Master's Thesis -master Energy Science

Sustainability criteria for bioenergy from forest biomass

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Abstract

Forest biomass is the main source of solid biomass in the EU and the main contributor to renewable energy generation. Because of its versatility and the possibilities for its use in various sectors to generate heat, electricity and in the future also biofuels and biobased materials, forest biomass is becoming increasingly attractive. This means that in the coming years, an increased demand for forest biomass can be expected. Therefore, it becomes necessary to address the possible sustainability risks that may arise from its increased use. Sustainability criteria define the essential elements related to the use of forest biomass that need to be assessed to guarantee its environmental, social and economic status across generations. A number of sustainability standards and certification schemes for forestry biomass and the production of bioenergy are available at national and international level, with the RED II setting the pathway for the minimum goals of the EU member states. This thesis starts from a comprehensive set of sustainability criteria going beyond those included in the RED II. The criteria in the RED II were compared to these criteria and to existing voluntary schemes and national legislation to identify its strengths and weaknesses. Secondly, the RED II was compared with a set of risk pathways. In these pathways, forest feedstock types, forest management and wood use practices are combined in a way that good and bad practices can be outlined to determine the risk of carbon impact. The objective of this second comparison was to find the cases in which even compliance with the RED II could result in bad practices or in the use of sources with high-risk of GHG emissions. After identifying the main sustainability risks, a stakeholder consultation was conducted to find why and how these risks can be tackled. It was found that although a EU-wide harmonized set of criteria is theoretically desirable, it should impose a bar above which MSs could set their national criteria. Also, such a set should be strengthened with adequate monitoring and verification mechanisms to ensure the sustainability of feedstock when sourced from high risk areas. Finally, it was found that some current sustainability concerns could be better tackled by means other than criteria, through other political or economic measures and mechanisms.

Foreword

This thesis was conducted in the context of the EU Horizon 2020 project ADVANCEFUEL, which aims to facilitate the commercialization of renewable transport fuels by providing market stakeholders with new knowledge, tools, standards and recommendations to help remove barriers to their uptake (http://www.advancefuel.eu). The research belongs to Subtask 4.1.2 of ADVANCEFUEL: *Development of sustainability criteria and indicators.* Therefore, the aim of this thesis is to better understand how and why some requirements that can demonstrate the sustainability of forestry biomass for bioenergy need to be included. This study focus is on the sustainability requirements of the cultivation and harvesting stages only.

This research was supported by all the stakeholders who took part in the consultation process. Their insights and expertise greatly assisted the progress of this research and constitutes an important part of the results. Thank you for the time given and for patiently withstanding my numerous emails.

1. Introduction

In 2014, bioenergy constituted 8% of the energy consumed in the EU-28 (EC 2016, p.11) and it is the largest source of renewable energy today (Alsaleh et al. 2018, p.2). Its importance as an energy source lies in the fact that, as opposed to other renewable energy sources, biomass can be converted into electricity, heat and transportation fuels as well as into bio-based products. Most bioenergy today is generated from solid biomass[1] and used mainly in electricity and heat sectors (Gonçalves 2018, p.7). Forest biomass is the main source of solid biomass for bioenergy (EC 2016, p.11 & AEBIOM 2017, p.39) and it is composed from different types of sources. These include stemwood, residues, i.e. branches and harvest losses, stumps, i.e. stumps and coarse roots, and woody biomass from early or energy thinnings in young forests (Verkerk et al. 2011, p.2008). In Europe, solid biomass is still mostly used in the residential sector (as fuelwood used in wood stoves) but increasingly also for more efficient modern uses such as "wood residues used in industrial, and residential heat sectors, cogeneration and power generation" (Hoefnagels & Germer 2018, p.4).

By 2030, it is expected that bioenergy use in the EU will increase with at least 29%[2] compared to 2015. This means that in 2030, 12%-13% of total energy demand will come from bioenergy (EC 2016, p.12-3). Biomass demand for bioenergy is furthermore expected to increase substantially towards 2050 if climate targets, as agreed upon in the Paris Agreement (COP21, 2015), are to be met. This is the case particularly for the transport sector, where advanced biofuels will most likely be the main option for aviation, maritime and heavy-duty road transport, since these cannot be electrified[3] (EC 2011, p.11). By 2050, the potential of biomass available in Europe is estimated to be of 597 Mtoe. Forest biomass is expected to remain the largest source of bioenergy, contributing between 25% to 36% of the total supply potential (up to 215 Mtoe) (Hoefnagels & Hermer 2018, p.5).

[1]Eurostat (2017) defines that solid biofuels "cover solid organic, non-fossil material of biological origin (also known as biomass) which may be used as fuel for heat production or electricity generation. In energy statistics, solid biofuels is a product aggregate equal to the sum of charcoal, fuelwood, wood residues and by-products, black liquor, bagasse, animal waste, other vegetal materials and residuals and renewable fraction of industrial waste."

[2] An increase of 29% from 2015 values means an increase in consumption from 140000 Ktoe to 180000 Ktoe (EC 2016, p.12).

[3] These sectors also have the disadvantage that their potential for technological development is slow due to barriers to entry such as long investment cycles, a capital-intensive nature, and for the aviation sector, high fuel certification standards (EC 2017, p. 14, 127-8).

Increasing demand of forest biomass for bioenergy could potentially lead to undesired changes in the market. These changes could in turn lead to an increase in harvesting levels (Verkerk et al. 2011, p. 2012) and additional mobilization of feedstocks from different origins within the EU, imported from third countries, or resulting from additional harvest instead of residue removal. The increase in demand for forest biomass would also have effects on forest owners and their lands. Not only would the price of wood be affected, but a higher harvesting intensity could lead to a decrease in the carbon stock (EC 2016, p.17). Therefore, an increased demand for forest biomass, reinforces the need of safeguarding forest biomass sustainability, both in terms of climate targets and for the protection of biodiversity.

Depending on the forest management and wood use practices involved, different forest biomass sources can be associated with different degrees of sustainability risks. Most existing literature suggests that it is possible to classify feedstocks in terms of "low" or "high" risk sources. However, the pathways leading to the use of sources with high risk of adverse GHG emissions is more likely dependent on the combinations of forest feedstock types, forest management and wood use practices (Matthews et al. 2015, p.18). These pathways need to be reviewed to ensure that the use of low risk sources is promoted and enforced. Next to the risk of adverse GHG emissions, the amount of forest biomass that can be sustainably produced varies depending on material uses and socio-economic and environmental sustainability criteria including (i) soil productivity, (ii) soil and water protection, (iii) biodiversity protection, (iv) recovery rate, (v) soil bearing capacity, (vi) distributed forest ownership and (viii) other environmental concerns (Verkerk et al. 2011, p. 2009). Taking these factors into account, in the most environmentally restricted scenario[4], the forest biomass potential[5] was estimated to be of 131 Mtoe[6] in 2030 while in a high mobilization scenario[7], the forest biomass potential increases to 188 Mtoe (Verkerk et al. 2011, p. 2009-11).

1.1 Sustainability criteria in the EU

[4] This is a low mobilization scenario motivated mainly by environmental concerns.
[5] This is the realisable potential of woody biomass supply for material and energy use. The potential can be as high as 895 million m3/y in a high mobilisation scenario.
[6] Conversion factor from EUWood (2010, p. 20). Original value: 623 Mm^3
[7] In the high mobilization scenario, a combination of economic, political, technological and social conditions lead to an increased mobilization of wood in Europe.

In 2009, the European Commission published the Renewable Energy Directive (RED I), setting a policy framework for the "production and promotion of energy from renewable sources in the European Union (EU)" (EC, 2019.). The RED I (and later, the RED II) intends to make the EU a leader in renewables[8] while setting the pathway for the achievement of the emission reduction commitments of the Paris Agreement (EC, 2019.). For the first time, this directive introduced a number of legally binding sustainability criteria for biofuels used in transport and other liquid biofuels produced or consumed in the EU (2009/28/EC, Articles 65-9) with the aim to mitigate the negative impacts they could have on biodiversity and climate change. Solid and gaseous biomass used in electricity, heating and cooling were exempted from EU-wide binding sustainability criteria.

In December 2018, the revised Renewable Energy Directive (RED II) was adopted by the European Parliament and by the Council of Ministers of the European Union (ECa, 2019). It provides more clarity on EU ambitions in the period 2020 – 2030 to promote the use of renewable energy sources by establishing a target of at least 27% of renewable energy consumption for 2030 (RED II, p. 5). It also establishes a minimum requirement of 14% final energy consumption in the transport sector, of which advanced biofuels and biogas[9] shall contribute to at least 3.5% by 2030.

The RED II intends to better ensure the sustainability of bioenergy by addressing all its uses. This means that electricity, heating and cooling are no longer exempted. Furthermore, the sustainability and GHG requirements were extended to include solid and gaseous biomass (ECa, 2019 and Hennenberg et al. 2017, p.6), and the criteria for agricultural and forestry biomass were also updated. Finally, the RED II was also extended to include sustainability requirements for biofuels and bioenergy from forestry feedstock. These "mirror the principles contained in the EU Land Use, Land Use Change and Forestry (LULUCF) Regulation" (EU Science Hub 2019). The sufficiency of these requirements for ensuring sustainability compliance is, however, still uncertain (Mai-Moulin et al. 2018, p. 56). In order for the use of biomass for bioenergy to be sustainable in the period after 2020, incentives and existing legislation need to be adapted. They need to guarantee the sustainability of an increased use of various biomass types for bioenergy.

[8] Including, but not limited to, biofuels.

[9] Both of which shall be produced from the feedstock listed in Part A of Annex IX.

The RED II will be the main instrument setting the policy guidelines for the use of biomass for bioenergy, including for advanced biofuels. Since the RED II is a Directive from the European Commission (EC), this means that EU MSs are required to adapt their national legislation to guarantee the achievement of the objectives set out in the directive. Conversely, this also means that the RED II needs to be sufficiently comprehensive so that it can verify the sustainability of forest biomass used for bioenergy.

1.2 Differences among certification schemes

Despite focusing on the certification of biomass or its use for bioenergy, there are differences in the type and comprehensiveness of the requirements of the various schemes available and approved for compliance with the RED I. The same is expected to happen when schemes are approved for compliance with the RED II. Fischer et al. (2005, p.15) argue that the variety of options can be detrimental as it can "create confusion among consumers and hinder competition among suppliers, who may not be able to afford multiple certifications for multiple clients[10] (Fischer et al. 2005, p.15). A great variety would also make it difficult for consumers to differentiate and identify the reliable certification labels, specially in international trade (Rametsteiner et al. 2002, p.97). Mutual recognition[11] was intended to tackle this problem by "recognizing that different certification systems can provide substantially equivalent standards of sustainable forest management (SFM)" (Fischer et al. 2005, p.19). However, with a single, strong certification system this could be addressed as "once a certification system reaches critical mass they could displace non-certified products" (Bocken et al. 2014, p. 51). Perhaps more importantly, this could facilitate trade within the EU, as biomass sustainability will have to adhere to the same requirements in every EU member state (MS). This highlights the importance of discussing the possibilities of a harmonized set of sustainability criteria which EU MSs can follow.

[10] However, it is usually the consumer who pays the premium to fund the benefits in the supply chain, rather than the retailer or manufacturer funding the premium (Fairtrade 2011 in Bocken et al. 2014, p. 51).
[11] Through a mutual recognition agreement, different forest certification programmes or bodies recognize and accept the components of others as equivalent to their own (Fischer et al. 2005, p.19).

1.3 Research aim and research questions

Proof of compliance with binding sustainability requirements for liquid biofuels defined in the RED I can be done either by national legislation or by participating in voluntary schemes that are recognized by the EC. The RED II was extended to include sustainability requirements for solid and gaseous biomass. Since its adoption in December 2018, schemes will have to be revised so they can apply for the EC's approval of compliance with the directive.

However, despite the RED II being the directive setting the pathway for sustainable practices in the EU, it only sets the minimum requirements that need to be complied with by EU MSs. Therefore, it is not yet adequate to either guarantee or stimulate full sustainability of forest biomass. This means that even when approved by the EC, schemes and national legislation might not be sufficient to verify the sustainability of forest biomass for bioenergy. The aim of this thesis is thus to identify the sustainability risks that still need to be addressed and find what is the most adequate means of doing so. In specific, harmonized criteria in the RED II was discussed.

The information obtained will allow to define what are the sustainable possibilities for the use of forestry biomass for the production of bioenergy -including advanced biofuels- in the future and will be used in further tasks of the AdvanceFuel project. It is also expected that the information obtained will be used to extend the sustainability requirements in the RED II.

The research question for this thesis is:

What criteria necessary to demonstrate the sustainability of forest biomass for the production of bioenergy at EU level are missing from the RED II and is the inclusion of these criteria in a EU-wide harmonised set the best approach to guarantee sustainability?

To adequately answer this main research question, the following sub-questions need to be addressed:

1. Are the criteria in the RED II sufficient to guarantee that the production of bioenergy from forestry biomass cover some minimum sustainability requirements?
2. Are the criteria in the RED II sufficient to verify that other sustainability risks are avoided?
3. How does the sustainability criteria in the RED II compare to the criteria found in other certification schemes and EU MSs national legislation and are there possibilities for learning?
4. What are some sustainability risks that still need to be addressed by the RED II?
5. Is the inclusion of these criteria in a EU-wide harmonised set the best way to tackle the currently unaddressed sustainability risks?

1.4 Research scope and assumptions

This study looks into the sustainability criteria of forest biomass used for bioenergy. It will focus on forestry biomass due to its large[12], readily available and relatively stable potential[13]. Moreover, forest biomass is already one of the main sources of solid biomass used for the production of bioenergy (EC 2016, p.11 & AEBIOM 2017, p.39). The scope of this study is also limited because, at the time it was carried out, no voluntary certification schemes have been approved by the EC for compliance with the RED II. This means that the results of this research are based on the analysis of the criteria included in other schemes up to January 2019, when the data collection for stage 1 was carried out. It is thus possible that the schemes the EC approves for compliance with the RED II will be more comprehensive than the ones analyzed in this thesis and will address the sustainability risks in a better way.

[12] "Recent projections for 2030 quantify the sustainably realisable potential of wood for energy from EU forests as high as 675 million cubic meters (146 million toe) per year, provided intensive wood mobilisation efforts are applied" (ECc, 2019)

[13] Based on information from a study by the European Environmental Agency (2006) and Commission's Impact Assessment of the Renewable Energy Roadmap, the European Commission concludes that: (i) "biomass potentials from forestry and waste are relatively stable over time", and (ii) "In the short to medium run, available but partly unused biomass potential from waste, forestry, and residues" could be used to achieve the renewable energy targets (ECc, 2019)

1.4.1 Biomass feedstock categories

There are two main categories of wood supply:

1. Forest woody biomass (primary wood)
2. Other woody biomass

This study will only focus on forest woody biomass. This includes all wood that is obtained directly from forest harvesting (without having any previous use), and woody biomass from harvest residues and stump removal (including branchwood and stumps) (Mantau et al 2010 in Forest Research 2014, p.60 & Matthews 2015, p.52).

More specifically, Forest Research (2015, p.203) defines primary wood as:

> "Any wood harvested from a forest, either in raw state or processed into a finished product or forming a by-product of a finished product. Specifically, it does not include wood in the form of a finished product that has come to the end of its useful life and which may either be recycled or enter the waste wood stream".

1.4.2 Definition of sustainability in this study

There is no single definition of sustainability. As a concept, it first became known in the context of *sustainable development*. That is, a development that "ensure[s] that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report 1987, p.15). Sustainability, should thus include requirements to guarantee that world's resources are preserved across generations. In this study, resources will be considered to be forest, the land in which they grow, its native species and ecosystems. The preservation of these resources should not only take into account environmental aspects, but also the social and economical aspects related to them and that can arise from their use.

Narrowing sustainability to the preservation of forest resources, it can still be understood in two ways. The first one, focuses on the requirements for maintaining and protecting biodiversity. The second one, focuses on the requirements for tackling global warming and climate change. However, both are correlated as changes caused by global warming can affect the biodiversity of a place.

Taking into account all the above mentioned concerns, sustainability of forest biomass for the use of bioenergy should include requirements for the following categories:

1. GHG emissions

2. Forest productivity and well- functioning
3. Carbon stock
4. Biodiversity
5. Ecosystem conservation
6. Protection of water resources, air and soil
7. Labour laws
8. Child labour
9. Land right
10. Human health impacts

1.4.3 Selection of voluntary schemes and national standards

The sustainability criteria in the RED II were compared and contrasted with a number of certification schemes and national initiatives. A small overview of the schemes chosen for this study and their main characteristics is presented in *Table 1*.

Two certification schemes were chosen:

1. the Roundtable on Sustainable Biomaterials (RSB)
2. the International Sustainability and Carbon Certification (ISCC).

These two schemes were chosen because they are recognised by the EC to demonstrate compliance with the requirements set out in the RED I for liquid biofuels. These are two of the most widely[14] used schemes in the EU for liquid biofuels and are among the most comprehensive. The Sustainable Biomass Partnership (SBP), which was created with the aim of ensuring compliance with the differing national schemes in place will also be reviewed.

Although the RED II was only adopted in December 2018, countries that import solid biomass, such as the Netherlands, the United Kingdom and Belgium have already implemented mandatory[15] sustainability criteria for solid biomass for heat and electricity production at the national level. Both, the Dutch Verification Protocol and the UK Renewable Transport Fuel Obligation (RTFO) include requirements for solid biomass[16] and were

[14] RSB is in fact recognized as "best-in-class" in addressing sustainability issues.
[15] Denmark has instead established a *voluntary* sustainability scheme in cooperation with the industry and NGOs.
[16] In the UK, the Renewable Obligation (RO), the Renewable Heat Incentive (RHI), the Contracts for Difference (CfD) and the RTFO include criteria for solid biomass (Mai-Moulin et. al. 2017).

therefore chosen for this study. Although both initiatives include requirements for the sustainability of solid biomass, their approach to do so is not the same. This is because the RED II only sets an overall policy pathway. It is ultimately up to MSs to decide how to achieve the targets set out in the directive, which is why national schemes are likely to be different from one another in the type and comprehensiveness of their requirements.

Finally, forest biomass certification is already well developed, although it is mostly used in non-energy markets. Two of the most important global certification schemes for forest biomass are the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification (PEFC). However, despite including very comprehensive SFM criteria, these two systems were not part of the EC approved schemes to guarantee compliance with the RED I. The RED II now includes sustainability requirements for gaseous and solid biomass as well as requirements for forestry biomass. This makes the PEFC and FSC potential EC recognised schemes in the future.

Table 1. RED II, certification schemes and national initiatives for biomass sustainability

Scheme	Type	Sector coverage	Feedstock coverage	Geographic coverage	Description
Renewable Energy Recast (RED II)	EU Directive	Electricity, heating and cooling and transportation	Bioliquids and biomass fuels produced from food and feed crops (Article 26), from waste and residues and from forestry	European Union	The RED I established an overall policy for the production and promotion of energy from renewable sources in the EU. In 2018 a revised proposal was approved and is now the successor of the RED I, raising the target for the consumption of energy from renewable sources for the period from 2020 to 2030. Most of the sustainability and GHG criteria in the RED II is similar to that established in the RED I, but it was extended to include sustainability for forestry feedstock and GHG criteria for solid and gaseous biomass (before it was only for bioliquids). It "mandates that harvesting takes place with legal permits, the harvesting level does not exceed the growth rate of the forest, and that forest regeneration takes place. In addition, biofuels and bioenergy from forest materials must comply with requirements which mirror the principles contained in the EU Land Use, Land Use Change and Forestry (LULUCF) Regulation."
Roundtable on Sustainable Biomaterials (RSB)	Certification scheme*	All	All	Global	It aims for the environmentally, economically and socially responsible production and processing of biomaterials, including biofuels and biomass. RSB sets standards for the entire supply chain. It includes GHG methodology, standards for end-of-life products and a section on low iLUC risk biomass.
International Sustainability and Carbon Certification (ISCC)	Certification scheme*	All	All	Global	It is a standard for the sustainable production of biomass which looks at environmental and social aspects. It aims to prevent ecological shortcomings while guaranteeing adequate working conditions and the health of employees. Its sets a framework for (i) the protection of land with high biodiversity value or high carbon stock, (ii) the protection of soil water and air, (iii) safe working conditions, (iv) the protection of human, labour and land rights, (v) compliance with regional and national laws and international treaties, and (vi) good management practices. "With ISCC, companies can demonstrate compliance with the legal requirements of RED, the FQD, and of the Liquid Fuel Supply Regulation of Queenslan". Compliance with the ILO convention is equivalent to (iv).
Verification Protocol	National Initiative	Electricity, heating and cooling and transportation	All	The Netherlands	It provides sustainability criteria for solid biomass for energy applications along the supply chain. It includes requirements for (i) GHG emissions savings and calculations, (ii) soil management, (iii) carbon and land use requirements, (iv) SFM, and (v) requirements relating to the Chain of Custody. It covers five biomass categories: (i) woody biomass from FMU, (ii) woody biomass from small (<500 ha) FMU, (iii) residues from nature and landscape management, (iv) agricultural residues, and (v) biogenic residues and waste flows.
UK Renewable Transport Fuel Obligation (UK RTFO)	National Initiative	Transport and Non-road mobile machinery (NRMM)	All	The United Kingdom	The RTFO is one of the main governmental policies aimed at reducing GHG emissions from fuel supplied in the transport sector. It requires that fuel passes sustainability criteria before being rewarded with a certificate. It requires the criteria to be verifiable along the chain of custody. It includes requirements for land use, GHG emissions, chain of custody and mass balance. It transposes the requirements of RED, the Fuel Quality Directive (FQD) and the iLUC directive.

Sustainable Biomass Partnership (SBP)	Certification scheme	Electricity and heating and cooling	Forest biomass	Europe	It was formed by European utilities "using biomass, mostly in the form of wood pellets or chips, in large thermal generating plants". It aims to demonstrate that solid biomass for energy production meets, at least, national requirements. It provides means for collecting data on the nature of the feedstock and data for the regulatory GHG calculations. "It also provides a means to demonstrate that risks to forest carbon stocks are managed and that forests' carbon sequestration capability is maintained". This framework can be used by actors along the entire supply chain.
Forest Stewardship Council (FSC)	Umbrella certification scheme		Forest biomass	Global, with national standards	FSC aims to promote responsible management of the world's forests. It offers (i) forest management certification and (ii) Chain of custody certification. Forest management certification aims to guarantee that the natural ecosystem is preserved, while being mindful of social aspects and economic viability. CoC certification guarantees the correct handling of products through every stage of production.
Programme for Endorsement of Forest Certification (PEFC)	Umbrella certification scheme		Forest biomass	Global, with national standards	It aims to promote SFM through independent third party certification, and is considered to be the chain of custody certification system of preference for small forest owners. It endorses national or regional certification systems that comply with PEFC requirements. However, this means national standards are not always equivalent with one another. It establishes ecological, social and ethical standards related to the production of forest products. It sets standards for: biodiversity, the protection of ecologically important areas, prohibition of forest conversions, prohibition of hazardous chemicals and GMOs, protection of workers rights and welfare, and it recognizes indigenous people's rights, land tenure rights, traditional rights and ILO convention.

*Approved by the EC to demonstrate compliance with the RED I.

2. Background

Sustainability criteria of biomass are addressed by different kinds of schemes, standards and in legislation. This section starts by presenting an overview of the tools of a sustainability framework available to guarantee biomass sustainability: certification schemes, criteria and indicators. Criteria and indicators are described to highlight their role in safeguarding the sustainability risks that might arise from the use of forest biomass for bioenergy. This section ends by introducing the schemes that are reviewed in this report and their relevance for the benchmarking of forest biomass sustainability criteria.

2.1 Certification, criteria and indicators

Certification can be defined as "the process whereby an independent third-party (called a certifier or certification body) assesses the quality of forest management in relation to a set of predetermined requirements (the standard)" (Rametsteiner et al. 2002, p.88). Certifications are usually carried by a third party to ensure its authenticity, and its success depends on the validity of the criteria and the trustworthiness of the process (Dean, p.42). Certifying bodies can either set performance or system-based guidelines that would have to be followed by those seeking certification. Performance-based guidelines "require specific actions, practices or outcomes [e.g. FSC], [... while] system-based guidelines [set] criteria for a landowner to design a personalized management system for tracking environmental performance [e.g. PEFC]"[17] (Fischer et al. 2005, p.2).

2.1.1 Criteria and indicators

According to the United Nations (UN) Food and Agriculture Organization (FAO), criteria "define the essential elements against which sustainability is assessed, with due consideration paid to the productive, protective and social roles of forests and forest ecosystems" (FAO 2019), with "each criterion relat[ing] to a key element of sustainability" (FAO 2001). Indicators are "parameters which can be measured and correspond to a particular criterion. They measure and help monitor the status and changes of forests in

[17] Fischer et al. (2005, p.18) consider that a system-based approach is more appropriate for the certification of SMF, although they recognize that a combination of a performance and a system based approach might be necessary.

quantitative, qualitative and descriptive terms that reflect forest values as seen by those who defined each criterion" (FAO 2019).

2.1.2 Sustainable Forest Management

While forest certification is based foremost in prescriptive standards and an assessment of their performance, sets of criteria and indicators (C&I) are used to describe the status of Sustainable Forest Management (SFM). That is, they do not contain targets or performance expectations (Rametsteiner et al. 2002). Instead, they complement certification by "providing a framework that characterizes the essential components of SFM" (FAO 2019) and allows to present data of forest conditions at varying scales (Rametsteiner et al. 2002).

The forest sector has developed a holistic approach to SFM by including C&I for environmental, economic, social and cultural values (Linser et al. 2018, p.2). Most of the schemes that will be studied (see *Table 1* in section 3.2.3) cover these three aspects, however each one of them has a different approach and/or focus to it. Although comparable, the C&I of these schemes do not cover the same sustainability risks, or do not do so in the same way.

2.2 EU Legislation

There are four types of legislation applicable at the EU level: (i) regulations and decisions, which are automatically binding, (ii) recommendations, which are not binding in nature, and (iii) directives, which require the achievement of a certain result but leaves national authorities to decide the way of doing so[18]. Directives require that countries adapt their national law to guarantee the achievement of the objectives set out in a directive. When the national law is not transposed by the deadline set at the moment of adoption of the directive, the country might face legal action (ECd, 2019).

2.3 Voluntary certification schemes

Biofuels and bioliquids used in the EU must comply with the sustainability criteria established by the EC in its directives: with the RED I until 2019 and with the RED II for the period from 2020 to 2030. Only when complying with the criteria can the biofuels and

[18] Article 288 of the Consolidated version of the Treaty on the Functioning of the European Union, 2012. Found in the Official Journal of the EU.

bioliquids be counted towards the mandatory national renewable energy targets set in these directives. Demonstration of compliance with the criteria can be done either by national legislation or by participation in recognized voluntary certification schemes (certification schemes) (ECb, 2019). Unlike other voluntary standards, certification schemes are recognised by the EC to comply with the minimum requirements set out in the directives, first in the RED I and now in the RED II.

When the RED I was approved, a number of certification schemes submitted their applications seeking for the European Commission's recognition of their compliance with the established sustainability criteria for biofuels and bioliquids. Currently there are 18 schemes (listed in the Appendix) which have been recognised by the EC and can be used to demonstrate compliance with the RED I (ECb, 2019). Although schemes like ISCC have been developing and adapting to gain the EC's recognition for compliance with the RED II, so far no certification schemes have been recognised. Two schemes that were approved for compliance with the RED I will thus be used in this study for the benchmarking of their criteria with minimum sustainability requirements for forest biomass: the Roundtable on Sustainable Biomaterials (RSB) and the International Sustainability and Carbon Certification (ISCC). These were chosen for being the two most comprehensive standards and due to their international character.

2.3.1 Roundtable on Sustainable Biomaterials (RSB)

The Roundtable on Sustainable Biomaterials (RSB) is an international standard which was established to promote the sustainability of biomaterials along the entire supply chain. Since 2013, the scope of the standard includes "all biomaterials (including biofuels, bio-based chemicals, bioplastics, etc.)" (RSB 2016, p.4). The standard sets requirements for the production, conversion and processing stages (RSB 2016, p.8).

RSB's principles and criteria focus on the environmental, social and economic aspects related to the production of biomass, biofuels and biomaterials (RSB 2016, p.4). These principles and criteria are designed to help the identification and management of context-specific sustainability issues (RSB 2016, p.4), which is why RSB is "recognised as best-in-class in addressing key sustainability issues in a comprehensive way" (RSBa 2016).

Compliance with the criteria and minimum progress requirements is verified by RSB-accredited certification bodies (RSB 2016, p.5).

2.3.2 International Sustainability and Carbon Certification (ISCC)

Developed in 2006, the International Sustainability and Carbon Certification (ISCC) is a global certification system addressing the sustainability requirements of all feedstocks and markets along the supply chain (ISCC 2019). Its approach to sustainability is also focused on the environmental, social and economic aspects related to the use of biomass.

EU countries that have implemented Cross Compliance need only to control principle 1. Likewise, ratification to the ILO convention is assumed to fulfill the social requirements of principle 4. The international ISCC standards can be adapted to local conditions through a National or Regional Initiative by specifying the standard (ISCC 2010, p. 4). It is also possible to extend the certificate to cover specific market requirements (ISCC 2019).

2.4 National initiatives

EU MSs have autonomy to decide how the requirements set out in the RED I, and now in the RED II, will be achieved. These requirements need to be added to each country's national legislation. In occasions, compliance with biomass sustainability criteria can be a requirement for subsidy eligibility (Fern 2016, p.2), such as in the feed-in premium Stimulation of Sustainable Energy Production (SDE+)[19] in the Netherlands, which must comply with the requirements set out in the Dutch Verification Protocol, or the United Kingdom's Renewable Transport Fuel Obligation (UK RTFO) quota system.

However, the implementation of regulations in the EC directives at the national level can lead to differences in terms of the quantity, quality and comprehensiveness of the requirements included in the legislation among EU MSs. With some countries having stricter regulations than others, trade between them can be hindered: biomass deemed sustainable in one country is not necessarily so in another. This could result in a fractionalization of the internal market, where biomass with 'lower' standards cannot be purchased in a country with 'higher', or simply different, standards.

[19] At the moment, the SDE+ applies only to the use of biomass for the production of electricity and heat.

Four countries that import solid biomass, Belgium, Denmark, the Netherlands and the United Kingdom, have already implemented sustainability criteria for solid biomass used for heat and electricity production at industrial level. The Dutch Verification Protocol and the UK RTFO[20] will be reviewed in this study because, as importers of biomass, both countries have already implemented criteria for the use of biomass for bioenergy. These two were chosen over the Danish scheme because the latter is voluntary, and over the Belgian Green Certificates (GCs) because it is regulated at federal and regional level rather than having equally applicable legislation at national level (Mai-Moulin et al. 2017, p.3). Moreover, because this research is conducted in the Netherlands, the relevance of studying the Dutch Verification Protocol is highlighted.

2.4.1 Verification Protocol for Sustainable Solid Biomass for Energy Applications

In order to promote the production of renewable energy in the Netherlands in the context of the national renewable energy targets of the RED I, the Ministry of Economic Affairs and Climate Policy launched the Stimulation of Sustainable Energy Production (SDE+), a feed-in premium subsidy through which producers of renewable energy receive a financial compensation for the renewable energy generated (RVO 2019). To be eligible for the subsidy, producers must demonstrate that their biomass supply is sustainable. This can be done through the use of one of the certification schemes approved by the Dutch Ministry of Economic Affairs and Climate Policy or by verification using the Verification Protocol (RVO a 2019). Under the Verification Protocol, the sustainability requirements need to cover "the whole chain of custody, from forest management unit/collection point to energy producer (continuous Chain of Custody)" (RVOa 2019).

2.4.2 UK Renewable Transport Fuel Obligation

The UK Renewable Transport Fuel Obligation is a policy from the British Government aimed at reducing GHG emissions from road transport by "encouraging the supply of renewable fuels" (Department for Transport.a 2018, p.7). Renewable fuel suppliers must comply with certain sustainability requirements, specified in the RTFO Guidance:

[20] The UK Renewables Obligation (RO) introduced sustainability criteria for solid biomass and biogas used for electricity and heat generation. Although the RO is the main support mechanism for the use of renewables in the UK, this paper will study instead the UK RTFO, which focuses on the transport sector, where advanced biofuels will be mostly used.

Carbon and Sustainability -Part 2. Only then would they be recognized and entitled to receive Renewable Transport Fuel Certificates (RTFC). The sustainability criteria required implements elements of the RED, the iLUC directive, and the Fuel Quality Directive (FQD). (Department for Transport.a, p.7-9). The renewable fuels that meet the requirements will be issued RTFCs and can be used by the suppliers to meet their own obligations, or they can be sold in the market to other suppliers that need them to meet their obligations (Department for Transport, p.7, 54-7).

2.5 Sustainable Forest Management and Forest Certification

The conservation of forests needs to address all three pillars of sustainability: economic, environmental and social. The maintenance and enhancement of these values for the benefit of present and future generations is known as Sustainable Forest Management (SFM) (A/RES/62/98 & PEFC 2019). It is an evolving process that is constantly adapting to new conditions and region specific requirements, while remaining in compliance with international requirements (PEFC 2019).

During the early 1980s tropical deforestation gained the attention of environmental groups who felt the need for action. The Earth Summit in 1992 was expected to address these concerns. However, it only managed to come up with a set of non-legally binding principles for the conservation and sustainable development of forestry, known as the 'Forest Principles'. In 1993, a stewardship[21] was developed to address this market failure and the Forest Stewardship Council (FSC) was established (Rametsteiner et al. 2002, p.88). It was expected that forest certification would offer an "alternative, fast-track route to sustainable forest management around the world" (Auld et al. 2008, p.189).

The Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification (PEFC) are two of the most important global certification schemes for SFM. Despite the scope in the criteria and requirements they establish, these two systems were not part of the EC approved schemes to guarantee compliance with the RED I. This is because the criteria in the RED I only applied to liquid biofuels[22]. Now that the RED II has been extended to cover the sustainability of solid and gaseous biomass and that forestry

[21] The role of a stewardship is to maximize positive societal and environmental impacts through "proactively engage with all stakeholders to ensure their long-term health and wellbeing" (Bocken et al. 2004, p.51)

[22] Liquid biofuels are are not made from forest biomass.

requirements are also included, it is expected that FSC and PEFC could be approved by the EC as adequate systems to guarantee compliance with the legislation.

2.5.1 Forest Stewardship Council (FSC)

The Forest Stewardship Council (FSC) is "a global not-for-profit organization that sets the standards for what is a responsibly managed forest, both environmentally and socially" (FSC, 2019). It was created to "promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests" (FSC 1994, p.1). The FSC sets standards for forest products along the supply chain (chain of custody certification) to guarantee that the products meet specific requirements. This way, the standard guarantees that any product bearing the FSC logo has been produced in an environmental, ethic and responsible way (FSC, 2019, Auld et al. 2008, p.190 & Fischer et al. 2005, p.3).

Although FSC is established as a global standard, it encourages the development of national versions customized to address local conditions. Once these have been approved by the board, national standards could be used for certification (Fischer et al. 2005, p.3 & Overdevest 2009, p.54). From 1999, after the establishment of FSC, other alternative industry schemes gradually moved under the umbrella of the PEFC[23] (Overdevest 2009, p.55).

2.5.2 Programme for the Endorsement of Forest Certification (PEFC)

The Pan-European Forest Certification Scheme[24] (PEFC), was created as an umbrella organization at the European level to facilitate the mutual recognition of national schemes. National certification systems are developed independently, and can become PEFC approved if they conform with the rules and C&I of the meta-standard (PEFC. 2019 & Auld et al. 2008, p.191). PEFC thus establishes a framework for the development and recognition of local schemes, which must adhere to the internationally recognized requirements for SFM (Fischer et al. 2005, p.4).

[23] The existence of more than one standard gives consumers flexibility to choose the system (and the factors) that they are willing or capable to certify.

[24] Due to its global reach, the name was later changed to Programme for the Endorsement of Forest Certification, maintaining the same acronym (PEFC).

2.6 Other certification schemes

Forest management certifications can make use of forest certification schemes "to establish proof of Sustainable Forest Management (SFM) in Forest Management Units (FMUs)" (Linser et al. 2018, p.13). For industry and trade, forest certification serves as an instrument for environmental marketing, as certification can signal a superiority of attributes that can lead to a competitive advantage in the marketplace (Rametsteiner et al. 2002, p.89 & Dean, p.43). They also solve communication asymmetry providing consumers with information on the environmental impacts of the products they purchase and allowing them to choose environmentally superior offers. Overall, it is a way to influence and promote sustainable forest management and sustainable consumption patterns (Rametsteiner et al. 2002, p.89). One important certification scheme is the Sustainable Biomass Partnership (SBP). It aims at the bioenergy markets and was created by the bioenergy industry itself.

2.6.1 Sustainable Biomass Partnership (SBP)

Established as an independent-third party certification system, the Sustainable Biomass Partnership (SBP) "was formed in 2013 by European energy utilities that are using biomass, mostly in the form of wood pellets or chips, in large thermal generating plants" (SBP 2015, p.2). Through its certification system, it aims to contribute to a sustainable biomass chain by assuring that woody biomass is sourced and produced responsibly (NEPcon, 2019).

The SBP certification framework is composed of six standards designed to demonstrate compliance with minimum sustainability requirements for solid biomass used for energy production (SBP 2015, p.2). SBP indicators address forest-specific sustainability objectives, including: "(1) Maintaining or increasing forests, (2) Conserving biodiversity and (3) Preserving forests of high conservation value" (SBP, 2019).

Upon demonstrating compliance with the principles, standards and processes set out in this framework, an organization can claim SBP certification. This certification framework is compatible with FSC and PEFC although it is not intended to replace them, but to complement them. Together, these three schemes are working for overcoming existing challenges related to biomass use (SBP 2019 & SBP 2019).

3. Method

This study is a qualitative research of the available sustainability criteria for forest biomass. *Figure 1* in Appendix 3 shows in a diagram the Research Framework that was followed in this thesis. First, a review of literature on sustainable forest management and of various certification schemes and national initiatives was conducted to obtain a state-of-the-art overview of sustainability criteria that are relevant for bioenergy from forest biomass. The information used to compare and analyze the criteria and indicators of the different certification schemes was obtained from the reports and standards published in the websites of the certification schemes. Other information for the literature review was obtained from information from the website of the European Commission and from reports published by stakeholders in their websites. Then, two approaches were combined to find the strengths and weaknesses of the RED II by comparing it with a set of sustainability requirements and risk scenarios for the use of feedstock. Other certification schemes and national initiatives were also compared to the same set of requirements and risk scenarios.

Stakeholder interviews were finally carried out to further discuss the possible gaps and sustainability risks of the RED II and the possibilities of establishing a EU-wide set of harmonized sustainability criteria for forestry biomass. The stakeholders interviewed for the consultation process were chosen to include the opinion of forest certification scheme owners, NGOs with an interest in biodiversity and environmental issues, and experts on the forestry areas or with knowledge and interest in the RED II. Organizations like PEFC were consulted to gain insights of the main concerns related to forest management. NGOs, on the other hand, have been highlighting the risks of unsustainable use of biomass for bioenergy. Therefore, their opinion allows to challenge the priorities of the RED II and other schemes. The contacts for these interviews were provided by dr. Ric Hoefnagels, dr. Martin Junginger and Thuy Mai-Moulin. Some others were found on the contact information of some of the reports reviewed or on the websites of the organizations.

The interviews were adapted to the availability of the interviewees. Some of the interviews were carried in person, some through phone calls, and some stakeholders answered a questionnaire sent online. When the stakeholders were not available to meet or a

phone call could not be arranged, their input was limited to answering the questions from the questionnaire. When a meeting or phone interview was possible, semi-structured interviews were conducted next to the structured questionnaire prepared. The semi-structured interviews allowed to obtain more detailed comments on the topic. In some cases, tailor-made questions were asked to the interviewees based on their recent articles or publications. The information obtained through the (spoken) interviews was summarized and sent back to the interviewees for their approval in order to guarantee transparency of the work done.

The steps followed to answer each of the sub-questions stated in this research are outlined in the following sections.

3.1 Minimum sustainability requirements

The first part of this research focused on the minimum sustainability requirements for the production of bioenergy from forest biomass. The sub-question that was addressed was:

Are the criteria in the RED II sufficient to guarantee that the production of biofuels from forestry biomass cover some minimum sustainability requirements?

This sub-question aims to identify whether the RED II is sufficient to verify the sustainability of biofuels from forestry biomass. The review of the minimum sustainability criteria used for this section builds on ongoing research within the ADVANCEFUEL project. A set of minimum sustainability requirements for the production of biofuels from forestry biomass constructed for this project was used as the basis from which the criteria in the RED II was compared and contrasted. The minimum sustainability requirements that were analyzed are:

1. GHG emissions
2. Chain of custody (CoC)

   Sustainable Forest Management
3. Legal and sustainable sourcing
4. Forest productivity and well functioning
5. Carbon stock
6. Biodiversity
7. Ecosystem conservation

8. Protection of water resources, air and soil

   Social requirements

9. Labour laws
10. Child labour
11. Land right
12. Human health impacts

Article 29 of the RED II was analyzed and each of its sub-articles were divided for ease of reading and of identification of relevant criteria. Then, the minimum sustainability requirements and the RED II were analyzed together. This way, it was possible to identify the articles and sub-articles of the RED II that contain the criteria covering each of the minimum sustainability requirements listed.

3.2 Other sustainability risks

After the coverage of the minimum sustainability requirements was analyzed, it was necessary to identify whether other sustainability risks were left to be addressed. To do this, the following sub-question was tackled:

Are the criteria in the RED II sufficient to verify that other sustainability risks are avoided?

To answer this sub-question it was first necessary to identify possible sustainability risks that can arise from the use of forest biomass for bioenergy. Based on the risk pathways from Forest Research's decision tree for the use of forestry feedstock (Matthews et al. 2015), it was possible to draft a set of requirements for avoiding the use of biomass sources with high-risk of GHG emissions. In these pathways, forest feedstock types, forest management and wood use practices are combined in a way that good and bad practices can be outlined to determine the risk of carbon impact. Following a similar procedure as in section 3.1.1, the criteria in the RED II were analyzed together with the risk pathways identified in this section. The objective of this second comparison was to find the cases in which even compliance with the RED II could result in bad practices or in the use of sources with high-risk of GHG emissions.

3.3 Comparison of the RED II with other certification schemes and national legislation

This section addresses the following sub-question:

How does the sustainability criteria in the RED II compare to the criteria found in other certification schemes and EU MSs national legislation and are there possibilities for learning?

The purpose of this sub-question was to find how the RED II can learn from the criteria included in other certification schemes and national legislation addressing the sustainability of forest biomass. This section extended the analysis and comparison carried out in sections 3.2.1 and 3.2.2 to analyze the criteria found in other certification schemes and national initiatives. Therefore, based on the set of minimum sustainability requirements and the risk pathways from sections 3.2.1 and 3.2.2, the RED II, the certification schemes and national initiatives were reviewed, compared and contrasted together. It was then possible to find the strengths and weaknesses of the RED II when compared to the other certification schemes and national initiatives. When these were more comprehensive than the RED II, they were highlighted as examples from which the RED II can learn and improve its criteria.

3.4 Risks to be addressed

After completing the previous steps, it was possible to find that the RED II is not sufficient to verify the sustainability of forest biomass for bioenergy. The sub-question that needs to be answered next is thus:

What are some sustainability risks that still need to be addressed by the RED II?

Building on the information obtained in the previous three steps it was possible to identify the risks related to the use of forest biomass for bioenergy that are unaddressed by the RED II. The possibilities for learning from other certification schemes and national initiatives was analyzed in the previous sections. The risks identified were then discussed with relevant stakeholders to find if these are indeed relevant for verifying the sustainability of forest biomass and if they were, what was the best way to address them.

3.5 Harmonization possibilities

The last part of this research focused on answering the following sub-question:

Is the inclusion of this criteria in a EU-wide harmonised set the best way to tackle the currently unaddressed sustainability risks?

The stakeholder consultation was the main source of information for this section. A number of questions in the questionnaire addressed the possibilities of harmonization, as well as the possible risks and benefits that can result from a harmonized set of sustainability criteria. Based on the stakeholders' opinions and priorities, it was possible to find whether a EU-wide set of sustainability criteria for forest biomass could be implemented and how extensive and strict it could be without threatening environmental, or socio-economic priorities.

4. Results

This section presents the results of this research. Each subsection is meant to addresses each of the sub-questions from the Research Question as presented in the Method section with two exceptions. First, the results of the third sub-question are directly included with the analysis of the minimum sustainability requirements (sub-question 1) and other sustainability risks (sub-question 2). Second, a section is added before sub-questions 4 and 5. This section is meant to address the results of the stakeholder consultation process.

4.1 Minimum sustainability requirements

Table 2 presents an overview of the sustainability criteria coverage of the RED II and the other schemes and initiatives studied when compared to a set of minimum sustainability criteria for forest biomass. A ++ indicates full coverage, while a +- indicates that the criterion is only partly covered. Full coverage (++) implies that the minimum requirement is fulfilled. That is, there is sufficient criteria referring to, for instance GHG emissions. Partial coverage (-), on the other hand, means that the aspect is mentioned as an issue but there is no specific criteria covering it, or just part of it is covered. For instance, on the *Legal and sustainable sourcing* criteria, the UK RTFO mentions legal sourcing while the sustainable sourcing can be assumed but it is not explicitly mentioned.

Table 2: Coverage of sustainability criteria for biomass

		Sustainable forest management							Social requirements			
Scheme	GHG emissions	Legal & sustainable sourcing	Forest productivity & well-functioning	Carbon stock	Biodiversity	Ecosystem conservation	Protection of water resources, air & soil	CoC	Labour laws	Child labour	Land right	Human health impacts
RED II	++	++		++	++		++	++	++			++
Roundtable on Sustainable Biomaterials (RSB)	++	++					++	++	++		++	
ISCC	++	++		++	++	+-	++	++	++	++	++	++
Verification Protocol	++	++	++	++	++		++	++	++			

UK RTFO	++	+-		++	++	++	++	++	++	++	++	++
FSC		++	++		++	++	++	++	++		++	++
PEFC	++	++		++	++	++	++		++		++	++
Sustainable Biomass Partnership (SBP)		++		++	++	++		++	++			++

4.1.1 Comparison of the RED II with other certification schemes and national legislation

Table 2 shows an overview of the sustainability requirements included in the reviewed schemes and national legislation. None of these schemes covers all of the minimum sustainability requirements that were identified to be relevant. The ISCC and the UK RTFO are the two most comprehensive schemes, including requirements in all three areas: environmental, social and economic. Conversely, when focusing on the environmental area alone, the Dutch Verification Protocol, PEFC and FSC are the most comprehensive schemes. The ISCC and the UK RTFO, both lack requirements for the area of *Forest productivity and well-functioning*. However, as mentioned above, they do include requirements for socio-economic aspects. The Dutch Verification Protocol, on the other hand, is lacking socio-economic criteria, but it is thorough in its environmental requirements.

Forest productivity and well-functioning, *Ecosystem conservation* and *Child labour* are the three requirements that are more poorly covered by the analyzed schemes. *Legal and sustainable sourcing* and *Labour laws*, are the two requirements that are included in all of the previous schemes. *Biodiversity*, *Protection of water resources, air and soil* and *Chain of custody* requirements, are also very well covered, with almost all schemes including requirements on these areas.

Most schemes address *forest productivity and well-functioning* by including a requirement that forests, their health and vitality, and/or their ecosystem services are maintained and, when possible, enhanced. Only FSC includes more detailed requirements by specifying the functions that should be taken care of. These are: (a) Forest regeneration and succession, (b) Genetic, species, and ecosystem diversity and (c) Natural cycles that affect the productivity of the forest ecosystem. On *Ecosystem conservation*, the schemes which include

criteria for it, set requirements to conserve the health and vitality of the ecosystem, its species and habitats. *PEFC's Criterion 2: Maintenance of forest ecosystem health and vitality,* covers the requirements for maintaining the ecosystem with five indicators. These can be found on *Appendix 4.*

With respect to social criteria, from the schemes studied, only the national legislation UK RTFO sets requirements establishing that children under the age of 15 should not be employed. As for *land right*, the comprehensiveness of the requirements is similar in all the reviewed schemes covering it (Table 2). These establish that land rights should be clearly defined and respected.

This section analyzed the coverage of certification schemes and national legislation, and whether they cover the minimum sustainability requirements for sustainability. It was found that none of the schemes analyzed cover all the requirements, and consequently, cannot guarantee full sustainability as defined in this thesis. Furthermore, there are other risks not necessarily covered in these minimum requirements, that can arise from the cultivation and harvesting of forest feedstocks. These risks are analyzed in the next section (4.2).

4.2 Other sustainability risks

The first section focused on finding the minimum criteria for bioenergy found in the RED II and compare it with the (possibly more extensive) criteria found in certification schemes and national legislation. The next step was to find whether these same schemes and national legislation include requirements to avoid sustainability risks other than the included in the minimum sustainability requirements (subsection 4.1). The decision tree for the risk of adverse GHG emission sources (Matthews et al. 2015, p.22-3) was used to identify other sustainability risks from the use of forest biomass. Appendix 3 presents the C&I found for each pathway studied.

Table 3 presents an overview of the coverage of the RED II and other schemes and initiatives towards the low risk pathways from the decision tree. The criteria has been enumerated from 1) to 13) for ease of reference. A ++ indicates coverage, while a +- indicates that the criteria is just partly covered. The logic for this classification is the same as explained in the previous section (4.1).

Table 3: Compliance with the requirements for low-risk sourcing based on the decision tree

	Criteria/statement from tree	RED II	RSB	ISCC	Verification Protocol	UK RTFO	FSC	PEFC
Recycled or waste wood	1) There is evidence that this wood has NOT been diverted from use as a feedstock for material products							
NOT recycled or waste wood	2) When the quantities of wood being harvested exceed the productive potential of the forest in the long term (Implies LUC), a. there should be valid positive external reasons why land-use change is taking place (LUC will take place anyway)	++	++		++		++	++
	3) When the quantities of wood being harvested DO NOT exceed the productive potential of the forest in the long term (No LUC), a. forest bioenergy must be produced from the forest areas as part of traditional or conventional management.	++	++		++		++	++
	4) b. The quantities of forest bioenergy being produced should be consistent with traditional/conventional management	++			++		++	++
	5) If the forest bioenergy being produced from the forest areas, and the quantities being produced are not part of traditional or conventional management, a. the productive potential of the forest area should NOT be very low (if it is, the risk is HIGH)	+-			++		+-	+-
	6) Forest areas that have been established by active afforestation since 2000, should take care that a. Afforestation DOES NOT take place on organic soils (otherwise, it would be high risk)		+-	++	+-	+-	++	++
	7) b. Afforestation SHOULD NOT cause leakage/iLUC				++	++	++	++
	8) If the forest areas have NOT been established by active afforestation since 2000, a. The harvesting of forest bioenergy should be accompanied by actions to enrich the growing stock and carbon stocks of the forest areas	++	++	++	++			+-
	9) b. If the harvesting of forest bioenergy is NOT accompanied by actions to enrich the growing stock and carbon stocks of the forest areas,							

	i. harvesting should involve extending existing rotations							
	10) When the extension of existing rotations is not involved, and the harvesting of forest bioenergy DOES NOT exclusively involve the extraction of what otherwise would be regarded as harvest residues, a. there should be valid positive external reasons for the changes in forest management (the changes would have taken place anyway)							
	11) When the extension of existing rotations is not involved, AND the harvesting of forest bioenergy exclusively involve the extraction of what otherwise would be regarded as harvest residues, the following measures should apply: a. if the residues include stumps and roots, there should be valid positive external reasons why the roots are being removed (the roots would have been removed anyway?) b. if the residues DO NOT include stumps and roots, previous forestry practice should involve burning harvest residues on site.				++	+-		
	12) i. if previous forestry practice does not involve burning harvest residues on site, there should be evidence to support the case that the extraction of harvest residues will not lead to significant depletion of the nutrient status of the soil or other deleterious effects on quality of the site (otherwhise HIGH risk)	++	++	++	++	++	v	+-
	13) b. if there are NO valid positive external reasons for the changes in forest management, AND the harvesting of forest bioenergy is accompanied by additional co-production of wood for material products, i. there should be policies in place to ensure the effective recycling or disposal of material wood at end of life. (otherwise HIGH risk)		++	+-	++		++	+-

4.2.1 Comparison of the RED II with other certification schemes and national legislation

From the comparison presented in *Table 3* it is possible to see that the RED II has almost the same coverage as that of the C&I of FSC, PEFC and the Dutch Verification Protocol, the latter being the most comprehensive of all schemes studied. Criterion 5) is classified as 'partly covered' by the RED II, while criterion 7) is not covered in the directive. These criteria, however, are covered by the Verification Protocol.

On criterion 5), for instance, the RED II, Article 29.6.b.(v) states that "management systems should be in place at forest sourcing area level [ensuring that harvesting] maintains

or improves the long-term production capacity of the forest". It does not specify that the productive potential of the forest should not be very low nor specifies how, and if, a lower bound will be estimated. The Verification Protocol, on the other hand, states in Principle 9.1.2 that:

> "The allowable harvest level is based on conservative, well-documented and most current estimates of growth and yield in order to not jeopardise the forest's productive potential in the medium to long term."

On the other hand, on criterion 7), the RED II does not specifically mention leakage/iLUC caused by afforestation. Article 20.7.a.(iii) of the RED II states that the levels of carbon stocks and sinks in forests are required to be maintained and evidence shall be provided proving that LULUCF sector emissions do not exceed removals, which is a way to make sure that LUC does not result in negative impacts. However, although LUC and forest carbon stock changes are addressed, there is no criterion in the RED II addressing *indirect* LUC. This is why the RED II was classified as not covering' this criterion. Likewise, *Table 3* shows that the RED II does not include requirements specifying the handling of residues like stumps and roots, or requirements to avoid afforestation on organic soils. Changes in soil organic carbon could enhance carbon dioxide concentrations, while conversion of land could lead to reductions of soil organic carbon stocks (García et al. 2018, p.2). Principle 4.2.3 of the Dutch Verification Protocol, however, does state that the removal of stumps took place for reasons other than the production of biomass.

Finally, there are two areas that are not covered by any scheme. First, the use of recycled wood and its use as a feedstock for material products. This aspect is important because it is intended to ensure that there is no competition between different uses of biomass, and that the lifetime of the biomass used is extended as much as possible, i.e. that the cascading use of biomass is ensured. Second, no scheme covers the extension of rotations or its relation to forest carbon stocks. Forestry rotations are important because of the effects they can have on the carbon stock of trees, soil and wood products (Kaipainen et al. 2004).

4.3 Stakeholder consultation process

A consultation with relevant stakeholders was carried out to verify the possibility of including more requirements to ensure sustainable practices. It was also used to find opportunities and challenges of implementing these criteria in certification schemes and their

transposition to national legislation. Finally, the possibility of a harmonized set of C&I at the European level was discussed.

4.3.1 Representativeness of the consultation

The level of response to the consultation is considered satisfactory. The stakeholders interviewed are highly relevant experts including scheme owners, certifiers or experts from various NGOs, all with different areas of expertise, which have provided a varied range of answers. It has to be noted, however, that most respondents belong to either the Netherlands or Belgium, while opinions from members of other EU countries have not been included. Although initially, a total of 21 stakeholders were contacted for the consultation, only seven replies were obtained.

All the respondents to the questionnaire answered all questions included. The interviewees, answered the questions from the questionnaire and additional open questions, providing more detailed comments. These comments allowed to get a broader picture of the current concerns that could not be expressed in the context of the questionnaire meant to cover the comprehensiveness of the RED II and the harmonization potential.

A significant number of respondents provided views on options beyond both the RED II and existing certification schemes, focusing instead on the role of the market and economic policy measures.

Figure 2: Nationality of stakeholders interviewed

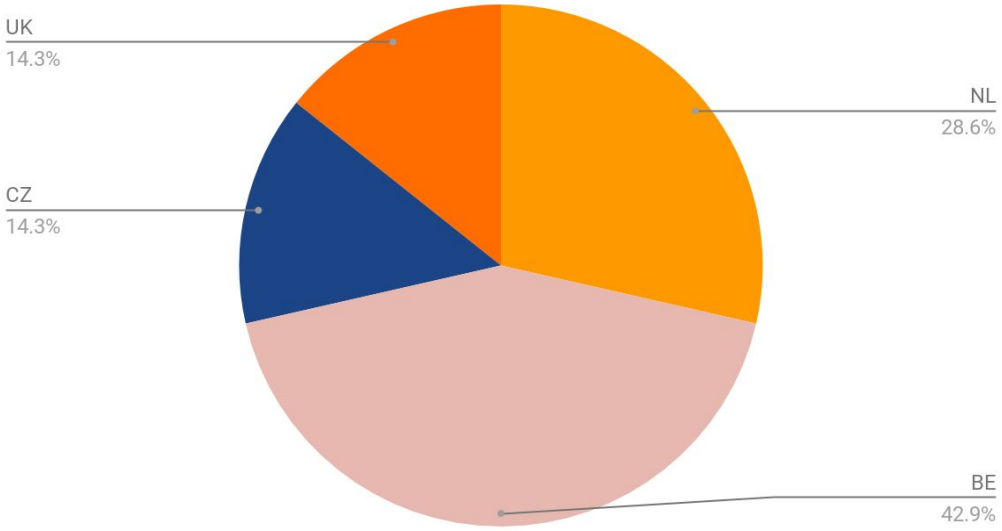
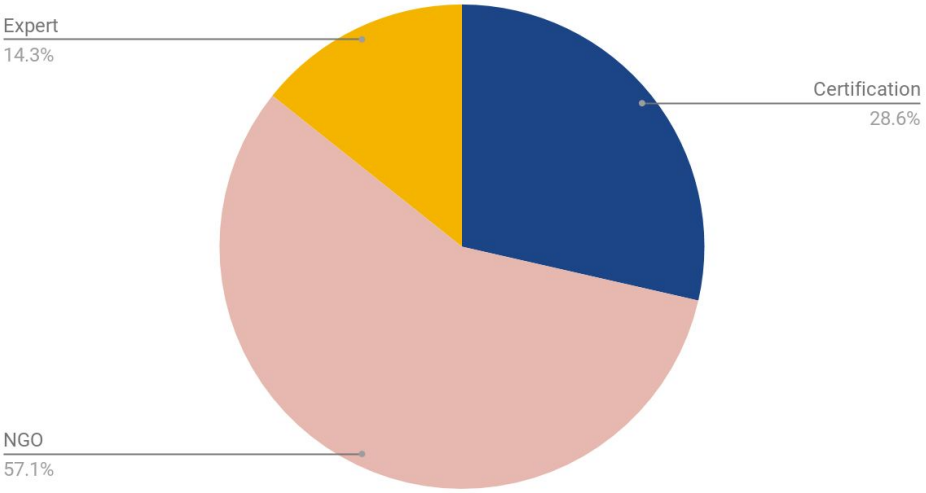


Figure 3: Classification of Stakeholders



4.4 Risks to be addressed

The results from this section are drawn from the discussion of the findings from the previous sections with the stakeholders interviewed. The section will be further divided into two sub-sections. The first one addresses the sufficiency of the RED II for verifying the sustainability of forest biomass for bioenergy. The second one focuses specifically on the sustainability risks that still need to be addressed.

4.4.1 Sufficiency of the RED II

The criteria in the RED II is not considered to be sufficient for guaranteeing sustainability of forest biomass. It is considered that it does not cover all relevant sustainability requirements. In the stakeholders' opinion, the RED II as it is framed now can cause a threat to European forests and to the climate at a global level by causing deforestation outside of the EU. From their point of view, there are several secondary effects that are currently unaccounted for in the RED II and the way it is framed. The most important ones are 1) an increased forest harvesting and a consequential increase on prices for wood products and 2) the large scale use of biomass in inefficient electricity installations and power stations. One of the respondents mentioned that although the RED II does not seem to be sufficiently strict, it would ultimately depend on the adequacy of the indicators included to evaluate the criteria. Moreover, it is emphasized that criteria needs to be easily monitored and enforced, while there should also be adequate verification mechanisms in place to guarantee that feedstock is sustainably sourced in all countries.

Most respondents also believe that although the RED II might not be sufficient, it should be taken as the *minimum* requirements' bar above which MSs can, and are expected to, implement the criteria in their national legislation[25]. In some countries this is indeed the case already. However, having country-specific criteria also means that the requirements in one country might be stricter than in other, resulting in a risk to the EU's internal market. The respondents believe that ultimately, this will not affect trade as producers will have to adapt to the highest standards if they want to remain in the market. Likewise, even with the RED II criteria acting as a bar for minimum requirements, this should imply that national legislation of MSs should be adaptive and try to align to the ambitions of the frontrunner countries. This way, undesired trade effects could be controlled and reduced.

4.4.2 Perceived sustainability risks

One of the main concerns related to sustainability has to do with the fact that burning forest biomass is assumed to be carbon-neutral. This leads to an inaccurate accounting of the emissions resulting from burning biomass and of the emissions in the land sector. The overall

[25] The RED II, (94) states that MSs can include stricter sustainability and GHG criteria for biomass fuels. However, the same does not apply for bioliquids.

perception is that without sufficient restrictions on biomass use, it cannot be carbon neutral. Likewise, it is perceived that focusing on forest management will not necessarily guarantee the sustainability of bioenergy. Instead, it would be necessarily to look into and restrict the kinds of feedstocks that can be used. In fact, all respondents agree that it is better to have stricter criteria even though it would mean that less feedstocks can be used. Section 4.2 is indicative of some of the risks that can arise from the use of biomass[26]. If these risks are to be avoided, it is possible that the use of some types of feedstocks would have to be restricted. It has already been identified that the use of roundwood, stumps and roots is one case in point.

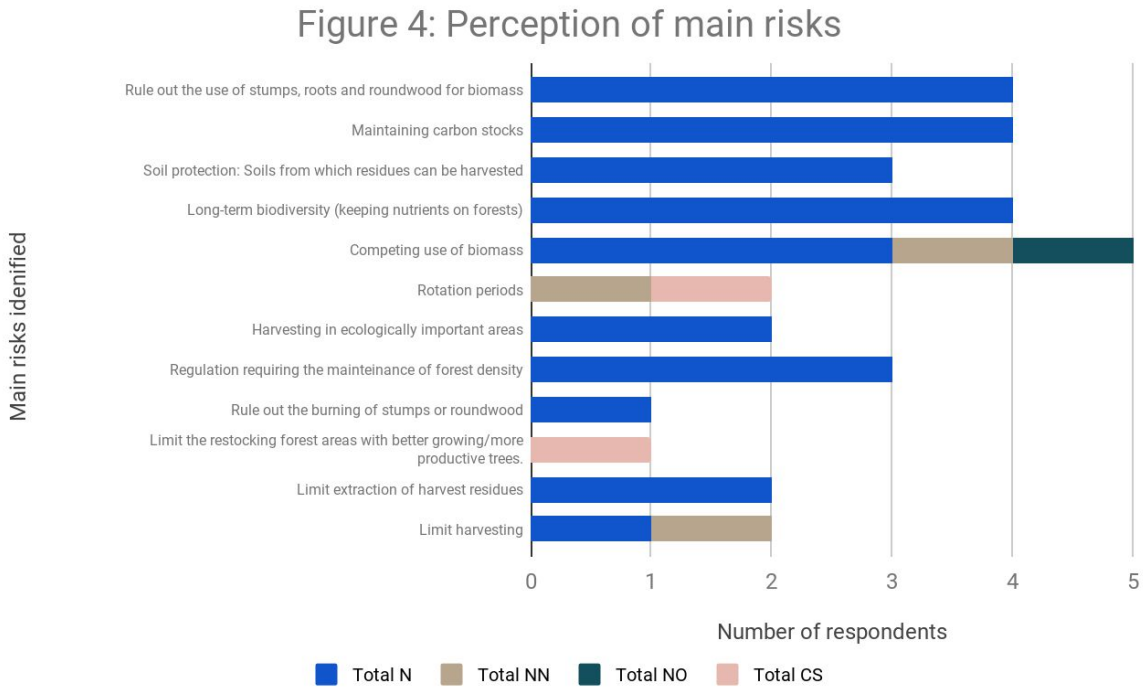


Figure 4 shows the main risks perceived by the stakeholders. The answers were recorded for whether criteria on the topic was considered *Necessary* **(N)**, *Not necessary* **(NN)**, *Needs other measures (e.g. economic, political)* **(NO)** and *Needs to be adapted to country-specific conditions* **(CS)**.

It is possible to see that there is a strong concern on the lack of criteria regulating the types of feedstocks that can be used for bioenergy. Four out of the six stakeholders interviewed mentioned that there is a need for criteria ruling out the use of stumps, roots and roundwood for biomass. There was a strong emphasis on limiting and, if possible, avoiding

[26] However, it is important to note that the decision tree for high risk sources is intended to exemplify that risks of GHG emissions are not only dependent on the type of feedstock used but on the way a whole range of actions are taken during the harvesting and cultivation of said feedstocks.

the extraction of harvesting residues and on ensuring that waste residues are used only as a last resource. Most stakeholders mentioned that there should be requirements in place that would ensure that biomass is not harvested specifically for bioenergy use whilst being deemed a residue. The respondents also mentioned that the RED II should include criteria disallowing the use of stumps and roots under all circumstances, even if they would otherwise be removed or burned. Overall, there was a strong opinion that the extraction of residues from a living forest should be controlled through requirements for the maintenance of carbon stock and soil nutrition balance and for supporting biodiversity. In fact, the maintenance of carbon stock and long-term biodiversity are the two other main sustainability concerns among the respondents (*Figure 4*).

Figure 4 shows that although the cascading use of biomass is perceived as a risk, there are mixed opinions in the way it should be addressed. Most respondents think that there is a need for criteria in the RED II that would (i) control the competing uses of forest biomass and (ii) restrict its volumes. One respondent, however, believes that criteria on the cascading use are not necessary, and that it would ultimately be market dynamics which determine the final use given to biomass. They emphasized that the effect of subsidies is questionable since they create an unlevel playing field for other biomass uses and therefore do not allow the market to decide independently. The last respondent believes that a combined approach is the best way to ensure that sustainable biomass is used in the most optimal way. In their opinion, an optimal utilization can be enforced through taxation and subsidies, while criteria should be employed if these two are not sufficient. The respondent also mentioned that criteria to determine what is optimal are: (i) the time that the sequestered carbon is taken from the atmosphere, (ii) the value of the whole chain of products and (iii) the availability of alternatives for utilization. As a concluding remark, regulations on the competing uses of biomass are deemed necessary since an increase in its use for bioenergy will decrease its availability for material uses. This could in turn result in more carbon intensive materials being used.

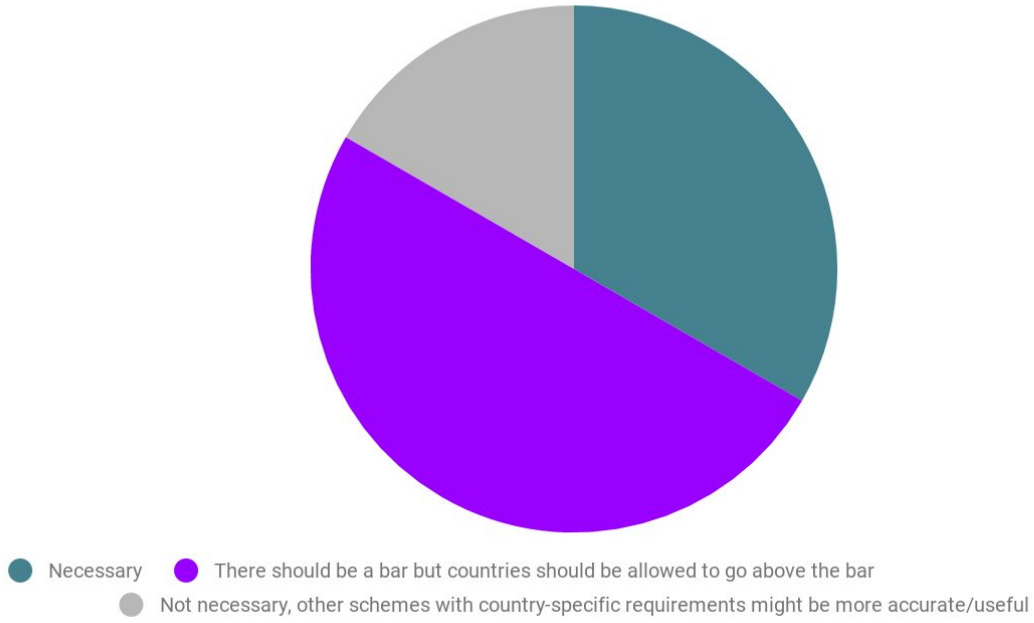
Finally, rotation periods are not considered as a major risk, and if anything, it is considered that criteria should be country specific. In the Netherlands, for instance, rotation periods are strongly dependent on the breeding season of birds and as such it is regulated by national law. This case exemplifies the fact that country-specific criteria are sometimes necessary to tackle country specific issues and comply with national law meant to control

them[27]. In cases as these, the harmonized criteria would be less accurate in regulating a certain practice.

4.5 Harmonization possibilities

The majority of the respondents believe that RED II should set a bar, while national legislation should be allowed and encouraged to include stricter criteria (*Figure 5*). The respondents acknowledged the fact that this would result in some countries having stricter criteria than others. However, this was not seen as a problem as long as the different frameworks adapt to the aims of the RED II. Differences in the criteria in MSs' national legislation was in fact seen as an incentive for producers to become more sustainable in order to continue supplying to the countries with the most strict standards. As long as harmonization does not lead to weakening of criteria in member states, it can have a positive impact on all the main sustainability concerns such as biodiversity, soil and air quality, among others. The main concern, thus, is that a harmonized set of criteria is adaptive and follow the ambitions of frontrunner countries. This way, the most comprehensive requirements will be looked up to and pursued.

Figure 5: Opinion on the necessity of a EU-wide harmonised set of criteria



[27] For instance, criteria in PEFC Netherlands has been adapted to comply with Dutch national law.

A harmonized set of criteria is also perceived to be beneficial because it would reduce mitigation costs and provide stability for the industry, which would not need to adapt to various and different requirements. Ideally, the system will also be less bureaucratic. Harmonized criteria would also facilitate trade between MSs. There will be, of course, side effects resulting from a harmonization of criteria, however, most of these would only be a problem during the initial, adaptation stages. These include, among others, a rise in the price of biomass for material use and for bioenergy and a disbalance between demand and supply[28].

Finally, it is worth noting that there are some benefits in framing criteria at national level: a scheme owner commented that since the scheme is created to adapt to country-specific risks and circumstances, there are some concerns that are applicable to the Netherlands, for instance, but will not necessarily apply for other EU countries. This is the case of rotation periods and the breeding seasons of birds, which are protected by national law.

[28] People will be incentivized to consume more sustainable biomass and products, but producers will be discentivated to produce biomass at higher costs.

5. Discussion

5.1 Research limitations

There are four main limitations for this research. First, the research is constrained by the definition of sustainability used and the requirements it was defined to include. These are only minimum requirements for sustainability, which means that even compliance with those requirements could lead to the use of unsustainable sources. Moreover, even if there was already an overarching definition of sustainability and its requirements, this would have to be constantly revised to adapt to the new scenarios. As the world changes and more knowledge is gained, certain practices that are currently considered to be sustainable, might be discovered to be actually unsustainable. Therefore, it is worth emphasizing that the minimum sustainability requirements included in the definition of section 1.4.2 are valid under current knowledge, but might change in the future.

Second, the RED II was only adopted in December 2018. Although there are already some efforts towards the creation of schemes that could be recognized by the EC for compliance with the RED II, there are still no schemes that have gained said recognition. It is possible that, despite their coverage, the schemes reviewed in this study will not be recognized by the EC. It is also possible that there will be better and more comprehensive schemes developed in the period during or after this thesis is done. The schemes analyzed in this study were chosen due to their areas of coverage (PEFC and FSC) and because they are ahead of other schemes in providing criteria for the use of solid biomass for bioenergy (UK RTFO and Dutch Verification Protocol). Also, some of these schemes have already been recognized by the EC for compliance with the RED I (RSB and ISCC), for which it is expected that their criteria will be extensive and comprehensive. Therefore, the schemes chosen are expected to provide a good sample for the study of sustainability criteria at the moment. However, it is worth emphasizing that the results found through this research thesis are subjected to change as schemes and national initiatives get EC certification for compliance with the RED II.

Third, most of the schemes that will be reviewed cover the sustainability of biomass for the production of heat and electricity but not for the production of bioenergy. However,

this study focuses on the sustainability criteria for feedstock on the cultivation and harvesting stages rather than on the entire supply chain. This means that the same sustainability criteria could be applied for revising the cultivation and harvesting of biomass that would be used for the production of bioenergy. It is important to bear in mind that biofuels are still not produced from forest biomass, so this research focuses on tackling the possible future risks. This also implies a limitation, as the real extent to which forest biomass will be harvested for the production of bioenergy is unknown and can only be estimated.

The final limitation is related to the stakeholder consultations. Originally, it was expected to be able to talk to a more extensive number of NGOs, certification schemes, and other experts. However, despite reaching to them there was not much responsiveness on their part. Furthermore, there was not a wide geographical variety among the interviewees, which might impose a slight bias in their opinion but also limit their knowledge to the conditions of these two neighboring countries (The Netherlands and Belgium). Finally, the information obtained from the interviews was limited to the area of expertise of the stakeholder interviewed. Since the interviews were conducted with stakeholders with interest and knowledge in different areas, it is expected that there will not be a single focus, so that information gaps will be covered. However, there is always the risk that, due to the small number of stakeholders interviewed, their expertise directs the focus in one direction while leaving other areas untouched. That is, there is still the possibility that some of the risks related to the sustainability of forestry biomass have not been mentioned or are not considered important by the group of stakeholders interviewed, even if they would have been considered relevant by other stakeholders.

5.2 Theoretical Implications

Previous research studies have focused on identifying the main risks and barriers for the introduction of advanced biofuels (Uslu et al. 2017) and on the risks and benefits of bioenergy (SWD (2016) 418). This study took these and other research studies as a basis from which the identified risks were assessed. The scientific relevance of this research lies on the fact that it goes above identifying the main risks, barriers and benefits and it asks stakeholders why these are perceived that way. Therefore, while previous research studies

asked what are the main concerns, this study explores those concerns to focus on why and how they can be addressed.

One of the most significant insights obtained from the interviews was that as a conceptual idea, a harmonized set of criteria could reduce administration costs and establish a stable framework on which producers can rely. However, stakeholders mentioned that one of the main problems of a harmonized set -if it is to be as the current RED II- is that it is heavily focused on how forests can provide biomass for the energy sector rather than focusing on climate change mitigation. There is also a perception that some of the main problems should be addressed through means other than criteria, such as taxation and subsidies, as part of a circular economy package or as part of waste legislation.

It is however important to keep the results of the consultation in perspective. That is, not as absolutes but being mindful that the statements and opinions of the interviewees are to a greater or lesser extent, influenced by their area of expertise and particular interests. For example, most interviewees mentioned the need for stricter criteria and the importance of banning the consumption of certain kinds of feedstocks such as stumps and roots, but also roundwood. However, this thesis emphasizes the fact that it is not specific types of feedstocks which need to be regarded as risky. Instead, it is the combination of feedstock type, forest management and wood use practices which would ultimately determine risky practices. Therefore, true sustainability cannot be guaranteed simply by banning the use of feedstocks such as stumps and roots. This statement does not attempt to undermine their importance for soil quality, its nutrient status and long-term biodiversity. It just aims to point to the fact that there might be scenarios in which specific circumstances would make the use of stumps and roots for bioenergy the most sustainable pathway available.

Finally, this research studied the sustainability criteria for forest biomass for bioenergy. That means that all types of bioenergy, electricity, heating and cooling and (advanced) biofuels, were looked at as part of the same package. At the moment, there are no advanced biofuels created from forestry biomass, but it is possible that this will be the case in the future. Future research could focus on criteria required specifically for the production of advanced biofuels and the different conversion pathways. That is, further research could focus on other steps of the supply chain, thereby also focusing on the technological conversion pathways.

5.3 Policy implications

The main policy implication following from this research is the need to extend the criteria in the RED II. Some of the sustainability requirements that were found to be unaddressed could be included in future legislation to guarantee and incentive good and sustainable practices. An important insight from the stakeholder consultation is the need of more criteria on forest biomass use and the need to improve the requirements regulating emissions in both the forest and energy sectors, but also regulating the harvesting of biomass for material uses. In the opinion of most, only with sufficient restrictions could forest biomass use be carbon neutral. However, not only more restrictions are required. In order to guarantee and stimulate sustainability, green practices should also be incentivized, both for suppliers and for consumers. One way of doing so is through economic incentives. Likewise, the RED II would benefit from including verification and monitoring mechanisms. This is particularly important to (i) guarantee that criteria are met and (ii) to control the sourcing from countries with high risk of unsustainability. Moreover, the inclusion of said mechanisms would easen the adoption of a EU-wide harmonized set of criteria, and consequently reduce administrative costs.

Second, despite the benefits of a EU wide harmonized set of criteria, its feasibility can be rather complicated. Any target set in the RED II needs to be incorporated into MSs national legislation. For countries which have already developed comprehensive legislation regarding national forests, any mandatory requirement from the EU could be seen as violating the principle of proportionality. Therefore, even when harmonization of criteria would be beneficial and preferred by most countries, it might encounter opposition by some EU MSs. In this regard, two possible scenarios can be expected. First, if the criteria is comprehensive enough so that real sustainability can be guaranteed and stimulated, its implementation would have to deal with opposition from MSs who perceive that said criteria could be better implemented at national level and does not require union action. Second, this problem could be avoided by setting the criteria as a minimum standard above which countries can set their own criteria. However, this means that, more often than not, only the minimum required would be implemented. Of course, it is possible that market dynamics would lead producers around the EU to adhere to the highest standards so that they can comply with the

requirements in all EU MSs and therefore avoid a fractionalization of the internal market. However, it would take some time for this to happen. Meanwhile, most countries would limit themselves to establish criteria that complies with the minimum requirements only.

Third, most stakeholders believe that competing uses of biomass can be addressed by other means than criteria alone. However, what is really necessary is to focus on providing more information for a better decision making. This includes information on the origins of the biomass, the type of feedstock (primary or secondary), its possible competing uses and why it has ended in one sector as opposed to others. With better information it could be possible to reduce unsustainable use of biomass. This also implies, however, that regulations regarding biomass' origins, its potential uses and the kind of forest management practices involved in their production should be applied and enforced to all markets and not only to the (bio)energy sector. If sustainability requirements only apply to the bioenergy sector, this would create an unlevel playing field for the different sectors using biomass: sectors with less strict criteria would use unsustainably produced biomass. For advanced biofuels this represents a great disadvantage. At the moment, the market introduction of advanced biofuels has to break other barriers. Making the costs of biomass for their production higher, especially when compared to other sectors, would slow down advanced biofuels' market introduction even further.

6. Conclusions

This research focused on identifying the criteria necessary to demonstrate the sustainability of forest biomass for bioenergy in the EU and whether the inclusion of this criteria in a EU-wide harmonised set is the best approach. It takes the RED II as a base for analysis as the directive provides a minimum set of sustainability criteria that needs to be included in the national legislation of the EU MSs. The RED II is then compared with voluntary schemes and national initiatives. Some of these have already been developed and include more ambitious sustainability targets, while others are tailored to comply with the RED or with the national requirements of each MS.

A state-of-the-art set of sustainability criteria that are relevant for bioenergy from forest biomass was obtained from existing literature. Then, sustainability criteria in the RED II, existing certification schemes and national initiatives were compared with this set of (minimum) sustainability requirements (approach 1). Secondly, the RED II, certification schemes and national initiatives were analyzed in the context of the Decision Tree (approach 2). The objective of this second stage was twofold. First, it intended to identify the strengths and weaknesses of the RED II. Second, it intended to use the most comprehensive schemes as a guideline to find how and with what criteria the sustainability risks that are not covered in the RED II can be addressed. Finally, a stakeholder consultation was carried out to identify why and how the risks of forest biomass for bioenergy need to be tackled to ensure sustainability, and whether it is possible to do so through a EU-wide harmonized set of criteria like the RED II. This paper thus aimed to identify the criteria necessary to demonstrate the sustainability of forest biomass for the production of bioenergy at EU level and to find whether a EU-wide harmonized set of sustainability criteria is an adequate means to enforce the inclusion of said criteria. The following conclusions can be drawn from this research:

1. The RED II is intended to set the *minimum* sustainability requirements for EU MSs to follow. However, it is difficult to determine what can really be considered as a minimum, especially since new evidence could change the current understanding. As can be seen in this study, for instance, the RED II by itself is not sufficient to guarantee that sustainability risks are avoided in all circumstances. In some cases, other approaches like the Decision Tree can

be indicative of the criteria and requirements that would also be necessary to guarantee sustainability. As a standard setting the minimum requirements, the RED II by itself thus cannot guarantee full sustainability. More importantly perhaps, it cannot *stimulate* sustainability. As it sets the minimum requirements, the schemes that would be drafted to obtain EC approval for compliance with the RED II would most likely be tailored to address those requirements set in the directive while overlooking at other important sustainability aspects.

2. Most of the relevant sustainability criteria found in the literature research are already included in the RED II. However, the RED II, as it is currently framed, is not sufficient to tackle the main sustainability risks related to the use of forest biomass for bioenergy and it does not include enough criteria to guarantee that the use of forest biomass is carbon neutral. Whether or not the inclusion of more criteria is feasible is also questionable. Particularly when taking into account the principle of proportionality and the fact that some EU MSs already have national laws regulating forestry.

3. The stakeholders identified five risks which they deem are not sufficiently addressed in the RED II and require the inclusion of more comprehensive criteria. These are:

a. Better accounting of emissions in the forest sector.

b. Stricter requirements to avoid the production of biomass in lands with high biodiversity value.

c. Stricter requirements to minimise the negative impacts on soil quality and biodiversity

d. Restrictions on the use of certain feedstocks (e.g. roundwood).

e. Forbid the burning of stumps and roots and their use as biomass for bioenergy.

However, feedstocks by themselves are not inherently "risky", but it is instead the combination of feedstock type, wood use and forest management practices which determine the risk. Therefore, clauses *d)* and *e)* should not be included in the RED II. Instead, a more comprehensive approach which evaluates different scenarios and their pathways would be required when regulating the use of these feedstocks.

4. It is often the case that standards set limitations and forbid certain practices. However, ensuring sustainability does not only depend on the practices that are avoided but also on

those that can be stimulated. At national level, this could be done through financial incentives such as tax reductions. This would incentive the production and consumption of sustainable biofuels and sustainable biomass. Other incentives at the harvest level could be achieved by setting various possible combinations of rotation periods that would result in positive impacts both in terms of sustainability and for the market production. Likewise, there should be criteria specifying the soils in which extraction is allowed and should moreover be stimulated. In countries where fires are an issue, such as in Portugal and in Spain, biomass extraction should be encouraged, as it would be more economically but also sustainably productive to make use of biomass that would otherwise be lost. Additionally, it should be encouraged that the harvesting of forest biomass should be accompanied by actions to enrich the growing stocks of the forest areas. Furthermore, there should be clearer guidelines mapping the origin, type and possible competing uses of the feedstocks. That way, producers and consumers can make more informed and sustainable decisions regarding the cascading use of biomass. Finally, although MSs are allowed to include stricter criteria in their national legislation regarding the use of biomass for heat and power, the same should be possible for the criteria regarding the use of biomass for the production of (advanced) biofuels.

5. The certification schemes and national initiatives analyzed were not created to comply with the RED II, but were rather a response to country specific conditions (imports of solid biomass) or were created with a different purpose (e.g. PEFC for forest management). Therefore, some sustainability issues are better addressed by these schemes and national legislation than they are by the RED II. When sustainability requirements are more comprehensive in certification schemes and national legislation, these could set the guidelines for the RED II to follow. However, it is important that these certification schemes and national initiatives are also revised and extended to include criteria on the points mentioned in point 2, as none of them included requirements for all the above mentioned criteria.

6. A EU-wide harmonised set of criteria could establish a stable framework for producers and reduce administrative costs. However, the experts interviewed agree that any harmonised set (in this case, the RED II), should set a bar above which MSs can implement their own criteria. This means that national legislation should, ideally, include stricter criteria than the one found in the RED II[29] while still aligning to the directive's aims. Therefore, even with a harmonised set of criteria there would be differences in the specific requirements at

[29] RED II, (94) states that MSs can include stricter sustainability and GHG criteria for biomass fuels.

national level. Biomass producers would have to adapt to these requirements and for that, the RED II should be capable of adapting to the ambitions of the frontrunner countries.

7. Some of the risks identified in the literature and analyzed through the two-method approach described at the beginning of this section, could be better tackled by means other than criteria. Therefore, although these risks require attention and legislation guiding its action, this legislation should be part of different packages, like a circular economy package or waste legislation.

8. Finally, a EU-wide harmonised set of criteria should include adequate monitoring and verification mechanisms to ensure that feedstocks are sourced adequately in countries with high risk of unsustainability.

7. APPENDIX

7.1 List of activities that may be classified as 'intensification of harvesting'.

Obtained from Forest Research 2014 (p.66-7)

- Increased biomass (more trees) removed during thinning.
- Adjustment of rotations applied to the felling of trees or stands closer to a productive optimum.
- Introduction of harvesting in forest areas previously not under management for production
- Increased extraction of biomass in harvesting operations (e.g. harvesting of so-called 'harvest residues' when previously this was not carried out).
- Increased density of tree planting/regeneration following harvesting, to enhance early productive potential.
- Fertilization of poor sites, or drainage of wet sites stimulating the increment.
- Restocking forest areas with better growing/more productive trees.
- Forest area expansion, allowing increased harvesting in the existing forest or new forest areas.
- Enrichment of areas of forest 'scrub' to 'high forest' with greater productive potential.

7.2 List of EC recognised certification schemes

1. ISCC (International Sustainability and Carbon Certification)

2. Bonsucro EU

3. RTRS EU RED (Round Table on Responsible Soy EU RED)

4. RSB EU RED (Roundtable of Sustainable Biofuels EU RED)

5. 2BSvs (Biomass Biofuels voluntary scheme)

6. Red Tractor (Red Tractor Farm Assurance Combinable Crops & Sugar Beet Scheme)

7. SQC (Scottish Quality Farm Assured Combinable Crops (SQC) scheme)

8. Red Cert

9. Better Biomass

10. RSPO RED (Roundtable on Sustainable Palm Oil RED)(Expired 14/12/2017)

11. Biograce GHG calculation tool (expired 21/06/2018)

12. HVO Renewable Diesel Scheme for Verification of Compliance with the RED sustainability criteria for biofuels (expired 30/01/2019)

13. Gafta Trade Assurance Scheme

14. KZR INIG System

15. Trade Assurance Scheme for Combinable Crops

16. Universal Feed Assurance Scheme

17. U.S. Soybean Sustainability Assurance Protocol (SSAP)

18. Austrian Agricultural Certification Scheme

7.3. Two-approach research framework

The research for this thesis was divided in phases, each one covering a sub-question of the major research question. The research framework of *Figure 1* will be followed:

Figure 1 Research framework

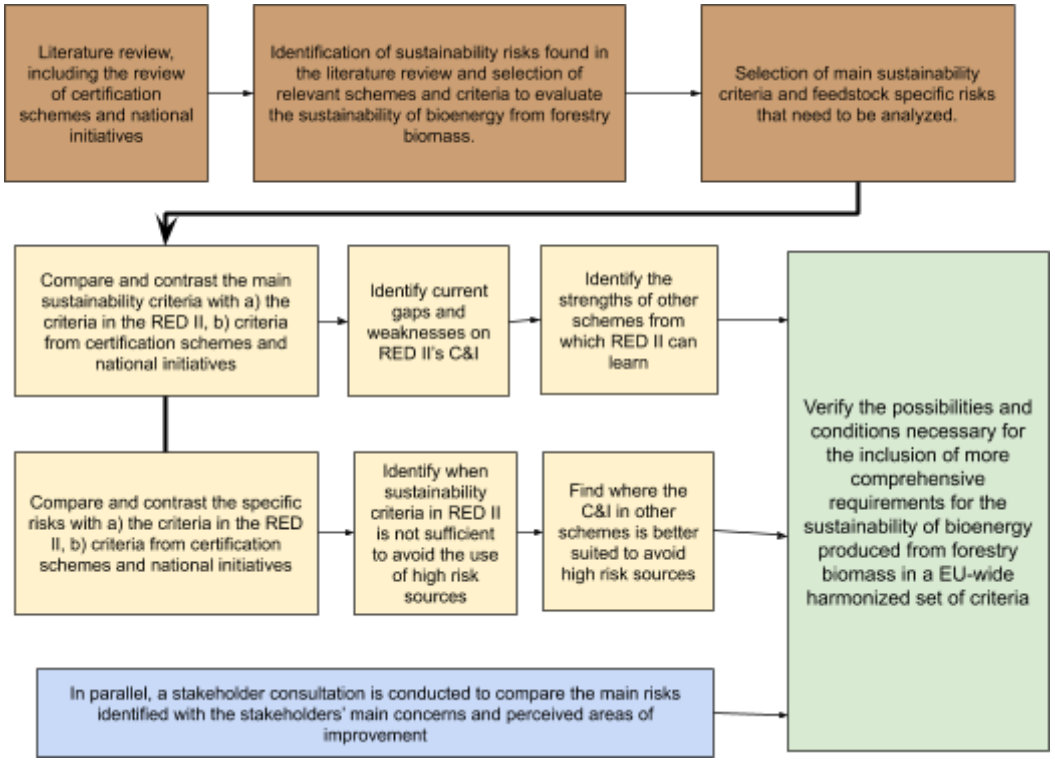


Figure 2: Approach 1: Evaluation of certification schemes compared with RED II

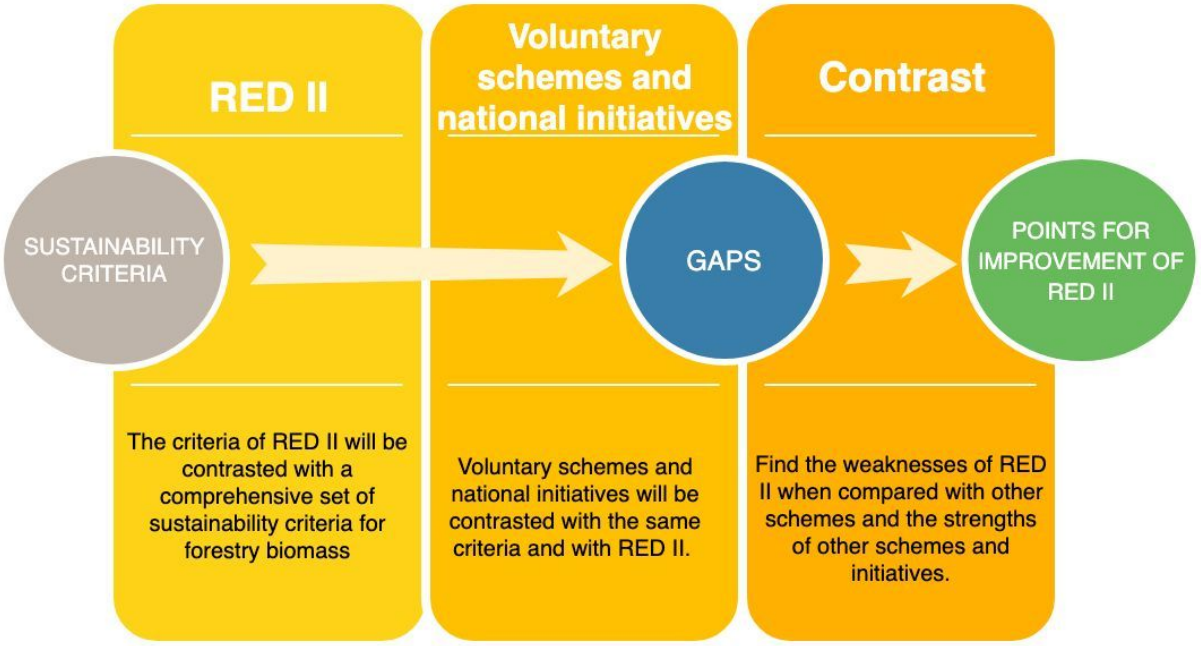
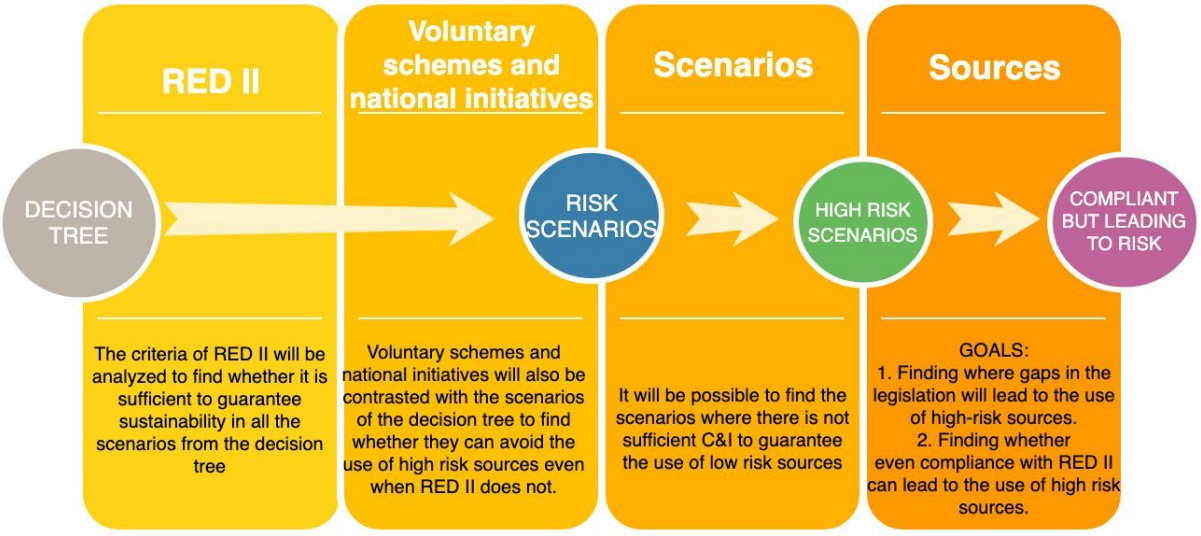


Figure 3: Approach 2: Evaluation of RED II and certification schemes related to the sustainability risk of the sources



7.4 Approach 1: Coverage of minimum sustainability requirements

A table showing the specific articles, criteria and indicators covering each of the minimum requirements can be seen in a Sheets document that can be accessed through the following link:

https://docs.google.com/spreadsheets/d/1IxmO59PGJnTH718ifr_eneYCGu9YcGeFU8qByzKghd0/edit?usp=sharing

7.5 Approach 2: Decision tree and sustainability risk of GHG emission requirements

A table showing the specific articles, criteria and indicators covering each of the pathways leading to the use of sources with low or high risk of GHG emissions, can be seen in a Sheets document that can be accessed through the following link:

https://docs.google.com/spreadsheets/d/1dnv6aZvM4Z8JWygt7Y-KkFp40hpfmlV4MCJ9ooFdMsI/edit?usp=sharing

7.6 Disaggregated sustainability and GHG criteria

The criteria and indicators from the RED II, the certification schemes and national initiatives analyzed can be found by accessing the link below. The criteria for each scheme has been disaggregated into individual statements.

https://docs.google.com/spreadsheets/d/1oDgfjuedazpts5EfE3pMDYddOHc7oM8HhfaHp3OukT8/edit?usp=sharing

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