Report

Certification Criteria for Sustainable Biomass for Energy

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EXECUTIVE SUMMARY

Biomass fuels offer many new opportunities, but if not managed carefully, they may also carry significant risks. Establishing certification schemes is a possible strategy to ensure that bioenergy is produced in a sustainable manner. Certification could become a prerequisite for biomass producers to obtain or secure positions in the EU market as well as globally. Biomass in this context is non-fossil material of biological origin from forest, energy crops, agriculture and different kind of wastes.

The role of certification efforts in this report is to participate in creation of a global market for sustainable biomass fuels and in extension sustainable bioenergy. The proposed system has a hierarchical structure in which the overall task of avoiding unsustainable biomass is translated into three principles. Each of the principles is designed to ensure that biomass is produced in accordance with sustainability requirements. The goal of the principles is to promote environmentally responsible, socially beneficial and economically viable management of the biomass-for-energy production systems, by establishing a worldwide standard of recognized and respected Principles of Biomass Certification System. Each principle is in the next hierarchical level guaranteed by a number of workable sustainability criteria.

PRINCIPLE 1: Biomass shall be produced in an environmentally responsible way. Principle 1 is covered by the following criteria: the use of chemicals; forest/land management planning; forest/land monitoring; maintenance of biological diversity; protection of areas of high ecological value; protection of the soil and prevention of erosion; protection or enhancement of water quality and regeneration following harvesting.

PRINCIPLE 2: Sustainable management of social capital. Principle 2 is covered by the following criteria: recognition and respect for the customary and traditional rights of indigenous/local people; protecting the health and safety of employees; provision of information to increase public awareness of forest management planning, forest operations and/or forest outcomes; protection of areas of particular historic, cultural or spiritual value and the rights of children.

PRINCIPLE 3: Biomass production shall be economically viable. Principle 3 is covered by the criterion: maintenance or enhancement of the economic viability of operations.

Setting up a certification system involves the process of development of sustainability criteria and their evaluation. The previous experience in the forestry sector was judged to be most relevant. The existing Forest Certification Schemes were evaluated against environmental sustainability through 15 indicators and against social and economic sustainability through 19 indicators identified from literature. The set of principles and criteria suggested is the final result of sampling, evaluation, filtering and completion following a review of literature, analysis of the activity and experience in forestry as well as in the other sectors.

At this time, a clear certification of traded biomass is needed. However, there is no international consensus on universal sustainability requirements and the inclusion or exclusion of certain exemplary criteria is one of the difficulties of setting up a certification scheme. The analyses of the existing certification systems and biomass sources as well as the review of technical and non-technical barriers published reveal that while the implementation of compulsory sustainability criteria and certification systems is possible, compulsory criteria cannot cover all aspects of sustainable biomass production. Development of various certification schemes for sustainable biomass production is taking place very fast. In the international arena, the one of the first lists of criteria was developed for the International Energy Agency by Lewandowski and Faaij in 2006. International organizations, e.g. the Food and Agriculture Organization of the United Nations (FAO), the Global Environment Fund

(GEF) and the United Nations Conference on Trade and Development (UNCTAD) have started projects to develop sustainability standards as well, but these indicators are often rather vague and have not yet been checked against feasibility criterions.

Despite a lot of initiatives and publicly respected certification schemes, such as energy crop certification schemes, certification systems in the power sector as well as certification systems related to emissions trading and certification programs in agriculture, no existing certification scheme has sufficient coverage to be adopted for general biomass certification. There are also other rules that will impact biomass production that are more of internal nature, e.g. for the European Union member states. Therefore, an important issue for the development of certification schemes for sustainable biomass is a harmonization of the many different initiatives which currently exist or are being started.

Biomass covers a large diversity of sources. Forest resources are in many regions relatively large and regionally provide good bases for development of bioenergy systems. Wood for energy is prioritized in energy policy and to an increasing extent supported by forest policy. More than 80% of primary bioenergy production in the EU relies on wood-based feedstock, compared to only 13% from municipal solid waste and the remaining 7% from other sources. Solid woody feedstock is the only feedstock well suited for the most of conversion technologies available at present.

Overall, rising energy prices, geopolitics as well as concerns over increasing oil prices, national security, and the impacts of greenhouse gas emissions on global climate change are driving large-scale efforts to implement bioenergy alternatives. Markets for energy generated from biomass are expanding at a fast pace. Certification programs developed to deal with forest products could be applied to biomass for energy production systems. However, some questions remain unsolved. Thus, such systems will only be effective if there is extensive international coordination. Otherwise, there is a risk of creating a complexity of multiple certifications and registrations.

ABSTRACT

Rising energy prices, geopolitics as well as concerns over increasing oil prices, national security, and the impacts of greenhouse gas emissions on global climate change are driving large-scale efforts to implement bioenergy alternatives. Biomass fuels offer many new opportunities, but if not managed carefully, they may also carry significant risks. Biomass in this context is non-fossil material of biological origin from forest, energy crops, agriculture and different kind of wastes.

Markets for energy generated from biomass are expanding at a fast pace. Sustainable use of biomass as an energy source requires comprehensive management of natural, social and economic resources. Establishing certification schemes is a possible strategy to ensure that bioenergy is produced in a sustainable manner.

At this time, a clear certification of traded biomass is needed. Different types of certification systems, international standards and initiatives relevant to biomass production already exist. However, an analysis of the experience gained with these systems, reveal that they are not effective to monitor and manage all effects of biomass production for energy. There is no international consensus on universal sustainability requirements and the inclusion or exclusion of certain exemplary criteria is one of the difficulties of setting up a certification scheme.

The role of certification efforts in this report is to participate in creation of a global market for sustainable biomass fuels and in extension sustainable bioenergy. In attempt to support the development of an implementable international certification scheme for sustainable biomass production, the existing Forest Certification Schemes were evaluated against environmental sustainability through 15 indicators and against social and economic sustainability through 19 indicators identified from literature. The set of principles and criteria suggested is the final result of sampling, evaluation, filtering and completion following a review of literature, analysis of the activity and experience in forestry as well as in the other sectors.

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PRINCIPLE 3: Biomass production shall be economically viable. Principle 3 is covered by the criterion: maintenance or enhancement of the economic viability of operations.

The proposed system has a hierarchical structure in which the overall task of avoiding unsustainable biomass is translated into three principles. Each of the principles is designed to ensure that biomass is produced in accordance with sustainability requirements. The goal of the principles is to promote environmentally responsible, socially beneficial and economically viable management of the biomass-for-energy production systems, by establishing a worldwide standard of recognized and respected Principles of Biomass Certification System. Each principle is in the next hierarchical level guaranteed by a number of workable sustainability criteria.

PREFACE

The information presented and analyzed in the present report largely originates from four groups of sources: (A) Presently valid forest certification standards under the Programme for the Endorsement of Forest Certification (PEFC) and Forest Stewardship Council (FSC) schemes available online; (B) Comprehensive list of records from information survey that share factors of "Certification" and "Certification and Sustainability" within renewable bioenergy results; (C) EU forest policy documents; (D) the Comparative Matrix of Forest Certification Schemes (CMFCS)).

Through a review of existing sources, this report synthesizes information in the field of certification criteria for sustainable biomass. Its aim is to contribute to the international attempt to regulate the production and trade of biomass for energy by establishing a set of universal certification criteria for sustainable biomass for energy. The report more specifically gives an overview of the existing forest certification schemes and of the existing sustainability principles that should satisfy the demands of various stakeholders and requirements for sustainable management of different forms of biomass sources such as forests, agricultural land, waste and other. The study is delimited to production and trade of biomass fuels, not the use of them. The focus of this report – the minimum universal certification criteria for sustainable biomass for energy - might be interesting not only to EU stakeholders, but as we believe the outcome can generally be valid for other parts of the world as well. The selected minimum criteria may be regarded as an attempt to evaluate the performance of the universal certification criteria for sustainable biomass for energy and therefore are of course debatable.

The present report was written as a part of the synthesis work within the WBA (World Bioenergy Association) project on Bioenergy, Certification Criteria, Quantifying and Sustainability Criteria & Bioenergy versus Food, Land-use and Water Supply. The research partner of the full project and its coordinator is Johan Vinterbäck, Swedish University of Agricultural Sciences, Department of Energy and Technology. Much of the improvement in this report has been the result of constructive discussions with Mr. Kent Nyström, President of WBA. A number of people from the reference group made valuable contributions to this report. We are deeply grateful to Associate Professor Pål Börjesson, Lund University, Dept. of Technology and Society, Mr Marcos Martin, AVEBIOM, Spain, and Mr Kjell Andersson and Ms Karin Haara, SVEBIO. We wish to thank Mr Magnus Norrby, Svenska PEFC for valuable comments. Financing of the project has been gratefully acknowledged from the Swedish Board of Agriculture.

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I. INTRODUCTION

Rising energy prices, geopolitics as well as concerns over increasing oil prices, national security, and the impacts of greenhouse gas emissions on global climate change are driving large-scale efforts to implement renewable energy alternatives. Among the different forms of renewable sources, biomass (i.e., non-fossil material of biological origin from forest, agriculture, different kind of wastes of other origins) is one of the most common and widespread fuel resources in the world. Traditional use of biomass for energy is the combustion of solid fuels such as firewood, charcoal and agricultural residues for cooking, heating and lighting.

Traditional bioenergy use is generally associated with undesirable side effects of various kinds such as indoor pollution and deforestation. The relative world contribution of traditional bioenergy is, however, projected to decrease during the coming decades, as it is gradually replaced by modern bioenergy, which involves the use of biomass in producing higher value energy carriers such as electricity, upgraded solid fuels, liquid and gaseous fuels, which are more efficient and versatile than traditional carriers. This is in combination with more efficient combustion facilities. Biomass can be used to provide energy in many forms including electricity, heat, and solid, gaseous, and liquid fuels. Biomass fuels (*i.e.*, untreated biomass or biomass-derived gaseous, liquid and solid fuels that have undergone mechanical, chemical, and/or biological processes) can thus be used to produce different forms of energy or energy carriers (electricity, heat and solid, gaseous, and liquid fuels), thus providing the whole range of energy services required in modern society, both locally and in most parts of the world. Overall, energy from biomass is one of the largest and most important renewable energy options at present with a potential to replace fossil fuels. Moreover, the overwhelming research activities identified on bioenergy compared to the other renewable energy types illustrates the role of bioenergy as maybe the most important renewable energy source for the near and medium-term future (*e.g.* Ladanai & Vinterback, 2009).

Markets for energy generated from biomass are expanding at a fast pace, driven by the above mentioned expectations and concerns. Policy makers, business representatives, academics as well as members of civil society have supported bioenergy. Expectations for the coming years indicate a growing increase in the production of biomass for energy for many nations and on a global scale. However, there are both advantages and disadvantages for different actors in biomass fuels utilization compared to energy production from fossil fuels (Stupak *et al.*, 2007a). Generally, cost-competitiveness is central to any technology. To reap the full market value of energy produced from renewables, suppliers need to know how and where and when to sell it. However, other factors also play important roles.

Thus, just as there are multiple goals that can be achieved through sustainable bioenergy production and use, there are also multiple concerns about the impact of bioenergy. Environmental and social impacts arising from the production of biomass have also an influence on the economic implications. Increased production of biomass for energy has the potential to offset substantial use of fossil fuels, but it also has the potential to threaten conservation areas, pollute water resources and decrease food security (Field *et al.*, 2008). Moreover, unsustainable biomass production would erode the climate-related environmental advantage of bioenergy. On the other hand, sustainable development of biomass and biomass fuels, when these are developed in ways that simultaneously help to meet the world's energy needs, protect the environment, and advance the livelihoods of farmers and other land users around the world is the major issue in order to increase the production of biomass and biomass fuels. Sustainable use of biomass as an energy source requires comprehensive management of natural resources such as land and water. More broadly, stakeholders have raised concerns about whether some biomass fuels and technologies are sustainable or not (Weeks, 2004).

There is now emerging evidence that regenerative and resource-conserving technologies and practices can bring both environmental and economic benefits for farmers, communities and nations (Pretty, 2008. p109). Consequently, there is more and more concern across the globe that businesses can be successful while also being environmentally and socially responsible. However, to be protected from some of companies who can cut out the socially and environmentally beneficial aspects of the bioenergy business, companies that are truly responsible need a nonprofit organization that can address this challenge by creating a set of strict standards to protect companies and consumers that seek to work for the greater good. One strategy to manage the above mentioned concerns is to certify that biomass for energy meets certain sustainability criteria. In recent decades, certification has become a popular tool in the environmental arena as a method to influence the environmental behavior of companies.

There is an international attempt to regulate the production and trade of bioenergy by establishing sustainability criteria (*e.g.*, Palmujoki, 2009). The European Union's biomass fuel targets have been bound to the condition that they have to be produced sustainable. The European Commission is currently developing sustainability criteria for biomass fuels (Schlegel & Kaphengst, 2007). The sustainable use of forest biomass for energy, roles and problems in relation to policy, legislation, certification standards, recommendations and guidelines is discussed by Stupak *et al.* (2007a). Sustainability can be supported by certification of substrates' origin (Skambracks, 2007). Certification is judged to be the most suitable instrument for the development of sustainable bioenergy systems. Establishing certification schemes is a possible strategy to ensure that bioenergy is produced in a sustainable manner.

Unfortunately, a perfect bioenergy governance model does not seem to exist. Therefore, a broad debate on the future governance of bioenergy should be stimulated, future research on governance systems may support this debate and the organization of bioenergy markets and governmental policies should be monitored (*e.g.*, Verdonk *et al.*, 2007). Moreover, the development of sustainability criteria and certification schemes for bioenergy production and use should proceed (Hansson, 2009). This report presents and assesses some of the existing certification schemes relevant for sustainable biomass production. The aim of the report is to develop a proposal for certification criteria for sustainable biomass for energy. While forest certification systems are reviewed in detail, other types of systems are reviewed only briefly. The report explores the possibilities for introduction of a global but possibly EU based certification system for energy use of biomass taking into account experiences with existing certification systems and criteria.

II. POLICIES

There is a strong commitment to financing sustainable development and renewable energy generation (Skambracks, 2007). The renewed Sustainable Development Strategy identified sustainable consumption and production as one of the key challenges for Europe (CEC, 2008). However, the future for different bioenergy options is to a large extent determined by multiple policies, both in the EU and in other parts of the world. Government policies play a key role in influencing investments in bioenergy. When carefully balanced with environmental and social conditions, such policies will also determine the long-term viability of these emerging opportunities.

Different methodologies for design of renewable energy policy instruments as well as different governance systems stimulating interest in bioenergy have been suggested and discussed (*e.g.*, Madlener & Stagl, 2005; Verdonk et al., 2007, Frombo et al., 2009). These policies have influenced the development of bioenergy and increasing bioenergy use has strong political support at present (*e.g.*, Hansson, 2009). However, many of these policy instruments suffer from the shortcoming that they do not explicitly account for the often widely varying environmental, social and economic impacts of the technologies concerned (Madlener & Stagl, 2005). More recent policies for renewable energy have in general been motivated not only by environmental externalities and activities aiming at finding solutions to climate change problems but also from a security of energy supply perspective, an important issue not least on the European energy agenda (*e.g.*, European Commission, 2006). Recently, a methodology for the design of renewable energy policy instruments was proposed based on integrated assessment where a participatory multicriteria evaluation as a part of the design of renewable energy promotion has been suggested (*e.g.*, Madlener & Stagl, 2005). Overall, in order for bioenergy to play an important role in future energy systems, the development of bioenergy should take place in accordance with sustainable development. Policy makers will have an important role to play in mitigating negative impacts of bioenergy and promoting a development that is attractive from a socioeconomic and environmental perspective (Hansson, 2009).

Generally, promotion of quality is the main reason for seeking certification. Bioenergy certification can help using biomass for energy by providing the needed economic long-term perspectives to the biomass owners and promoting positive aspects of an environmentally sound biomass use. Unfortunately, the sustainability concept does not seem to be recognized as directly related to bioenergy certification which confirmes that bioenergy certification has been communicated more as an economic market tool for achieving a price premium or better market access, rather than an assurance for ecologically responsible activity. Moreover, with the need of climate change mitigation, energy policy, forest policy and environmental policy have to converge (*e.g.*, Kraxner et al., 2009). The need for a coordination of forest policies with other policies, including energy policy, is recognized by the European Council (CEC, 2005). A definite forest energy policy hardly exists in any country (Roos, 2002) or at EU level. The EU, for example, argued in favor of forest certification schemes as a market based and voluntary tool, with less governmental involvement and stressed that certification schemes should not be regarded as trade barriers, as they are voluntary (Reischl, 2009). However, there are no strong driving forces in forest policy to utilize forest biomass for energy, although such utilization is generally recognized and supported for environmental and social reasons (Stupak *et al.*, 2007a).

Overall, there is a need in policies that aim at tackling the problems of climate change issues by concentrating on increasing people's knowledge and positive attitudes towards an environmentally sound use of biomass sources by promoting sustainable biomass/bioenergy certification as necessary drivers.

III. MARKETING BIOENERGY

Historically, trade flows of solid biomass for energy or biomass fuels have been rather limited, as most of the production has been directed for domestic consumption. However, in the coming years, international trade in biomass fuels and feedstocks is expected to escalate rapidly to satisfy increasing worldwide demand. At present, bioenergy is marketed in different ways in different parts of the world and there is a range of tools for supporting a renewable bioenergy market. In the U.S., for example, green power markets grow and develop and biomass represents a significant share of current and planned generating capacity in green power programs. There are utilities there that offer green pricing options and consumers can purchase renewable energy through a green power marketing program, in which independent power suppliers offer electricity generated from biomass (*e.g.*, Weeks, 2004). In contrast to the governance systems that use price premium, there is the other important innovation in bioenergy marketing from the perspectives of both producers and consumers of green power and this is renewable energy certificates (RECs) also known as renewable energy credits, tradable renewable certificates or green tags, which offer a fast-growing option for buying green power. Currently, there are other proposals for governance systems for bioenergy use. Thus, experts in the research process suggest several conditions that governance systems for bioenergy should meet in order to be effective, such as facilitative government, professional monitoring and using certification combined with a price premium (Verdonk *et al.*, 2007).

However, the foundation of a bio-based industry depends on an abundant supply of biomass. A reliable and sustainable supply of biomass is vital to any market activity aimed at bioenergy production. Without a well-functioning biomass market that can assure a reliable and lasting supply, the existing high ambitions for bioenergy may not be met (Faaij, 2008). However, a precondition to the welfare governance of biomass supply as well as bioenergy production in an international context is that a supranational institution or agreement must exist and this institution is able to implement its policies (*e.g.,* Verdonk *et al.*, 2007). Although at present a perfect bioenergy governance model does not seem to exist (*ibid.*), bioenergy markets have potential to evolve into a global bioenergy commodity market with linkages to other energy and biomass markets and related financial services within the near future (*e.g.*, Faaij & Domac, 2006). One visible fact is that compared to the past when biomass has long been considered as an energy source to be used at the local or regional level, relatively recently international biomass trade has been picked up by the market at a very rapid pace. However, a global biomass industry should not develop further unless the environmental and social concerns are addressed. Certification could become a prerequisite for biomass producers to obtain or secure positions in the EU market as well as globally.

IV. DEVELOPMENT OF CERTIFICATION CRITERIA FOR SUSTAINABLE BIOMASS

1. Bioenergy certification: State of the art

There are multiple goals that that can be achieved through sustainable bioenergy production and use, but there are also multiple concerns about the impact of bioenergy. Global biomass fuel industry will not develop further unless these environmental and social concerns are addressed. However, it is worth to point out that many of the concerns are not exclusive to bioenergy—the same criticisms could be levied against any food or non-food crop.

The substantial differences that are seen in existing bioenergy production systems in terms of impacts, where production of some biomass for energy can result in a variety of negative environmental, economic, and social impacts, call for the need of new institutions, methodologies and science to ensure that bioenergy production can meet new demand for supply without causing major social and environmental damage. Nowadays, it’s important to demonstrate that the advantages of bioenergy exceed the cost of potential environmental damage caused by their production. In the context of sustainable development the use of biomass for energy is only justifiable if biomass is produced in environmentally, economically and socially sustainable ways. A strategy to achieve sustainability includes the need for certification systems. Certification is always related to a standard and certification as a substitute for regulation can work to ensure product safety or quality.

Already in the later 1980´s certification was predicted to be a major issue in bioenergy planning (*e.g.*, Kimmins, 1997). Contributing to certification procedures and development of best practice guidelines, especially for integrating the production of biomass for energy and subsequent export into agricultural and agro-forestry systems is a key element in the development of a framework to secure the sustainability of biomass resources and utilization (Faaij, 2008). Biomass certification is a way to implement biomass production systems in an acceptable and responsible way, which promotes the sound implementation and growth of bioenergy in the energy sector (Biomass Technology Group, 2008). General development of certification schemes for sustainable biomass production is going very fast. The German Federal Environmental Agency has initiated research to assess existing certification systems for sustainability of biomass production worldwide. Many other relevant national, international and non-governmental initiatives have also been taken. The focus has been on three main topics: the greenhouse gases balance, ecological consequences of land use for bioenergy production and socio-economic effects (Fehrenbach, 2007). There are of course risks related to such factors as supply, fuel quality, price increases, and issues such as competition for land area and the degree of renewability of given resources. Sustainability reduces such risks, and can be supported by certification of substrates' origin (Skambracks, 2007).

Publications on sustainable use of forest biomass for energy, roles and problems in relation to policy, legislation, certification standards, recommendations and guidelines and science is discussed by Stupak *et al.* (2007a). An internationally valid certification system which may provide an incentive for more sustainable and effective bioenergy production methods has been recommended by Reinhardt *et al.* (2008). It remains internationally contentious to evaluating social equity when producing energy from biomass. Criteria to ensure the sustainable production of biomass are still needed urgently (van Dam *et al.*, 2008).

Different types of certification systems relevant to biomass production already exist (Figure 1). These systems are, however, not regarded efficient enough to monitor and manage indirect effects of biomass production for energy and there are many other barriers towards successful achievement of the benefits for environment and society of the use of sustainable, certified biomass. Nevertheless, when developing a sustainable biomass certification system, an analysis of the experience gained with existing certification systems can be helpful, in particular, when considering the difficulties of initial implementation. An assessment of the structure and development of these systems is interesting for the attempt to create minimum universal sustainability criteria.

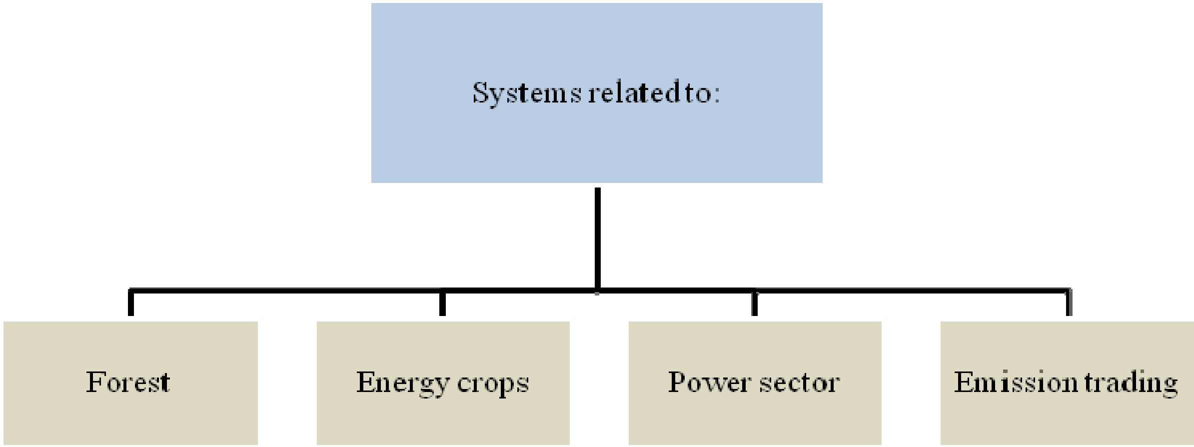

Figure 1. Different types of existing certification systems.

2. Overview of biomass sources as feedstocks for energy

This chapter addresses the range of biomass feedstocks that can be used to produce bioenergy within the context of their range of impacts and technologies that are needed to be developed to increase the sustainability of bioenergy production.

Potential biomass feedstocks come in many forms (Figure 2). The most common include: dedicated energy crops; agricultural residues; forest residues; paper and lumber mill residues; organic municipal solid waste; animal manure. For convenience, the wide range of biomass sources was further aggregated into forestry, plantation, agriculture and waste types. Different certification systems might be developed for these different types of biomass. That is, as the biomass resources currently available are supplied from a wide range of sources (Figure 2), a certification system for biomass may be source based. However, it is challenging to formulate sustainability criteria that are relevant for all types imaginable. Therefore, we aggregate the wide range of biomass sources into forestry, plantation, agriculture, waste/residues and “other” types. This report explores the opportunity of this action in view of proposing minimum sustainability criteria and certification systems for the production of biomass.

However, despite their many sources, biomass feedstocks are remarkably uniform coming to many other fuel properties, especially compared to competing fuels such as coal or petroleum. For example, many types of coal have heating values in the range of of 20-30 gigajoules per metric tonne (GJ/tonne), while nearly all biomass feedstocks fall in the range of 15-19 GJ/tonne (Anon, 2009). Further, the moisture content, being probably the most important determinant of heating value, is about the same for oven-dried biomass (*e.g.*, Anon, 2009).

Some biomass challenges in terms of public perception. Thus, some experts and environmental organizations do not consider every biomass feedstock as sufficiently "environmentally friendly". Particularly controversial is organic municipal solid waste as a feedstock. Often, the degree to which a feedstock is considered "green" varies by region. The availability and type of biomass feedstock also differs by region. Most liquid biofuel feedstocks from agricultural crops such as sugar, starch and oil, raise several concerns about land-use and the security and quality of the food chain. However, energy from the forest is one of the most attractive alternatives to the use of fossil fuels, assuming environmental and social impacts are properly managed. Bioenergy production from lignocelluloses holds a considerable potential, given the amount of energy in the biomass and the extent of biomass that is available globally, particularly in residues and co-products from forestry and paper and pulp processing (*e.g.*, Anon, 2008). Forests and short- and medium-rotation woody crops provide major potentials of lignocellulose feedstocks for bioenergy production. Moreover, the forest-based sector has not only provided sources of fuels for millions but has also long contributed to society and has been driving economic growth. The forest resources are underpinning a vast complexity of environmental and economic benefits beyond simply the bioenergy sector.

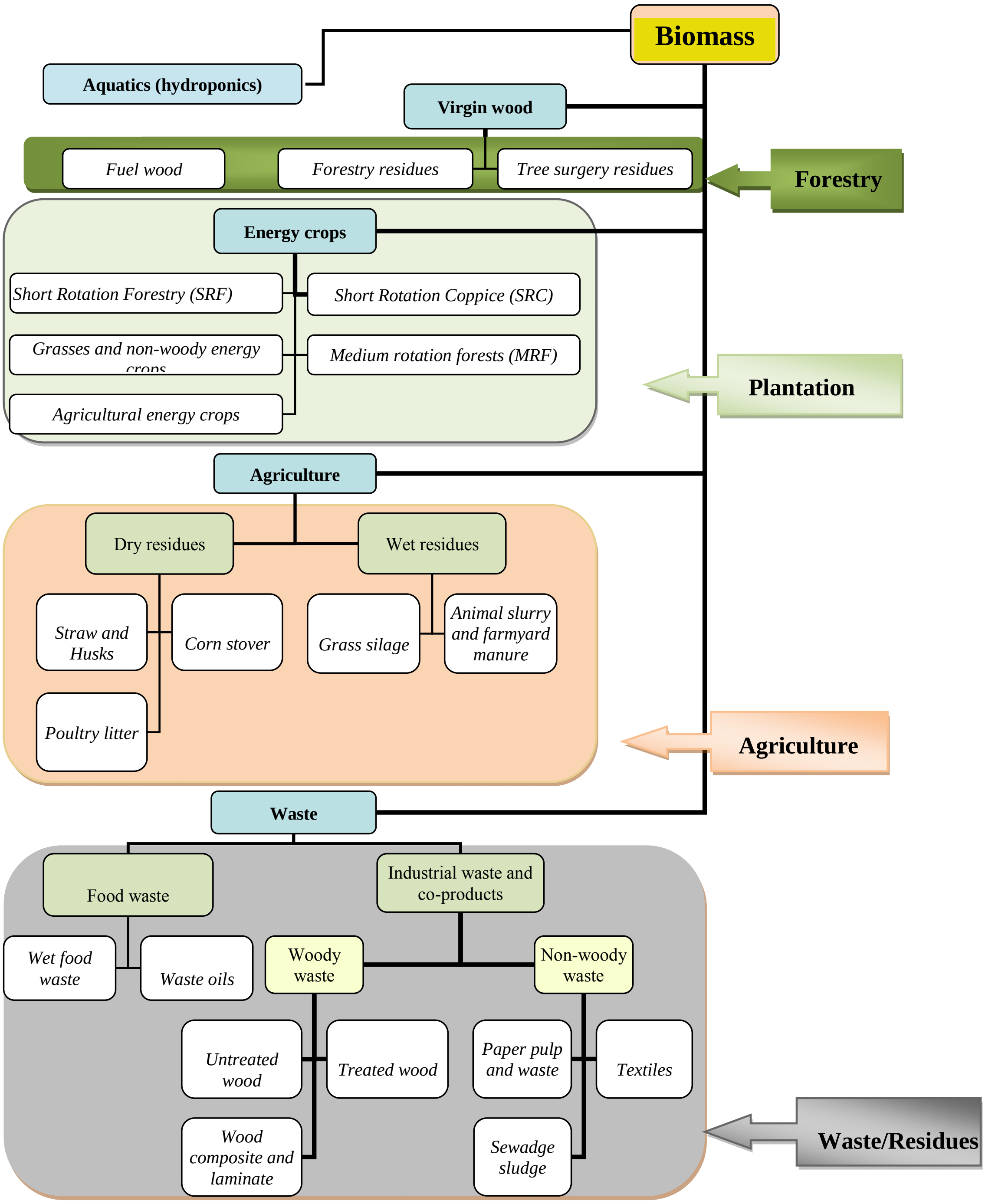

Figure 2. Sources of biomass for production of energy where different types of biomass are in differently colored shaded areas. (Left arrow callouts suggest that a certification system for biomass may be source based, i.e., comes from different type of biomass: forest (forestry + plantations), agriculture, waste/residues and other (e.g. aquatics (hydroponics)).

More than 80% of primary bioenergy production in the EU presently comes from wood-based feedstocks, compared to only 13% that comes from municipal solid waste and the remaining 7% from other sources. Moreover, our assessment of the biomass-to-energy conversion processes (Anon, 2009) reveals that solid woody feedstocks are the only feedstocks well suited for the most of conversion technologies available at present. Furthermore, these technologies (direct combustion, gasification and pyrolysis) are those that are most well-understood and well-developed worldwide. Heat, electricity and transportation fuels can thus be produced from solid woody feedstocks.

3. Analyzing the existing biomass certification systems

Developing certification systems for biomass feedstock to be used in bioenergy production gains a lot from assessment of existing systems. This chapter assesses the existing developments in national and regional assurance and certification systems.

3.1. Energy crop certification systems

While certification systems are under development for some crops that can be used for energy purposes like soy, palm oil and sugar cane, specific certification systems or initiatives do not seem to exist for other crops (Biomass Technology Group, 2008). Of the existing initiatives to develop energy crop certification systems only the Roundtable for Sustainable Palm Oil (RSPO) has developed a complete set of criteria. However, the RSPO does not cover some of the aspects specifically perceived as important by stakeholders for use of palm oil for energy purposes. For example, dramatic CO_2 emissions from drained peat land are well known, but the RSPO criteria do not prevent oil palm plantation to be located on these lands. Further, the increasing demand for energy does increase the demand for palm oil, thereby increasing the pressure on land that might be converted to plantation in a non sustainable manner, but voluntary sustainability certification of palm oil plantation does not prevent that non-certified palm oil will still be produced for less environmentally conscious markets (Biomass Technology Group, 2008).

3.2. Certification systems in the power sector

Some certification systems and standards have been developed especially for the use of biomass in power plants. Thus, electricity companies have developed biomass certification standards initially for their own use (Essent Green Gold Label or GGL), or primarily to present carbon or energy balances that have to be established to obtain green certificates (Laborelec) (Biomass Technology Group, 2008). Unfortunately, the standard setting process and management of the certification system in the power sector is less transparent than in the case of forest certification systems and less information is available about experiences with this system. Moreover, according to the Green Gold Label (GGL) certification system for sustainable biomass for power production, biomass from forestry (GGL, 2005) should originate from sustainably managed forests certified by one of the forest management certification systems. The Programme for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC) are among the suggested. However, a more general observation from the other suggested systems is that the weakest forest certification system determines the quality of the GGL standard. One general lesson to be learned is that the various systems for green electricity labeling, being mainly focused on environmental sustainability, and missing criteria regarding social aspects, did not result in a system for sustainable electricity.

3.3. Other certification systems or initiatives related to biomass production

The European Ecolabel is a voluntary scheme, established in 1992 to encourage businesses to market products and services that are kinder to the environment. The EU Ecolabel is part of a broader action plan on Sustainable Consumption and Production and Sustainable Industrial Policy adopted by the Commission on December 4, 2008[1]. However, the EU Ecolabel award process is not transparent to outside observers and it is therefore extremely difficult to know on what basis the Ecolabel has been awarded. Moreover, the EU Ecolabel appears not to have a formal complaint mechanism and given the serious problems that forest operations are causing, FERN[2] calls upon the European Commission to withdraw the EU Ecolabel (Lang, 2010)

Certification systems related to emission trading, for example Tradable Green Certificates (TGC); were developed to certify emission reductions and not biomass. However, the ability of bioenergy to mitigate greenhouse gas emissions is the key facet of environmental sustainability. There is broad agreement that CO2 emissions from land which is forested or whose forest has been largely cleared must be sharply reduced worldwide, but, there appears to be much uncertainty as to where (and why) most such emissions take place (Anon, 2010). It seems likely that the most rapid reductions in “deforestation” emissions can be achieved by ceasing most trade in pulp and palm oil from Indonesia and products which derive from cattle and soya from Brazil – and restoring the former forest. However, the consequences (GHG emissions) are particularly difficult to be accurately attributed to the expansion of biomass fuels production in a given country and consequently it would be delicate to include them in the GHG emission balance at a country level (Gnansounou *et al.*, 2008).

A variety of voluntary environmental and social standards and certification programmes in agriculture have appeared during the past twenty years. One of the best known environmental labels on food is the organic label. Other, more recent, environmental labels on food include the Rainforest Alliance Certified label (formerly ECO-OK); the Smithsonian Institute's Birdfriendly coffee label, and various declarations of the use of "integrated production methods" and integrated pest management (IPM). Also, the International Organization for Standardization (ISO) has developed an environmental management systems standard, ISO 14001.

However, setting international standards has proven to be very difficult due to the variety of circumstances that exist around the world and this is especially true for agricultural practices, which have to respond to differences in climate, soils and ecosystems, and are an integral part of cultural diversity. In response to this diversity, international environmental and social standards are often normative standards, i.e. generic standards or guidelines to be used as a framework by local standard-setting or certification bodies to formulate more specific

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[1] On 16 July 2008 the European Commission presented the Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan. The Council endorsed the Action Plan in its conclusions adopted on 4 December 2008.

[2] FERN is a non-governmental organisation (NGO) created in 1995 to keep track of the European Union’s involvement in forests and coordinate NGO activities at the European level.

standards. It has to be noted that environmental and social standards in agriculture usually do not have the purpose of standardization *per se*, but are developed to improve environmental and social sustainability in the variety of existing farming and agro-trade systems. Further, most social and environmental food standards have been developed by non-governmental organizations. Although such voluntary environmental and social standards affect areas that are of concern to many governments, such as the environment, labour conditions, access to niche markets and price premiums, for governments, trying to serve producers, traders and consumers, it might not always be clear what role they could or should take on with respect to these developments.

The history of labour standards goes back to the creation of the International Labour Organization (ILO). The Constitution of the International Labour Organization was adopted at the end of the First World War. The ILO is a tripartite organization that brings together representatives of governments, employers and workers in its executive bodies.

The World Trade Organization (WTO) does not currently have a trade regime specific to biomass fuels. Criteria that aim to avoid competition with food products and social criteria like social well being of local populations are most probably not compliant with WTO rules (Biomass Technology Group, 2008). In addition to the WTO, several regional and bilateral trade agreements, mostly involving the United States and the EU, currently regulate biomass fuel trade. CEN[3] standards can be used as a base for certification systems in the EU. However, as much of Europe is populated with high per capita energy use, meeting any substantial internal biomass fuel supply target in many cases will require a significant level of imports of biomass fuels. To avoid conflict with international trade rules any system applied must be applicable around the world.

Some European Union Member States have also established internal certification schemes for biomass fuels or other rules that will impact biomass fuel production and use. Thus, the Netherlands has created sustainability criteria for biomass fuels, extending what are known as the Cramer principles to biomass. The United Kingdom's 2007 Renewable Transport Fuels Obligation (RTFO) requires that five percent of all road vehicle fuel comes from sustainable renewable sources by 2010. In Sweden, an agreement has emerged between the biggest Swedish bio-ethanol importer (SEKAB) and Brazilian ethanol producers. Germany has developed Biomass-electricity-sustainability Ordinance. There are other publicly respected certification schemes, such as for example EUREPGAP, UK ACCS, LEAF, Roundtable on Responsible Soy Oil (RRSO) and ECOFYS.

Overall, despite the existence of a lot of initiatives and publicly respected certification schemes, no existing certification scheme has sufficient coverage to be adopted for general or universal biomass certification.

3.4. Biomass certification systems

The use of forest biomass for energy is generally acknowledged as being in agreement with the principles for sustainable development (Stupak *et al.*, 2007a). Biomass-for-energy certification provides assurance that biomass used comes from responsibly managed forests, taking equal account of economic, environmental and social impacts.

Bioenergy and particularly biomass fuel supply chains can be very complex. They are often, geographically long and dispersed. Location is important the fundamental factors that govern

[3] CEN. European Committee for Standardization

biomass productivity. Site properties (soil, water, temperature) vary significantly according to location. The heterogeneity in impacts and opportunities arises because the feedstock production, conversion and end-fuel supply chains for biomass fuels are often longer (geographically and technically) and considerably more complex than existing or alternative transport energy supply chains. The bioenergy supply chains are also very diverse and are likely to become increasingly diverse as new technologies for feedstock supply, conversion and use come onto the market (Woods & Diaz Chavez, 2007). Therefore, only certification of biomass-for-energy production is of interest in this report.

Germany is the first EU member state to approve a certification scheme for sustainable biomass production. The International Sustainability and Carbon Certification (ISCC) System is an international certification system for biomass and biofuels (fuels and electricity) that documents the bioenergy`s path all the way back to the field or plantation and describes the rules and procedures for certification. The ISCC System is in the works and has implemented high social standards, including norms for working hours and anti-discriminatory practices.

Currently, there are activities to develop also global sustainability certification systems for biomass production. Thus, the main aim of the project - The Global-Bio-Pact (Global-Bio-Pact Global Assessment of Biomass and Bioproduct Impacts on Socio-Economics and Sustainability) - is the development and harmonization of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Global-Bio-Pact develops a set of socio-economic sustainability criteria and indicators for inclusion into a future effective certification scheme, and the project elaborates recommendations on how to best integrate socio-economic sustainability criteria in European legislation and policies on biomass and bioproducts. There are on the other hand cautions against overloading biomass fuel certification systems, that argues that the industry could be halted before it even begins (e. g., Devereaux and Lee, 2009).

3.5. Forest certification systems

Forest certification emerged in the early 1990s as a market-driven way to limit the destruction wrought on tropical forests, giving consumers, retailers, and manufacturers the opportunity to purchase products derived from environmentally and socially responsible forest operations. Thus, already during the Rio Earth Summit in 1992, world leaders adopted the Statement of Forest Principles and Agenda 21, which recognized the importance of forests to sustainable development throughout the world. Environmental organizations established the first forest certification scheme under the Forest Stewardship Council (FSC) banner. Several other schemes followed and they focused on specific regional conditions and other factors. Today, the second most prevalent system is the Program for the Endorsement of Forest Certification (PEFC). Certification has been a contentious issue in the forest negotiations. The EU argued in favor of certification schemes as a market based and voluntary tool, with less governmental involvement and stressed that certification schemes should not be regarded as trade barriers, as they are voluntary (Reischl, 2009). Certification programs have been developed that apply to forest management systems and forest products and guarantee they achieve specific performance standards. These programs can be international, national, or regional in scope (Table 1).

Table 1. Global, international and national forest certification schemes. Shaded schemes are those that have been endorsed by the PEFC Council as meeting the PEFC Council's requirements for forest certification schemes.

Schemes/ Standards-setting bodies	Country/Region	Abbreviations	When the scheme came into existence	Principles that form the basis of the forest certification standard
Forest Stewardship Council A.C. http://www.fsc.org/	Global	FSC	1993	FSC P&C
Programme for the Endorsement of Forest Certification schemes	International	PEFC	1999	Pan-European Montreal ITTO Amazon Tarapoto ATO FAO Near East Lepaterique FAO Dry Africa
Australian Forest Certification Scheme	Australia	AFCS [a]	1999	Montreal
PEFC Austria	Austria	PEFC Austria	1998	Pan-European
Belarusian Association of Forest Certification	Belarussia	FCB Belarussia	2000	GOST, STB, TCP
WoodNet asbl - PEFC Belgique	Belgium	BFCS/PEFC	2007	Pan-European
Bolivian Council for Voluntary Forest Certification	Bolivia	FSC CFV	1995	FSC P&C
FSC Brazil Working Group	Brazil	FSC Brazil	1996	FSC P&C
INMETRO (on behalf of CERFLOR)	Brazil	INMETRO	1993	ITTO Amazon Tarapoto
National Institute of Metrology, Standardization and Industrial Quality	Brazil	CERFLOR/PEFC	2005	Pan-European
FSC-Canada British Columbia Chapter	British Columbia	FSC BC	1996	FSC P&C
Cameroon National Working Group on SFM and Certification	Cameroon	FSC Cameroon	1999	FSC P&C
Cameroonian Association of the Pan African Forestry Certification	Cameroon	PAFC Cameroon		ATO-ITTO
Canadian CSA	Canada	CSA	1996	Montreal
FSC Canada Working Group	Canada	FSC Canada	1996	FSC P&C
CSA Sustainable Forest Management Program	Canada	PEFC Canada	2001	Pan-European
FSC Canada, Maritime Regional Initiative	Canada	FSC Canada MRI	1996	FSC P&C
CERTFOR Chile	Chile	CFCH	2002	Pan-European Montreal FSC P&C
Czech Forest Certification Scheme	Czech Republic	CFCS	2006	
PEFC Czech Republic	Czech Republic	PEFC Czech	2002	Pan-European Montreal
PEFC Denmark	Denmark	PEFC Denmark	2002	Pan-European
Estonian Forest Certification Council	Estonia	EMSN	2001	Pan-European ESFS
FSC Estonia Working Group	Estonia	FSC Estonia	1998	FSC P&C
Finnish Forest Certification Council	Finland	FFCS	1997	Pan-European
Finnish Forest Certification Scheme	Finland	PEFC Finland	2003	Pan-European
PEFC France	France	PEFC France	2001	Pan-European
PAFC Gabon Forest Certification Schemes	Gabon	PAFC Gabon	2006	Pan-European
FSC Arbeitsgruppe Deutschland e.V	Germany	FSC Germany	1993	FSC P&C
PEFC Germany e.V	Germany	PEFC Germany	1999	Pan-European
Lembaga Ekolabel Indonesia	Indonesia	LEI	1994	ITTO FSC P&C
PEFC (Ireland) Ltd	Ireland	PEFC (Ireland) Ltd	1999	Insufficient info

PEFC Italia	Italy	PEFC Italy	2001	Pan-European
Japan Sustainable Green Ecosystem Council	Japan	SGEC	2003	Montreal
Latvian Forest Certification Council	Latvia	FSC LS	2001	FSC P&C
PEFC Latvia Council	Latvia	PEFC Latvia	1999	Pan-European
PEFC Lietuva	Lithuania	PEFC Lithuania	2004	Pan-European
PEFC Luxembourg	Luxembourg	PEFC Luxembourg	2002	Pan-European
Malaysian Timber Certification Scheme	Malaysia	MTCS	2008	Pan-European
MTCC Timber Certification Council	Malaysia	MTCC	1998	ITTO FSC P&C
PEFC Nederland	Nederland	PEFC Nederland	2008	Pan-European
Forest Certification New Zealand Inc	New Zealand	FSC New Zealand	2001	FSC P&C
Living Forest Norway - PEFC	Norway	PEFC Norway	1999	Pan-European
FSC Ontario Boreal Pilot Project	Ontario, Canada	FSC Ontario	1999	FSC P&C
Poland FSC Contact Person	Poland	FSC Poland	2001	FSC P&C
PEFC Poland	Poland	PEFC Polska	2003	Pan-European
Portuguese Forestry Sector Council	Portugal	PEFC Portugal	2004	Pan-European
Russia FSC Contact Person	Russia	FSC Russia	1999	FSC P&C
Partnership on the Development of Forest Certification	Russia	PEFC Russia	2009	Pan-European
National Council of Voluntary Forest Certification	Russia	RSFC	2003	Insufficient info
Slovak Forest Certification Association	Slovakia	SFCA	2002	Pan-European
Institute for Forest Certification in Slovenia	Slovenia	Institute for Forest Certification	2006	Pan-European
PEFC Spain	Spain	PEFC España	1999	Pan-European
Association for Spanish Forest Certification	Spain	CEF	1998	Pan-European
Swedish FSC-Council	Sweden	FSC Sweden	1995	FSC P&C
Swedish PEFC Co-operative	Sweden	PEFC Sweden	2000	Pan-European
Revised Swiss Forest Certification Scheme	Switzerland	PEFC Switzerland	2001	
United Kingdom FSC Working Group	The United Kingdom	FSC UK	1999	FSC P&C
PEFC UK Ltd	The United Kingdom	PEFC UK Ltd	2002	Pan-European
UK Woodland Assurance Standard	The United Kingdom	UKWAS	2001	UKWAS
Forest Stewardship Council US	US, 9 biogeographic regions	FSC US	1995	FSC P&C
American Tree Farm System	USA	ATFS	1941	Montreal
Sustainable Forestry Initiative	USA and Canada	SFI	1994	Montreal

(Sources: based on information from ICFPA homepage)

The standards most widely applied are given in Table 2.

Table 2. Certified forest standards/programs

Standards/Programs	**Area, Millions ha**	**Year**
PEFC	220.0	2009
FSC	115.6	2009
SFI	60.0	2008
CSA	77.8	2008
AFS	9.9	2008
MTCC	4.9	2008

However, the Programme for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC) both covers a large area of certified forest and a large number of national systems and strives to achieve the same ultimate objective of sustainable forest management. Thus, by the end of 2009, 115.6 million ha of forest is certified by FSC and more than 220 million hectares by PEFC. PEFC is the largest forest certification system in the world and has strong grass roots support from many stakeholders including the forestry sector, governments, trade associations, trade unions and non-governmental organizations.

The SFI Standard is the most widely applied certification standard in North America, with over 60 million hectares of certified forest lands. A second FSC competitor scheme in North America is the Canadian Standard Association (CSA) scheme. CSA is an independent, non-governmental organization. The Malaysian Timber Certification Council (MTCC) and Australian Forest Certification (AFS) are the other forest certification systems most important.

While certification was initially created to combat deforestation in the tropics, most certified forests are located in the Northern hemisphere. Although certification programs that have been developed to specifically deal with forests and conventional forest management schemes could be applied to biomass production systems, some questions with regard to the design and implementation of sustainability criteria and certification schemes remain unsolved. Thus, while several sustainability and certification initiatives are currently underway, such systems will only be effective if there is widespread international coordination. Otherwise, there is a risk of creating a complex web of certification processes which could require producers to go through multiple certifications and registrations. The ultimate outcome may be a lack of confidence – and perhaps compliance – with the various systems in place, as well as charges of international trade discrimination. For example, analysis of information on forest certification reveals an increasing number of standards and schemes – with the Food and Agricultural Organization (FAO) recording some 90 different initiatives worldwide (Anon, 2006) which has raised concerns that the variety of schemes might confuse both producers of forest and consumers of forest bioenergy. Overall, better international coordination between initiatives is required to improve coherence and efficiency in the development of sustainable biomass certification systems, to avoid proliferation of multiple standards and to provide a clear direction in the approach to be taken (van Dam *et al.*, 2008).

4. How to create a workable, international sustainability certification system for biomass

Given the strongly increasing demand for biomass fuels, initiating development and demonstration activities as well as an international dialogue on a comprehensive sustainability framework is urgent. Setting up a certification system involves the process of development of sustainability criteria and their evaluation. Certification procedures need to be applicable at both global and local levels and relate both to small biomass-for-energy producers as well as large conglomerates. The economic impact of certification on aspects such as product costs also needs to be evaluated.

However, the development of sustainability frameworks is complex and new fields and ways of looking at land use, agriculture and governance and a reasonable learning period to develop experience in the market is required. Thus, forest certification is a contentious issue, the market for certification and marking of biomass for energy might be confusing for actors coming to different operating forest certification schemes. As a result companies are left with the following possibilities: Choose one scheme, with the risk of not having sufficient supplies of certified biomass; choose more than one scheme with a higher cost; choose not to use any scheme until the conflict is sorted out with the risk of unsustainable biomass production or illegal logging. Avoiding a fragmented biomass market with many different national standards, certification schemes, quality labels, etc. is an important part of facilitating trade in biomass.

The analyses in the previous sections of existing certification systems and biomass sources as well as the review of technical and non-technical barriers published by Biomass Technology Group (2008) reveals that while the implementation of compulsory sustainability criteria and certification systems is possible, compulsory criteria cannot cover all aspects of sustainable biomass production. Therefore, in agreement with others (*e.g.*, Verdonk *et al.*, 2007) we suggest that limiting the number of sustainability concerns could help to manage the creation of universal certification criteria for sustainable bioenergy, at least in its starting phase. In other words, a set of minimum criteria is advocated to ensure that major negative environmental, social and economic impacts are avoided in an efficient way.

Even suggesting that a certification system for biomass may be source based and aggregating the wide range of sources into forestry, plantation, agriculture and waste/residue types, it is still a large diversity of sources that biomass covers (Figure 1). This makes it challenging to formulate a minimum set of sustainability criteria that is relevant for all types imaginable.

Forest certification systems are voluntary systems that have been in use for long time and the experiences from the forestry sector, for example the information regarding market dynamics of these systems, are relevant for the development of a biomass certification system. Policies aimed at combating illegal logging as well as the very recent renewable energy and biomass fuels policies of the EU, have placed forest certification at the core of EU Member States' forest and wood-related products policies.

Discerning strong and weak points of a lot of other systems, the FSC governance system was considered to be the most promising one, this because it is able to address most sustainable concerns (*e.g.*, Verdonk *et al.*, 2007). Moreover, while the FSC is mainly designed for forests managed for the production of wood products, they are also relevant, to varying degrees, to forests managed for non-timber products and other services. With respect to energy policies, the utilization of wood for energy is generally supported in forest policies, but forest legislation is seldomly used as a direct tool to encourage the utilization of wood for energy (Stupak *et al.*, 2007a). An increased use of wood-based biomass for energy can also, if well managed, enhance the socioeconomic benefits from forests, particularly for small forest owners substituting purchased energy resources with their own wood fuels. However, the increased use of wood-based biomass must be fully in accordance with the principles of sustainable forest management (Stupak *et al.*, 2007b).

One of the opportunities for the development of certification schemes for sustainable biomass is the harmonization of the many different criteria which currently exist. In the international arena, the first list of indicators was developed for the International Energy Agency by Lewandowski and Faaij (2006). From different existing certification systems, they took a multiplicity of criteria and indicators applicable to bioenergy. International organizations, *e.g.* the Food and Agriculture Organization of the United Nations (FAO), the Global Environment Fund (GEF) and the United Nations Conference on Trade and Development (UNCTAD) have started projects to develop sustainability standards as well, but their indicators are often rather vague and have not yet been checked against any feasibility criterion (Delzeit & Holm-Müller, 2009).

Trimble and Crosson (2000) mentioned that the problem of resource or environmental management can only be rationally addressed if true space and time dimensions are known. Thus, according to them a detailed study of the economic impact of erosion at a European scale can probably only be done by collecting data obtained by local or regional studies, that are carried out by regional or provincial authorities, sometimes even at local community level.

On the other hand, some criteria such as for example biological diversity, can only be measured on the macro-level and not in the biomass production sites only.

Overall, biomass sustainability requirements will need to be agreed upon internationally, applied locally and to all biomass regardless of end use.

5. Principles of sustainable biomass

It is crucial that political actions are not going to exacerbate the problems they were meant to reduce (e. g., Delzeit & Holm-Műller, 2009). Thus, certification schemes could reduce the potential of bioenergy if pushed too vigorously, but if targeted at a specific and limited set of problems and designed with flexibility, certification can enhance the public's acceptance of the bioenergy option while protecting key environmental goals.

Given in mind that sustainable development debate is based on the assumption that societies need to manage economic, social and natural capitals, certification effort to create sustainability of biomass requires comprehensive management of these capitals. Pan-European Six Criteria and Forest Stewardship Council (FSC) ten principles for Sustainable Forest Management widely used across Europe today are given in Table 3 and 4.

Table 3. Pan-European Six Criteria for Sustainable Forest Management.

1	Maintaining and enhancing forest resources and thus their contribution to the global carbon cycle and the reduction of CO_2 in the atmosphere.
2	Preserving the health and vitality of forest ecosystems.
3	Sustaining and encouraging forests productive functions (wood and non-wood).
4	Maintaining and enriching the biological diversity found in forest ecosystems
5	Retaining and strengthening forest management's protective functions (particularly soil and water).
6	Preserving other socio-economic functions and conditions of forest.

Table 4. Forest Stewardship Council (FSC) principles for Sustainable Forest Management.

1	Compliance with laws and FSC principles
2	Tenure and use rights and responsibilities
3	Indigenous peoples'rights
4	Community relations and worker´s rights
5	Benefit from the forest
6	Environmental impact
7	Management plan
8	Monitoring and assessment
9	Maintenance of high conservation value forests
10	Plantations

Assesing Pan-European Six Criteria (Table 3) and Forest Stewardship Council (FSC) principles (Table 4) we suggest that sustainable management of economic, social and natural capitals might be reasonably covered at aggregated level by the following principles (Table 5).

Table 5. Principles for sustainable biomass.

Principles	Description
PRINCIPLE 1: Environmental	*In order to manage natural capitals, biomass:* a) shall be produced in an environmentally responsible way protecting natural resources such as land and water; b) operations shall be guided by good management practices.
PRINCIPLE 2: Social	*In order to manage social capitals, biomass production shall*: a) take place in compliance with regional, national and relevant international laws; b) offer safe working conditions c) not violate human rights
PRINCIPLE 3 Economic	*In order to manage economic capitals, biomass production*: shall be economically viable

6. Selecting sustainability criteria

Considerable uncertainty remains regarding the impact of the sustainability criteria on biomass fuel markets. More empirical research is needed on the role of certification in biomass fuel feedstocks, based on carbon content and the respect of sustainability criteria etc. More research on the situation and likely evolution of the share of different production pathways could reduce uncertainties regarding direct emission savings. It would help to get a better understanding of the actual impact of the sustainability criteria in the EU RED on emissions and the market for biomass fuels (Al-Riffai *et al.*, 2010).

Assessing the actual environmental and socio-economic impacts of increased production of biomass for energy will depend sensitively on the scale and mix of technology, options employed and on the location. Location is important as the fundamental factors that govern biomass productivity vary significantly according to site properties. Across a range of indicators, one batch of biomass fuel may not be the same as another, even where the final fuels are chemically and physically identical. There is also uncertainty in a range of potentially important factors that govern the assessment of the net impacts of biomass for energy production and use. These uncertainties, divided into three categories, are shown in Figure 3

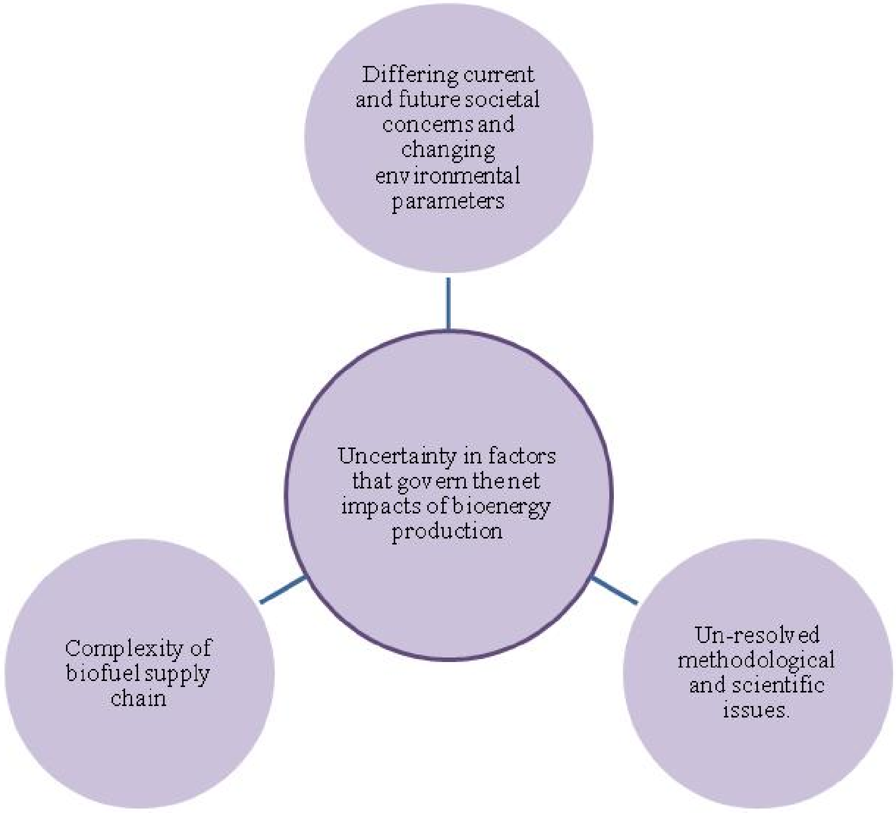

Figure 3. Uncertainty in a range of potentially important factors that govern the assessment of the net impacts of bioenergy production and use (Source: based on Woods and Diaz Chavez, 2007).

Uncertainty resulting from the complexity of a biomass fuel supply chain can be resolved by more detailed accounting methodologies; uncertainty resulting from un-resolved methodological and scientific issues can only be resolved through additional research; uncertainty arising from differing current and future societal concerns and changing environmental parameters, for example a better understanding of the nitrogen cycle, and therefore in the indicators and criteria that will need to be developed, measured and monitored (Woods & Diaz Chavez, 2007).

In practice, in case of supply chain, very substantial differences in terms of environmental impacts are seen in existing biomass fuel chains. Such impacts include the GHG performance and wider impacts such as on biodiversity, water use, nitrogen use and flows, air and water quality impacts (*e.g.*, *ibid.*). Although this variance in impacts provides the justification for national policies in the UK, Netherlands and Germany that support the application of assurance and certification systems for biomass fuels, a number of questions remain about the application of assurance and certification of biomass energy. The questions centre on the level of detail and therefore regulation needed and the nature and validity of the indicators that might be used to demonstrate compliance with minimum environmental standards (*ibid.*). Further doubts exist about the scope and coverage of the institutions around the world that are currently involved in environmental and social certification (mainly of food and timber) and their ability to expand their coverage to include the production and supply of biomass fuel feedstocks (*ibid.*).

Biomass-for-energy certification may be an independent verification procedure to check that biomass production is managed in a sustainable way. A variety of approaches for promotion of sustainable forestry are being adopted by the different forest certification schemes. The most complete and up to date information on 39 different Certification schemes on line - "On-line Matrix" have been created by the International Council of Forest and Papers Association (ICFPA), following a wide ranging review of existing forest certification schemes and an extensive exercise to consult with interested parties including customers, forest owners, forest industry, environmental groups, and the representatives of forest certification schemes. To ensure the objective and consistent treatment of all schemes covered by the Matrix, the data collection, analysis and development of the Matrix were carried out by an independent consultant not affiliated to any certification scheme (ICFPA, 2009).

Two main points ought to be kept in mind when analyzing, comparing and discussing certification information from "Matrix-on-line". One of the points was that although forest certifications schemes operate in different ways, illustrating the diversity of forest ecology, heritage, regulatory frameworks and ownership structures, the majority of certification schemes display important common characteristics that relate to the basic credibility criteria. The other one was that the leading schemes can be seen to: demonstrate a commitment to conform with internationally recognized ISO guides for accreditation and independent third-party certification; seek to involve as wide a variety of stakeholders as possible in a standard-setting process; require compliance with all applicable national and international laws; recognise the importance of conformance with international governmental or non-governmental forestry principles; build on the need to address environmental, economic and social objectives in a balanced way; include requirements in terms of forest management planning, consultation during forest operations, maintenance of forest cover, biodiversity conservation, protection of soil and watercourses, and protection of social and cultural values of forests.

The sets of 19 social and economic sustainability criteria (Box 1) and of 15 environmental sustainability criteria (Box 2) have been selected certification developed by ICFPA. More detailed definitions of criteria are available following a wide ranging review of existing literature , studies and sources that compare forest certifications schemes (se references) as well as extensively analyzing the comparative matrix of forest on the ICFPA`s Comparative Matrix of Forest Certification Schemes (On-line Matrix"). These common criteria are fundamental to the credibility of the certification schemes and demonstrate commitment to sustainability.

Box 1	Social and economic sustainability criteria selected by ICFPA[4]:
Abbreviation	Criteria description
A	Provision of public access to the forest
B	Provision of recreational opportunities
C	Enhancement of the landscape and aesthetic value of the forest
D	Limiting the visual impact of harvesting operations
E	Clear land tenure and long term use rights to the land
F	Recognition and respect for the customary and traditional rights of indigenous/local people
G	The use of chemicals
H	Protecting the health and safety of employees
I	Forest management planning
J	Forest monitoring
K	Training of forestry workers

[4] Explanations of principles/standards are given in Table A, Appendix.

L	Consultation during forest operations
M	Provision of information to increase public awareness of forest management planning, forest operations, and/or forest outcomes
N	Protection of areas of particular historic, cultural or spiritual value
O	Provision of employment for local people
P	Provision of employment opportunities in forestry
Q	Maintenance or enhancement of the economic viability of forest operations
R	Ensuring efficient utilisation of forest products
S	Game management

Box 2	Environmental sustainability criteria selected by ICFPA[5]:
Abbreviation	Criteria description
1	Maintenance of biological diversity
2	Maintenance or enhancement of endangered species populations
3	Restrictions or controls on the use of exotic tree species
4	Restriction/controls or prohibition on the use of genetically modified organisms
5	Protection of areas of high ecological value
6	Implementation of formal environmental management systems such as ISO14001
7	Maintenance of sustained yield of timber
8	Maintenance of flow of non-wood products
9	Protection of the soil and prevention of erosion
10	Protection or enhancement of water quality
11	Maintenance of forest cover and area
12	Forest regeneration following harvesting
13	Prevention of conversion to other land uses
14	Protection of forest against pests
15	Protection of forest against fire

It is worth to point out that in forest certification schemes, forests are certified according to nationally adapted standards with a hierarchical structure using concepts such as "principles", "criteria", "indicators" and ''verifiers". However, at this time, there is no international consensus on sustainability requirements and the inclusion or exclusion of certain exemplary criteria is one of the difficulties of setting up a certification scheme. Therefore, we will refrain from discussing the hierarchical structure of the standards as we attempt to create a set of minimum universal sustainability criteria.

In our attempt to support the development and testing of an implementable certification scheme for sustainable biomass and bioenergy production, the existing Forest Certification Schemes were evaluated against the criteria selected by ICFPA (Boxes 1 & 2) to satisfy the demands of stakeholders and requirements for sustainable forest managements. Thus, we evaluated the existing Forest Certification Schemes against social and economic sustainability through the 19 criteria selected by ICFPA (Table 6). Then we also evaluated the existing schemes against environmental sustainability through the 15 criteria selected by ICFPA (Table 7).

Table 6. Comparative assessment of international and national forest certification schemes against social and economic sustainability criteria.

[5] Explanations of principles/standards are given in Table B, Appendix.

Abbreviations	Social and Economic criteria																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Global/International																			
FSC	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
PEFC	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
National																			
AFS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-
ATFS	-	-	+	+	+	+	+	+	-	+	+	-	-	+	-	-	-	+	+
CFCH	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
CSA	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
EFCS	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	+	-
FCB Belarussia	+	+	+	+	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-
FFCS	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+	-	-	+
FSC Bolivia	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Brazil	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC British Columbia	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Cameroon	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+
FSC Canada	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Canada MRI	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Estonia	+	+	+	+	+	-	+	+	+	+	+	**0**	+	+	+	-	+	+	+
FSC Germany	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Latvia	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC New Zealand	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Ontario	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Poland	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Russia	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC Sweden	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC UK	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
FSC US	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
INMETRO	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+
JFCS	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-	-
LEI	+	-	-	-	+	+	-	+	-	-	-	-	-	+	+	+	+	+	-
MTCC	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PEFC Austria	-	+	-	+	-	-	+	+	+	+	+	-	+	+	+	+	+	-	+
PEFC Belgium	+	+	+	-	+	+	-	+	+	+	+	+	+	+	-	-	-	-	+
PEFC Czech	-	+	+	+	+	-	+	+	+	+	+	-	-	+	+	+	+	-	-
PEFC Denmark	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	-	+	+	+
PEFC France	+	+	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+
PEFC Germany	+	+	+	+	-	-	+	+	+	+	+	-	-	+	+	+	+	+	+
PEFC Italy	+	+	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+
PEFC Latvia	+	+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	-	+
PEFC Luxembourg	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+
PEFC Norway	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	-	-	-	-
PEFC Polska	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PEFC Portugal	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	-	-
PEFC Spain	-	+	+	-	-	-	+	+	+	+	+	-	-	+	+	+	+	-	+
PEFC Sweden	+	+	+	-	+	+	+	+	+	+	+	-	-	+	+	+	+	-	-
PEFC UK Ltd	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+
RSFC	+	+	-	-	-	+	-	+	+	+	-	+	+	+	+	+	-	+	+
SFI	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-
UKWAS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S

+ means that standards/principles are established/relevant/mentioned/

- means that standards/principles are not established/relevant/specified/

0 means no information

Table 7. Comparative assessment of international and national forest certification schemes against environmental sustainability criteria.

Abbreviations	Environmental criteria														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Global/International															
FSC	+	+	+	+		-	+	+	+	+	+	+	+	+	-
PEFC	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
National															
AFS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ATFS	+	+	+	-	+	-	+	+	+	+	+	+	-	+	+
CFCH	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
CSA	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+
EFCS	+	+	+	+	+	-	+	+	+	-	+	+	+	+	-
FCB Belarussia	+	+	+	-	+	-	-	-	+	+	+	+	+	+	+
FFCS	+	+	+	-	+	-	+	-	+	+	+	+	+	+	+
FSC Bolivia	+	+	+	+	+	-	+	-	+	+	-	+	+	+	+
FSC Brazil	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC British Columbia	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC Cameroon	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+
FSC Canada	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC Canada MRI	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC Estonia	+	+	+	+	+	**0**	+	**0**	+	-	+	+	+	+	+
FSC Germany	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC Latvia	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
FSC New Zealand	+	+	+	+	+	-	+	-	+	+	-	+	+	+	+
FSC Ontario	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
FSC Poland	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-
FSC Russia	+	+	+	+	+	**0**	+	-	+	+	+	+	+	+	+
FSC Sweden	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC UK	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
FSC US	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+
INMETRO	-	+	+	+	+	+	+	-	+	+	-	-	-	+	+
JFCS	+	+	+	-	+	-	-	-	+	+	-	+	-	+	+
LEI	+	+	-	-	+	+	+	+	+	+	-	-	+	-	+
MTCC	+	+	+	+	+	-	+	+	+	+	-	+	+	+	-
PEFC Austria	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
PEFC Belgium	+	-	-	+	+	+	-	-	+	+	-	+	-	+	-
PEFC Czech	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
PEFC Denmark	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+
PEFC France	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PEFC Germany	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-
PEFC Italy	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
PEFC Latvia	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+
PEFC Luxembourg	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PEFC Norway	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
PEFC Polska	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
PEFC Portugal	+	+	-	-	+	+	-	+	+	+	+	+	-	+	+
PEFC Spain	+	+	-	-	+	-	+	+	+	+	+	+	+	+	+
PEFC Sweden	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PEFC UK Ltd	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
RSFC	+	-	+	-	+	-	+	+	+	+	+	+	-	-	+
SFI	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+
UKWAS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

+	means that standards/principles are established/relevant/mentioned/
-	means that standards/principles are not established/relevant/specified/
0	means no information

Comments to Tables 6 and 7 are given in Box 3.

Box 3	
Abbreviation used in Tables 3 and 4	Comments
CSA – 3	Exotic tree species are not handled directly in the CSA standard. However various SFM Criteria and CSA SFM elements imply restrictions and controls on the use of exotic tree species
CSA – 4	GMOs are not handled directly in the CSA standard. However various SFM Criteria and CSA SFM Elements imply restrictions and controls on the use of GMOs
CSA – D	None of the SFM Criteria and CSA SFM Elements refer directly to visual impact during harvesting, however this aspect is covered indirectly under various elements including CCFM Criterion 5 — Multiple Benefits to Society
CSA – R	Efficient utilization of forest products is not addressed directly in the CAN/CSA Z809 standard. However it is seen as implicit to Criterion 2
PEFC Germany – D	The aspect "visual impact of harvesting operations" is not mentioned in the German FSC-Standard. But it is addressed indirectly in the German FSC-Standard 5.3.1, 5.3.2, 6.5.1, 6.5.2, 6.5.3, 6.5.4 and 6.5.5.

All schemes reviewed have established high standards with respect to forestry performance, transparency, stakeholder participation, and independence. Based on our assessment of the ICFPA's Comparative Matrix of Forest Certification, there are many more similarities between the certification schemes than differences as shown in Tables 6 and 7.

However, we focus on the most widely applied certification systems such as PEFC, FSC, CSA, SFI, MTCC and AFS. Analyzing these systems (Tables 6 and 7) reveal that the most of sustainability criteria (Boxes 1 and 2) are established/relevant/mentioned in them. The criteria that these systems were missing were suggested to be excluded from the set of universal sustainability criteria that we attempt to create. Moreover, there is an additional explanation for a few of these exclusions. Thus, the reason for excluding "provision of public access to the forest"(A) as well as "maintenance of flow of non-wood products" (8) is that compensation schemes for non wood forest goods and services can be restricted to provision of public access to land including forests (*e.g.*, in the Netherlands). On the other hand, each hectare acquired for public access will cost a lot of and should therefore be the subject of a specific business plan. To withdraw public access to forests is therefore among the options of reducing the annual net cost of forestry (*e.g.*Anon, 2011). The result of the above mentioned selection process - the set of 22 principles – is presented in Table 8. The environmental part of this selection (colored area in Table 8) represents different environmental impact categories in biomass-for-energy production systems, broadly identified in the literature, such as soil, land, water, productivity and biodiversity. We aggregated all criteria into environmental, social and economical categories. Then we additionally aggregated all the environmental criteria into different impact categories, such as *soil, land, water, productivity and biodiversity.*

Table 8. *Selected sustainability criteria for biomass certification, where criteria that will be additionally excluded are in shaded area, and the different environmental impact categories (soil, land, water, productivity and, biodiversity) are in colored area.*

Abbreviation	Selected environmental, social and economic sustainability criteria	Impact Categories
C	Enhancement of the landscape and aesthetic value	Social
F	Recognition and respect for the customary and traditional rights of indigenous/local people	Social
G	The use of chemicals	Social.
I	Forest/land management planning	Social
J	Forest monitoring	Social
H	Protecting the health and safety of employees	Social
K	Training of workers	Social
L	Consultation during operations	Social
M	Provision of information to increase public awareness of forest management planning, forest operations, and/or forest outcomes	Social
N	Protection of areas of particular historic, cultural or spiritual value	Social
P	Provision of employment opportunities	Social
Q	Maintenance or enhancement of the economic viability of operations	Economy
1	Maintenance of biological diversity	Biodiversity
2	Maintenance or enhancement of endangered species populations	Biodiversity
5	Protection of areas of high ecological value	Land
7	Maintenance of sustained yield	Productivity
9	Protection of the soil and prevention of erosion	Soil
10	Protection or enhancement of water quality	Water
12	Regeneration following harvesting	Productivity
13	Prevention of conversion to other land uses	Land
14	Protection against pests	Productivity
15	Protection against fire	Productivity

6. Minimum universal sustainability criteria

The debate surrounding the design of bioenergy certification processes will remain for the foreseeable future. New criteria/standards may be set to prevent unsustainable biomass to be introduced to the market. However, as the trade in sustainable biomass can only grow if there is an agreement that sustainable biomass is used for energy production, suppliers and buyers are asking more questions at present about the biomass quality and they want to be sure that their biomass meets sustainability criteria. Therefore a clear certification of traded biomass is needed already now.

As can be seen (Table 8), the list of 22 criteria that have been selected is still large. On the other hand, many of the poorest regions of the world may not have the financial resources and the social infrastructure to administer certification systems.

In our attempt to participate in developing of sustainability criteria for biomass feedstock that can provide required assurances that biomass come from well managed sources, we make an effort to create a set of minimum universal sustainability criteria. For this we additionally evaluate each of the selected socio-economical and environmental sustainability criteria given in Table 8.

First of all, as results of this additional evaluation, some of the criteria will be excluded. Thus, for example, the reason for excluding “landscape” and “aesthetics” (C) is that it is already institutionalized, with landscape architects employed by some state forest services to develop and use separate guidelines on best practice in landscape design. Similar guidelines exist for private forest owners and companies (*e.g.*, Edwards, 2006). Moreover, “aesthetic quality” and “ecological quality” are not always synonymous, on the contrary there are many situations where the opposite is the case (*e.g.*, Ulrich, 1986). The aspect "visual impact of harvesting operations" (D) even if it is not directly mentioned in the most of systems is of course an important aspect which is addressed indirectly (*e.g.*, it is not mentioned in the German FSC-Standard, but addressed indirectly (Elmar Seizinger, personal communication)).

Recognition and respect for the customary and traditional rights of indigenous/local people (F) or the non-woody benefit of forest can be thought of in the terms of the notion of social capital. Despite that the numerous efforts to quantify changes in social capital and link these to positive economic and social outcomes are of varying success (*e.g.*, Edwards, 2006), we consider the F criterion to be important and therefore it will not be excluded when creating the set of universal sustainability criteria. It is worth to point out here that certification criteria for biomass for energy are most important in the policy context where it is crucial that political actions are not going to exacerbate the problems they were meant to reduce (*e.g.*, Delzeit & Holm-Műller, 2009).Training of workers (K) and Provision of employment opportunities (P) were regarded as sub-criteria within criteria “employment”. However, the net impact of employment takes into account alternative land use, can be measured in terms of its “displacement effect” and is also dependent on the type of forest (*e.g.*, Edwards, 2006). Consultation during operations (L) seems to overlap with Provision of information to increase public awareness of forest management planning, forest operations, and/or forest outcomes (M) and therefore was excluded. Further, some environmental principles/standards represent the same environmental impact categories. For example, Maintenance of sustained yield (7), Protection against fire (15) and Protection against pests (14) belong to the environmental impact category called Productivity. These criteria were excluded because they overlap with Regeneration following harvesting (12) – the important criterion belonging to the same Productivity category.

Secondly, the set of universal criteria that we are attempting to create is suggested to be complemented by some additional tools. Thus, the issue of social standards is important. However, some important concerns, for example the United Nations Convention on the Rights of Children, are not addressed. Child labor is an issue which is often discussed in public and is therefore a subject of reputation, with much potential for bad publicity. Child labour is a criterion very important to consumers and seems to be needed to include. The United Nations Convention on the Rights of Children and ILO Conventions and Recommendations that cover a broad range of subjects concerning work, employment, social security, social policy and related human rights should be included. The ILO Conventions and Recommendations are broadly covered by FSC and PEFC schemes.

Thirdly, criteria that are more often missed in the other than widely applied certification systems (Tables 6and 7) are also suggested to be excluded when creating the set of minimum universal sustainability criteria. The reliability of available data for some of the important social criteria can be challenged. The themes that will be excluded in order to create the universal minimum sustainability criteria are in shaded area (Table 8).

The final result of the sampling, additional consideration/evaluation/exclusion/filtering and finally complementation is the set of minimum universal sustainability criteria given in Table 9.

Table 9. Selected minimum universal sustainability criteria for biomass certification for the different sectors, aggregated into environmental, social and economic principles given in Table 5.

Principles	Minimum universal sustainability criteria	Forestry	Agriculture	Waste	Other
1a	The use of chemicals (G)	+	+	+	+
1a	Maintenance of biological diversity (1)	+	+	(-)	?
1a	Protection of areas of high ecological value (5)	+	+	(+)	?
1a	Protection of the soil and prevention of erosion (9)	+	+	-	?
1a	Protection or enhancement of water quality (10)	+	+	+	?
1a	Regeneration following harvesting (12)	+	(+)	-	?
1a,b	Forest/land monitoring (J)	+	+	+	?
1b	Forest/land management planning (I)	+	?	-	?
2a	Provision of information to increase public awareness of management planning, forest operations, and/or forest outcomes (M)	+	+	+	+
2b	Protecting the health and safety of employees (H)	+	+	+	+
2c	Recognition and respect for the customary and traditional rights of indigenous/local people (F)	+	+	+	+
2c	The rights of children (RC)	+	+	+	+
2a,c	Protection of areas of particular historic, cultural or spiritual value (N)	+	+	+	+
3	Maintenance or enhancement of the economic viability of operations (Q)	+	+	(+)	(+)

This set of criteria **aggregated into six principles** provide assurance that biomass-for-energy comes from responsibly managed ecosystems, taking equal account of economic, environmental and social impacts.

V. DISCUSSION AND CONCLUSIONS

Biomass fuels offer many new opportunities, but if not managed carefully, they may also in a sense carry significant risks. In the large scale, it is how bioenergy development is supported and regulated that determines whether or not bioenergy will be sustainable. Sustainable biomass management should be a holistic approach defined as the stewardship of biomass production in a way and at a rate that maintains the potential to maintain or improve ecological, economic and social functions of biomass production land.

The role of certification efforts in this report is to participate in creation of a global market for sustainable biomass fuels and bioenergy. Certification efforts must be clearly matched to specific goals. The goal of the criteria is to promote environmentally responsible, socially beneficial and economically viable management of the biomass-for-energy production systems, by establishing a worldwide standard of recognized and respected Principles of Biomass Certification System.

The experience in the forestry sector was judged to be most relevant for the development of the minimum universal sustainability criteria for biomass for energy. Forestry standards, principles, criteria and indicators developed by existing and emerging voluntary standards around the world were compared. It was suggested to focus on the most widely applied certification systems such FSC and PEFC as well as CSA, SFI, MTCC and AFS endorsed by the PEFC. These systems can act as examples when developing biomass sustainability criteria. From them first of all the set of basic principles was identified (Table 5). Then, only the criteria that all major systems use were selected and suggested to be included in the set of criteria that the current project attempts to define. The use of carbon balances in certification systems is a relatively new field, experiences with this tool are still limited and therefore it was not chosen already now. However, carbon balance will probably be needed to be taken into account when development in the balance calculations make it standardized and thus ready to serve the biomass energy market in the practical way. Completion of criteria, based on a policy and literature review and analysis of other certification schemes, included the United Nations Convention on the Rights of Children.

The final result of the sampling, filtering and completion is the set of principles and criteria suggested. Our proposed system like most of certification systems has a hierarchical structure in which the task of avoiding unsustainable biomass is translated into the principles. Each of the principles was designed to ensure that biomass is produced in accordance with sustainability requirements. In order to make the principles workable sustainability criteria were developed. Each principle furthermore includes a number of criteria as shown in Table 9. Thus, PRINCIPLE 1, requiring that biomass shall be produced in an environmentally responsible way, is covered by criteria G, I, J, 1, 5, 9, 10, 12. PRINCIPLE 2, requiring sustainable management of social capital, is covered by criteria F, H, M, N, RC. PRINCIPLE 3, requiring that biomass production shall be economically viable, is covered by criteria Q. Each of the selected criteria is suggested to be explained by indicators in order to measure whether the criteria are met.

This set of sustainability criteria for certification of biomass for energy - might be interesting not only to EU stakeholders, but as we believe the outcome can generally be useful for other parts of the world as well. In order to ensure confidence in sustainable biomass-for-energy production, the proposed set of certification criteria focuses on the pressing but at the same time broadly universal sustainability requirements. Following a wide ranging review of existing literature as well as extensively analyzing the ICFPA`s (2002) “On-line Matrix” the verifiability of the selected criteria have been assessed to be high.

The selected criteria may be regarded as an attempt to evaluate or adapt the performance of existing standards and therefore are of course arguable. It should be pointed out that the universal sustainability criteria do not regulate the whole bioenergy production chain, but only the production of biomass for energy. The selected criteria constitute one part of a hierarchical structure of concepts such as "principles" "criteria" and furthermore "indicators" and ''verifiers". The last two concepts will be elaborated later as the criteria are further developed for practical use.

One finding from this study is that industry represents most of information regarding comparison of different certification schemes. This seems natural since forestry industry is concerned about certification schemes, enhancing and promoting as well as justifying the quality of their activities. Cooperation with industry (among other parties) is therefore recommended in creating final recommendations. However, certification schemes operated by only national industry associations might hamper the internationalization of biomass-for-energy certification schemes.

In this report the features of different forestry certification schemes have been compared. A variety of approaches for promotion of sustainable forestry are being adopted by these schemes. The schemes reviewed, from our judgment, have established acceptable standards with respect to forestry performance, transparency, stakeholder participation, and independence. Based on the assessment of ICFPA's Comparative Matrix of Forest Certification, there are many more similarities between the certification schemes than differences.

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APPENDIX

Table A. Explanations of social and economic criteria for forest certification schemes.

Abbreviation	Principles/standards	One of explanations	References
A	Provision of public access to the forest	Existence of a legal / regulatory framework, and the extent to which it recognizes customary and traditional rights of indigenous people, and provides means of resolving access disputes	CRITERION 6 of PEFC: Maintenance of other Socio-Economic Functions and Conditions
B	Provision of recreational opportunities	Provision of recreation: area of forest with access per inhabitant, % of total forest area	CRITERION 6 of PEFC: Maintenance of other Socio-Economic Functions and Conditions
C	Enhancement of the landscape and aesthetic value of forest	Existence and capacity of an institutional framework to develop and maintain programmes to conserve culturally valuable sites and landscapes	CRITERION 6 of PEFC: Maintenance of other Socio-Economic Functions and Conditions
D	Limiting the visual impact of harvesting operations	Written guidelines shall be prepared and implemented to control erosion; minimize forest damage during harvesting, road construction, and all other mechanical disturbances; and protect water resources.	Criterion 6.5 of Swedish FSC, version 4:2.
E	Clear land tenure and long term use right to the land	Clear evidence of long-term tenure and use rights to the land (*e.g.* land title, customary rights, or lease agreements) and forest resources shall be clearly defined, documented and legally established	Principle #2 of FSC: Tenure and use rights and responsibilities
F	Recognition and respect for the customary and traditional rights of indigenous/local people	The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected. One of four criteria of Principle #3 of FSC is: Indigenous peoples shall control forest management on their lands and territories unless they delegate control with free and informed consent to other agencies.	Principle #3 of FSC: Indigenous peoples' rights
G	The use of chemicals	Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides. If chemicals are used, proper equipment and training shall be provided to minimize health and environmental risks. Chemicals, containers, liquid and solid non-organic wastes including fuel and oil shall be disposed of in an environmentally appropriate manner at off-site locations.	Principle #6 of FSC: Environmental impact
H	Protecting the health and safety of employers	The forest manager shall foster a safe working environment and comply with relevant Occupational Health and Safety (OH&S) employment legislation	Criterion 9 of AFCS: Forest management shall maintain and enhance long-term social and economic benefits
I	Forest management planning	The management plan shall provide: a) Management objectives. b) Description of the forest resources to be managed, environmental limitations, land use and ownership status, socio-economic conditions, and a profile of adjacent lands. c) Description of silvicultural and/or other management system, based on the ecology of the forest in question and information gathered through resource inventories. d) Rationale for rate of annual harvest and species selection.	Principle #7 of FSC: Management plan

		e) Provisions for monitoring of forest growth and dynamics.	
J	Forest monitoring	Monitoring shall be conducted -- appropriate to the scale and intensity of forest management -- to assess the condition of the forest, yields of forest products, chain of custody, management activities and their social and environmental impacts.	Principle #8 of FSC: Monitoring and assessment
K	Training of forestry workers	Forest workers shall receive adequate training and supervision to ensure proper implementation of the management plan.	Principle #7 of FSC: Management plan
L	Consultation during forest operations	Management planning and operations shall incorporate the results of evaluations of social impact. Consultations shall be maintained with people and groups (both men and women) directly affected by management operations.	Principle #4 of FSC: Community relations and worker's rights
M	Provision of information to increase public awareness of forest management planning, forest operations and/or forest outcomes	While respecting the confidentiality of information, forest managers shall make publicly available a summary of the primary elements of the management plan, a summary of the results of monitoring indicator.	Principle #8 of FSC: Monitoring and assessment, Principle #7 of FSC: Management plan
N	Protection of area of particular historic, cultural or spiritual value	1. Sites of special cultural, ecological, economic or religious significance to indigenous peoples shall be clearly identified in cooperation with such peoples, and recognized and protected by forest managers. 2. Existence of economic policy framework and financial instruments, and the extent to which ịt supports forestry constituencies to conserve special environmental, cultural, social and scientific values in relation to recreational services	1.Principle #3 of FSC: Indigenous peoples' rights 2. CRITERION 6 of PEFC: Maintenance of other Socio-Economic Functions and Conditions
O	Provision of employment for local people	Existence of economic policy framework and financial instruments, and the extent to which it supports programmes to ensure employment in rural areas in relation to forestry.	CRITERION 6 of PEFC: Maintenance of other Socio-Economic Functions and Conditions
P	Provision of employment opportunities in forestry	The communities within, or adjacent to, the forest management area should be given opportunities for employment, training, and other services.	Principle #4 of FSC: Community relations and worker's rights
Q	Maintenance or enhancement of the economic viability of forest operations	Forest management should strive toward economic viability, while taking into account the full environmental, social, and operational costs of production, and ensuring the investments necessary to maintain the ecological productivity of the forest.	Principle #5 of FSC: Benefits from the forest
R	Ensuring efficient utilization of forest products	Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits	Principle #5 of FSC: Benefits from the forest
S	Game management	Total amount of and changes in the value and/or quantity of non-wood forest products (e.g., hunting and game, cork, berries, mushrooms, etc.). Existence and capacity of an institutional framework to: support appropriate organizations for extension services on non-wood benefits	CRITERION 3 of PEFC: Maintenance and Encouragement of Productive Functions of Forests (wood and non-wood)

Table B. Explanations of environmental principles/standards for forest certification schemes.

Abbreviation	Principles/standards	One of explanations	One of references
1	Maintenance of biological activity	Existence and capacity of an institutional framework to maintain, conserve and appropriately enhance biological diversity at the ecosystem, species and genetic levels	CRITERION 4 of PEFC: Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems
2	Maintenance or enhancement of endangered species population	Changes in the number and percentage of threatened species in relation to total number of forest species (using reference lists e.g., IUCN, Council of Europe or the EU Habitat Directive)	CRITERION 4 of PEFC: Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems
3	Restriction or controls on the use of exotic tree species	The use of exotic species shall be carefully controlled and actively monitored to avoid adverse ecological impacts	Principle #6 of FSC: Environmental impact
4	Restriction/controls or prohibition on the use of genetically modified organisms	Use of biological control agents shall be documented, minimized, monitored and strictly controlled in accordance with national laws and internationally accepted scientific protocols. Use of genetically modified organisms shall be prohibited.	Principle #6 of FSC: Environmental impact
5	Protection of areas of high ecological value	Sites of special cultural, ecological, economic or religious significance to indigenous peoples shall be clearly identified in cooperation with such peoples, and recognized and protected by forest managers.	Principle #3 of FSC: Indigenous Peoples' Rights
6	Implementation of formal environmental management systems such as ISO 14001	Requirements for standard setting procedures are based on ISO Guide 59[i]	PEFC
7	Maintenance of sustainable yield of timber	Existence of a legal / regulatory framework, and the extent to which it supports sustainable management while increasing the growing stock of both merchantable and non-merchantable tree species on forest land available for timber production	CRITERION 1 of PEFC: Maintenance and Appropriate Enhancement of Forest Resources and their Contribution to Global Carbon Cycles
8	Maintenance of flow of non-wood products	Existence of a legal / regulatory framework, and the extent to which it provides legal instruments to regulate forest management practices for recreation and the harvesting of important non-wood forest products 2. Existence and capacity of an institutional framework to support appropriate organisations for extension services on non-wood benefits 3. Existence of economic policy framework and financial instruments, and the extent to which it enables the implementation of guidelines for management of non-wood benefits 4. Existence of informational means to implement the policy framework, and the capacity to develop management plans for non-wood benefits	CRITERION 3 of PEFC: Maintenance and Encouragement of Productive Functions of Forests (wood and non-wood)
9	Protection of soil and prevention of erosion	1. Existence of a legal / regulatory framework, and the extent to which it: - provides for legal instruments to regulate or limit forest management practices in areas with vulnerable soils	CRITERION 5 of PEFC: Maintenance and Appropriate Enhancement of

		2. Existence and capacity of an institutional framework to: -strengthen institutional instruments to regulate or limit forest management practices in areas with vulnerable soils 3. Existence of economic policy framework and financial instruments, and the extent to which it: - supports the preparation of management guidelines for areas with vulnerable soils 4. Existence of informational means to implement the policy framework, and the capacity to: - conduct inventories and research on soil erosion	Protective Functions in Forest Management (notably soil and water)
10	Protection or enhancement of water quality	Written guidelines shall be prepared and implemented to protect water resources: 1. Existence of a legal / regulatory framework, and the extent to which it provides for legal instruments to regulate or limit forest management practices in favour of water conservation or protection of water resources. 2. Existence and capacity of an institutional framework to develop and maintain institutional instruments to regulate or limit forest management practices in favour of water conservation or protection of water resources. 3. Existence of economic policy framework and financial instruments, and the extent to which it supports the preparation of management guidelines for taking into consideration water conservation in forest management practices. 4. Existence of informational means to implement the policy framework, and the capacity to conduct inventories and research on water quality and flow characteristics in relation to land use practices / forest management	CRITERION 5 of PEFC: Maintenance and Appropriate Enhancement of Protective Functions in Forest Management (notably soil and water)
11	Maintenance of forest cover and area	- ensure regeneration of managed forests; - conduct inventories on proportion of area covered by trees significantly older than the acceptable age of exploitation currently used - monitor changes in the proportions of afforested or reforested areas covered by indigenous and introduced species, conifer and deciduous species .	CRITERION 4 of PEFC: Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems
12	Forest regeneration following harvesting	Develop and maintain institutional instruments to ensure regeneration of managed forests	CRITERION 4 : Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems
13	Prevention of conversion to other land uses	Forest conversion to plantations or non-forest land uses shall not occur, except in circumstances where conversion: a) entails a very limited portion of the forest management unit; and b) does not occur on high conservation value forest areas; and c) will enable clear, substantial, additional, secure, long term conservation benefits across the forest management unit.	Principle #6 of FSC: Environmental impact
14	Protection of forest against pest	Integrated pest management shall form an essential part of the management plan, with primary reliance on prevention and biological control methods rather than chemical pesticides and fertilizers. Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticider.	Principle #10 of FSC: Plantations Principle 6.6 of MTCC in compliance with Principle #6 of FSC: Environmental Impact
15	Protection of forest against fire	The forest manager shall implement effective measures to reduce the extent and impact of unplanned fires.	Criterion 4 of AFS:Forest management shall maintain the productive capacity of forests

[i] ISO/IEC Guide 59:1994 Code of good practice for standardization

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