.
- Spatially explicit indicators for which boundaries of an area can be established (e.g. protected areas, soil erosion sensitive areas, drought prone areas etc.).
- Other indicators, as e.g. those related to certain soil properties and water availability. Soil nutrients might be difficult to measure and this also applies to exact soil and ground water recharge capability. For this type of indicators, a precautionary approach should be applied and biomass production and harvesting (whenever main product or primary residues) should maintain or enhance the properties for that indicators. When thresholds at the international level exists for the different types of circumstances, these should be taken in place.

Table 9 distinguishes between the various types of thresholds for non-circumstantial indicators. Non-circumstantial indicators comprise spatially explicit indicators and indicators partially attributable to spatial distribution.

Table 9 Types of Limits (Thresholds) for Non-Circumstantial Indicators

Criterion	Indicator	Based on LCA	Easy categorization	Non-easy categorization
Resource Use	Land use efficiency	✓		
	Energy efficiency	✓		
Climate	Life cycle GHG emissions incl. direct LUC	✓		
	Other GHG emissions	✓	✓	
Biodiversity	Conservation areas and land with significant biodiversity values		✓	
	Land management w/o negative effects on biodiversity			✓
Soil quality	Erosion			✓
	Soil Organic Carbon			✓

Criterion	Indicator	Based on LCA	Easy categorization	Non-easy categorization
	Soil nutrient balance			✓
Water	Water availability and regional water stress		✓	
Air	SO_2 equivalents	✓		
	Particulates PM_{10}	✓		

Source: own elaboration

Given the difficulties to categorize some of these indicators, the BioTrade2020plus project assesses sustainability attending to those indicators that are based on LCA or which categorization is feasible.

The indications provided in the following paragraphs for indicators based on LCA and easily categorizable indicators are based on the results of the Biomass Futures project (Fritsche et al. 2012) which also provided guidance to assess other indicators such as food security.

In Table 10, the minimum net energy yield requirements for bioenergy carriers are provided.

Table 10 Minimum Net Energy Yield Requirements for Bioenergy Carriers (GJ_{bio}/ha)

Setting	2020	2030
Smallholder, marginal/degraded land	>25	>35
Plantation, marginal/degraded land	>50	>75
Plantation, arable land (mainly for intercropping, agro-forestry systems, etc.)	>100	>150

Source: Fritsche et al. (2012)

Establishing a **secondary resource use efficiency** for solid bioenergy carriers (chips, pellets, etc.) is not necessary since their conversion efficiency is typically high.

According to JRC (2014), **GHG savings** for solid biomass pathways are in general above 60%, both for power and heat. Some pathways are able to achieve savings above 70%. This varies depending on the conversion efficiency and fossil fuel input in the value chain.

Fritsche et al. (2012) suggest that for bioenergy carriers being used for electricity and heat, the minimum GHG reduction requirements should be based on natural gas as comparator, and be set to 60% by 2020, and increased to 75% by 2030, taking into account direct LUC. For primary residues, it should be demonstrated from 2020 onwards that the minimum GHG requirements are met when soil carbon changes are taken into account.

In addition to grandfathering land cultivated before 2008, a zero **ILUC** factor should be applied for bioenergy cultivation on land not in competition (e.g. unused, abandoned, or degraded areas) and not in conflict with biodiversity protection.

For land converted after 2008, an ILUC factor should be in the order of 3.5 t CO_2/ha/year (Fritsche et al. 2012), and be applied for any bioenergy feedstock cultivation established on previously used agricultural land (including grassland and pasture land). The cut-off date Jan 1, 2008 should be used, i.e. bioenergy feedstock cultivation on land being already used for this purpose before that date should be considered as ILUC-free.

When land is not in competition (e.g. unused, abandoned, or degraded areas) and not in conflict with biodiversity protection a zero ILUC factor should be applied for bioenergy cultivation. A revised ILUC factor should be determined by 2018 which reflects any progress regarding international policies to contain or reduce LUC effects in agriculture and forestry.

Water for irrigation of bioenergy feedstock cultivation and for process water used in bioenergy conversion facilities must, together with existing agricultural, industrial and human (residential) water uses, not exceed the average replenishment from natural flow in a watershed, expressed in total actual renewable water resources (TARWR).

Economic operators must demonstrate that the life cycle **emissions** of SO_2 equivalents (SO_2, NO_x, NH_3 and HCl/HF) from bioenergy provision, calculated in accordance to the life cycle emission methodology for GHG, are lower than the respective benchmark. The methodology to quantify of small-scale particulates (PM_{10}) should be the same than for SO_2 equivalents, but should consider coal-based heating as the benchmark.

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